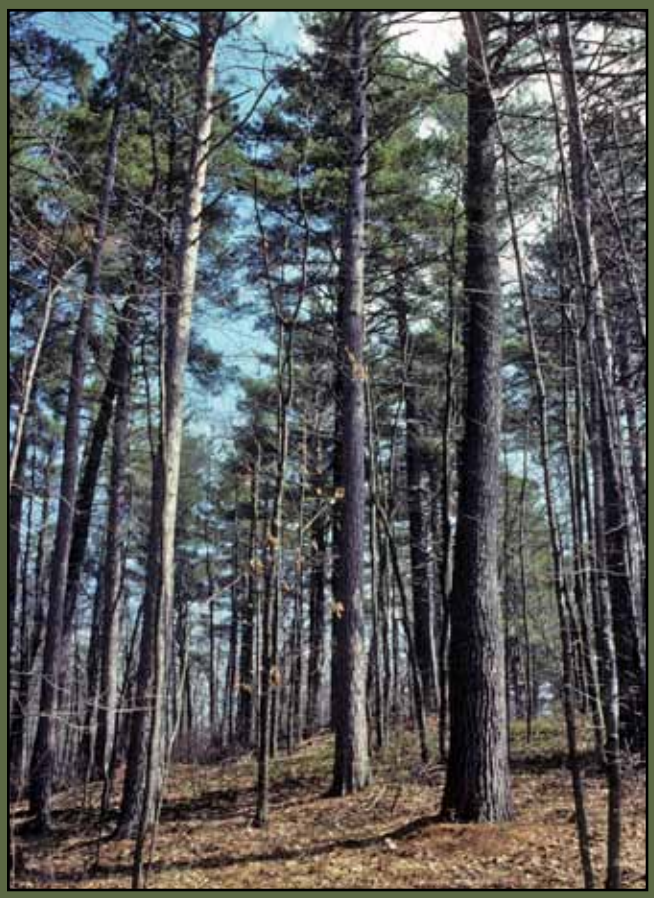
Chapter 14

Northern Highland Ecological Landscape



Where to Find the Publication

The Ecological Landscapes of Wisconsin publication is available online, in CD format, and in limited quantities as a hard copy. Individual chapters are available for download in PDF format through the Wisconsin DNR website (http://dnr.wi.gov/, keyword "landscapes"). The introductory chapters (Part 1) and supporting materials (Part 3) should be downloaded along with individual ecological landscape chapters in Part 2 to aid in understanding and using the ecological landscape chapters. In addition to containing the full chapter of each ecological landscape, the website highlights key information such as the ecological landscape at a glance, Species of Greatest Conservation Need, natural community management opportunities, general management opportunities, and ecological landscape and Landtype Association maps (Appendix K of each ecological landscape chapter). These web pages are meant to be dynamic and were designed to work in close association with materials from the Wisconsin Wildlife Action Plan as well as with information on Wisconsin's natural communities from the Wisconsin Natural Heritage Inventory Program.

If you have a need for a CD or paper copy of this book, you may request one from Dreux Watermolen, Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, WI 53707.

Photos (L to R): Black Tern, photo by Brian Collins; river otter, photo by Brian Collins; showy lady's-slipper, photo by Thomas Meyer, Wisconsin DNR; Chestnut-sided Warbler, photo by Brian Collins; Common Loon, photo by Ryan Brady, Wisconsin DNR.

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Cover Photos

Top left: *Supercanopy eastern white and red pines are prominent in this stand of old-growth dry-mesic to mesic forest near Dry Lake on the Northern Highland-American Legion State Forest, Vilas County. Photo by Eric Epstein, Wisconsin DNR.*

Bottom left: *Wild rice and other aquatic plants fill the shallow south basin of this drainage lake. Resident animals include Bald Eagle, Osprey, Common Loon, and Black Tern. Photo by Eric Epstein, Wisconsin DNR.*

Top right: *With its abundant lakes, the Northern Highland is a Wisconsin stronghold for Common Loons. Pictured here is an adult on its nest. Photo by Ryan Brady, Wisconsin DNR.*

Center right: *Older dry-mesic forest of eastern white pine and northern red oak on an isthmus between two lakes. Note the tamarack-fringed pond on the isthmus. Northern Highland-American Legion State Forest, Vilas county. Photo by Eric Epstein, Wisconsin DNR.*

Bottom right: *Swamp-pink orchid (*Arethusa bulbosa*) is a characteristic though usually uncommon plant of open, boggy peatlands known as "poor fens." Photo by Ryan Magana, Wisconsin DNR.*

Drew Feldkirchner, WDNR

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Ryan Magana, WDNR

Northern Highland Ecological Landscape at a Glance

Physical and Biotic Environment

Size

The Northern Highland encompasses 2,081 square miles (1,331,970 acres), or 3.7% of the area of the state of Wisconsin.

Climate

The climate is typical of northern Wisconsin, with a mean growing season of 122 days. The mean annual temperature is 39.5°F, the lowest of any ecological landscape in the state and almost two degrees lower than other northern ecological landscapes. The mean annual precipitation is 31.6 inches, similar to other northern ecological landscapes. The mean annual snowfall is 68.1 inches, the second largest amount of snowfall in the state. Only the Superior Coastal Plain receives more snowfall (87.4 inches). Snowfall varies dramatically within the Northern Highland, with the northern part of the ecological landscape being within the outer edge of the lake effect "snowbelt" of Upper Michigan and northwestern Wisconsin. The cool temperatures, short growing season, and sandy soils are not adequate to support agricultural row crops such as corn. Only about 1% of the Northern Highland is used for agricultural purposes. The climate is favorable for forests, which cover more than 76% of the ecological landscape.

Bedrock

The Northern Highland Ecological is predominantly underlain by igneous and metamorphic rock, generally covered by deposits of glacial drift from 5 feet to over 100 feet in depth.

Geology and Landforms

Most of the ecological landscape is an undulating, gently rolling glacial outwash plain with many kettle lakes, wetlands, and bogs. Remnant moraines and drumlins occur, often with their lower slopes covered with outwash sands.

Soils

Most soils are sands and gravels, some with a loamy mantle. Soil productivity is low compared to glacial till but relatively high for outwash sands. Wetlands are numerous; most have organic soils of peat or muck.

Hydrology

There is a globally significant concentration of glacial lakes in the Northern Highland: 4,291 lakes and 1,543 miles of streams, including the headwaters of the Wisconsin and Manitowish-Flambeau-Chippewa river systems. Many lakes are connected by small streams. Rare aquatic species and extensive wetlands occur here.

Current Land Cover

Land cover consists of 48% upland forest, 34% wetlands (both forested and nonforested), 13% open water, 5% grassland and open land, and 1% urban.

Socioeconomic Conditions

The counties included in the Northern Highland socioeconomic region are Iron, Oneida, and Vilas counties.

Population

The population was 63,344, or 1.1% of the state total, in 2010.

Population Density

23 persons per square mile

Per Capita Income

$26,853 in 2006

Important Economic Sectors

Tourism-related businesses (16.9% of all jobs in the Northern Highland), Retail Trade (15.0%), Construction (13.5%), Government (13.1%), and Health Care and Social Services (9.3%) provide the largest portion of jobs in Northern Highland counties.

Public Ownership

Thirty percent of the land area and 43% of the forestland in the Northern Highland Ecological Landscape is in public ownership. Some of the larger properties are the Chequamegon-Nicolet National Forest, Northern Highland-American Legion State Forest, Turtle-Flambeau Flowage, Willow Flowage, and the Iron, Vilas, and Oneida county forests. A

map showing public land ownership (county, state, and federal) and private lands enrolled in the forest tax programs in this ecological landscape can be found in Appendix 14.K at the end of this chapter.

Other Notable Ownerships

Tribal ownership is significant; the large reservation of the Lac du Flambeau Band of Lake Superior Chippewa Indians is here. The University of Wisconsin maintains research-oriented field stations at Trout Lake and Kemp Station and also has stewardship responsibilities for several ecologically significant tracts.

Considerations for Planning and Management

There has been a steady increase in both seasonal and permanent residents, creating a pattern of dispersed urbanization. This has been especially evident along shorelines, where habitat loss has occurred in the littoral zone and on lands adjacent to the shore. Residential development is also increasing in the forests that surround many lakes. Population growth and associated development appear likely to limit some management options in the future, such as the ability to manage at large scales, maintaining ecosystem connectivity, and protecting important spawning, nesting, and foraging habitats. Restoration of shoreline habitats and the processes that maintain them will become more difficult over time.

Several large industrial forest holdings have changed ownership in recent years. In some cases, these properties have been sold to public agencies, but they have also been sold to other industrial owners, real estate developers, or other private entities. When large contiguous ownerships are broken up, habitat fragmentation is often one of the results, and this parcelization makes it difficult to meet the desires of all of the new landowners, potentially limiting management options. Development of seasonal and permanent homes, along with roads and other infrastructure to service the residents, has also increased habitat fragmentation and reduced the size of formerly connected habitats.

Excessive white-tailed deer herbivory can suppress or eliminate the regeneration of trees such as eastern hemlock and northern white-cedar and reduce populations of sensitive understory plants, including native plants in the lily and orchid families. The winter feeding of white-tailed deer can lead to increased overwinter white-tailed deer survival, larger white-tailed deer populations than habitats can sustain, and ultimately, serious habitat damage.

Invasive species are present in both terrestrial and aquatic ecosystems. The "Clean Boats, Clean Waters" program and other educational efforts attempt to limit the introduction and spread of invasive species to aquatic habitats, but more awareness, persistence, and follow-through are needed. In terrestrial ecosystems, some invasive species are present but most are not yet abundant enough to cause serious problems—making this the most effective time to initiate control measures.

Management Opportunities

The Northern Highland is especially rich in rare species associated with waters and wetlands, including some of the north's most iconic animals such as the Bald Eagle, Osprey, and Common Loon. There are major opportunities to protect aquatic ecosystems, including one of North America's highest concentrations of glacial lakes, some of which are rare lake types. Lakes connected by perennial streams are common here and support a diverse aquatic fauna that includes rare and uncommon species. Protecting undeveloped lakes, restoring disturbed shorelines, and protecting the integrity of lake-stream complexes are all extremely important management opportunities. Maintaining forest cover around and between lakes and streams is also needed to maintain high water quality and provide habitat for numerous species.

Feeding deer has become increasingly popular, increasing winter survival and the overall size of the herd in the Northern Highland Ecological Landscape. This has resulted in serious regeneration problems for important species such as eastern hemlock and northern white-cedar. Photo by Mike Dudenas.

Lake Alva Hemlock-Hardwoods, a remnant stand of old-growth forest, embedded within extensive working forests of pine, aspen, and northern hardwoods. Several undeveloped lakes and wetlands are scattered throughout this site, which supports several rare species. Photo by Eric Epstein, Wisconsin DNR.

The ecological landscape's rivers and streams provide critical habitat and support many rare species. Significant protection and management opportunities include the headwaters region and upper stretches of the Wisconsin River as well as the Manitowish, Tomahawk, and Squirrel rivers. A concentration of springs and spring ponds in the northeastern part of the Northern Highland-American Legion State Forest offers management opportunities for aquatic species associated with coldwater systems.

The extensive forests here present major opportunities and include the state's greatest acreage of dry-mesic eastern white pine-red pine forests. These could be managed in the wide range of patch sizes, age classes, seral stages, and environmental settings characteristic of the Northern Dry-mesic Forest community in this ecological landscape. Other less abundant forest types providing good management opportunities include mesic hemlock-hardwood and northern hardwood forests; swamp conifers of black spruce, tamarack, or northern white-cedar; dry jack pine forests; and hardwood swamps. Northern red oak, important for both ecological and economical reasons, is now a major forest component in some areas. White birch is declining, and regeneration has proven difficult on many sites in the absence of fire. Extensive public ownerships create opportunities to manage these forests at large scales within and across ownerships.

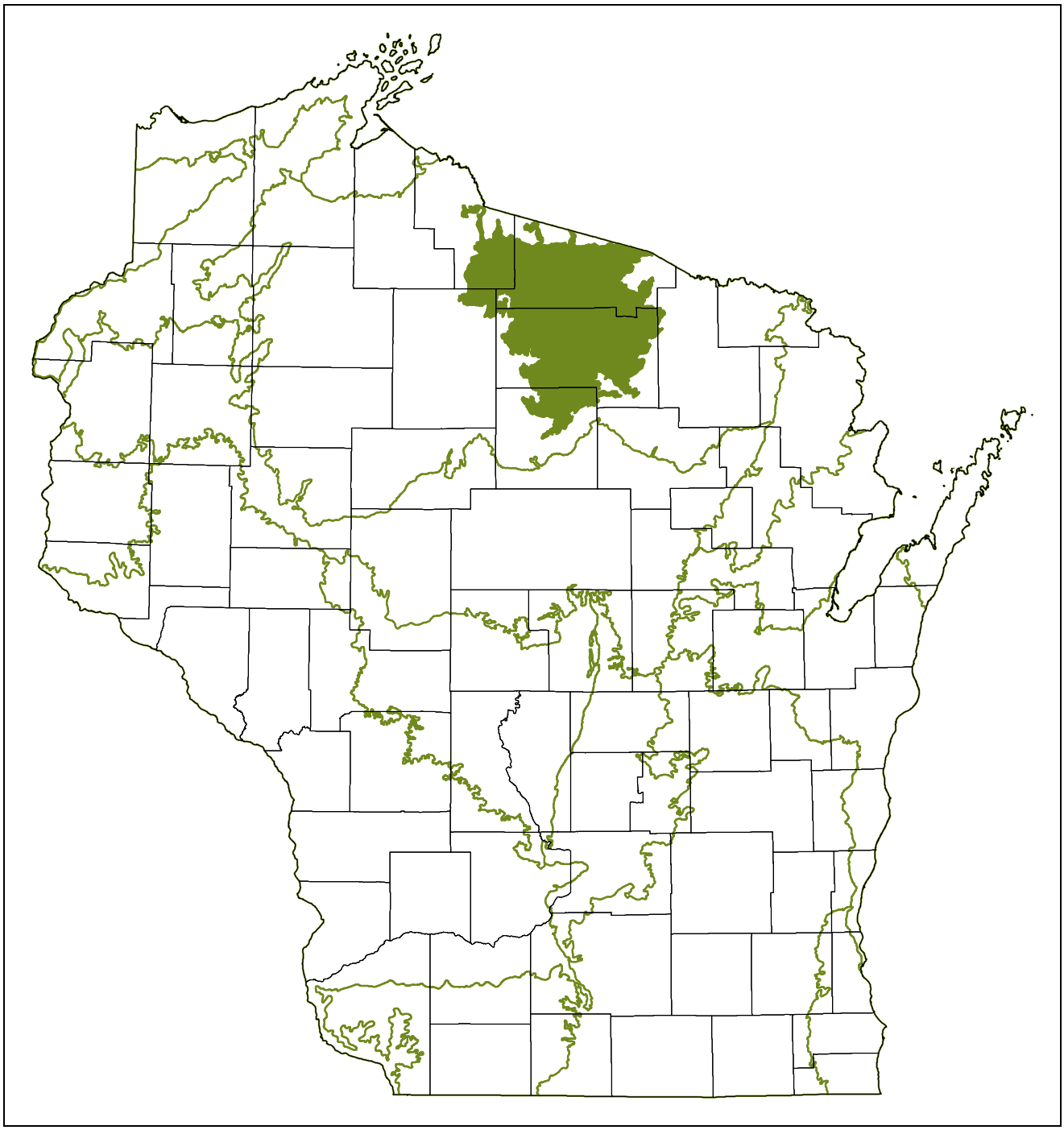
Old forests are a rare and declining resource in Wisconsin. The Northern Highland offers especially important opportunities for the development and restoration of older forests of eastern white pine, red pine, northern red oak, hemlock-hardwoods, northern hardwoods, and swamp conifers. Working forests, both publicly and privately owned, could include areas with extended rotations, the development of old-growth forest characteristics, and stands of "managed old-growth."

The Northern Highland historically consisted of a diverse mosaic of habitats, patch sizes, stand ages, ecotones, and aquatic features. Although management is often conducted at the stand-level, there are major opportunities here to plan and coordinate management from a much broader perspective to accommodate all patch sizes and ages for forest communities and to establish and maintain connections between them. This would help maintain the full range of habitat diversity and connectivity needed across this ecological landscape.

Abundant wetlands include several of the state's largest and least disturbed acid peatland ecosystems as well as shrub communities, hardwood swamp, northern white-cedar swamp, emergent marsh, and wild rice marsh. These wetlands provide important habitats and are critical for maintaining water quality in the ecological landscape's high-quality lakes and streams. Maintaining wetland hydrology and avoiding conversion to other wetland types is important and necessary to provide habitat for numerous wetland-dependent plants and animals.

The Bittersweet Lakes complex features deep, hard-bottomed, oligotrophic seepage lakes embedded within extensive second-growth pine-hardwood forest. Northern Highland-American Legion State Forest, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Extensive open peatlands along Hwy 47, Powell Peatlands, Iron/Vilas counties. Photo by Eric Epstein, Wisconsin DNR.



Northern Highland Ecological Landscape

Michele Woodford, WDNR

Northern Highland Ecological Landscape

Introduction

This is one of 23 chapters that make up the Wisconsin DNR's publication *The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management*. This book was developed by the Wisconsin DNR's Ecosystem Management Planning Team and identifies the best areas of the state to manage for natural communities, key habitats, aquatic features, native plants, and native animals from an ecological perspective. It also identifies and prioritizes Wisconsin's most ecologically important resources from a global perspective. In addition, the book highlights socioeconomic activities that are compatible with sustaining important ecological features in each of Wisconsin's 16 ecological landscapes.

The book is divided into three parts. Part 1, "Introductory Material," includes seven chapters describing the basic principles of ecosystem and landscape-scale management and how to use them in land and water management planning; statewide assessments of seven major natural community groups in the state; a comparison of the ecological and socioeconomic characteristics among the ecological landscapes; a discussion of the changes and trends in Wisconsin ecosystems over time; identification of major current and emerging issues; and identification of the most significant ecological opportunities and the best places to manage important natural resources in the state. Part 1 also contains a chapter describing the natural communities, aquatic features, and selected habitats of Wisconsin. Part 2, "Ecological Landscape Analyses," of which this chapter is part, provides a detailed assessment of the ecological and socioeconomic conditions for each of the 16 individual ecological landscapes. These chapters identify important considerations when planning management actions in a given ecological landscape and suggest management opportunities that are compatible with the ecology of the ecological landscape. Part 3, "Supporting Materials," includes appendices, a glossary, literature cited, recommended readings, and acknowledgments that apply to the entire book.

This publication is meant as a tool for applying the principles of ecosystem management (see Chapter 1, "Principles of Ecosystem and Landscape-scale Management"). We hope it will help users better understand the ecology of the different regions of the state and help identify management that will sustain all of Wisconsin's species and natural communities while meeting the expectations, needs, and desires of our public and private partners. The book should provide valuable tools for planning at different ***scales***, including master planning for Wisconsin DNR-managed lands, as well as assist in project selection and prioritization.

Many sources of data were used to assess the ecological and socioeconomic conditions within each ecological landscape. Appendix C, "Data Sources Used in the Book" (in Part 3, "Supporting Materials"), describes the methodologies used as well as the relative strengths and limitations of each data source for our analyses. Information is summarized by ecological landscape except for socioeconomic data. Most economic and demographic data are available only on a political unit basis, generally with counties as the smallest unit, so socioeconomic information is presented using county aggregations that approximate ecological landscapes unless specifically noted otherwise.

Rare, declining, or vulnerable species and natural community types are often highlighted in these chapters and are given particular attention when Wisconsin does or could contribute significantly to maintaining their regional or global abundance. These species are often associated with relatively intact natural communities and aquatic features, but they are sometimes associated with cultural features such as old fields, abandoned mines, or dredge spoil islands. Ecological landscapes where these species or community types are either most abundant or where they might be most successfully restored are noted. In some cases, specific sites or properties within an ecological landscape are also identified.

Although rare species are often discussed throughout the book, "keeping common species common" is also an important

Terms highlighted in green are found in the glossary in Part 3 of the book, "Supporting Materials." Naming conventions are described in Part 1 in the Introduction to the book. Data used and limitation of the data can be found in Appendix C, "Data Sources Used in the Book," in Part 3.

consideration for land and water managers, especially when Wisconsin supports a large proportion of a species' regional or global population or if a species is socially important. Our hope is that this publication will assist with the regional, statewide, and landscape-level management planning needed to ensure that most, if not all, native species, important habitats, and community types will be sustained over time.

Consideration of different scales is an important part of ecosystem management. The 16 ecological landscape chapters present management opportunities within a context of ecological functions, natural community types, specific habitats, important ecological processes, localized environmental settings, or even specific populations. We encourage managers and planners to include these along with broader landscape-scale considerations to help ensure that all natural community types, ***critical habitats***, and aquatic features, as well as the fauna and flora that use and depend upon them, are sustained collectively across the state, region, and globe. (See Chapter 1, "Principles of Ecosystem and Landscape-scale Management," for more information.)

Locations are important to consider since it is not possible to manage for all species or community types within any given ecological landscape. Some ecological landscapes are better suited to manage for particular community types and groups of species than others or may afford management opportunities that cannot be effectively replicated elsewhere. This publication presents management opportunities for all 16 ecological landscapes that are, collectively, designed to sustain as many species and community types as possible within the state, with an emphasis on those especially well represented in Wisconsin.

This document provides useful information for making management and planning decisions from a landscape-scale and long-term perspective. In addition, it offers suggestions for choosing which resources might be especially appropriate to maintain, emphasize, or restore within each ecological landscape. The next step is to use this information to develop landscape-scale plans for areas of the state (e.g., ecological landscapes) using a statewide and regional perspective that can be implemented by field resource managers and others. These landscape-scale plans could be developed by Wisconsin DNR staff in cooperation with other agencies and nongovernmental organizations (NGOs) that share common management goals. Chapter 1, "Principles of Ecosystem and Landscape-scale Management," in Part 1 of the book contains a section entitled "Property-level Approach to Ecosystem Management" that suggests how to apply this information to an individual property.

How to Use This Chapter

The organization of ecological landscape chapters is designed to allow readers quick access to specific topics. You will find some information repeated in more than one section, since our intent is for each section to stand alone, allowing the reader to quickly find information without having to read the chapter from cover to cover. The text is divided into the following major sections, each with numerous subsections:

- Environment and Ecology
- Management Opportunities for Important Ecological Features
- Socioeconomic Conditions

The "Environment and Ecology" and "Socioeconomic Conditions" sections describe the past and present resources found in the ecological landscape and how they have been used. The "Management Opportunities for Important Ecological Features" section emphasizes the ecological significance of features occurring in the ecological landscape from local, regional, and global perspectives as well as management opportunities, needs, and actions to ensure that these resources are enhanced or sustained. A statewide treatment of integrated ecological and socioeconomic opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management."

Summary sections provide quick access to important information for select topics. "Northern Highland Ecological Landscape at a Glance" provides important statistics about and characteristics of the ecological landscape as well as management opportunities and considerations for planning or managing resources. "General Description and Overview" gives a brief narrative summary of the resources in an ecological landscape. Detailed discussions for each of these topics follow in the text. Boxed text provides quick access to important information for certain topics ("Significant Flora," "Significant Fauna," and "Management Opportunities").

Coordination with Other Land and Water Management Plans

Coordinating objectives from different plans and consolidating monetary and human resources from different programs, where appropriate and feasible, should provide the most efficient, informed, and effective management in each ecological landscape. Several land and water management plans dovetail well with *The Ecological Landscapes of Wisconsin*, including the Wisconsin Wildlife Action Plan; the Fish, Wildlife, and Habitat Management Plan; the Wisconsin Bird Conservation Initiative's (WBCI) All-Bird Conservation Plan and Important Bird Areas program; and the *Wisconsin Land Legacy Report*. Each of these plans addresses natural resources and provides management objectives using ecological landscapes as a framework. Wisconsin DNR ***basin*** plans focus on the aquatic resources of water basins and watersheds but also include land management recommendations referencing ecological landscapes. Each of these plans was prepared for different reasons and has a unique focus, but they overlap in many areas. The ecological management opportunities provided in this book are consistent with the objectives provided in many of these

plans. A more thorough discussion of coordinating land and water management plans is provided in Chapter 1, "Principles of Ecosystem and Landscape-scale Management."

General Description and Overview

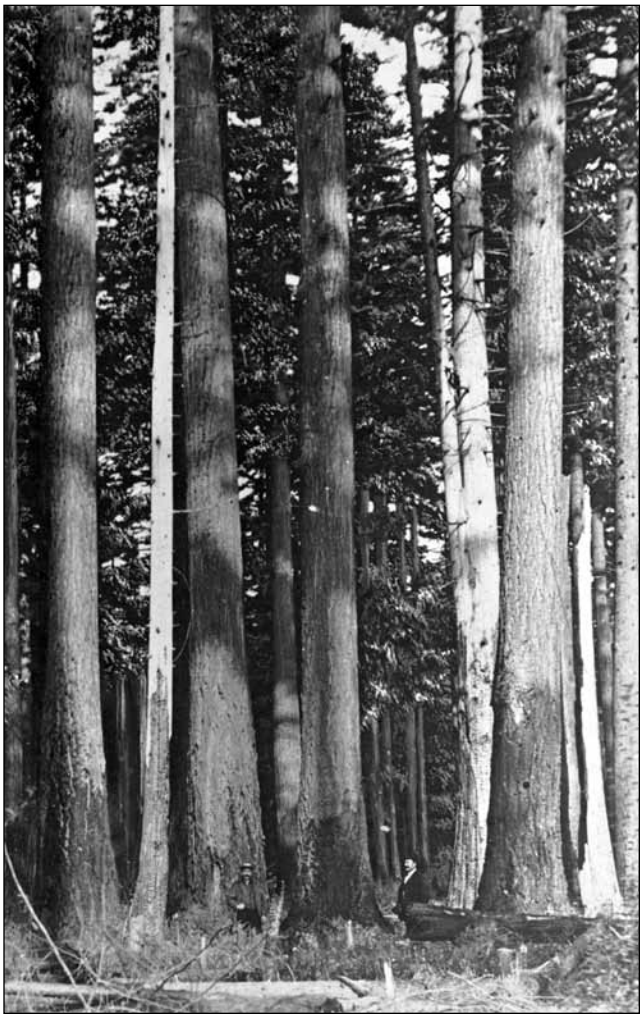
The Northern Highland Ecological Landscape is located in north central Wisconsin. It is notable for its large number of lakes, extensive forests, and large wetlands. The primary landforms are mainly outwash sands, with both pitted and unpitted surfaces, as well as some remnant morainal hills, drumlins, and a few eskers. Most soils in the ecological landscape are sandy, although loamier soils occur on the remnant moraines. In areas with relatively level topography, the water table may be close to the surface. The Northern Highland Ecological Landscape is approximately 1.3 million acres in size, of which about 64% is forested. Almost 30% of the land is in public ownership, including the largest state-owned property, the Northern Highland-American Legion State Forest.

The Northern Highland is well known for having one of the highest concentrations of ***kettle lakes*** in the world, and some of these lakes are large (including Trout, 3,816 acres; Fence, 3,555 acres; Tomahawk, 3,392 acres; and Lac Vieux Desert, 2,853 acres). Many of these lakes have sand bottoms and shorelines, making them among the most desirable locations for water-based recreation and second home development in the state. The Wisconsin and Manitowish are the two largest rivers that run through this ecological landscape. Overall, water quality is much better than in most other ecological landscapes. Many ***Outstanding Resource Waters*** (ORW) and ***Exceptional Resource Waters*** (ERW) have been designated here, and atmospheric deposition of mercury is the most common contaminant affecting waters that do not fully meet water quality standards (see Appendix 14.A at the end of the chapter).

Historically, the Northern Highland contained Wisconsin's greatest pinery. Forests composed of eastern white (*Pinus strobus*) and red (*Pinus resinosa*) pines were the dominant vegetation, with smaller pockets of jack pine (*Pinus banksiana*). Hemlock-hardwood forests were found in some areas with loamier soils. Aspen-birch forests occurred in openings formed by disturbances such as wind or fire. Overall, quaking aspen (*Populus tremuloides*) is now the primary forest dominant, sometimes mixed with pines (*Pinus* spp.), red maple (*Acer rubrum*), and white birch (*Betula papyrifera*). Much of the red pine and some of the jack pine are now grown in plantations. Northern hardwood forests, though reduced in extent, still occur on the more mesic soils. The many acid peatlands that are scattered throughout this ecological landscape are vegetated with spruce-tamarack swamps, muskeg, and open bog/poor fen communities.

Fire was formerly an important and widespread disturbance factor. Return intervals for wildfires may have been

Older stands of red and eastern white pines border this undeveloped soft-water seepage lake and extensive peatlands near the Manitowish River. Frog Lake and Pines State Natural Area, Iron County. Photo by Eric Epstein, Wisconsin DNR.



Old-growth pine forest, late 19th century. Two men stand at the base of huge old pine trees and appear tiny by comparison. The trees show evidence of past fires by their blackened lower trunks. Photograph courtesy of the Wisconsin Historical Society, Image ID WHi-68498.

longer here than in some other sandy ecological landscapes (e.g., Northwest Sands). In the Northern Highland, lakes, streams, wetlands, and hills acted as barriers that altered the extent, severity, and behavior of fire. Human development, windthrow, and timber harvest are now the most important disturbances affecting vegetation in this ecological landscape, along with herbivory, ice damage, diseases, and insects. Virtually all of the forest vegetation now is second-growth, excepting those few stands that were "reserved" by the Board of Commissioners of Public Lands as part of the Wisconsin School Trust Land system, conifer swamps of low commercial value, and a few stands that may have been young due to natural disturbances that predated the Cutover by a few years.

Recreation-related and government jobs are significant in the Northern Highland counties. The timber industry is also important to local economies. Agriculture is not a major part of the local economy due to the low productivity for most crops, the short growing season, and sandy soils. Population density of the counties (23 persons per square mile) is less than a quarter of that for the state as a whole (105 persons per square mile), and its economic indicators are below average. Per capita income is lower than for the state as a whole, although it has been increasing. The service sector employs the most people. The regional poverty rates for all people and for children under age 18 are higher than average for the state. The Northern Highland counties each have unemployment rates higher than the state average. Iron, Oneida, and Vilas counties are all service-dependent.

Environment and Ecology

Physical Environment

Size

The Northern Highland Ecological Landscape encompasses 2,081 square miles (1,331,970 acres), representing 3.7% of the area of the state of Wisconsin.

Climate

Climate data were analyzed from 14 weather stations within the Northern Highland Ecological Landscape (Buckatabon, Lac Vieux Desert, Phelps, Deerskin Dam, Rice Reservoir, Sugar Camp, Willow Reservoir, Eagle River, Minocqua Dam, North Pelican, Rainbow Reservoir, Rest Lake, Rhinelander, and St. Germain; WSCO 2011). This ecological landscape has a continental climate, with cold winters and warm summers, similar to other northern ecological landscapes. The northern ecological landscapes in Wisconsin generally tend to have shorter growing seasons, cooler summers, colder winters, and less precipitation than the ecological landscapes farther south. Ecological landscapes adjacent to the Great Lakes generally tend to have warmer winters, cooler summers, and higher precipitation, especially winter lake effect snows.

The average growing season length is 122 days (base 32°F), ranging from 113 to 128 days. The growing season is similar to other northern ecological landscapes with the exception of the Northern Lake Michigan Coastal Ecological Landscape, which has a longer growing season (140 days) because of the moderating influence of Lake Michigan. Growing season length varied by 15 days among weather stations within the Northern Highland with no discernible pattern. Likely local topography is affecting growing season length.

The mean annual temperature is 39.5°F (38.2–40.8°F), which is the lowest of any ecological landscape in the state and almost two degrees lower than other northern ecological landscapes. Mean annual temperature varied among weather stations by 2.6 degrees within the Northern Highland, with no discernible pattern. The January minimum temperatures averages -1.8°F, almost a degree colder than other northern ecological landscapes. The August maximum temperatures average 75.5°F, the coolest of any ecological landscape in the state and two degrees cooler than other northern ecological landscapes. The west-central portion of the ecological landscape, an area known as the "Harshaw Hole," tends to be colder than the rest of the ecological landscape.

Annual precipitation averages 31.6 inches, ranging from 29.6 to 32.9 inches; these values are similar to other northern ecological landscapes. Annual precipitation varied by almost 3 inches among weather stations within the Northern Highland. Average annual snowfall is 68.1 inches (40.9–114.9 inches); this is the second highest amount of snowfall compared with other ecological landscapes in the state. Only the Superior Coastal Plain receives more snowfall (87.4 inches). Mean annual snowfall varies considerably within the ecological landscape (by around 65 inches), from 49.5 inches at the Willow Reservoir to 112.4 inches at the Minocqua dam and 114.9 inches in Lac Vieux Desert. Part of this variability is likely due to observer differences and optional methods employed at some volunteer weather stations (Kunkel et al. 2007). For example, a volunteer weather station in Rhinelander reports mean annual snowfall as 40.9 inches while an automated station at the Rhinelander airport provides a more reliable data source with a mean annual snowfall of 66.7 inches. Lake States data indicate that the northern part of the Northern Highland receives more snowfall because it is within the outer edge of the lake effect "snowbelt" of Upper Michigan.

The cool temperatures and short growing season, along with sandy soils, are not adequate to support agricultural row crops, such as corn. Only 1% of the Northern Highland Ecological Landscape is in agriculture. The climate is favorable for forests, which cover 63% of the ecological landscape (both upland and wetland forest).

Bedrock Geology

The Northern Highland Ecological Landscape is located on the ***Wisconsin Dome***, an upwarping section of the stable North American "craton," the central portion of the continental crust. The continental crust is also known as the Precambrian Shield, or the Canadian Shield, because most of its surface exposures are in Canada. The craton is formed of Precambrian bedrock

of volcanic and metamorphic origin. The Wisconsin Dome was forced upward following continental rifting to the north at about 1 billion years ago. Volcanic eruptions and lava flows in northwest Wisconsin and Upper Michigan produced great quantities of basalt and rhyolite. Afterward, the continental crust slowly subsided due to the weight of the cooling lava, and it is thought that as this area sank it effectively bent the crust and caused the upwarping of the Wisconsin Dome (Dott and Attig 2004). Bedrock of the Wisconsin Dome is generally quite resistant to glacial abrasion, so it was not as extensively worn away as the softer Paleozoic rocks. This, along with the upwarping of the crust, is why the Northern Highland has the highest elevations in the state.

Most bedrock was formed during the Lower Proterozoic, but some originated during the Upper Archean at more than 1.1 billion years ago. The ecological landscape has a few bedrock outcrops, but most of the area is deeply buried beneath glacial drift, and bedrock is not easily examined. Attig (1985) describes a few small outcrops of Precambrian bedrock in Vilas County. See the map "Bedrock Geology of Wisconsin" in Appendix G, "Statewide Maps," in Part 3, "Supporting Materials." (Nomenclature used here is according to the Wisconsin Geological and Natural History Survey Open-File Report *Bedrock Stratigraphic Units in Wisconsin*; WGNHS 2006).

The difficulty of characterizing Precambrian bedrock has been described by Schultz (2004), who noted that this rock has the most complex history of any in Wisconsin. The Precambrian Shield is more than 1 billion years old and has been subject to considerable metamorphism, erosion, and mixing during its existence. It is made up of many different kinds of rocks of types and ages that do not occur in the systematic layers that are often seen in the Paleozoic limestones and sandstones, where more recent deposits lie above older ones. Also, there are almost no Precambrian-age fossils to help identify a sequence of geologic events. Because of these factors, there is much that is unknown about the bedrock beneath this ecological landscape.

The predominant bedrock underlying the northern portion of the ecological landscape is Lower Proterozoic metasedimentary rock including quartzite, granite, and amphibolite, with some occurrences of Archean gneiss and amphibolite (Attig 1985). In the southern portion, bedrock is mostly Lower Proterozoic basaltic to rhyolitic metavolcanic rock and some metasedimentary rock. Other minor bedrock types are hornblende diorite and meta-gabbro.

Landforms and Surficial Geology

The Northern Highland Ecological Landscape is a glaciated area that is unique in the state. It is predominantly a sandy outwash plain of the Copper Falls Formation, formed of sediment deposited during the Late Wisconsin glaciation by shallow braided ***proglacial*** streams originating in the Ontonagon, Langlade, and Wisconsin Valley lobes. It is more hummocky and pitted than the other outwash-dominated ecological landscapes (the Northwest Sands, Northeast Sands, and parts of the Central Sand Plains and Central Sand Hills). Outwash in some areas was deposited on solid ground and still retains a flat topography, but in most areas it was lain on stagnant glacial ice and collapsed as the underlying ice melted, resulting in a hummocky topography (***pitted outwash*** plains and collapsed heads of outwash). Outwash sands are mostly underlain by glacial till that impedes drainage, so the area has high water tables with extensive areas of wetlands and kettle lakes. Remnant moraines, head-of-outwash hills, drumlins, and eskers protrude through the mantle of outwash in some locations. Glacial sediment is approximately 50–100 feet thick in most of the ecological landscape but ranges from less than 5 feet to more than 100 feet thick over bedrock.

The land surface was formed during the Late Wisconsin glaciation from about 25,000 to 10,000 years ago. At some time before 21,000 years ago, the Langlade Lobe expanded from the northeast, while at the same time the Wisconsin Valley Lobe advanced from a north-northeasterly direction. The Langlade Lobe covered the eastern part of the ecological landscape, depositing material of the Copper Falls Formation, Nashville Member. These deposits are made up of crudely stratified brown gravelly sand to gravelly sandy loam supraglacial debris-flow sediment, and thin discontinuous compact loamy sand till. The Wisconsin Valley Lobe covered the western portion of the ecological landscape. Deposits from this lobe are known as the Wildcat Lake Member, Copper Falls Formation, composed of brown to reddish-brown, crudely stratified gravelly loamy sand supraglacial debris-flow sediment, and compact loamy sand to sandy loam till. Both lobes also deposited sand and gravel from meltwater streams (Attig 1985).

The Langlade and Wisconsin Valley lobes began retreating from their terminal positions in Langlade, Lincoln, and Taylor counties around 15,000 years ago, stabilizing at several positions in the ecological landscape during the retreat. At the time of the advance of the Ontonagon Lobe, there were still extensive areas of stagnant ice, partly or completely buried under stream sediment. Additional stream sediments flowed from the Ontonagon Lobe during formation of the ***Winegar Moraine,*** which is located just north of the ecological landscape boundary. These Ontonagon Lobe sediments are known as the Crab Lake Member of the Copper Falls Formation, and they buried some deposits of the Langlade and Wisconsin Valley lobes and the stagnant ice that still remained. Ontonagon Lobe deposits are particularly evident in the relatively flat areas near Boulder Junction and Land O' Lakes (Attig 1985).

Landforms built by glacial outwash include outwash plains, braided stream channel deposits, and pitted outwash. Much of the area is pitted outwash, formed when ice blocks were left stranded at the edge of melting glacial ice. As the ice blocks slowly melted, outwash sands and gravels collapsed into the remaining depressions, or "kettles." Often, kettle lakes and bogs formed in the low-lying depressions. Outwash deposits from slow-moving braided streams have relatively

flat surfaces, but hummocky deposits are more common. Hummocky topography is due to the uneven deposition of proglacial stream sediment, when the ice margin fluctuated to concentrate supraglacial flows or due to collapse of the surface as underlying ice melts, similar to the formation of kettles but involving a more extensive ice sheet (Attig 1985). Remnant moraines and drumlins are also present within the ecological landscape; often, their lower slopes have been covered with outwash sand so that they occur as islands of coarse-loamy till within the outwash deposits. Some remnant morainal hills are located near Woodboro in Oneida County; others are found in central Vilas County in the vicinity of Lake Laura. Eskers were once common in the western part of the ecological landscape, but many of them have been extensively mined for stones and gravel, and they are becoming a scarce glacial feature. There are a few relatively intact eskers, including one near Deer and Heart Lakes in eastern Vilas County, but most remaining eskers in this part of the state are found north of the ecological landscape in the Winegar Moraine. Drumlin fields, partially buried by glacial outwash, occur in the northwestern part of the ecological landscape, in Iron County, and also in the area west of Trout Lake in Vilas County. The Northern Highland also has ice-contact sand deposits, or head-of-outwash features—hills of sand and gravel that formed as outwash accumulated at the edge of rapidly melting glacial ice (Attig 1985). The variety of glacial processes that occurred in this ecological landscape has created a complex and heterogeneous environment of closely interspersed lakes, wetlands, and uplands, and much of the area consists of ecotones that lie between these features.

A map showing the Landtype Associations (WLTA Project Team 2002) in this ecological landscape, along with the descriptions of the Landtype Associations, can be found in Appendix 14.K at the end of this chapter.

Topography and Elevation

Land surface elevation ranges from 1,398 to 1,866 feet (426 to 569 meters) in the Northern Highland Ecological Landscape. The lowest point is at the Wisconsin River where it crosses into the North Central Forest Ecological Landscape. The highest point is at the location of the Monahan Lookout Tower in Vilas County (northern boundary of Sec. 33, T. 42 N., R. 9 E.) in an area of hummocky topography where stream sediment was deposited over glacial ice and subsequently collapsed. The Northern Highland, as the name implies, is a part of the state where elevations are relatively high due to upwarping of the Earth's crust following continental rifting to the north at about 1 billion years ago (Dott and Attig 2004). The Precambrian bedrock was resistant to glacial abrasion, so the Northern Highland area was not as extensively worn down by repeated ice advances as were other parts of the state.

The land surface in this ecological landscape was shaped by glacial activity during the latter part of the Wisconsin Ice Age. Topography is undulating or gently rolling on the pitted, hummocky outwash surfaces that are common in most of the ecological landscape. In the unpitted outwash plains, topography can be nearly level. Some remnant moraines and head-of-outwash features have hilly or steep topography (Hole et al. 1968, Attig 1985).

Soils

Most soils in the Northern Highland Ecological Landscape are formed in thick sands and gravels of glacial outwash origin. Silty loess deposits are relatively thin in this part of the state and are typically less than 6 inches thick in the ecological landscape (Hole 1976). Soil productivity, based on moisture holding capacity, nutrient levels, and organic material content, is low as compared with glacial till soils but still relatively high for outwash sands. Many outwash soils in the Northern Highland are stratified with finer-textured soil layers that originated as supraglacial debris-flows from melting glaciers or settled out of glacial lakes and ponds. In these soils, drainage is not as rapid, and moisture availability can be relatively high. The dominant soil is excessively drained and sandy with a loamy sand surface, very rapid permeability, and low available water capacity. Overall, the soils range from excessively drained to somewhat poorly drained and have sand to sandy loam surface textures, very rapid to moderately rapid permeability, and low to moderate available water capacity.

The remnant moraines and drumlins within the Northern Highland have loamier soils formed in glacial till. These soils often have thicker spodic layers and inclusions of finer-textured loam or sandy loam material, so productivity is higher in these areas. Throughout most of the area, the water table is held close to the surface by underlying fine-textured soil layers. Large areas of the ecological landscape are wetlands, formed in kettle depressions or former glacial drainways. The wetlands typically have organic soils of peat or muck, but some are poorly drained sands.

Hydrology

Glacial activity during the Pleistocene created the foundation for current hydrologic conditions. An area densely populated with lakes lies in Vilas, Oneida, and adjacent counties. Their total number and nearness to one another is reflected in the fact that, although one of the largest bodies of water, Trout Lake, covers only 6.5 square miles, lakes and ponds cover 140 square miles of Vilas County, or more than 15% of the area of the county. There are few parts of the world with more lakes per square mile (Martin 1932).

The many small, irregularly shaped and closely spaced lakes are connected by highly meandered streams. This pattern is typical of lakes in a glaciated landscape, but the origins of the lake basins are varied. Some lakes lie in shallow depressions in the ground moraine, some exist within recessional moraines, and many fill the hollows of outwash gravel plains (Martin 1932, Attig 1985).

Open swamps (these are mostly acid peatland communities) or marshes are common in this part of northern Wisconsin and are referred to by some using the American Indian

Two seepage lakes with very different attributes: The lake in the foreground is shallow, muck-bottomed, and bordered by boggy wetlands; the other lake is deep, with a firm bottom, and has an upland shoreline. Northern Highland-American Legion State Forest, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

term "muskeg." There are also cranberry and blueberry swamps, drier marshes and swamps, level, forested tamarack (*Larix laricina*) and black spruce (*Picea mariana*) swamps, and hummocky northern white-cedar (*Thuja occidentalis*) swamps. Some of the marshes are filled lakes, but a greater number are simply areas of poor drainage due to the effects of glacial deposits (Martin 1932).

Basins

The Northern Highland Ecological Landscape overlies most or part of three major basins: the Upper Wisconsin, Upper Chippewa, and Lake Superior basins. Twenty-one watersheds lie wholly or partially within this ecological landscape (see the "Water Basins" map in Appendix G, "Statewide Maps," in Part 3). These watersheds and their nonpoint pollution rankings are listed in Appendix 14.A.

Inland Lakes

A major management opportunity and primary consideration in this ecological landscape is the high number and density of glacial lakes. The Northern Highland comprises a central and significant portion of that part of northern Wisconsin that has one of the highest freshwater lake densities in the world, rivaled globally only by parts of northern Minnesota, Ontario, and Finland. This characteristic alone makes the ecological landscape globally distinctive.

The Northern Highland Ecological Landscape is the most lake-dominated ecological landscape in Wisconsin. Vilas and Oneida counties make up the majority of the land surface here, and lakes occupy 12.7% of the total surface area across these two counties (WDNR 2012). Early in Wisconsin's statehood, soil scientist and geologist F.H. King wrote about this area, noting that "nearly all of these lakes, so far as observed, possess the characteristics peculiar to those of broad, morainic belts. They are beautiful sheets of water, clear, soft and deep, encircled by bold, fantastic rims, and dotted with tree-clad island cones of such varied beauty in the autumn season, that as one looks in unexpectedly upon them up the rapids of the narrow shaded rivers, he forgets his fatigue and revels in an exquisite garden of foliage plants. Sometimes a fringe of northern white-cedar lies upon the water's edge; higher up a wreath of white birch, then a belt of poplar, and, capping the rounded hilltops, maple (*Acer* spp.) and yellow birch (*Betula alleghaniensis*), throughout all of which there is a generous setting of rich green white and [red] pines" (WGNHS 1882).

Past glacial action is directly or indirectly responsible for creating the 4,291 lakes that have been identified here (only the much larger North Central Forest Ecological Landscape contains more lakes, and these comprise a much lower percentage of the total land area). The 999 named lakes in the Northern Highland cover 125,414 acres, while the 3,292 unnamed lakes are small (less than 10 acres) and total only 7,680 acres (WDNR 2012). Impoundments have created an additional 87,984 acres of surface water.

More than half of the 4,291 lakes in this ecological landscape larger than 10 acres are seepage lakes, lacking inlets and outlets (WDNR 2012). Approximately 25% of the lakes here are drainage lakes. The remaining lakes are spring lakes and drained lakes (see Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions and additional information on Wisconsin lake types). A few of the larger lakes include Trout (3,816 acres), Fence (3,555 acres), Tomahawk (3,392 acres), Lac Vieux Desert (2,853 acres), Big St. Germain (1,617 acres), Crawling Stone (1,466 acres), Presque Isle (1,280 acres), and Star (1,206 acres). Lac Vieux Desert, nearly half of which lies in Michigan, is the source of the 420 mile-long Wisconsin River.

Of all the lakes in this ecological landscape, Trout Lake has received the most research attention (UW-Madison Center for Limnology 2013). It is one of the Northern Highland's deeper lakes, with a maximum depth of 114 feet and a mean depth of 46 feet. Because the watershed is mostly forested, relatively few pollutants enter the lake, and the deeper waters are cold, Trout Lake maintains significant populations of many fish species, including those adapted to great depth.

Several rare or geographically limited lake types occur within the Northern Highland Ecological Landscape. Especially well represented are the deep, hard-bottomed, circumneutral seepage lakes with exceptionally low nutrient availability. These lakes support unusual plants and invertebrates, including species that are quite rare or that are more common in this lake type than in any other aquatic habitat. Because of the physical nature of the waters and the basins they occur in, these lakes are poorly buffered against acidification and eutrophication and are vulnerable to degradation. The greatest threats at this time are the spread of invasive species and residential or industrial developments that alter or destroy riparian zones. The characteristics of these lakes,

especially those with upland shores, make them attractive targets for residential development. ***Oligotrophic*** seepage lakes that receive most of their water from overland flow and direct atmospheric inputs (rain and snow), as opposed to lakes with significant groundwater inputs, are the most vulnerable to eutrophication or other forms of water quality degradation.

Shallow soft-water drainage lakes that support beds of wild rice (*Zizania* spp.) are relatively common here and are highly significant ecological and cultural resources. At least 99 lakes within this ecological landscape support these culturally and biologically important populations of wild rice (WBCI 2010; see also NR 103.04, Wis. Adm. Code). On many of these waters, which are within the ***Ceded Territory*** (see the "Ceded Territory and Native American Ownership" map in Appendix G, "Statewide Maps," in Part 3, "Supporting Materials"), the Great Lakes Indian Fish and Wildlife Commission establishes rice harvest dates through a shared management agreement with the Wisconsin DNR related to American Indian treaty rights (GLIFWC 2014).

Spring Ponds are small waterbodies of 10 acres or less that receive most of their water from underground sources. Typically, there is no inlet stream (though short spring runs or seepages may feed the ponds), but a well-defined outlet stream is present that discharges cold, clear, clean water. Many of the trout streams in the Northern Highland Ecological Landscape are dependent on stable discharges of water with these characteristics. Spring Ponds are important, though localized, aquatic features in some parts of the ecological landscape.

Several lakes in this ecological landscape have been given special protection and are now contained within management areas such as ***state natural areas*** or federal ***research natural areas***. These waterbodies were selected because of their undisturbed nature, the type and quality of associated plant communities in and around them, and the significant biological diversity they support. Among the lakes in the Northern Highland that have received special management designation are Allequash, Alva, Atkins, Aurora, the Bittersweet Lakes complex, Day, Dunn, Frog, Nixon, Shallow, Wabasso, and part of Wind Pudding.

The Eagle River and Three Lakes Chain of Lakes is considered to be the world's largest chain of freshwater inland lakes (UWSGI 2014). The "Chain" includes 28 lakes that are connected by the Eagle River and its tributaries, amounting to 3,928 acres of surface water, with 68 miles of shoreline. Water levels have been raised by several dams to facilitate navigation by power boats. The Otter Rapids Dam, built in 1906 on the Wisconsin River, has a 12-foot head. The Burnt Rollways Dam adds 2.75 feet of head to the Three Lakes Chain. This area is extremely popular for its long-distance boating opportunities and for recreational fishing. Housing developments now form multiple concentric "rings" that encircle many of these lakes.

Residential and commercial developments are common around most of the larger lakes with privately owned shorelines. The ecological consequences of such developments can be significant and include the loss and degradation of aquatic plant communities, invertebrate populations, herptiles, and fish habitat.

Impoundments

Impoundments are created when streams are dammed to generate power, provide recreational opportunities, and create habitat for desired fish and wildlife, especially game species. In the past, waters were impounded to aid in the transport of timber. There are 141 man-made dams remaining in this ecological landscape, creating 87,984 acres of impoundments (WDNR 2010b). About 95 of these are small dams with heads of less than 6 feet, which have been built on smaller streams or at the outlets of small lakes. The remaining dams are classified as large dams, based on dam height and impoundment volume. Twenty-five constructed dams have been removed in the past several decades due to structural issues, financial liability, or other concerns. American beaver (*Castor canandensis*) have created impoundments on many streams, though these are less permanent and generally far smaller than dams built by humans.

Dam construction on some major rivers of this ecological landscape has created large impoundments such as the Rainbow and Rhinelander flowages on the Wisconsin River, the Turtle-Flambeau Flowage on the Flambeau River, and the Willow Flowage on the Tomahawk River. The uppermost portion of the Rhinelander Flowage contains a large marsh composed of wild rice and other aquatic emergents and is attractive to waterfowl, wading birds, terns, and fish-eating raptors.

The operation of five dams for the generation of hydroelectric power on the Wisconsin River and numerous hydropower water storage dams on Wisconsin and Flambeau River tributaries involves periodic drawdowns, which may create problems for wildlife unable to adapt to the timing or rapidity of such changes (affected wildlife may include mussels, amphibians, reptiles, and nesting birds). The timing, duration, and volume of impoundment drawdowns affect water-dependent species to varying degrees and in different ways. Planning and coordination is needed to ensure that impoundment water levels provide secure habitat for nesting birds and to avoid inadvertent damage to fish, mussel, amphibian, and reptile populations during droughts or drawdowns.

While impoundments can create open water habitat and deep marshes that benefit some species, they may also inundate rivers and their associated wetlands, eliminating some riverine habitats. This has the potential to diminish the amount of shallow marsh, sedge meadow, and open bog communities, to the detriment of the species dependent on them.

Rivers and Streams

At least 1,543 miles of perennial streams originate in and flow throughout the Northern Highland Ecological Landscape, including the Wisconsin and Flambeau rivers WDNR 2012). Approximately 96 miles of the total 420 miles of the Wisconsin River flow through this ecological landscape, beginning

at the outlet of Lac Vieux Desert, which spans the border of Wisconsin and Michigan. There are also approximately 116 coldwater streams or ***stream segments*** here that support trout or other coldwater communities. Scores of additional streams and stream segments in this ecological landscape are either coolwater or warmwater streams that fully support either warmwater sport fish or ***nongame*** fish communities. Brandy Creek, Mud Creek, North Pine Lake Creek, Pickerel Creek, and Shishebogama Creek are just a few examples of these higher quality streams. Important lake and stream biota are highlighted in the "Significant Fauna" section of this chapter.

Springs

There are 253 springs documented in the Northern Highland (Macholl 2007). These springs are scattered fairly uniformly across the ecological landscape, although there is a slightly greater density of springs in the west central portion, within northwestern Oneida County, in the vicinity of trout streams tributary to the Willow River. Some of these springs provide vital cold water to trout streams in the area and in general support communities of coldwater invertebrates.

Wetlands

Wetlands are abundant in the Northern Highland Ecological Landscape, comprising approximately 26% of the surface area, or more than 325,000 acres according to the Wisconsin Wetlands Inventory (WDNR 2010c) (see Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for a discussion of the Wisconsin Wetlands Inventory). This is the fifth largest number of wetland acres and the second largest percentage (26.0%) of wetlands covering an ecological landscape of all ecological landscapes in the state. The Wisconsin Wetlands Inventory indicates approximately 187,000 acres are forested, over 108,000 acres are of the "shrub-scrub" wetland type, and almost 15,000 acres are "emergent/wet meadow" wetland.

The entire continuum of acid peatland communities is especially well represented here. The peatland communities vary structurally but are composed of boreal swamp conifers (black spruce and tamarack), ***ericaceous shrubs***, sedges, and continuous carpets of peat mosses (especially mosses in the genus *Sphagnum*). The saturated organic soils are strongly acidic and low in nutrient and oxygen availability. Because of the difficult growing conditions, many of the plants possess special adaptations. The most common peatland communities include Black Spruce Swamp, Tamarack Swamp, Muskeg, Open Bog, and Poor Fen. Associated communities, often growing on the less acidic peatland margins, include Alder Thicket and Northern Sedge Meadow. In the Northern Highland Ecological Landscape, these communities occur at scales that vary from complexes encompassing thousands of acres down to patches of less than an acre. The individual communities often grade into one another and may co-occur within the same basin or "kettle." Conservation efforts will likely have a higher probability of success over time if the local watershed, rather than any individual natural community, is the management unit.

Besides the widespread and abundant acid peatlands, other wetland communities found here include marshes, sedge meadows, shrub swamps, hardwood swamps, "rich" conifer swamps (dominated by northern white-cedar), and floodplain forest. The Emergent Marsh–Wild Rice community is well represented here compared to other ecological landscapes. Alder Thicket and Northern Sedge Meadow are also common and widespread wetland communities. All of these natural communities provide habitat for assemblages of native plants and animals, including rare species. All are important to protect to ensure that high water quality is maintained in the ecological landscape's lakes and streams.

More detailed descriptive information on the individual natural communities may be found in Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," in Part 1 of this publication.

Water Quality

The streams, rivers, lakes, and groundwater samples that have been assessed within the Northern Highland Ecological Landscape run the gamut from high to low water quality (see Appendix 14.A). Outstanding Resource Waters (ORW) or Exceptional Resource Waters (ERW) are surface waters that have good water quality, support valuable fisheries and wildlife habitat, provide outstanding recreational opportunities, and are not significantly impacted by human activities. Waters with ORW or ERW status warrant additional protection from the effects of pollution. Both designations have regulatory restrictions, with ORWs being the most restricted. These designations are intended to meet federal Clean Water Act obligations and prevent the reduction of water quality or degradation of aquatic habitats in these waters. They are also used to guide certain land use changes and human activities near these waters.

The Northern Highland Ecological Landscape contains the headwaters for numerous streams with ORW designations, including the Manitowish, Trout, and Deerskin rivers and Allequash, Bearskin, Little Pine, McGinnis, New Wood, Radke, and Trout creeks. A complete list of ORWs and ERWs in this ecological landscape can be found on the Wisconsin DNR website (WDNR 2010a).

Waters designated as impaired on the ***U.S. Environmental Protection Agency 303(d) list*** exhibit various water quality problems including ***polychlorinated biphenyls*** (PCBs) in fish, sediments contaminated with industrial metals, mercury from atmospheric deposition, bacteria from farm and urban runoff, and habitat degradation. Since the 303(d) designation is narrowly based on the criteria above, a waterbody could be listed as a 303(d) water as well as an ORW or ERW. These designations are not mutually exclusive. A plan is required by the U.S. Environmental Protection Agency on how 303(d) designated waters will be improved by the Wisconsin DNR. This designation is used as the basis for obtaining federal

funding, planning aquatic management work, and meeting federal water quality regulations.

There are a number of watersheds within the Northern Highland Ecological Landscape that are considered 303(d) waters due to nonpoint source pollution and other degradation. These include the Eagle River, Noisy and Pine creeks, Rhinelander Flowage, and Upper Tomahawk River watersheds (see Appendix 14.A). Problems include hydrological modifications, streambank erosion, streambank pasturing, the presence of American beaver dams, municipal point source discharges, and the operation of cranberry farm marshes in ways that allow nutrients, pesticides, and sediments to run off into streams, lakes, and impoundments. The complete list of 303(d) impaired waters and criteria can be viewed at the Wisconsin DNR's impaired waters web page (WDNR 2014c).

Permeable soils are common throughout this ecological landscape and are at a relatively high risk of groundwater contamination from herbicides and other biologically active substances. Such substances should be used with caution here, especially where sandy or gravelly soils and steep erodible slopes occur. The implementation of ***best management practices*** (BMPs) for erosion control is encouraged to eliminate or minimize sediment input to waterbodies and wetlands.

Persistent bioaccumulative toxins (PBTs) such as DDT, lead, mercury, and flame retardants may accumulate in lakes. Many Northern Highland lakes have mercury levels high enough to warrant a fish consumption advisory more stringent than the statewide "safe eating guidelines," including three of the largest waterbodies: the Turtle-Flambeau Flowage, Willow Flowage, and Sugar Camp Chain of Lakes (WDNR 2014a). The primary source is atmospheric deposition of mercury released by large numbers of coal-fired electrical generation plants from the Great Plains to the Ohio Valley and from other industrial sources, including factories and waste incinerators. One large industrial source in central Wisconsin is due to be greatly reduced by approximately the year 2020. State and federal mercury reduction efforts are under consideration to achieve long-term reductions in mercury releases. Use of coal in Asia is another source of long-distance transport of mercury (Esposito 1998).

The University of Wisconsin Trout Lake Biological Station collects and maintains data on water levels, water chemistry, biological diversity, limnological processes, and human use of selected lakes as part of the North Temperate Lakes Long-Term Ecological Research network (UW-Madison Center for Limnology 2013). Monitoring wells scattered throughout the area that contributes water to Trout Lake are used to calibrate and test regional groundwater flow models. Water chemistry is measured annually in a subset of these wells to characterize regional groundwater chemistry in the Trout Lake area (Greenfield 2000).

Groundwater and many streams and rivers in the Northern Highland are not presently degraded and are not immediately threatened by point or nonpoint source pollution (Appendix 14.A). This is most likely due to the ecological landscape's extensive forest cover.

Biotic Environment

Vegetation and Land Cover

Historical Vegetation

Several sources were used to characterize the ***historical vegetation*** of the Northern Highland Ecological Landscape, relying heavily on data from the federal General Land Office's public land survey (PLS) conducted in Wisconsin between 1832 and 1866 (Schulte and Mladenoff 2001). PLS data are useful for providing estimates of forest composition and tree species dominance over large areas (Manies and Mladenoff 2000). Finley's map of historical land cover, based on his interpretation of PLS data, was also consulted (Finley 1976). Additional inferences about vegetative cover were sometimes drawn from information on land capability, climate, disturbance regimes, the activities of native peoples, and from various descriptive narratives and historical photographs. More information about these data sources is available in Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials." According to Finley's map and data interpretation, in the mid-1800s the Northern Highland was Wisconsin's most extensive pinery, with 34% of the ecological landscape forested in red and eastern white pine (Figure 14.1). Jack pine-***scrub oak*** barrens made up 11% of the area, mostly concentrated in the southern portion of the ecological landscape, and hemlock-hardwoods, together with northern hardwoods, comprised another 21%. Aspen-birch forests are shown as occupying 2% of the area, while swamp conifers, especially tamarack, made up 19% (also see the map "Vegetation of Wisconsin in the Mid-1800s" in Appendix G, "Statewide Maps," in Part 3 of the book).

PLS information has been converted to a database format and importance values for tree species calculated based on the average of tree species density and ***basal area*** (He et al. 2000). These analyses also indicate that eastern white and red pines dominated the mix of tree species (39% of the relative

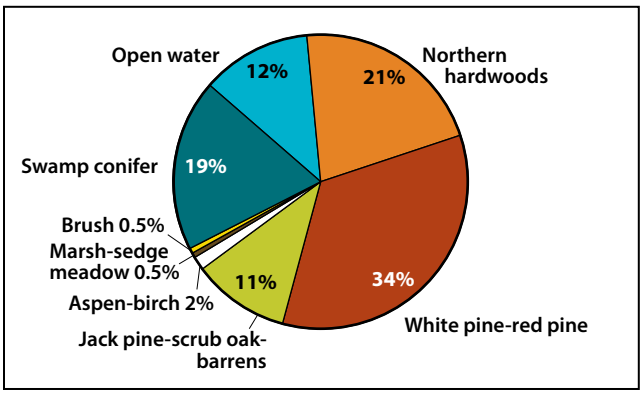


Figure 14.1. *Vegetation of the Northern Highland Ecological Landscape during the mid-1800s, as interpreted by Finley (1976) from federal General Land Office public land survey information.*

Large-scale logging began in the Northern Highland in the latter half of the 19th Century. Large eastern white and red pines were originally the most sought after trees, but loggers turned to eastern hemlock and various hardwoods as the pines were depleted. Photo from Wisconsin DNR photo collection.

importance value, or RIV). In this analysis, jack pine and oak (*Quercus* spp.) species were of minor importance (jack pine was 3.1% of RIV, and oaks were 1.0%), which is consistent with Finley's interpretation of areas classified as jack pine-scrub oak barrens, which would have had both low (though sometimes highly variable) densities and low basal areas. Hemlock-hardwood forests occurred on sites with loamier soils, and sugar maple (*Acer saccharum*), yellow birch, and eastern hemlock (*Tsuga canadensis*) together made up 18.8% of RIV. Aspen-birch forests were found in openings created by disturbance events, typically fire. Aspens (*Populus* spp.) made up 7.1% of RIV, and white birch another 9.1%. Tamarack was another important species, with a RIV of 12.7%. See the map "Vegetation of the Northern Highland Ecological Landscape in the Mid-1800s," in Appendix 14.K at the end of this chapter.

Current Vegetation

There are several data sets available to help assess current vegetation on a broad scale in Wisconsin. Each was developed for different purposes and has its own strengths and limitations in describing vegetation. For the most part, WISCLAND (Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data), the Wisconsin Wetlands Inventory (WWI), the U.S. Forest Service's Forest Inventory and Analysis (FIA), and the National Land Cover Database (NLCD) were used. Results among these data sets often differ because they are the products of different methodologies for classifying land cover, and each data set was compiled based on sampling or imagery collected in different years, sometimes at different seasons, and at different scales. In general, information was cited from the data sets deemed most appropriate for the specific factor being discussed. Information on data source methodologies, strengths, and limitations is provided in Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials." The Northern Highland Ecological Landscape is approximately 1,259,000 acres in size, of which almost 30% is in public ownership, including the Northern Highland-American Legion State Forest. WISCLAND land use/land cover data from 1992 (WDNR 1993) indicate that 24% of this ecological landscape was nonforested, 63% was forested, and 13% was open water (Figure 14.2). Nonforested areas were mostly open or shrub-dominated wetlands, with a small amount of grassland, upland brush, and agricultural cropland. Urban areas made up less than 1%.

Extensive wetlands occur in the Northern Highland and comprise a significant portion (26%) of the land cover here. According to the Wisconsin Wetlands Inventory (WDNR 2010c), forested wetlands cover over 187,000 acres of this ecological landscape, making these the most abundant wetlands in the Northern Highland. Black spruce, tamarack, and, to a lesser extent, northern white-cedar and balsam fir (*Abies balsamea*) are the most common tree species in these wetlands. Associates may include jack pine, black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), eastern white pine, yellow birch, red maple, and silver maple (*Acer saccharinum*). Shrub/scrub wetlands occur across approximately 108,000 acres. Wet meadows occupy over 11,000 acres. Approximately 17,000 acres of wetland have been delineated but not yet classified by type. Other classified wetland types all occupy less than 10,000 acres. The largest wetland complexes straddle the Iron-Vilas County line within the Manitowish River drainage. Other large wetlands occur in the Big Swamp area south and east of the Rainbow Flowage, an impounded stretch of the Wisconsin River. Additional information on wetlands and wetland flora may be found in the "Natural Communities" and "Flora" sections of this chapter and in Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," in Part 1 of the book.

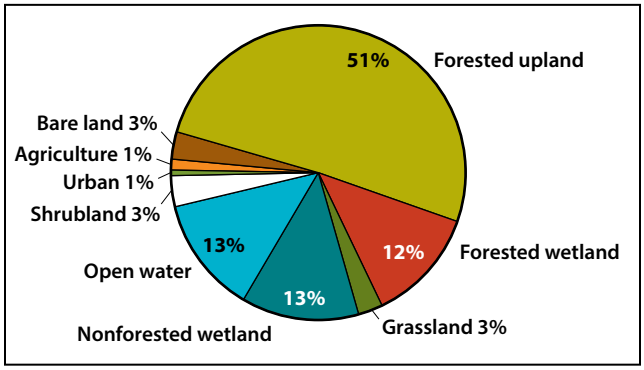


Figure 14.2. *WISCLAND land use/land cover data showing categories of land use classified from LANDSAT satellite imagery (WDNR 1993) for the Northern Highland Ecological Landscape.*

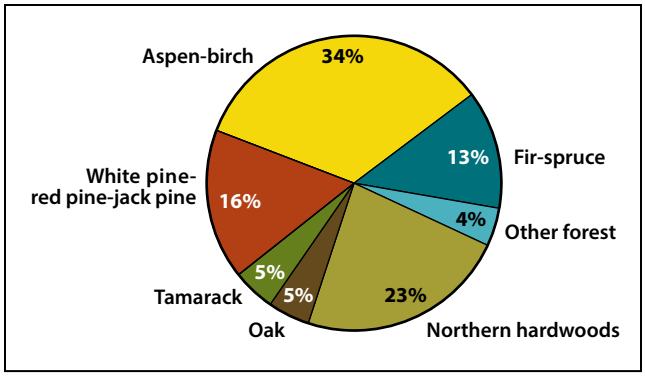


Figure 14.3. *Forest Inventory and Analysis (FIA) data (USFS 2004) showing forest type groups (greater than 17% crown cover) as a percentage of total forested land area for the Northern Highland Ecological Landscape. For more information about the FIA data, see Appendix C, "Data Sources Used in the Book," in Part 3.*

Forest Inventory and Analysis data summarized in 2004 are shown in Figure 14.3. Approximately 29% of land area in the Northern Highland Ecological Landscape is nonforested, and about 71% is forested (this figure does not include open water as part of the total percentage) (USFS 2004). The predominant forest ***cover type*** group is aspen-birch (34% of the forested area, or more than 320,000 acres), followed by northern hardwoods (23%, or more than 220,000 acres). Red pine only makes up approximately 8% of the total forest cover of this ecological landscape; however, there is a relatively high proportion (25% of this type, or 2% of the total forest cover) of red pine forest that has been identified by Forest Inventory and Analysis data as of natural origin (see Table 3.10 in Chapter 3, "Comparison of Ecological Landscapes"). In other ecological landscapes, much more of the red pine is now of plantation origin.

The National Land Cover Database estimated that in 2001 63.2% of the Northern Highland Ecological Landscape's land area was covered by tree canopies, which ranks well above the statewide average of 39.0% (MRLC 2010). Note that the NLCD canopy coverage does not imply that the area is 63.2% forested, but rather that 63.2% of the land of the ecological landscape is covered by tree canopies (e.g., a tree in someone's yard or trees in a cemetery or on a golf course would count as "canopy" in the NLCD data but is not necessarily forest). The NLCD data also estimate that 0.6% of the land area is covered by impervious surfaces, below the statewide average of 1.5%. For more information about FIA or NLCD, see Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials."

Changes in Vegetation over Time

The purpose of examining historical conditions is to identify ecosystem factors that formerly sustained species and communities that are now altered in number, size, or extent or that have been changed functionally (for example, by constructing dams, suppressing fires, or due to fragmentation). Although data are limited to specific snapshots in time, they provide valuable insights into Wisconsin's ecological capabilities. Maintaining or restoring some lands to more closely resemble historical ecosystems and including some structural or compositional components of the historical landscape within actively managed lands can help conserve important elements of biological diversity. We do not mean to imply that entire ecological landscapes should be restored to historical conditions, as this is neither possible nor necessarily desirable within the context of providing for human needs and desires. Information on the methodology, strengths, and limitations of the vegetation change data is provided in Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials." The relative importance value (RIV) for tree species at the time of the federal public land survey was compared with FIA data summarized in 2004 in order to assess the change in tree species over roughly the last 150 years (Figure 14.4). Here, only FIA data for trees greater than 6 inches in diameter were used, to make data more comparable to the PLS data.

Current forest vegetation (based on FIA) is primarily aspen-birch (25% of RIV), eastern white and red pine (23%), and red maple (10%) (Figure 14.4). Aspen has increased as compared with historical conditions from 7.1% to 17.4% of RIV (because of how aspen is regenerated, this number would be considerably higher if trees greater than 6 inches in diameter were included), while white birch has declined from 9.1% to 7.6%. The RIV of 7.1% for historical aspen levels in this ecological landscape is high as compared with most parts of Wisconsin; only the Western Prairie and the Superior Coastal Plain ecological landscapes had a higher aspen component. The historical RIV for white birch, at 9.1%, was the highest of all ecological landscapes. Pine species currently occur in both natural stands and plantations (most red pine is now planted), and RIVs are considerably decreased from the historical condition. Oak species have increased in importance, mostly on sites formerly dominated by eastern white or red pines, while the most dramatic increase has been in red maple (probably due to fire suppression, more than any other factor). Sugar maple has increased slightly, while yellow birch and eastern hemlock have declined.

Balsam fir, and to a lesser extent, spruce species (*Picea* spp.), have increased in importance. Lowland conifers, including tamarack, occupy many of the peatlands that are scattered throughout this area. The Northern Highland had the second-highest RIV for tamarack as compared with other ecological landscapes; only the Northwest Lowlands had a higher value. Currently, tamarack has declined here considerably, as it has throughout the Lake States.

Natural Communities

This section summarizes the abundance and importance of major physiognomic (structural) natural community groups in this ecological landscape. Some exceptional opportunities, needs, and actions associated with these groups or with some

of the individual natural communities are discussed briefly. For details on the composition, structure, and distribution of the specific natural communities found in the Northern Highland Ecological Landscape, see Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin." Information on invasive species can be found in the "Natural and Human Disturbances" section of this chapter.

Forest Communities. The Northern Highland Ecological Landscape was the heart of one of the Upper Midwest's major pineries. Forests dominated by large eastern white and red pines were widespread here and formed the basis of early Euro-American settlement and employment. Much of the pinery was destroyed or severely altered by heavy logging and subsequent slash fires, and the pines were often replaced by stands of aspen, white birch, or more rarely, northern red oak (*Quercus rubra*). In recent decades, there has been significant recovery by pines in some areas, especially by eastern white pine. Natural stands of red pine or mixed stands of red and eastern white pines remain localized and relatively scarce. Plantation-grown red pine is now prevalent in many areas.

Mesic forests dominated by eastern hemlock or mixed with sugar maple, yellow birch, and American basswood (*Tilia americana*) are important on some landforms (e.g., on remnant moraines), and the mesic remnants include a few stands with old-growth characteristics. Other important forest communities, due to their abundance and/or the existence of large stands in good condition, include the forested peatlands of black spruce and/or tamarack (the "Northern Wet Forest" described by Curtis [1959]), dry forests of jack pine (which at a few locations include red pine and upland black spruce as canopy components), and wet-mesic forests dominated by either swamp hardwoods (Northern Hardwood Swamp) or northern white-cedar (Northern Wet-mesic Forest). Forest communities with very limited presence here include Boreal Forest and Floodplain Forest.

With only a few exceptions, such as some of the Wisconsin School Trust Lands (WBCPL 2004), all of the upland forests within the Northern Highland Ecological Landscape had been logged by the early 20th century. The subsequent fires altered successional pathways (e.g., by removing many of the young regenerating pines) and set the stage for the tremendous increase in pioneering species such as quaking and big-tooth (*Populus grandidentata*) aspens, white birch, and pin cherry (*Prunus pensylvanica*).

Savannas. Savannas have not been documented in this ecological landscape, although recently disturbed stands of xeric forest may have a sparse or patchy canopy and bear a superficial structural resemblance to the Pine Barrens community. Jack

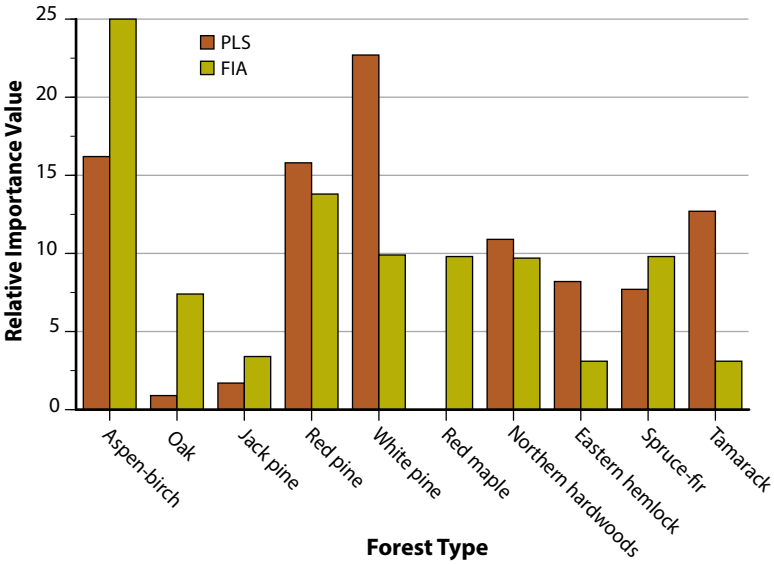


Figure 14.4. *Comparison of tree species' relative importance value (average of relative dominance and relative density) for the Northern Highland Ecological Landscape during the mid-1800s, when federal General Land Office public land survey (PLS) data were collected, with 2004 estimates from Forest Inventory and Analysis (FIA) data (USFS 2004). Each bar represents the proportion of that forest type in the data set (totals equal 100). Trees of less than 6-inch diameter were excluded from the FIA data set to make it more comparable with PLS data. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information about the PLS and FIA data.*

Mature stand of eastern white pine, red pine, northern red oak, red maple. Historically, this was the dominant forest community in much of this ecological landscape. Near Oberlin Lake, Northern Highland-American Legion State Forest, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

pine, red pine, and "scrub" oak (usually *Quercus ellipsoidalis*) occur on such sites, but there is an almost total absence of the prairie flora that characterizes the barrens communities elsewhere in Wisconsin.

Shrub Communities. Alder Thicket is by far the most common shrub-dominated community in this ecological landscape, where it borders lakes and streams and often occurs in a zone at the margins of open wetlands such as sedge meadow, bog or fen, or at wetland-upland interfaces. The conservation values of shrub swamps have often been overlooked or even dismissed, but they provide important habitat for a broad array of native plants and animals, including species that are rare or are otherwise of high conservation and management concern. Examples include game species such as snowshoe hare (*Lepus americanus*), Ruffed Grouse (*Bonasa umbellus*), and American Woodcock (*Scolopax minor*) as well as the Wisconsin Threatened wood turtle (*Glyptemys insculpta*) and Species of Greatest Conservation Need such as Veery (*Catharus fuscescens*) and Golden-winged Warbler (*Vermivora chrysoptera*). Shrub swamps composed mostly of willows (*Salix* spp.) and dogwoods (*Cornus* spp.) ("Shrub-carr") are also present, e.g., along the Manitowish River and its tributaries and in extensive wetlands at Thunder Marsh and near the Rainbow Flowage but are comparatively limited in abundance and distribution.

Herbaceous Communities. Natural communities dominated by herbs and low shrubs are mostly wetland types. A majority of these belong to acid peatland ecosystems, including Open Bog, Poor Fen, and Muskeg. Northern Sedge Meadow adjoins some of the Northern Highland's streams or spring-fed drainage lakes and is locally common in a few areas. Boreal "Rich" Fens, rare everywhere in Wisconsin, have been identified in the Northern Highland Ecological Landscape.

Marshes occur in the protected bays of lakes and impoundments and in some low gradient rivers and streams. The most familiar and widespread type is the Emergent Marsh, composed of species such as cat-tails (*Typha* spp.), bulrushes (*Scirpus* spp.), bur-reeds (*Sparganium* spp.), and other robust graminoids. This marsh type is more common in other ecological landscapes. However, the Emergent Marsh–Wild Rice community is well represented in the Northern Highland and presents an important management opportunity. The Oligotrophic Submergent Marsh is an unusual marsh community of very limited distribution in Wisconsin and is composed of aquatic plants that form beds of "sterile rosettes" in the sandy littoral zones of the clear, infertile waters of the Northern Highland's deep seepage lakes.

Inland Beach is a community that is relatively common here because of the abundance of lakes with sandy bottoms and relatively stable shorelines that transition quickly to uplands. Bracken Grasslands are herbaceous communities that occur on uplands, usually in frost pockets where tree and shrub growth is inhibited by growing season frosts. Bracken

Older mesic forest with a canopy of large eastern hemlock, yellow birch, and sugar maple. Lake Laura, Vilas county. Photo by Eric Epstein, Wisconsin DNR.

Some of Wisconsin's largest and least disturbed open peatland complexes occur in the Northern Highland Ecological Landscape. Mud Creek Springs, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Grasslands may also occur on nutrient-poor sites that were severely burned in the slash fires that accompanied or followed the Cutover. Additional surveys of beach habitats and bracken grasslands are needed to better document their abundance, distribution, variability, and condition across Wisconsin.

Miscellaneous Communities. Bedrock exposures of any sort are extremely rare here because this ecological landscape is almost entirely buried beneath glacial deposits, and the dominant landforms are outwash plains with remnant moraines. The few documented outcrops are all well under 1 acre in size.

Forest Habitat Types

Within the Northern Highland Ecological Landscape, site variability is high, and all six northern forest habitat type groups commonly occur (Table 14.1). The most common upland habitat type groups are very dry to dry and dry to dry-mesic. Sandy soils are relatively dry and nutrient poor. The most common trees currently growing on these sites are eastern white pine, red pine, jack pine, aspen, white birch,

Table 14.1. *Forest habitat type groups and forest habitat types of the Northern Highland Ecological Landscape (NH EL).*

Northern forest habitat type groups common within the NH EL[b]	Northern forest habitat types[a] common within the NH EL[b]	Northern forest habitat types present but not common within the NH EL[b]
Dry to dry-mesic (D-DM)	PArVAa	
Wet-mesic to wet (WM-W)	Forest Lowland (habitat types not defined)	
Very dry to dry (VD-D)	PArV	PQE
Mesic to wet-mesic (M-WM)	ArAbVC	ArAbCo
	TMC	ACaI
Dry-mesic (DM)	AVVb	
Mesic (M)	ATM	ATD
		AOCa

Source: Kotar et al. (2002).
[a]Forest habitat types are explained in Appendix 14.B ("Forest Habitat Types in the Northern Highland Ecological Landscape") at the end of this chapter.
[b]Groups listed in order from most to least common:
Common occurrence is an estimated 10–50% of forested land area.
Minor occurrence is an estimated 1–9% of forested land area.
Present – Other habitat types can occur locally, but each represents < 1% of the forested land area of the ecological landscape.

northern red oak, and red maple. Potential late-successional dominants are eastern white pine, red maple, northern red oak, white spruce (*Picea glauca*), and balsam fir.

Dry-mesic and mesic sites are commonly associated with well-drained, nutrient-medium sandy loam soils. Currently, hardwoods tend to dominate, particularly aspen, white birch, northern red oak, red maple, and sugar maple; many other hardwoods and conifers occur, typically as associates. Potential late-successional dominants are sugar maple, red maple, yellow birch, and eastern hemlock.

The mesic to wet-mesic group typically occurs on somewhat poorly drained, nutrient-poor to medium sandy to loamy soils. The most common trees currently growing on these sites are aspen, white birch, red maple, sugar maple, balsam fir, white spruce, and eastern white pine. Potential late-successional dominants are eastern hemlock, yellow birch, red maple, sugar maple, balsam fir, white spruce, and eastern white pine.

Forested lowlands are abundant. The wet-mesic to wet group typically occurs on poorly drained, nutrient poor to medium, muck and peat soils. Most stands are dominated by swamp conifers, including black spruce, tamarack, balsam fir, and northern white-cedar. A few sites with richer mineral soils dominated by hardwoods also occur.

Flora

The Wisconsin Natural Heritage Inventory database (WDNR 2009) contains records for 35 rare plant species documented in the Northern Highland Ecological Landscape within the past 30 years ("historical" records are those over 30 years old, and these are not considered here). Moor rush (*Juncus stygius*) is listed as Wisconsin Endangered. Fairy slipper (*Calypso bulbosa*), shore sedge (*Carex lenticularis*), large water-starwort (*Callitriche heterophylla*), and algae-like pondweed (*Potamogeton confervoides*) are listed as Wisconsin Threatened. An additional 30 species are Wisconsin Special Concern. No federally listed or globally rare plants are known to occur here at this time. A complete list of plant species receiving either endangered, threatened, or special concern status by the State of Wisconsin may be found in Appendix 14.C.

Significant Flora in the Northern Highland Ecological Landscape

- Wetlands and intact waterbodies are extraordinarily important habitats for rare and highly specialized plants in this ecological landscape.
- Some of the aquatic and wetland habitats that support rare plants are themselves rare and merit strong protection. Many of these also support rare animals.
- Emergent Marsh–Wild Rice communities are relatively common here compared to other parts of Wisconsin where water quality degradation and hydrological alterations have reduced or eliminated many rice beds.
- Additional surveys of peatland and aquatic habitats have high potential to yield additional rare plant records.
- The flora of inland beaches needs to be better documented, and the dynamics of beach habitats better understood.
- More study of nonvascular plants is needed, especially in peatlands and older forests.
- Maintaining high quality natural communities of documented significance to rare plant species is a conservation priority here.
- Major threats to rare plants and sensitive plant habitats include shoreline developments, which lead to habitat loss, water quality degradation, and the spread of invasive species.

Twenty-eight of the 35 rare plant species documented here grow primarily or exclusively in aquatic or wetland habitats. Of these 28 species, 18 are found primarily in wetlands, and ten are aquatic, inhabiting lakes, streams, or springs. The remaining seven rare plant species occupy terrestrial habitats. The high proportion of rare plant species associated with wetlands and aquatic habitats underscores the abundance, diversity, unique qualities, intact watersheds, and generally high water quality of lakes, streams, and wetlands in the Northern Highland.

Habitats that have especially high potential to harbor concentrations of rare plants include the open and forested northern fen communities (i.e., Poor Fen, Boreal Rich Fen, and Northern Wet-mesic Forest) and the deep, hard-bottomed, oligotrophic seepage lakes that support the unusual assemblages of rosette-forming species. Additional surveys for rare plants in acid peatland habitats (e.g., Open Bog, Muskeg, Black Spruce Swamp, Tamarack Swamp) are also likely to be productive because these habitats are widespread and extensive, often remote, and can be difficult to access. Forested peatlands are extensive, and these have been neither adequately evaluated nor thoroughly surveyed. Forests with old-growth characteristics have some potential to harbor rare species (WDNR 2006a). For example, the Wisconsin Endangered and globally rare little goblin moonwort fern (*Botrychium mormo*) was tentatively identified by a competent botanist in the 1990s who was familiar with that species. The habitat was an older stand of mesic hardwood forest near Lake Laura in the eastern part of the ecological landscape. No specimen or photograph was obtained, so that species has yet to be confirmed here.

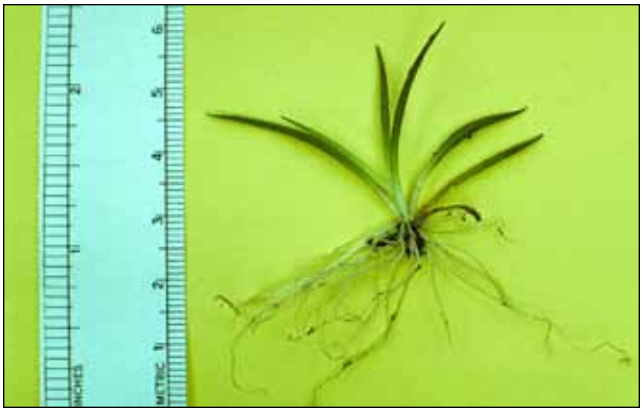
Some rare plant habitats in the Northern Highland are vulnerable to invasion by aggressive invasive species, such as purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), Eurasian water-milfoil (*Myriophyllum spicatum*), and glossy buckthorn (*Rhamnus frangula*). Additional threats of high significance include hydrological disruptions, ecosystem simplification, acidification, eutrophication, stand conversion, and outright habitat destruction.

Excellent opportunities exist at sites in the Northern Highland to conserve populations of rare plants such as algae-like pondweed, shore sedge, Robbins spikerush (*Eleocharis robbinsii*), and American shoregrass (*Littorella uniflora* var. *americana*). These species are represented by multiple populations, which include some of Wisconsin's largest populations, in habitats at sites that appear relatively well protected and secure. Large populations of marsh willow-herb (*Epilobium palustre*), leafy white orchis (*Platanthera dilatata*), hidden-fruited bladderwort (*Utricularia geminiscapa*), eastern purple bladderwort (*Utricularia purpurea*), and northeastern bladderwort (*Utricularia resupinata*) also occur here.

Surveys for nonvascular plants have been spotty and incomplete across most of Wisconsin. Intact peatlands, northern white-cedar swamps, and older stands of mesic hardwoods and conifers are among the habitats that should receive survey attention for mosses, lichens, and other taxa in the near future.

This undisturbed, muck-bottomed, shallow, soft-water seepage lake supports at least five species of rare plants. Oneida County. Photo by Eric Epstein, Wisconsin DNR.

*Showy lady's-slipper (*Cypripedium reginae*), Wisconsin Special Concern, is a spectacular though uncommon orchid that occurs in a small number of mineral-enriched peatlands within the Northern Highland. Photo by Thomas Meyer, Wisconsin DNR.*



American shoregrass has a limited Wisconsin distribution, which is centered on deep, clear, hard-bottomed seepage lakes of extremely low fertility in the Northern Highland. Photo by Robert H. Read, Wisconsin DNR.

Purple bladderwort is locally common in several seepage lakes of low fertility in the Northern Highland. Iron County. Photo by Drew Feldkirchner, Wisconsin DNR.

Fauna

Changes in Wildlife over Time

Many wildlife populations have changed dramatically since humans arrived on the landscape, but these changes were not well documented before the mid-1800s. This section discusses only those wildlife species documented in the Northern Highland Ecological Landscape. Of those, this review is limited to species that were known or thought to be especially important here in comparison to other ecological landscapes. For a more complete review of historical wildlife in the state, see a collection of articles written by A.W. Schorger, compiled into the volume *Wildlife in Early Wisconsin: A Collection of Works by A.W. Schorger* (Brockman and Dow 1982).

The Osprey is a large, fish-eating raptor that nests along or near shorelines in the Northern Highland. This ecological landscape is one of the bird's Wisconsin strongholds. Photo by Brian Collins.

The Northern Highland was historically important for a number of wildlife species, especially those species requiring aquatic, peatland, or coniferous forest habitats. This ecological landscape was particularly important for the Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), Common Loon (*Gavia immer*), American beaver, North American river otter (*Lontra canadensis*), and, possibly, American marten (*Martes americana*). As forests were logged in the late 19th and early 20th centuries and the Northern Highland was inhabited by Euro-American settlers, wildlife populations changed.

Until the 1800s, the Bald Eagle bred throughout Wisconsin. As the state was settled by Euro-Americans, Bald Eagle populations began to decline. Habitat disturbance and destruction and shooting were major causes for their decline. With the passage of the Migratory Bird Treaty in 1916 and the U.S. Bald Eagle Protection Act in 1940, it became illegal to shoot the Bald Eagle. But enforcement of the law was weak. By 1950 the Bald Eagle no longer nested in the southern two-thirds of Wisconsin. Bald Eagle populations remained stable in northern Wisconsin until the 1950s when use of ***organochlorine pesticides***, including DDT, became common. In 1972 the Bald Eagle was placed on the Wisconsin endangered species list. The same year, the federal government banned the use of DDT and other organochlorine pesticides in the United States. With the ban of these pesticides, the Bald Eagle and Osprey recovered from population lows and reoccupied areas from which they had been extirpated (Quamen 2004). Aerial surveys of Bald Eagle and Osprey nests conducted by the Wisconsin DNR since 1973 indicated rising Bald Eagle and Osprey nest numbers until 1993 (Gieck 1989, Eckstein 1999). From 1993 to 1999, Osprey nest numbers stabilized while Bald Eagle nest numbers continued to rise to record levels (Eckstein et al. 2006).

McIntyre (1988) described population declines for the Common Loon, especially in the southern part of their range during the late 19th and early 20th century, as habitat was degraded or lost with increasing development and more intensive use of lakes and lakeshores by humans. Other causes suspected for population declines are mercury poisoning, ingestion of lead (especially from sinkers used by fishermen), and oil spills on the wintering grounds. Early in the 20th century, the Common Loon was shot for "sport" and because it was thought to eat game fish. Development of lakeshores for homes and cottages increased disturbance at nest sites and likely forced the Common Loon to nest in less than optimal habitat, which may have led to reduced productivity (McIntyre 1988). Although no clear continent-wide trends in Common Loon population size have been described for the last two decades, there appear to have been substantial increases in southern parts of the breeding range during the mid to late 1900s, including Wisconsin. Summarizing reports based on U.S. breeding bird surveys from 1969 and 1989, McIntyre and Barr described a 124% increase in Wisconsin's Common Loon population (cited in Dunn 1993). These breeding bird survey results, showing large increases in Wisconsin and elsewhere, may represent recovery from declines described for the early 20th century (McIntyre 1988). The Wisconsin Loon-Watch program reported stable Common Loon population numbers, based on 1985–2000 survey data (Gostomski and Rasmussen 2001). As lakeshores are developed for residential, recreational, or industrial use, there is concern that Common Loon nesting habitat will decline.

Historically, the American beaver was present in the Northern Highland as it was across the entire state. Here, as elsewhere in the state, American beaver populations declined dramatically through the 1700s to the mid-1800s with unregulated trapping and hunting for the fur trade (Schorger 1965). American beaver populations have recovered, and this is now an important species in this ecological landscape because of the numerous lakes and streams and the abundance of aspen and other preferred foods.

White-tailed deer (*Odocoileus virginianus*) were found throughout the state and were likely more abundant in southern Wisconsin than in the northern part of the state (Schorger 1953) at the time of Euro-American settlement. Northern Wisconsin was primarily mature coniferous-deciduous forest and not optimal habitat, limiting the white-tailed deer population here. The white-tailed deer population expanded in northern Wisconsin after large-scale logging took place in the late 1800s. The former mature, mixed conifer-hardwood forest in northern Wisconsin was eventually replaced by young hardwoods, including vast acreages of aspen, white birch, and other forage plants that provided an abundant food supply for white-tailed deer. Subsistence harvest, together with market hunting, likely reduced the white-tailed deer population to its lowest level around the turn of the 20th century. Conservative harvests in the early 1900s along with regrowth of the northern forest permitted white-tailed deer population to increase in the north.

As white-tailed deer populations grew, the impacts of browsing on forest vegetation became apparent. Starvation of white-tailed deer was first reported in 1930. From 1934 through 1954, large-scale feeding was done in an effort to prevent starvation. Failure of this feeding program prompted attempts to institute antlerless white-tailed deer harvests to control and reduce the white-tailed deer herd. After much public resistance to shooting female white-tailed deer, the current white-tailed deer management programs were put in place, setting white-tailed deer population goals for units within the state and using antlerless white-tailed deer harvests in an attempt to keep the white-tailed deer at the established goals (Figure 14.5).

White-tailed deer populations in the Northern Highland today are large compared to those present prior to Euro-American settlement. Logging and other human activities have maintained large acreages of the northern forest in young deciduous growth, which has provided abundant food for white-tailed deer. Relatively mild winters during the decades of the 1990s and 2000s have prevented winter starvation and allowed the white-tailed deer herd to increase. Winter feeding of white-tailed deer by well-intentioned people became popular in the 1990s and may be contributing to increased winter survival and increased production of offspring the following spring. This is especially true in this ecological landscape with its concentration of lake front homes surrounding its many lakes. The white-tailed deer herd has often been above goal for most northern forest deer management units in the last decade (Figure 14.6), and overbrowsing, with heavy negative impacts on vegetation, has occurred in many forested portions of this ecological landscape. In 2008–11, white-tailed deer populations were near or below goals.

Based on trapping records, the North American river otter was historically as or more abundant than the American beaver across the state (Schorger 1970). The North American river otter was likely abundant

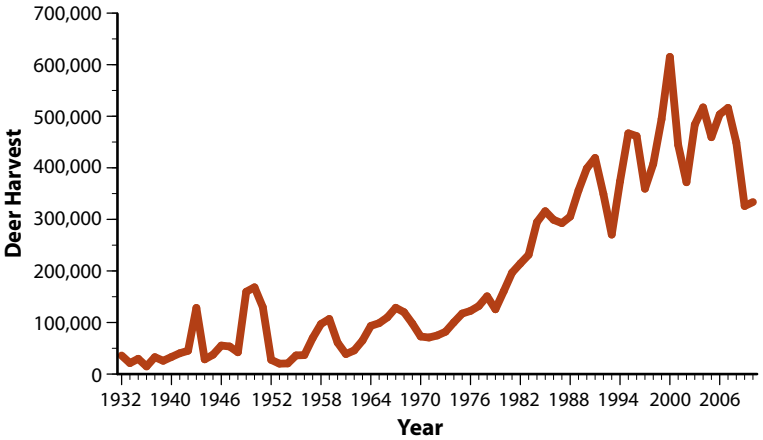


Figure 14.5. *Statewide white-tailed deer harvest, 1932–2010 (Wisconsin DNR unpublished data).*

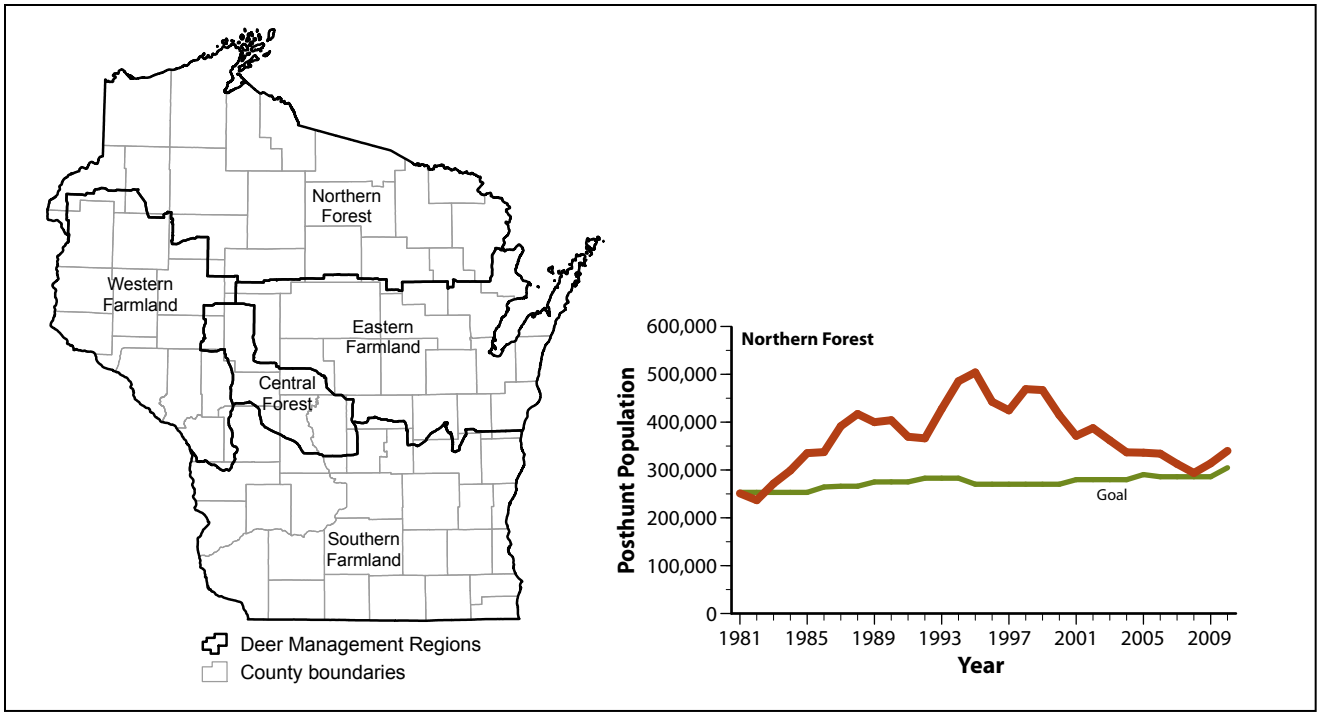


Figure 14.6. *White-tailed deer population size in relation to population goal in the northern forest deer management region, 1981–2010 (Wisconsin DNR unpublished data).*

in the Northern Highland because of the many lakes and streams and excellent populations of fish as a primary food source. North American river otter populations declined dramatically throughout the state with unregulated trapping for the fur trade, as they did for the American beaver. Today North American river otter populations have recovered, and in 2007 the counties in this ecological landscape showed some of the highest harvest levels for this species in the state (Dhuey and Olson 2007). The North American river otter has again become an important species here.

Significant Wildlife

Wildlife are considered significant for an ecological landscape if (1) the ecological landscape is considered important for maintaining the species in the state and/or (2) the species provides important recreational, social, and economic benefits. To ensure that all native species are maintained somewhere in Wisconsin, "significant wildlife" includes both common species and species that are considered "rare" (in this book "rare" species are those listed as endangered or threatened by either Wisconsin or the federal government or species that are listed as "special concern" by the State of Wisconsin). Four categories of species are discussed below: rare species, Species of Greatest Conservation Need (SGCN), responsibility species, and socially important species (see definitions in text box). Because conserving or restoring wildlife communities and habitats is the most efficient way to manage and benefit a majority of species, we discuss management of different wildlife habitats in which significant fauna occur.

■ **Rare Species.** As of November 2009, the Wisconsin Natural Heritage Working List (WDNR 2009) documented 63 rare animal species within this ecological landscape, including 6 mammals, 22 birds, 6 herptiles, 7 fishes, and 22 invertebrates. These include one U.S. Endangered species, two Wisconsin Endangered species, 10 Wisconsin Threatened species, and 52 Wisconsin Special Concern species. See Appendix 14.C for a comprehensive list of the rare animals known to exist in the Northern Highland Ecological Landscape.

■ ***Federally Listed Species:*** No U.S. Endangered species occur in this ecological landscape. The gray wolf (*Canis lupus*), which occurs in this ecological landscape, was removed from the federal threatened species list in January 2012, granting management authority to the State of Wisconsin. The Wisconsin state legislature passed a law in April 2012 authorizing hunting and trapping seasons for wolves and directed that wolf hunting and trapping seasons be held starting in the fall of 2012. The first hunting and trapping seasons of wolves were conducted during October–December 2012. Wolves are now being managed under a 1999 wolf management plan (WDNR 1999) with addenda in 2006 and 2007, but the plan is being updated to reflect these recent changes in wolf management in Wisconsin.

The Bald Eagle (formerly U.S. Threatened) is now a common nesting bird here. After statutory delisting, it remains federally protected under the U.S. Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The Bald Eagle is now listed as a Wisconsin species of special concern.

Categories of Significant Wildlife

- **Rare species** are those that appear on the Wisconsin Natural Heritage Working List as Wisconsin or U.S. Endangered, Threatened, or Special Concern.
- **Species of Greatest Conservation Need** are described and listed in the Wisconsin Wildlife Action Plan (WDNR 2005c) as those native wildlife species that have low or declining populations, are "indicative of the diversity and health of wildlife" of the state, and need proactive attention in order to avoid additional formal protection.
- **Responsibility species** are both common and rare species whose populations are dependent on Wisconsin for their continued existence (e.g., a relatively high percentage of the global population occurs in Wisconsin). For such a species to be included in a particular ecological landscape, a relatively high percentage of the state population needs to occur there, or good opportunities for effective population protection and habitat management for that species occur in the ecological landscape. Also included here are species for which an ecological landscape holds the state's largest populations, which may be critical for that species' continued existence in Wisconsin even though Wisconsin may not be important for its global survival.
- **Socially important species** are those that provide important recreational, social, or economic benefits to the state for activities such as fishing, hunting, trapping, and wildlife watching.

■ ***Wisconsin Endangered Species:*** One Wisconsin Endangered mammal, the American marten, and one Wisconsin Endangered bird, the Black Tern, occur in this ecological landscape. There are no herptiles, fishes, or invertebrates listed as Wisconsin Endangered here.

■ ***Wisconsin Threatened Species:*** Wisconsin Threatened species that occur in this ecological landscape include four birds: Red-shouldered Hawk (*Buteo lineatus*), Yellow Rail (*Coturnicops noveboracensis*), Cerulean Warbler (*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List), and Spruce Grouse (*Falcipennis canadensis*); two herptiles: wood turtle and Blanding's turtle (*Emydoidea blandingii*); three fish: longear sunfish (*Lepomis megalotis*), greater redhorse (*Moxostoma valenciennesi*), and pugnose shiner (*Notropis anogenus*); and one invertebrate: a dragonfly, the pygmy snaketail (*Ophiogomphus howei*). No Wisconsin Threatened mammals occur here.

■ ***Wisconsin Special Concern Species:*** The 52 Wisconsin Special Concern species occurring in the Northern Highland Ecological Landscape include 5 mammals, 18 birds, 4 herptiles, 4 fish, and 21 invertebrates (see Appendix 14.C for a complete endangered, threatened, and special concern species list).

The Wisconsin Threatened Spruce Grouse is an uncommon resident of the Northern Highland, where it inhabits extensive stands of conifers with low branches, especially spruces, fir, northern white-cedar, and jack pine. Photo by Ray White.

■ **Species of Greatest Conservation Need.** Species of Greatest Conservation Need (SGCN) are those that appear in the Wisconsin Wildlife Action Plan (WDNR 2005c). SGCN include species already recognized as endangered, threatened, or special concern on Wisconsin or federal lists. In addition, other declining species in jeopardy of being added to the state or federal lists are included as SGCN. There are 34 birds, six mammals, four herptiles, and four fish species listed as SGCN for the Northern Highland Ecological Landscape (see Appendix 14.E for a complete list of SGCN in this ecological landscape).

■ **Responsibility Species.** The Bald Eagle, Osprey, and Common Loon have large, high density populations here, associated with the many lakes and streams that provide suitable nest sites and abundant food. Forest interior bird species, including neotropical migrant songbirds such as wood warblers, vireos, flycatchers, and thrushes; conifer specialists, such as Boreal Chickadee (*Poecile hudsonicus*), Gray Jay (*Perisoreus canadensis*), Connecticut Warbler (*Oporornis agilis*), and several northern finches; and forest raptors such as the Northern Goshawk (*Accipiter gentilis*) and Red-shouldered Hawk are common or relatively well represented in this ecological landscape. Maintaining or restoring large blocks of unfragmented forest and increasing the coniferous component of these forests will be necessary to maintain these species. Peatland specialists such as the Yellow Rail, Lincoln's Sparrow (*Melospiza lincolnii*), and Palm Warbler (*Setophaga palmarum*) are found in this ecological landscape, and this is among the best places in the state to manage for them. Marsh and sedge meadow specialists and their preferred habitats also occur here. These include Black Tern (*Chlidonias niger*), American Bittern (*Botaurus lentiginosus*), LeConte's Sparrow (*Ammodramus leconteii*), Sedge Wren (*Cistothorus platensis*), and several species of waterfowl.

The Wisconsin Threatened greater redhorse is found in the Manitowish River, Trout River, Trout Lake, Bearskin Lake,

and Island Lake. The Wisconsin Threatened pugnose shiner is found in the Manitowish River, Trout River, and Manitowish Lake, and the Wisconsin Threatened longear sunfish is found in the Trout River.

Waters in this ecological landscape support a number of Wisconsin Special Concern species, including the redside dace (*Clinostomus elongatus*) in Little Rice River, Brown Creek, Clukey Creek, Lamer Springs, Thunder Creek, Willow River, Little Willow Creek, and an unnamed creek in Oneida County; banded killifish (*Fundulus diaphanus*) in the Willow Flowage, Trout River, Stevenson Creek, Little Arbor Vitae Lake; pirate perch (*Aphredoderus sayanus*) in Swamp Creek, Rocky Run Creek, Swamp Lake; and the least darter (*Etheostoma microperca*) in the Trout River. Lake sturgeon (*Acipenser fulvescens*) occurs in the Turtle-Flambeau Flowage and spawns in the Manitowish and Turtle River systems.

Socially Important Fauna. Species such as white-tailed deer, American black bear (*Ursus americanus*), American beaver, North American river otter, fisher (*Martes pennanti*), Ruffed Grouse, American Woodcock, Mallard (*Anas platyrhynchos*), Wood Duck (*Aix sponsa*), and Ringed-necked Duck (*Aythya collaris*) are all important for hunting, trapping, and wildlife viewing in this ecological landscape. The Northern Highland has an important warmwater fishery due to the large number of lakes that support populations of muskellunge (*Esox masquinongy*), walleye (*Sander vitreus*), northern pike (*Esox lucius*), smallmouth bass (*Micropterus dolomieu*), and largemouth (*Micropterus salmoides*) bass in addition to bluegill (*Lepomis macrochirus*), yellow perch (*Perca flavescens*), and other panfish sought by anglers. Because of their low buffering capacity, some lakes have a fish advisory warning for mercury contamination. There are coldwater streams in the eastern and southern parts of the ecological landscape that support populations of native brook trout (*Salvelinus fontinalis*).

Wildlife Habitats and Communities. The Northern Highland Ecological Landscape contains important wildlife species associated with the high density of kettle lakes, pine-dominated dry and dry-mesic forest communities, forested and nonforested acid peatlands, wild rice marshes, sedge meadows, mixed mesic hardwood-conifer forests, headwaters of major streams, and forested watersheds.

The Northern Highland now supports and has high potential to continue supporting wide-ranging mammals, forest interior songbirds and raptors, species that use lake, stream, and shoreline habitats, conifer specialists (especially those associated with forests of pine, eastern hemlock, spruce, and balsam fir), peatland specialists, and certain marsh species. There is potential for large block management for forest

Significant Wildlife in the Northern Highland Ecological Landscape

- Bald Eagle, Osprey, Common Loon.
- Forest interior bird species (e.g., many neotropical migrant songbirds such as wood warblers, vireos, flycatchers, and thrushes; also forest raptors).
- Coniferous Forest specialists (e.g., Boreal Chickadee, Gray Jay, Connecticut Warbler, "northern" finches).
- Open peatland specialists (e.g., Yellow Rail, Le Conte's Sparrow).
- Marsh and sedge meadow species (e.g., Black Tern, American Bittern, herptiles, invertebrates).
- Mammals: American beaver, North American river otter, American black bear, and snowshoe hare.
- Herptiles: Wood turtle, mink frog, and four-toed salamander.
- Fish: Muskellunge, walleye, northern pike, largemouth and smallmouth bass, panfish, greater redhorse, longear sunfish, and pugnose shiner.
- Invertebrates: Freija fritillary, frigga fritillary, mottled darner, lake emerald, and pygmy snaketail, and robust Dubiraphian riffle beetle.

North American river otters are among the iconic animals strongly associated with the water-rich Northern Highland Ecological Landscape. Photo by Brian Collins.

interior species here since the forest is only moderately fragmented, and it is possible to maintain or create forested connections to the Chequamegon-Nicolet and Ottawa National Forests and other public lands. The large public land base that the Northern Highland-American Legion State Forest, county forests, and federal forests provides is important for the gray wolf in north central Wisconsin, providing that road densities and additional housing developments are not increased substantially. In 2007, at least 49 gray wolves in 13 packs occurred in the Northern Highland Ecological Landscape, with 19 gray wolves in six packs within the Northern Highland-American Legion State Forest (WDNR 2007). Since 2007 the population has increased.

Because of the abundant aquatic resources, the Northern Highland Ecological Landscape supports significant populations of water-dependent wildlife species, such as Common Loon, Osprey, Bald Eagle, Black Tern, and North American river otter. All fish, amphibians, many invertebrates, and aquatic plants also depend on lake and stream habitats. Figure 14.7 shows the distribution of nesting sites for the Bald Eagle population throughout northern Wisconsin and the heavy concentration of nesting sites in this ecological landscape. The lakes and streams are also important for nesting Mallard, American Black Duck (*Anas rubripes*), Ring-necked Duck, and Wood Duck populations.

The large number of rare aquatic animals reflects the abundance of high-quality lakes, streams, and wetlands in this ecological landscape as well as the generally good condition of most watersheds here (which are mostly forested). Trout Lake maintains populations of deepwater species such as ciscoes (*Coregonus* spp.) and lake trout (*Salvelinus namaycush*) among its total of 41 fish species. Trout Lake and its outlet stream, the Trout River, also support rare plant and animal species. In addition to the species mentioned above, aquatic environments are highly significant to several rare dragonflies, for example, the mottled darner (*Aeshna clesydra*), the lake emerald (*Somatochlora cingulata*), and the Wisconsin Threatened pygmy snaketail. One of two Wisconsin locations for the globally rare robust Dubiraphian riffle beetle (*Dubiraphia robusta*) is in the Northern Highland Ecological Landscape.

Lakeshore marshes support a small breeding population of the Trumpeter Swan (*Cygnus buccinator*) as well as populations of American Black Duck, American Bittern, Black Tern, and the American bullfrog (*Lithobates catesbeianus*). Lakes containing wild rice beds are important for breeding and migratory waterfowl and other water birds. Large wetlands such as Powell Marsh (in part a state wildlife area) are managed for waterfowl and are important breeding and migratory habitat for ducks, geese, Sandhill Crane (*Grus canadensis*), and others. The importance of open and wetland habitats in this ecological landscape for sensitive birds is identified by Sample and Mossman (1997), who list five Sites for Management Focus for grassland birds within the Northern Highland Ecological Landscape: Powell Marsh, Johnson Lake barrens, Rainbow Flowage Sedge Meadow, Big Swamp, and Thunder Lake Wildlife Area. The Manitowish River peatlands also deserve to be mentioned here because they cover thousands of acres and support many rare or specialized plants and animals (including "grassland" birds). Large sedge meadows and open bog/poor fen habitats support Yellow Rail, Northern Harrier (*Circus cyaneus*), Nelson's Sparrow (*Ammodramus nelsoni*), Le Conte's Sparrow, and the southern bog lemming (*Synaptomys cooperi*).

Forested and nonforested peatland communities (including black spruce, tamarack, and northern white-cedar swamps) support a broad array of animals that are strongly associated with North America's boreal regions. Examples from forested peatlands include Spruce Grouse, Northern Saw-whet Owl (*Aegolius acadicus*), Gray Jay, Boreal Chickadee, Cape May Warbler (*Setophaga tigrina*, listed as *Dendroica tigrina* on the

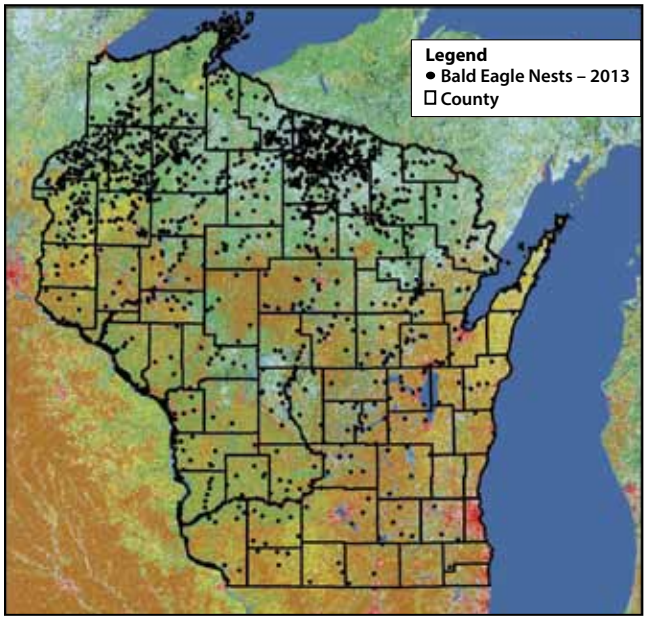


Figure 14.7. *Distribution of Bald Eagle nests in Wisconsin, 2013 (Wisconsin DNR unpublished data).*

Wisconsin Endangered Black Tern on nest. Photo by Brian Collins.

Wisconsin Natural Heritage Working List), Connecticut Warbler, Red Crossbill (*Loxia curvirostra*), and Evening Grosbeak (*Coccothraustes vespertinus*). In more open peatlands (Muskeg, Poor Fen, Open Bog), rare boreal lepidotera such as the freija fritillary (*Boloria freija*) and frigga fritillary (*Boloria frigga*) have been documented here, and there is high potential for additional discoveries of rare species with boreal habitat affinities from this taxonomic group.

Shrub swamp habitats (e.g., Alder Thicket and Shrub-carr) are widespread and provide important habitat for species of management concern such as the Golden-winged Warbler, American Woodcock, Veery, wood turtle, and snowshoe hare. Upland "shrub" habitats such as Bracken Grassland or cutovers are significant to Chestnut-sided Warbler (*Setophaga pensylvanica*), Mourning Warbler (*Geothlypis philadelphia*), and Brown Thrasher (*Toxostoma rufum*).

This ecological landscape has major potential for red and eastern white pine management on dry to dry-mesic sites, a mix of conifer and hardwood forests on more mesic sites, and for all of the species that use these habitats. The Northern Highland presents a significant opportunity to provide secure habitat for a large number of forest interior, area-sensitive animals, including the Northern Goshawk, Red-shouldered Hawk, Swainson's Thrush (*Catharus ustulatus*), Evening Grosbeak, and many wood warblers as well as fisher and American black bear. Some of the highest nesting densities of Northern Goshawks in the state occur in Vilas and Oneida counties. Currently, aspen forests are abundant, and these habitats are important for species that utilize dense deciduous saplings and young deciduous forest as habitat, such as white-tailed deer, Ruffed Grouse, American Woodcock, Chestnut-sided Warbler, and Golden-winged Warbler.

The Northern Parula is a long distance, migratory wood warbler that nests in older stands of conifers. Photo by Brian Collins.

The Mourning Warbler is a neotropical migrant that breeds in moist deciduous thickets of shrubs and saplings across northern Wisconsin. Photo by Brian Collins.

Natural and Human Disturbances

Fire, Wind, and Flooding

Fire was the dominant historical disturbance agent in the Northern Highland, although fires here would have been less severe and less frequent than in the drier and more contiguous upland habitats in other ecological landscapes with somewhat similar outwash landforms and vegetation, such as the Northwest Sands or Northeast Sands. The frequency of recurrence of stand-replacing fires (i.e., fire intervals) may have ranged from about 75–250 years, based on studies in other parts of the Lake States with comparable landforms dominated by mixed pine-oak-aspen forests (Dickmann and Cleland 2002).

In northeastern Lower Michigan, historical fire intervals in mixed pine forests were 129–258 years and in oak-pine forests were 172–344 years (Whitney 1986). These forests occur in a diverse landscape that includes glacial features such as ***heads-of-outwash***, former dune/beach ridge features, and overwashed moraines, so they may be comparable to the Northern Highland. In the Pictured Rocks National Lakeshore of Upper Michigan, surface fires impacted eastern white pine-red pine forests on sandy soils on average every 22 years (Loope 1991). Eastern white pine-red pine-mixed hardwood forests in Itasca State Park, Minnesota, burned more frequently during warmer, drier climatic periods during the last 750 years (Clark 1990). Surface fires burned at about nine-year intervals during the 15th and 16th centuries and at about 13-year intervals in recent times.

Studies of fire in jack pine forests of the Lake States were conducted in areas with fewer fire barriers than the Northern Highland, so fire intervals would likely be longer here. Whitney (1986) reported return intervals of 83–167 years for jack pine forests in Michigan, based on GLO-PLS data that likely did not include small areas with lighter burns. Simard and Blank (1982) determined that the fire interval for small areas within the Mack Lake area, Michigan, was 27 years during the time period prior to Euro-American settlement. At Itasca State Park, Minnesota, jack pine forests experienced fire at a return interval of about 22 years, with burn sizes varying from 580 acres to 31,960 acres (Frissell 1973).

Historical fire intervals in the Northern Highland would have been shortest, perhaps around 100 to 150 years, in the southern part of the ecological landscape where conditions

are driest and jack pine forests are common. Longer fire intervals of 250 years or more would have prevailed in the more mesic areas and where landscape barriers such as hills, wetlands, and kettle lakes occur. Low-intensity surface fires were undoubtedly common here, with a fire interval of around 20 years. Windthrow also occurred in these forests but was less widespread an influence than fire in initiating forest regeneration (Canham and Loucks 1984).

It is often difficult to use fire as a management tool in today's forests because of the presence of homes and other structures, so managers often regenerate pine forests through clearcutting. This disturbance partially resembles the effects of fire in that both are intensive disturbances that open the site to full sunlight. Some differences are that fire reduces not only canopy density but also the density of saplings, shrubs, and herbaceous litter, thereby reducing competition for regenerating trees. Fire also mineralizes organic material, making nutrients available to plants, whereas logging removes a proportion of the nutrients and does not mineralize organic matter.

The extent and frequency of flood disturbance prior to Euro-American settlement is unknown, but the sandy soils of the ecological landscape would have absorbed water quickly and limited the extent of flooding. It is likely that flooding has now been reduced from historical levels due to a combination of stream channel downcutting and changes in bank structure that occurred during early logging and effects of dams and other water control structures. A reduction in flooding affects food webs in streams and riparian zones. Drought, on the other hand, can severely limit the habitat available to aquatic organisms and cause harmful increases in water temperatures. Impoundments typically are not managed to mitigate these negative impacts of drought.

Natural disturbance regimes have been altered by human activities. Fire suppression activities have reduced the frequency of fire disturbance, leading to changes in species composition and landscape patch structure. Wind disturbance, in the mesic and wet portions of the ecological landscape, is likely reduced from historical conditions because forests are generally younger and less subject to windthrow. As a result, canopy gaps are scarcer, and their absence can impact species like the Black-throated Blue Warbler (*Setophaga caerulescens*, listed as *Dendroica caerulescens* on the Wisconsin Natural Heritage Working List). Natural flood disturbance has been reduced by the installation of water control structures, but the placement of some of these structures has resulted in the inundation of large areas, altering some wetland communities, or replacing them with expanses of open water.

Disturbances in the current landscape are largely due to human activities, including the long-term conversion of land to roads, buildings, agriculture, and utility corridors. Shorter-term disturbances result from logging and recreational pursuits. Some effects are indirect, such as the high level of herbivory by white-tailed deer, which is largely the result of human activities that affect the size of white-tailed deer populations. A major difference from historical disturbances is that today's impacts are multiple and pervasive, affecting most of the landscape almost constantly. Historically, many landscape ecosystems existed in a quasi steady-state condition where disturbances impacted parts of the area

Active logging in the Northern Highland-American Legion State Forest, adjacent to Bittersweet Lakes State Natural Area, Vilas County. Photo by Eric Epstein Wisconsin DNR.

A severe windstorm has flattened much of this remnant stand of old-growth hemlock-hardwoods at the University of Wisconsin's Kemp Natural Resources Station, Oneida County. Photo by Eric Epstein, Wisconsin DNR.

but typically moved around the landscape so that portions were undisturbed for long or varying time.

Forest Insects and Diseases

The Northern Highland Ecological Landscape is a heterogeneous area due to the complexity of its physical environment. It supports a wide variety of forest types, each of them associated with different insects and diseases. Thus, there are a number of species that can periodically affect forests in this ecological landscape.

Aspen can be impacted by forest tent caterpillar (*Malacosoma disstria*) and *Phellinus* and *Hypoxylon* fungi. White birch can be affected by bronze birch borer (*Agrilus anxius*), and drought can predispose this species to many diseases.

Conifers, including red pine, eastern white pine, jack pine, and white spruce, can be affected by Annosum root rot, caused by the fungus *Heterobasidion annosum*, particularly in plantations. Red pine is also subject to pocket mortality, caused by a complex of insects and the fungal species *Leptographium terrebrantis* and *L. procerum*. Red pine is also susceptible to pine blight fungus (*Dipoldia pinea*) and pine sawfly (*Neodiprion* spp., *Diprion* spp.). White pine blister rust is an introduced fungal disease caused by *Cronartium ribicola*; it is most severe in low-lying areas. The jack pine budworm (*Choristoneura pinus*) is a native insect whose infestations can cause large-scale mortality of mature jack pine, setting up fuel conditions for catastrophic fire to which jack pine is well adapted.

Gypsy moth (*Lymantria dispar*) is a nonnative insect currently becoming established in this ecological landscape, which will periodically affect oak and aspen forests. The two-lined chestnut borer (*Agrilus bilineatus*) is a bark-boring insect that attacks oaks. Oak wilt is a vascular disease caused by the native fungus *Ceratocystis fagacearum*.

The emerald ash borer (*Agrilus planipennis*) is not expected to have as great an impact on forest structure here as in many other ecological landscapes in the state. Ash species (*Fraxinus* spp.) are minor components of the forest in the Northern Highland, making up only 0.49% of RIV as indicated by FIA data (including trees of 1 inch or more in diameter), so the vast majority of forests in this ecological landscape are not at high risk from the emerald ash borer. There is at least one notable exception because of its size, condition, and context: the Toy Lake complex on the Vilas-Iron county line, which contains one of the state's best ash swamps.

More information about these diseases and insect pests of forest trees can be found at the Wisconsin DNR's Forest Health web page (WDNR 2014b) and at the U.S. Forest Service Northeastern Area forest health and economics web page (USFS 2013).

Invasive Species

Due to many lakes, a large public land base, and high levels of recreational use, many invasive species are potential problems here. Nonnative invasive plants and animals can outcompete native species and may eventually completely dominate native ecosystems, decreasing the abundance and diversity of native species and disrupting ecosystem function.

Terrestrial invasive species occur in the Northern Highland but are not yet at high levels. Care needs to be taken to prevent their spread and introduction. In forested communities, nonnative invasive species such as glossy and common (*Rhamnus cathartica*) buckthorns, honeysuckles (e.g., *Lonicera morrowii, L. tatarica,*and the hybrid *Lonicera X bella)*, garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), Dame's rocket (*Hesperis matronalis*), forget-me-not (e.g., *Myosotis scorpioides*, *M. sylvatica*), Norway maple (*Acer platanoides*), and black locust (*Robinia pseudoacacia*) already pose problems. Japanese knotweed (*Polygonum cuspidatum*) is also known to be present. These species may initially colonize disturbed areas and edges but once established can invade surrounding habitats, including forests. Along roads, in pastures, and in other open or partially forested areas, spotted knapweed (*Centaurea biebersteinii*), wild parsnip (*Pastinaca sativa*), leafy spurge (*Euphorbia esula*), Canada thistle (*Cirsium arvense*), and common tansy (*Tanacetum vulgare*) have been documented.

In aquatic and wetland ecosystems, Eurasian water-milfoil, curly pondweed (*Potamogeton crispus*), rusty crayfish (*Orconectes rusticus*), rainbow smelt (*Osmerus mordax*), common reed (*Phragmites australis*), purple loosestrife, and reed canary grass are the primary problem species. The nonnative watercress (*Nasturtium officinale*) is also present and can dominate springy areas and headwaters streams. Pond gardening is increasing in popularity in the area, and some of the nonnative species available for purchase appear to be escaping into lakes and water treatment facilities.

The Northern Highland Ecological Landscape is vulnerable to invasion by additional invasive species and to the spread of already established invasives into new sites. Human activity is the primary vector for the transport of many invasive species, and the generally high levels of tourism and outdoor recreation make this area a likely candidate for initial introductions. The ongoing development of new homes and businesses contributes to a high level of site disturbance, and many invasive species are adapted to be highly competitive under these conditions. Some ornamental plants used in landscaping can also spread and become invasive in native community types.

The invasion of forests by European earthworms of the family Lumbricidae is a concern here (though perhaps less so in the sandier areas). Native earthworms were absent from the Northern Highland after the last glaciation, but exotic earthworms have been introduced since Euro-American settlement, primarily as discarded fishing bait (Hendrix and Bohlen 2002, Hale et al. 2005). Exotic earthworms can have dramatic impacts on forest soils and the forest floor by greatly reducing organic matter (Hale et al. 2005), microbial biomass (Groffman et al. 2004), nutrient availability (Bohlen et al. 2004, Suarez et al. 2004), and fine-root biomass (Fisk et

al. 2004). These physical changes to the forest floor reduce densities of tree seedlings and herbs (Gundale 2002) and can favor invasive plants (Kourtev et al. 1999).

For more information, see the Wisconsin DNR's web page on invasive species in Wisconsin (WDNR 2014d).

Land Use Impacts

Historical Impacts. Ecological impacts of destructive logging and land uses in the latter half of the 19th century were immense, and some of them persist today. After an almost complete removal of trees, extensive fires often followed, burning slash and debris left from logging operations and consuming regenerating forests. Access to forested lands and delivery of logs to sawmills was expedited by the network of waterways (lakes and streams) used to float logs to the mills. Riverways were cleared of large woody material to allow navigation, river bottoms and banks were scoured during log drives, and deposition of bark and other woody debris on stream bottoms changed the character and biota of many water bodies. After the extensive logging, the ecological landscape attracted settlers who engaged in activities such as agriculture, housing construction, and railroad building. The forests of the Northern Highland have regenerated, but tree species dominance has changed, as have age structures and patch sizes compared with the historical forests (Schulte et al. 2007).

Current Impacts. In recent decades, the Northern Highland has experienced a continuous influx of humans. There has been a steady increase in both seasonal and permanent residents, creating a pattern of dispersed urbanization. This population growth has increased housing and road densities, occurring first in rings around lakeshores and now spreading into the forests surrounding lakes. Parcelization and subsequent development in remote areas has fragmented contiguous habitats and reduced their effective size, increased land values and the cost of public services, and contributed to wildfire risks. Some of the ecological consequences of these human-influenced factors include an increase in generalist species and nonnative habitats (e.g., roads, utility rights-of-way, lawns, landscaping, golf courses, sand blankets, sand and gravel quarries), harassment of wildlife, feeding of wildlife, introduction of invasive plants, and predation by free-ranging dogs and cats.

Shoreline Development. Impacts of land use, particularly shoreline development, dispersed residential development, and associated infrastructure, have created long-term alterations in aquatic and terrestrial ecosystems. The abundance of large, clear, sand-bottomed lakes makes the Northern Highland Ecological Landscape a very desirable location for recreational use and residential development. These aquatic resources also make it an important area in which to conserve native aquatic species, associated wetlands, and many types of water-dependent wildlife. When native vegetation is removed from shorelines and replaced with impervious surfaces or manicured lawns, many habitat values and benefits to native species are often compromised. These include the loss of food, cover, and breeding habitat for birds, herptiles, invertebrates, and other species (Elias and Meyer 2003), the loss of shoreline shade by tree removal resulting in increased water temperatures, the destabilization of fragile shorelines (or, conversely, the hardening of shorelines by the construction of rock walls and steel jetties), and loss of spawning areas for fish. In addition, when shorelines are modified, it can cause the disruption of natural flow regimes, the loss of stormwater storage capacity, and the loss of a safe and sufficient water supply for residential and industrial uses and can diminish aesthetically pleasing shorelines. These shoreline changes have caused a reduction in aquatic and terrestrial species abundance and diversity (Lindsay et al. 2002, Woodford and Meyer 2003), favoring habitat generalists over more sensitive habitat specialists. Without strong efforts and cooperation by riparian owners and local governments to protect

New homes are being built in previously undeveloped white pine-red pine forests. Oneida County. Photo by Eric Epstein, Wisconsin DNR.

Human populations continue to increase in the Northern Highland, with some of the heaviest concentrations of new residential developments on lake shores and in riparian areas. Photo by Colleen Matula, Wisconsin DNR.

shorelines and shoreline environments, these problems and trends are expected to continue and the effects amplify into the foreseeable future.

The ecological impacts of shoreline development have been documented in studies in northern Wisconsin and similar environments elsewhere in North America. In general, developed lakeshores take on a suburban quality, with areas of native vegetation and shoreline habitat replaced by manicured lawns. This can lead to excess nutrient (or pesticide) runoff after lawn fertilization or other treatments. Poorly managed construction sites on or near shorelines can contribute sediments and other pollutants to lakes and streams. The removal of native vegetation decreases habitat values for mammals, birds, herptiles, fish, many invertebrates, and plants (Lindsay et al. 2002, Woodford and Meyer 2003).

In the littoral, or shallow-water, zone of lakes, shoreline development has been associated with a number of negative impacts, including the loss of desirable aquatic vegetation; a reduction in the diversity and productivity of fishes; the loss of disturbance-sensitive fish; lower green frog (*Rana clamitans*) populations; the loss of ***coarse woody debris***, which creates important habitat for many fish, herptiles, and invertebrates; and ***cumulative impacts*** whereby many small, site-specific habitat losses or changes will ultimately have significant effects over broader areas.

In a study of lakes in Minnesota, vegetative cover in littoral areas adjacent to developed shores was less abundant than along undeveloped shorelines (Radomski and Goeman 2001). On average, there was a 66% reduction in vegetative cover with development. The estimated loss of emergent and floating-leaf vegetative cover from human development for all Minnesota's clear water "panfish-walleye lakes" was 20% to 28%. Significant positive correlations were detected between occurrence of emergent and floating-leaf plant species and relative biomass and mean size of northern pike, bluegill, and pumpkinseed (*Lepomis gibbosus*). Current shoreline regulatory policies and landowner education programs need to be improved to address cumulative impacts to North American lakes.

Developed lakeshores take on a suburban quality when native vegetation is replaced by manicured lawns. The lack of shoreline buffering exacerbates nutrient and sediment runoff problems. Photo by Michele Woodford, Wisconsin DNR.

Undeveloped ***shorelands*** serve as ***buffers*** to runoff because they prevent water along with pollutants and nutrients from flowing directly into lakes. With developed shoreland there is little opportunity to filter or infiltrate pollutants and nutrients from shoreland sources because they proceed unimpeded directly into surface waters. Controlling lot size, width, and the extent and location of impervious surfaces are important tools that can decrease these cumulative environmental impacts.

Mitigating the adverse effects after shoreland development has occurred can reduce the negative impacts of impervious surfaces and compacted soils. However, it's important to realize that mitigation can be expensive and difficult to consistently implement and maintain and will not replace the original shoreline habitats with equivalent values for native plants and animals. Negative impacts of development density and impervious surfaces can be mitigated to some extent through low impact designs that minimize the amount of impervious surfaces and void or reduce soil compaction. Installing stormwater ponds, leaving natural shoreline buffers, seeding and mulching construction sites, and reducing or eliminating fertilizer applications can also help to mitigate shoreline development problems.

Changes in Hydrology. Some of Wisconsin's largest and least disturbed peatlands occur within the Northern Highland. Changes to wetland hydrology and the conversion of bog, fen, muskeg, or conifer swamp to commercial cranberry or rice production diminishes the amount of natural habitat available for native peatland species, alters drainage patterns, water chemistry and water quality, and can ultimately have ecological impacts on the entire peatland ecosystem. The conversion of peatlands to marshier habitats more suitable for waterfowl can have similar effects. The cumulative habitat impacts of these sorts of hydrological alterations that result in type conversions need to be assessed at local and landscape-level scales.

Forest Management. The Northern Highland historically consisted of a diverse ***mosaic*** of habitats and patch sizes due to its glacial history and complex landforms and a variety of natural disturbances, offering a heterogeneous blend of sizes and ages of natural community types and ecotones not found elsewhere in the state at so large a scale. A focus on stand-level forest management has resulted in many small to medium-sized patches of similar species composition and age-class structure, while at the broader scale there has been a loss of patch size and age-class diversity. Older forests and large contiguous forest patches are in especially short supply at this time. The creation of large amounts of edge habitats throughout the Northern Highland has promoted generalists at the expense of interior forest habitat specialists, area-sensitive species, and disturbance-sensitive species.

Forest openings have been created and maintained as habitat for white-tailed deer and other wildlife (for more details on forest openings, see "Natural and Human Disturbance" in Chapter 12, "North Central Forest Ecological Landscape"). Although it has been shown to benefit white-tailed deer, creating artificial openings fragments otherwise contiguous forest and provides an avenue for introducing invasive plants. Maintaining white-tailed deer populations at artificially high levels can negatively affect native vegetation. Several species are especially sensitive to browse, including northern white-cedar, eastern hemlock, and Canada yew (*Taxus canadensis*) but also eastern white pine and other species such as yellow birch and understory species in the lily and orchid families.

Fragmentation and Parcelization. In recent years, sales of large industrial forest ownerships have been common in northern Wisconsin. Sometimes these lands are sold to another industrial forest enterprise and sometimes to developers or other private entities, resulting in parcelization and habitat fragmentation, with many future ecological and socioeconomic impacts. These types of changes in land ownership may reduce the amount of land open to the public for recreation, concentrating recreational uses, some of which conflict, on a static public land base. It may also decrease the amount of wood products previously available from the industrial forests, increasing pressure to harvest elsewhere (including on public lands). Only a small proportion of these liquidated industrial lands have gone into public ownership.

Management Opportunities for Important Ecological Features of the Northern Highland

Natural communities, waterbodies, and significant habitats for native plants and animals have been grouped together as "ecological features" and identified as management opportunities when they

- occur together in close proximity, especially in repeatable patterns representative of a particular ecological landscape or group of ecological landscapes;
- offer compositional, structural, and functional attributes that are important for a variety of reasons and that may not necessarily be represented in a single stand;
- represent outstanding examples of natural features characteristic of a given ecological landscape;
- are adapted to and somewhat dependent on similar disturbance regimes;
- share hydrological linkage;
- increase the effective conservation area of a planning area or management unit, reduce excessive edge or other negative impacts, and/or connect otherwise isolated patches of similar habitat;
- potentially increase ecological viability when environmental or land use changes occur by including environmental gradients and connectivity among the other important management considerations;
- accommodate species needing large areas and/or those requiring more than one habitat;
- add habitat diversity that would otherwise not be present or maintained; and
- provide economies of scale for land and water managers.

A site's conservation potential may go unrecognized and unrealized when individual stands and habitat patches are always managed as stand-alone entities. A landscape-scale approach that considers the context and history of an area, along with the types of communities, habitats, and species that are present, may provide the most benefits over the longest period of time. This does not imply that all of the communities and habitats associated with a given opportunity should be managed in the same way, at the same time, or at the same scale. We, instead, suggest that planning and management efforts incorporate broader management considerations and address the variety of scales and structures approximating the ***natural range of variability*** in an ecological landscape—especially those that are missing, declining, or at the greatest risk of disappearing over time.

Both ecological and socioeconomic factors were considered when determining management opportunities. Integrating ecosystem management with socioeconomic activities can result in efficiencies in the use of land, tax revenues, and private capital. This type of integration can also help to generate broader and deeper support for sustainable ecosystem management. Statewide integrated opportunities can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management."

Significant ecological management opportunities that have been identified for the Northern Highland Ecological Landscape include

- Inland lakes: seepage, drainage, spring, ***meromictic***
- Extensive forests:
  - Dry-mesic eastern white pine-red pine forests
  - Northern Mesic Forest: northern hardwoods, hemlock-hardwoods
  - Dry forest: jack pine, red pine, scrub oak
  - Other forest communities: Northern Wet-mesic, Boreal, swamp hardwoods
- Peatland complexes: Open Bog, Poor Fen, Boreal Rich Fen, Muskeg, Black Spruce Swamp, Tamarack Swamp
- Other wetlands: marshes, sedge meadows, shrub swamps, hardwoods
- Rivers, streams, and springs

- Miscellaneous opportunities: Bracken Grassland, scattered populations of rare and /or wide-ranging species.

Natural communities, community complexes, and important habitats for which there are management opportunities in this ecological landscape are listed in Table 14.2. Examples of some locations where these important ecological places may be found within the ecological landscape are on a map entitled "Ecologically Significant Places within the Northern Highland Ecological Landscape" in Appendix 14.K at the end of this chapter.

To support the development of a new property master plan for the Northern Highland-American Legion State Forest, Wisconsin DNR's Bureau of Endangered Resources designed, coordinated, and conducted an inventory of natural communities, rare species, and aquatic features on this property and in the surrounding area. This project culminated in a report (Epstein et al. 1999) that identified areas within the Northern Highland-American Legion State Forest and surrounding landscape that contained significant plant communities (due to their size, condition, context, or rarity), undisturbed aquatic features, and rare species populations.

Inland Lakes: Seepage, Drainage, Spring, Meromictic

The Northern Highland Ecological Landscape presents exceptional opportunities to protect and manage inland lakes. The density of lakes here is rivaled in few other parts of the world, making this ecological landscape globally important for this resource. Past glacial action and other forces created topography and drainage patterns that resulted in 4,291 lakes that cover 125,414 acres (WDNR 2012). Seepage lakes, many of them glacial "kettles," are the most abundant type, followed by drainage lakes, drained lakes, and spring lakes. Sizes and depths vary. The largest lakes exceed 3,000 acres, and some are over 100 feet deep. Several rare or geographically limited lake types occur within the ecological landscape.

Inland Lake: Deep, Hard, Drainage type. Johnson Lake State Natural Area, Northern Highland-American Legion State Forest, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Outstanding Ecological Opportunities in the Northern Highland Ecological Landscape

- **Inland lakes:** The Northern Highland Ecological Landscape contains one of the Upper Midwest's greatest concentrations of freshwater lakes.
- **Extensive forests:** Much of this ecological landscape is forested, and embedded within these forests of deciduous hardwoods and conifers are abundant lakes, streams, and wetlands. These forests are contiguous with lightly developed areas to the north, east, and west and also occur along several of the major river corridors that drain to the south, especially the Wisconsin River. The forests of the Northern Highland occupy an exceptionally strategic location.
- **Eastern white pine-red pine forests:** Historically the Northern Highland was the site of Wisconsin's greatest pinery, which is now becoming reestablished in some areas.
- **Northern Mesic Forest:** Northern Mesic Forest is less extensive here than in several other northern Wisconsin ecological landscapes, but there are some small but excellent remnants of older forests composed of hemlock and mesic hardwoods.
- **Dry forest:** Dry Forest of jack pine, red pine, oaks, and aspens is locally important in some parts of the Northern Highland.
- **Conifer swamps:** Acid conifer swamps of black spruce and tamarack are well represented here, and these support associated boreal wildlife. In a few places, more alkaline conifer swamps occur in which northern white-cedar dominates.
- **Other forest communities:** Examples of hardwood swamps, boreal forest, and oak-dominated dry-mesic hardwood forest are scattered across this landscape. Aspen remains abundant here, and white birch, though declining, remains common.
- **Peatland complexes:** Some of Wisconsin's largest and most intact areas of conifer swamp. Muskeg, poor fen, and bog occur in the Northern Highland.
- **Other wetlands:** Marshes, sedge meadows, shrub swamps, and hardwood swamps are among the wetland communities associated with lakes and streams.
- **Rivers, streams, and springs:** Rivers, streams, and springs are common features, and medium-sized streams that connect lakes are especially important.
- **Miscellaneous opportunities:** Bracken Grassland and scattered populations of rare and/or wide-ranging species are found here. Small upland openings known as "frost pockets" occur naturally on pitted outwash landforms. Various rare plant and animal species not associated with the features listed above may present local management opportunities wherever they are found.

Table 14.2. *Natural communities, aquatic features, and selected habitats associated with each ecological feature within the Northern Highland Ecological Landscape.*

Ecological features[a]	Natural communities,[b] aquatic features, and selected habitats
Inland lakes	Submergent Marsh – Oligotrophic Inland Beach Inland Lakes: Seepage, Drainage, Drained, Spring Spring Pond
Extensive forests	Northern Dry-Mesic Forest (eastern white pine-red pine, red oak) Northern Dry Forest (jack pine, red pine, scrub oak, aspen) Northern Mesic Forest (northern hardwoods, hemlock-hardwoods) Boreal Forest
Peatlands	Northern Wet-Mesic Forest Black Spruce Swamp Tamarack Swamp Northern Sedge Meadow Open Bog Boreal "Rich" Fen Muskeg Poor Fen
Other wetlands: marshes, shrub swamps, lowland forests	Northern Hardwood Swamp Floodplain Forest Alder Thicket Shrub-carr Boreal Rich Fen Emergent Marsh Emergent Marsh – Wild Rice Submergent Marsh
Rivers, streams, and springs	Coldwater Stream Coolwater Stream Warmwater Stream Warmwater River
Miscellaneous opportunities	Bracken Grassland Scattered rare species populations

[a]An "ecological feature" is a natural community or group of natural communities or other significant habitats that occur in close proximity and may be affected by similar natural disturbances or interdependent in some other way. Ecological features were defined as management opportunities because individual natural communities often occur as part of a continuum (e.g., prairie to savanna to woodland, or marsh to meadow to shrub swamp to wet forest) or characteristically occur within a group of interacting community types (e.g., lakes within a forested matrix) that for some purposes can more effectively be planned and managed together rather than as separate entities. This does not imply that management actions for the individual communities or habitats are the same.

[b]See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types.

Along with numerous common native species, rare fish, invertebrates, and plants have been documented in Northern Highland lakes. Water-dependent wildlife species such as Bald Eagle, Osprey, Common Loon, waterfowl, and North American river otter are common here.

Deep, clear, hard-bottomed seepage lakes of extremely low nutrient status are especially well represented here, and these support rare invertebrates and unusual assemblages of plants. Such lakes are vulnerable to degradation and diminished water quality from pollution, which may be deposited via the atmosphere or by other sources. Because such lakes often have upland shorelines, they are highly sought after as residential development sites.

"Ponds" are defined here as lakes of less than 10 acres, and "Spring Ponds" receive much of their water from the ground and have active discharge outlets. Many of the Northern Highland's trout streams are dependent on stable discharges of clean, cold, highly oxygenated water from such sources. Spring Ponds are important, though localized, aquatic features in some parts of this ecological landscape.

Residential and commercial development is common around most of the larger lakes, where shorelines are partially or entirely in private ownership. Lakeshore development can lead to the loss of important shoreline habitats, negatively impact water quality, and facilitate the introduction or spread of invasive species. Important means of maintaining

The Bald Eagle is one of several characteristic species strongly associated with lakes and northern forests. Photo by Jack Bartholmai.

the function of aquatic systems include the protection or restoration of shoreline vegetation and littoral zones, using recommended best management practices or other means that protect water quality, identify and control already established invasive species, and implement methods designed to prevent the introduction of additional invasive species.

There are few undeveloped lakes and shorelines left in the Northern Highland Ecological Landscape other than those within public lands (and some of these have developed private inholdings), emphasizing the importance of protecting as many of the remaining undeveloped lakes as possible where such opportunities exist and working more effectively with private shoreline owners to increase protection and implement actions that will prevent degradation of water quality and loss of important habitats.

In addition to the glacial lakes, impoundments have been created by damming rivers to generate power, provide habitat for selected wildlife species, create recreational opportunities, and, historically, to float logs. Major impoundments here include the Rhinelander and Rainbow Flowages (both on the Wisconsin River), the Willow Flowage (on the Tomahawk River), and, straddling the western edge of this ecological landscape, the Turtle-Flambeau Flowage (on the Flambeau-Turtle-Manitowish system). The flowages have created open water habitat that have some significant benefits but these have been at the expense of habitats associated with or dependent on free-flowing rivers.

Management Opportunities, Needs, and Actions

- In recent years, the State of Wisconsin has acquired several large impoundments, primarily to provide public recreation. In the Northern Highland Ecological Landscape, additional attention needs to be directed toward the protection of natural lakes and free-flowing rivers and streams.
- Protect undeveloped shorelines, springs, and wild rice beds. A variety of means of accomplishing this may be available, including (but not limited to) acquisition, easement, grants to lake associations or private individuals, and working with local land trusts or other nongovernmental organizations (NGOs).
- Restoration of riparian fish and wildlife habitat on private and public lands should be a priority in this ecological landscape. Management emphasis on conserving uncommon, sensitive animals dependent on water such as Bald Eagle, Osprey, Common Loon, and Black Tern is appropriate and should be continued.
- Encourage the use of the Wisconsin DNR's voluntary best management practices (BMPs) to protect water quality, especially for areas in which timber harvests are planned.
- Managers of public lands and waters should consult Wisconsin DNR's Natural Heritage Inventory database for the locations of rare species populations, sensitive habitats, and high quality natural communities.
- Work with lake management districts as well as the internal Wisconsin DNR invasive species team to develop additional strategies and research projects that would lead to minimizing the spread of invasive species now present in the lakes and streams of the Northern Highland Ecological Landscape (e.g., rusty crayfish, rainbow smelt, purple loosestrife, Eurasian water-milfoil, and curly pondweed).
- Improve regulations and education regarding actions such as boat cleaning and disinfection to help prevent the introduction of new invasive species and slow the spread of invasive species that have already become established.
- An efficient and effective monitoring program designed to enable early detection of "new" invasives is needed.
- Prevent or limit the spread of the recently introduced (confirmed in 2007 in Wisconsin) viral hemorrhagic septicemia (VHS).
- Work with county zoning officials, local communities, and other organizations to develop higher protection standards for resources that fall under either Exceptional Resource Waters (ERW) or Outstanding Resource Waters (ORW) classifications.
- Reduction of sediments and pollutants from shoreline development may be achieved in developed areas by leaving or restoring natural vegetation along the shoreline, erecting erosion barriers during construction, and reducing or eliminating the use of fertilizers and herbicides on lawns adjoining lakes and streams.
- Manage lakes to protect critical habitats identified by Wisconsin DNR critical habitat surveys (habitats identified for this program include Echo Lake in Iron County, Lake Minocqua in Oneida County, Half Moon, North Twin, and South Twin lakes in Lincoln County, and Big Portage

lake in Vilas County). (Note that this is only one of several programs that identify or designate important habitats.)

- Continue seeking statewide and regional reductions in mercury emissions from key sources.
- Work with lake management districts and lake associations to develop and promote bio-stabilization and other new biologically oriented products and techniques that protect and restore lake and river shorelines; guide and help prioritize shoreline restoration projects with lake management districts, lake associations, riparian owners, and the University of Wisconsin Extension (e.g., replacing mowed lawns with vegetation appropriate for the restoration site, removing sand blankets from selected areas).
- Encourage implementation of shoreland habitat restoration projects through the Wisconsin DNR's Lake Protection grant and the Wisconsin Department of Agriculture, Trade, and Consumer Protection County Conservation cost-share grant programs.
- Restore and protect littoral habitat through the removal or scaling-down of large, illegal piers to conform with statewide pier requirements (WDNR 2013).
- Maintain healthy lakes and streams by implementing ***Total Maximum Daily Load*** (TMDL) projects to improve impaired waters via educational programs and grants to shoreline owners and conservation groups and by minimizing the issuance of riprap permits.
- Programs such as the federally funded Landowner Incentive Program may be available during certain budget cycles and can provide technical expertise and financial assistance to private landowners who are interested in providing long-term habitat for "at-risk" species (plants or animals that are Species of Greatest Conservation Need) or habitats that are at risk and important in this ecological landscape.
- Continue Wisconsin DNR assistance to monitor and evaluate lake sturgeon restoration efforts on the Flambeau Chain of Lakes and Bear River within the Lac du Flambeau Chippewa Reservation, as recommended in the Wisconsin Lake Sturgeon Management Plan (WDNR 2000). The lake sturgeon was formerly abundant here before the construction of dams in the early 1900s.
- Impoundment managers should seek to establish water level management regimes that more closely mimic the timing and magnitude of natural water level fluctuations, reduce threats to sensitive native species (especially those that are attempting to nest, spawn, overwinter, or disperse), improve watershed and riparian land use practices to reduce nonpoint pollution, protect and restore shoreline and littoral zone habitat, and improve regulations and education regarding actions such as boat cleaning and disinfection to prevent the introduction of invasive species and slow the spread of existing populations.

Extensive Forests

Dry Mesic Eastern White Pine-Red Pine Forests

The Northern Highland represents Wisconsin's best opportunity to manage for dry-mesic eastern white pine-red pine forests in the full range of patch sizes, age classes, and seral stages characteristic of the type. The eastern white pine-red pine forest type has been singled out for attention from other forest communities because of its past, present, and potential future importance in this ecological landscape.

Eastern white pine-red pine forest was historically the prevalent forest community here, and extensive areas were dominated by large eastern white and red pines. Common canopy associates included white birch, northern red oak, balsam fir, big-tooth aspen, and quaking aspen. Fire was the primary disturbance factor that maintained and periodically renewed these forests. Light ground fires occurred frequently, at intervals of several years to several decades. Catastrophic stand-replacing fires occurred at intervals of one to several centuries.

By the early 20th century, almost all of the larger pine had been logged, and much of the pine forest had been replaced by even-aged stands of white birch and aspen and, less commonly, northern red oak. The severe fires that often accompanied or followed the heavy logging destroyed stands of young regenerating pine. Despite this, remnant pine forests persisted in some areas, scattered individual pines served as seed sources at many locations, and pine, especially eastern white pine, is an important understory component in many birch and aspen stands today. Opportunities for the restoration and maintenance of eastern white pine-red pine forests here are excellent and better than in any other ecological landscape in the state.

Fire disturbance was historically common in the Northern Highland, although fires here were not typically as large, frequent, or intense as those that occurred in the more contiguous xeric forests of sandy outwash plains elsewhere in the state. The abundant lakes, streams, wetlands, and, in some areas, hilly topography limited the scale (and perhaps the

Glacial kettle lakes embedded within extensive conifer-hardwood forests are common and characteristic features of the Northern Highland Ecological Landscape. Photo by Eric Epstein, Wisconsin DNR.

frequency and behavior) of fires, and this contributed to the heterogeneous character of the Northern Highland. Fire has been greatly reduced here, as it has elsewhere in the state, to protect property and existing timber values.

The attributes of this ecological landscape (such as soils, topography, landforms, disturbance history, and ownership patterns) and the persistence and proximity of remnant pine forests make this one of the very few areas in Wisconsin in which eastern white pine might be restored, not only to the dry-mesic forests but also to mesic forests. Eastern white pine was historically widespread in northern Wisconsin's mesic forests where it often occurred in very low densities as huge, very old, ***supercanopy*** individuals. Their presence added a structural element to forests that is now extremely scarce across the state.

Natural forests dominated by red pine are now very rare in Wisconsin. Historically the acreage of natural red pine forest (or mixed eastern white and red pine forest) was likely greater in the Northern Highland than in any other ecological landscape. According to 2004 Forest Inventory and Analysis data (USFS 2004), the Northern Highland had about 73,000 acres of red pine forest. Of this, approximately 60% was in plantations, and only 25% was of natural origin. The origin of the other 15% was unknown.

Virtually all of the northern red oak in the present landscape is ***second growth***, much of it in the 70- to 100-year old-range. Stands now dominated by northern red oak were often dominated by eastern white and red pines prior to the Cutover. Northern red oak is generally considered a desirable species because of its ecological and social benefits (including its aesthetic appeal and high commercial value), and it was a natural component of the pinery before Euro-American settlement, albeit a minor one. Good opportunities to manage for larger blocks of dry-mesic forest with a significant northern red oak component occur on the Northern Highland-American Legion State Forest (WDNR 2001).

Observations that northern red oak sometimes regenerates well beneath pines and that eastern white pine can regenerate well under oak have led to a hypothesis that oak and pine may replace each other periodically in a long-term cycle (Crow 1988, Buckley et al. 1998). This theory seems reasonable in light of the role of fire in pine forests, which could top-kill young oaks while removing most of the pine overstory, creating conditions suitable for vigorous oak resprouting. In oak stands, light ground fires can create suitable seedbeds for pine. This topic has not been well investigated and deserves further research. In a study in which oaks were planted beneath red pine, mortality of oaks was high, due in part to excessive white-tailed deer browse, and results were inconclusive (Buckley et al. 1998).

Northern Mesic Forest: Northern Hardwoods, Hemlock-Hardwoods

There are significant areas of other forest communities embedded within or found on the periphery of the more prevalent, historically pine-dominated Northern Dry-mesic Forest. Opportunities exist in the Northern Highland to manage forests of different types in a more coordinated manner to maintain habitat diversity across the ecological landscape, better ensure the representation of all forest patch sizes and ages, emphasize diminished conifers at the most appropriate sites, reduce the amount of hard edge that is now often found at forest type or compartment boundaries in the present forest, and protect or restore the natural ecotones that are such a characteristic attribute of this ecological landscape. An important aspect of more coordinated management is the maintenance or reestablishment of ecological connectivity between other large forested areas such as the Chequamegon-Nicolet and Ottawa National Forests, which occur mostly outside of the Northern Highland Ecological Landscape boundaries.

Northern Mesic Forest includes hemlock-hardwoods and northern hardwoods, and these forest types are locally common where site conditions can accommodate the growth needs of plants with higher nutrient and/or moisture demands than the pines and oaks or where landscape patterns historically offered the greatest protection from periodic wildfires.

The mesic forests occur as small to medium-sized patches (tens to hundreds of acres, or more rarely, a few thousand acres) within a ***matrix*** of upland pine or aspen forests and peatland vegetation. Within the Northern Highland Ecological Landscape, mesic forests are associated more with remnant moraines and drumlins, where such landforms occur as "islands" of coarse-loamy till within a larger landscape dominated by outwash sands.

Prior to Euro-American settlement, fires originating in the outwash sands also impacted vegetation on moraines and drumlins. Such fires were more likely to have burned more intensively and frequently on the drier, more exposed south- and west-facing slopes of these landforms. Thus, many of the areas now dominated by Northern Mesic Forest were once eastern white pine and eastern hemlock forests with a component of deciduous species. According to early survey notes, the vegetation mosaic of dry-mesic pine forest and peatlands contained less extensive areas of hemlock-hardwood forest, sometimes with a supercanopy of huge eastern white, or rarely red, pine. More extensive areas of mesic forest occurred in the eastern part of the ecological landscape near Lake Laura, and in the northwestern corner, in Price and southeastern Iron counties. Fire suppression and forest management since Euro-American settlement have contributed to the succession of some formerly pine-or aspen/birch-dominated systems to forests dominated by maple-basswood.

Nutrient-rich maple-basswood forests are absent from this ecological landscape. There are areas of apparent "transition" between mesic and dry-mesic types, where the forests contain mixtures of tree and understory species characteristic of each of the respective forest communities. Landforms, soils, surrounding vegetation, and the location of natural fire barriers may have played roles in both creating and maintaining such areas historically.

Hemlock-dominated mesic forest occurs on rolling ground moraine near Plum Lake. Northern Highland-American Legion State Forest, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Older age classes of Northern Mesic Forest still occur at a small number of scattered localities within the Northern Highland, usually in areas of remnant moraines rather than on outwash. Many of these older remnants are, or were, Wisconsin School Trust Lands, owned by the Board of Commissioners of Public Lands (WBCPL 2004). All such remnants are small, though several have now been afforded long-term protection. Several of these older stands have been incorporated into the State Natural Area system. While the restoration of eastern hemlock and mixed pine-hemlock forests is a conservation opportunity here, heavy browse pressure from white-tailed deer may limit the widespread establishment of eastern hemlock and other browse-sensitive plant species.

Dry Forest: Jack Pine, Red Pine, Scrub Oak

Dry forest communities occur but are less prevalent here than in other sandy ecological landscapes, such as those in northwestern or central Wisconsin. In the Northern Highland, the xeric forests are limited to a few areas of coarse, excessively drained outwash sands of low nutrient availability. The topography on sites supporting this community is most often level or slightly rolling, with relatively few natural barriers to fire. Common cover types include jack pine, red pine, quaking aspen, and white birch. Balsam fir and, locally, (upland) black spruce are important components of some stands. Many sites that historically supported xeric forests of jack pine, red pine, or "scrub" oak (most often "northern pin oak," *Quercus ellipsoidalis*) have been converted to aspen or plantation-grown red pine. At some of these sites, there may at some point be opportunities to increase the extent of dry conifer forest (jack or red pines) and/or scrub oak. Emphasize natural forest regeneration techniques where feasible and consider the use of prescribed burning as alternatives or in addition to planting nursery-grown stock, scarification, and herbicide use.

Stands dominated by jack pine and/or balsam fir are of potentially high significance to conifer-dependent animals such as Connecticut Warbler, Red Crossbill, White-winged Crossbill (*Loxia leucoptera*), Evening Grosbeak, Pine Siskin (*Spinus pinus*), and Spruce Grouse. The value of dry conifer forests to sensitive wildlife species may increase if such forests are adjacent to or in close proximity with lowland conifer forests of black spruce, tamarack, and northern white-cedar and/or to dry-mesic forests of eastern white and red pines.

Other Forest Communities: Northern Wet-Mesic, Boreal, Swamp Hardwoods

Other forest communities that occur here, albeit in very limited amounts, include Boreal Forest (white spruce-balsam fir cover type in mature, late successional stands), Floodplain Forest dominated by green ash, box elder (*Acer negundo*), bur oak (*Quercus macrocarpa*), and red or silver maple, and black ash-dominated Northern Hardwood Swamp. Management opportunities for these communities are better in other ecological landscapes, but the condition, and especially the context, of stands can make them valuable additions to conservation efforts here because they may provide unusual natural community variants or support species that would otherwise be rare or absent.

Management Opportunities, Needs, and Actions

- This ecological landscape represents Wisconsin's best opportunity to protect, manage, and restore forests of large eastern white and red pines. Site capability, historical events, scattered remnants, current patterns of succession, and a large public land base well suited to supporting this forest type make this possible at multiple scales. Forest restoration priorities have been identified here for eastern white pine, red pine, eastern hemlock, tamarack, and jack pine (WDNR 2001, 2005a).
- It may be easier to develop an eastern white pine component on more mesic sites in the Northern Highland compared with other ecological landscapes possessing loamier soils because of landscape heterogeneity, local successional patterns, the historical behavior of fire, the presence of remnant pines on some mesic sites, an ample pine seed source on adjacent areas of pine-dominated outwash sands, and the management flexibility and potential that comes with extensive areas of contiguous public ownership.
- Maintaining and restoring larger patches of contiguous eastern white and red pine forest in some areas will provide suitable habitat for species that are declining in more fragmented landscapes, especially where the loss of coniferous forests is a significant limiting factor (as it is in many places in northern Wisconsin).
- There are opportunities to create large areas of conifer-dominated forests by emphasizing the conifer component in stands of adjoining pine, eastern hemlock, black spruce, and fir. Retaining conifers as a component of aspen or white birch stands is also possible in some areas. Increasing the amount of coniferous forests remains a statewide

restoration need, but the opportunity to accomplish that goal is particularly good in the Northern Highland.

- There may be opportunities to incorporate prescribed fire into the management of some forest and wetland communities. The use of prescribed fire as a tool to achieve management goals remains problematic and will almost certainly be confined to public lands. Reducing the density of shrubs and deciduous saplings that compete with the light-demanding pines is proving to be difficult on some sites from which fire has been totally excluded.
- Forest management at multiple scales is possible here, from individual stands to large landscapes. Though management emphasis might be focused on those forest communities that are best represented here and for which site conditions are most suitable, the Northern Highland historically featured a diverse mosaic of natural communities, successional and developmental stages, habitats, and patch sizes. In addition, the heterogeneous mix of vegetation types was connected by natural ecotones that occur at few other Wisconsin locations in such abundance or at this scale.
- The landscape pattern referenced above provides excellent opportunities to manage for species that use combinations of forest, wetland, lake and stream habitats and which are important for many animals that travel between water and uplands as part of their daily or seasonal activities. Ecotones may be disrupted by roads, residential developments, logging operations, and shoreline disturbance. There are opportunities to protect or restore these ecotones or modify human developments to make them more permeable and hospitable for the species that use and depend upon them.
- Most of the Northern Highland Ecological Landscape is forested. Much of the land is managed for early successional species, especially aspen, to provide a ready source of pulp for paper mills and to provide habitat for popular game animals such as white-tailed deer and Ruffed Grouse. Aspen management is currently emphasized on many state-owned properties, including the Northern Highland-American Legion State Forest, the Willow Flowage, and several Wisconsin wildlife areas. County forests and industrial lands tend to emphasize aspen and plantation-grown pine. There is both the opportunity and the need to provide the full spectrum of early successional and older forests, especially on state-owned lands such as the Northern Highland-American Legion State Forest, and better ensure that a broader array of natural communities, patch sizes, successional and developmental stages, and scarce habitat niches are available over time.
- Inventories of tracts owned by the Wisconsin Board of Commissioners of Public Lands (WBCPL 2004) have identified the locations of sites with exceptionally high ecological values. Though small and scattered, several of these sites are within the boundaries of or adjacent to other public lands and could be incorporated into statewide vegetation management and conservation goals. Some of the Board of Commissioners of Public Lands properties contain ***old-growth forest*** or ***old forest*** remnants and a number of the sites also support rare species.
- Although the extent of northern hardwoods forests is limited here, there is an opportunity to restore diminished species, such as yellow birch, and scarce structural elements, such as large coarse woody debris and very large trees, to mesic forests. Several sites on public lands have good potential for forest management of this sort.
- Maintain natural stands of jack pine where they exist, especially in the larger block sizes, and plan for the representation of missing developmental stages (both young and old stands may be in short supply).
- The ecological benefits of maintaining jack pine and scrub oak will sometimes outweigh the economic returns from type conversions, especially on dry, nutrient poor sites.
- For several important forest types, older age classes and larger size classes are currently scarce or under-represented compared to their historical presence. Older forests, and especially old-growth forests, have compositional, structural, and functional properties unlike younger forests. In the Northern Highland, there are opportunities to address the lack of old-growth and old forest for eastern white pine, red pine, hemlock-hardwoods, northern hardwoods, northern red oak, and swamp conifers (WDNR 2001). Guidelines to aid in the management of some of these cover types may be found in Wisconsin DNR's *Old-growth and Old Forests Handbook* (WDNR 2006a).
- Some "working forests" in this ecological landscape can be managed to provide at least some missing or diminished structural and compositional components, including large living trees and snags, large coarse woody debris, a multi-layered canopy, and long-lived species that were more important in past forests, such as eastern white pine, eastern hemlock, and yellow birch. Several research projects examining the ecological and socioeconomic aspects of this issue are currently underway in northern Wisconsin to determine how this might best be done. One of the major study sites is on the Northern Highland-American Legion State Forest.
- The best restoration opportunities to address the historical declines in certain communities or cover types are for eastern white pine, red pine, hemlock-hardwoods, tamarack, and jack pine (WDNR 2001).
- Field inventories from which high conservation value forests are identified on public lands (necessary for ***forest certification***) and the state's property master planning process are important means of addressing the lack of old forests on some public lands.

- Forests should be managed at broader scales with a diversity of patch sizes and age classes. Current stand-level management has resulted in many small to medium-sized patches of similar composition and age-class structure.
- More stand-level features that contribute to habitat quality should be maintained in managed forests (e.g., snags, large woody debris, tip-up mounds, vertical forest structural layers such as emergent canopy trees, or a shrub layer).
- Opportunities exist to plan management from a more regional perspective to accommodate all sizes and ages of forest communities and ecotones, to maintain habitat diversity at appropriate scales across the ecological landscape, and to maintain or reestablish ecological connectivity between large forested areas.
- The Northern Highland contains large blocks of eastern white pine-red pine, northern hardwoods, aspen-birch, lowland conifers (mostly black spruce-tamarack), hemlock-hardwoods, and jack pine, presenting conservation and management opportunities for forest interior species of many kinds. Maintaining or, as needed, developing blocks of large forest, especially for the conifer-dominated types, will enhance populations of forest interior species within the ecological landscape and in Wisconsin.
- Parcelization occurs when large contiguous ownerships are split into numerous small ownerships. Development of seasonal and permanent homes along with roads and other infrastructure to service these dwellings and their inhabitants has increased habitat fragmentation and reduced the size of contiguous habitats. A landscape-scale plan would help to ensure that adequate connectivity remains or is restored between large habitat blocks and along riparian corridors.
- The strategic location of this ecological landscape offers the potential for coordinating landscape-level management goals across administrative boundaries and linking the Northern Highland State Forest with the extensive forests to the north, east, and west (e.g., Chequamegon-Nicolet and Ottawa National Forests). There is a high percentage of publicly owned land in this ecological landscape that would make connectivity between large forested areas in other ecological landscapes possible and desirable.
- White-tailed deer herbivory has been reducing, suppressing, or eliminating populations of sensitive plants, including saplings or seedlings of woody species such as eastern hemlock and northern white-cedar, the shrub Canada yew, and native herbs such as lilies and orchids. Feeding of white-tailed deer by well-intentioned people may contribute to this problem by increasing overwinter survival. Discouraging the feeding of white-tailed deer and encouraging hunters to harvest more white-tailed deer, especially does, may help to reduce their overwinter populations and maintain herds at more sustainable levels.

Peatland Complexes: Open Bog, Poor Fen, Boreal Rich Fen, Muskeg, Black Spruce Swamp, Tamarack Swamp

Peatland communities often occur together in complexes of several types that occupy the same wetland basin, where they are linked by and dependent on site hydrology. Planners and managers need to consider the potential impacts of proposed management throughout entire basins and not assume that management actions will affect only a single community or stand. Peatlands are most effectively managed as functional complexes that may include forested, "semi-treed," shrub, and open (treeless) communities (examples of these include Black Spruce Swamp, Tamarack Swamp, Muskeg, Open Bog, and Poor Fen). On alkaline, or less acid, peats, Northern Wet-mesic Forest (with northern white-cedar dominant), Boreal Rich Fen, and Northern Sedge Meadow may be the dominant plant communities.

Large peatland complexes covering thousands of acres occur in the Northern Highland, affording excellent opportunities to manage for the full spectrum of associated natural communities, in a wide range of characteristic patch sizes and configurations and for virtually all associated plants and animals. The acid peatlands are abundant and widespread, and these feature a more or less continuous carpet of sphagnum mosses (often referred to collectively as peat mosses) upon which a limited but specialized group of sedges, ericaceous shrubs, insectivorous plants, and coniferous trees grows. The dominant trees are most often black spruce or tamarack, with jack pine sometimes being an important component. On strongly acid sites in which the deep layers of sphagnum peat have isolated the plants from nutrient-enriched groundwater, the trees may be stunted and grow sparsely. For details on the composition and structure of the acid peatland communities see Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin."

"Kettle bogs" are common features in the pitted outwash landforms that are predominant in much of the Northern Highland Ecological Landscape. This kettle contains a small soft-water pond, bordered by concentric rings of open fen and bog, tall shrubs, and swamp conifers. Vilas County. Photo by Eric Epstein, Wisconsin DNR.

The dominant tree in lowland forests that develop on more alkaline peats fed by nutrient-enriched groundwater is often northern white-cedar. Relatively few northern white-cedar swamps, the "Northern Wet-mesic Forests" of Curtis (1959), occur within the Northern Highland, but among those that do is one very large example at the base of the Winegar Moraine; another that co-occurs with good quality Boreal Rich Fen, Black Spruce Swamp, and mesic hemlock-hardwood forest; and a small site that has a long history of study by University of Wisconsin-Madison plant ecologists (Trout Lake Conifer Swamp State Natural Area). Northern white-cedar swamps are known to harbor many rare plants and animals, and the stands in the Northern Highland are no exception—they are exceptionally rich repositories of rare biota.

Northern white-cedar is experiencing regeneration problems throughout most of its Great Lakes range due to excessive browse pressure from white-tailed deer. Successful maintenance of this type over the long-term will need to take landscape factors into account (especially the density, distribution, and behavior of white-tailed deer and the promotion, maintenance, and distribution of habitats that favor high white-tailed deer populations).

Only a few "rich" fens have been documented in this ecological landscape, and each of them is highly significant because of the diverse and unusual plant life they support. Ecological landscapes underlain by calcareous till or with alkaline groundwater are more likely to support this natural community, which is rare and localized in the Northern Highland and not common anywhere in Wisconsin.

Sedge meadows lack the carpet of sphagnum mosses, high acidity, and low nutrient status of the more acid peatland communities of Open Bog, Poor Fen, Muskeg, and Black Spruce Swamp. Sedge meadows may occur in the same basin containing other peatland types, provided there is a source of available nutrients (usually via the groundwater, sometimes from a nearby lake or stream).

Sedge meadows and poor fens are the primary native "grasslands" found in this ecological landscape. They provide important habitat for rare animals such as American Bittern, Northern Harrier, Yellow Rail, and Le Conte's Sparrow.

This extensive wetland complex is one of only a few sites in the Northern Highland Ecological Landscape that feature lowland forests of northern white-cedar and black ash. Spring-fed sedge meadows are also present. Toy Lake, Northern Highland-American Legion State Forest, Vilas-Iron counties. Photo by Eric Epstein, Wisconsin DNR.

Poor Fen, Northern Sedge Meadow, and Emergent Marsh border this spring-fed lake in Vilas County. Northern Highland-American Legion State Forest. Photo by Eric Epstein Wisconsin DNR.

Management Opportunities, Needs, and Actions

- The acid peatlands merit increased attention and additional protection. In the past, they have often been ignored because of their relatively low commercial value, i.e., they were considered "worthless." All of the largest peatlands in the Northern Highland Ecological Landscape have been at least somewhat altered or compromised by developments such as highways, cranberry farms, commercial "wild" rice paddies, ditches, and dikes. Pressures to develop, alter, and exploit such "under-utilized" resources may be expected to increase in the future.

- Knowledge of the plants and animals inhabiting acid peatlands is less complete than for many other habitats, and this is especially true for nonvascular plants (e.g., the peat mosses) and rare species. Additional survey work is needed for selected taxa, and such information will be essential to address proposed actions that may significantly alter future peatland composition, structure, or function.

- Acid peatlands are widespread and common in this ecological landscape. While species richness may be relatively low in most of the characteristic plant communities that make up the peatland complexes, many of the associated plants and animals are highly specialized and occur only in these habitats. Loss of peatlands would precipitate a significant loss of native species as well as compromise key functional values associated with these wetlands.

- Protection of site hydrology is the key management consideration for maintaining healthy peatlands. Ditching, diking, peat mining, road or other right-of-way construction, and logging are some of the activities that may have

negative impacts on peatland sites by altering water levels or water chemistry, channeling water, compacting fragile organic soils, fragmenting contiguous habitats, or facilitating the colonization and spread of invasive plants.

- Protect the upland-wetland interface and prevent sediment or pollutant-laden runoff from entering peatlands and negatively impacting ground water chemistry or allowing invasive plants to move into the wetlands.
- Regeneration methods for forested peatlands need additional research. Some methods, such as strip-cutting, can have serious secondary effects such as reducing the amount of forest interior and greatly increasing the amount of forest edge. Acid peatlands are low nutrient ecosystems, and recovery from the removal of the largest trees may be extremely slow.
- Many peatland species are at or near their southern range margins in Wisconsin. Some of these species would make good candidates to monitor over the long-term due to possible changes in climate, new management directions, or the increase and spread of invasive species.
- Examination of the federal public land survey notes from the mid-19th century indicates that tamarack has declined in abundance in this ecological landscape. There is a potential need for more study to clarify the cause of this problem, followed by the development of reliable and cost effective restoration.
- There is high potential to support diverse and viable populations of conifer-dependent wildlife at locations where conifer swamps are embedded within upland forests dominated by other conifers, such as pine, eastern hemlock, or fir.
- Climate change may pose a serious threat to these essentially boreal plant communities and the many species associated with and highly dependent on them. Long-term monitoring at local, regional, and continental scales is needed to track changes in the composition and structure of the conifer swamps, muskegs, open bogs, and other peatland communities. Wisconsin DNR's statewide Peatlands Project (Anderson et al. 2008) yielded information on species presence and distribution, habitat condition, specific monitoring needs, and conservation priorities.

Other Wetlands: Marshes, Sedge Meadows, Shrub Swamps, Hardwoods

Wetlands are abundant and widespread in the Northern Highland Ecological Landscape. Their protection is vital to the maintenance of high water quality throughout the ecological landscape's watersheds to provide secure habitat for wetland-dependent native plants and animals (including many rarities and socially important plants such as wild rice) and as an effective means of achieving flood attenuation. The Northern Highland also hosts a large number of rare or otherwise important species that are dependent on the maintenance of high quality aquatic habitat in lakes, rivers, and streams.

Hardwood swamps are uncommon and of limited distribution here, but there is one outstanding management opportunity (based on its size, condition, and context) in the northwestern part of the ecological landscape along the southern edge of the Winegar Moraine. At this site, and at similar though much smaller sites nearby, black ash is the dominant tree. Characteristic features include muck soils, seepages, spring runs, and a floristically diverse ground layer. This hardwood swamp is part of a large wetland complex that also includes the largest acreage of northern white-cedar swamp known from the Northern Highland Ecological Landscape.

Tall shrub communities border streams, lakes, and open wetlands. Alder Thicket is the most common and widespread of the "shrub swamp" communities occurring in this ecological landscape, sometimes occupying a distinct zone between open wetlands and forests. Speckled, or "tag," alder (*Alnus incana*), the dominant shrub, fixes nitrogen and is indicative of the presence of oxygenated, mineral-enriched, moving groundwater. Often overlooked as "important" habitats, shrub swamps in general and Alder Thicket in particular provide excellent habitat for game species such as snowshoe hare and American Woodcock as well as species of conservation concern because of rarity, decline, or sensitivity such as Golden-winged Warbler, Veery, and wood turtle. Some rare plants, such as lesser wintergreen (*Pyrola minor*) and arrow-leaved sweet-coltsfoot (*Petasites sagittatus*), also have an affinity for Alder Thicket.

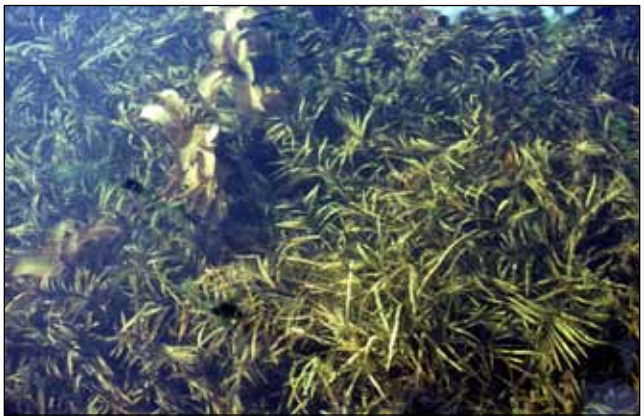
Shrub wetlands dominated by species other than speckled alder are generally more common in southern Wisconsin, but the Shrub-carr community (willow-dogwood swamp) does occur here. Distribution of this type is spotty in the Northern Highland, but extensive stands are known from wetland complexes along the Manitowish and Wisconsin rivers, e.g., in the wetlands around parts of the Rainbow Flowage.

Marshes offer critical habitat to many kinds of wildlife, including mammals, birds, amphibians, reptiles, fish, and invertebrates. Citizen interest in lake and shoreline protection and management creates opportunities to protect aquatic vegetation and associated wildlife and for expansion of the ***Critical Habitat Designation*** program.

Emergent marshes composed of robust graminoid species such as cat-tails, bur-reeds, and bulrushes occur in water from the strand line to a depth of 1–2 meters. This type of marsh develops and persists in relatively fertile waters and in substrates of silt or muck (rarely peat) and is localized in the Northern Highland compared with ecological landscapes with more fertile soils. Floating-leaved and Submergent Marshes occur in deeper waters than the emergent stands and are composed of plants such as pond lilies (*Nymphaea odorata* and *Nuphar* spp.), water-shield (*Brasenia schreberi*), and pondweeds (*Potamogeton* spp.). These marsh types are significant in the Northern Highland, where they occur mostly in shallow bays of lakes and impoundments that are protected from

strong winds, heavy motorboat traffic, and ice action, and they sometimes develop in sluggish, low-gradient streams. The depths in which marshes occur can vary with season, year, substrate, water clarity, and productivity. The marsh types, and some of the individual plant species characteristically found within each type, often stratify by water depth, but some vertical overlap among the species is common.

Wild rice marshes are relatively common in the Northern Highland, where beds may develop in shallow bays of drainage lakes or sometimes in widenings along the margins of slow-moving streams of low to moderate fertility (WBCI 2010). The rice marshes provide an important source of forage for many wildlife species, including waterfowl, and are of great cultural significance to the local Ojibwe people (Thompson and Luthin 2010). At least 99 lakes within the Northern Highland support biologically and culturally important populations of wild rice. Within the Ceded Territory (see the "Ceded Territory and Native American Ownership" map in Appendix G in Part 3, "Supporting Materials"), the Great Lakes Indian Fish and Wildlife Commission establishes rice harvest dates for many of the lakes via a shared management agreement with Wisconsin DNR related to American Indian treaty rights (GLIFWC 2014).



Warmwater stream with diverse stands of submergent aquatic macrophytes. Rice Creek, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Wild Rice Marsh along low gradient stream, Vilas County. Note old-growth hemlock-white pine forest on uplands behind rice marsh. Photo by Eric Epstein, Wisconsin DNR.

Wild rice marshes are sensitive to changing water levels, eutrophication, and mechanical damage from power boats and other machines. Rice beds, and the lakes and streams in which they occur, are high priorities for protection.

Management Opportunities, Needs, and Actions

- Identify occurrences of wetland communities (including hardwood swamp, floodplain forest, shrub swamp, sedge meadow, and marsh) not covered by or encompassed within the management opportunities discussed above and evaluate their condition and significance within this ecological landscape. Follow up with more detailed surveys and conservation actions as warranted.
- Monitor marsh vegetation to detect the presence of invasive species as soon as possible. Marshes known to harbor sensitive species such as Black Tern or American Bittern should be monitored to detect population changes.
- Sample water characteristics, vegetation, and populations of rare plants in both developed and undeveloped oligotrophic lakes, which are abundant in this ecological landscape. Such lakes support a number of rare or otherwise sensitive species with apparently narrow habitat tolerances.
- Monitor a subset of wild rice marshes in lakes and streams to track the extent, density, and use of the rice beds over time. Selected animals that make heavy use wild rice could be monitored at the same time.
- The Wisconsin DNR's Wild Lakes program can provide information to stakeholders regarding various means and funding sources available to protect wild lakes that support intact aquatic plant communities.
- Use lake survey data from Wisconsin DNR staff (such as critical habitat surveys for plants and habitat features) and lake stewardship and invasive species survey volunteers on lakes that receive moderate to heavy motorized use to assist local lake districts to identify areas that should limit or exclude such use.

Rivers, Streams, and Springs

Excellent opportunities exist to protect the headwaters regions and upper stretches of large, ecologically important rivers such as the Wisconsin and Manitowish-Flambeau systems. Wisconsin's largest and longest interior river, the 420-mile-long Wisconsin River, originates in Lac Vieux Desert, which straddles the Wisconsin-Michigan border. Approximately 96 miles of the Wisconsin River flow through the Northern Highland Ecological Landscape. This ecological landscape also contains the headwaters of numerous streams designated as Outstanding Resource Waters (ORW), including the Manitowish, Tomahawk, Squirrel, Trout, and Deerskin rivers and Allequash, Bearskin, Little Pine, McGinnis, New Wood, Radke, and Trout creeks.

There are approximately 116 streams or stream segments out of the 500 total streams in this ecological landscape that support coldwater communities. Coolwater and warmwater streams that connect lakes are common in this ecological landscape, and some support uncommon biota, for example, certain rare dragonflies for which the Northern Highland offers especially good conservation opportunities.

Protecting the watersheds of these streams by maintaining extensive forest cover, using BMPs, protecting wetlands, and encouraging uses that have positive, or at least neutral, impacts on shoreline environments will help to ensure good water quality and aquatic diversity in the Northern Highland's rivers, streams, and lakes.

An ecologically important concentration of springs and spring ponds occurs in the northeastern part of the Northern Highland-American Legion State Forest (WDNR 2005a). The major river systems, such as the Wisconsin and the Manitowish-Flambeau, provide a means of ecologically connecting the Northern Highland with other ecological landscapes to the south, especially the North Central Forest.

This drained lake is fed by numerous springs and bordered by a floristically rich meadow and fen. Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Management Opportunities, Needs, and Actions

- Maintaining the corridors of the Wisconsin, Manitowish, Tomahawk, Squirrel, and other rivers in an intact and unfragmented condition is a highly significant conservation opportunity. These rivers and streams are worthy of priority conservation attention because of generally good water quality, important aquatic biota, large acreages of adjoining wetlands (which are themselves often of high significance), mostly forested watersheds, and value as connecting corridors within and between ecological landscapes.
- There are coldwater streams of high importance in the northeastern portion of the ecological landscape. Actions that may help to protect coldwater streams (including native brook trout waters) include effective shoreline protection, proactive placement of new wells (especially those being installed to replace wells with high iron content), restricting excessive ground water pumping through a well permit system, improving watershed and riparian land use practices to reduce nonpoint pollution, and contributing to the statewide, national, and global goal of reducing greenhouse gas emissions to slow the rates of climate warming and increasing stream temperatures.
- Small streams that connect lakes are common and biologically important features of the Northern Highland Ecological Landscape. Such waterbodies provide critical habitat for rare dragonfly and fish species. Effective shoreline protection, maintaining a high percentage of forest cover in the local watersheds, and maintenance of high water quality in the lakes that such streams connect, are the keys to maintaining the ecological health of these streams.
- Work with county zoning officials, local communities, and other organizations to develop higher protection standards for resources that fall under either Exceptional Resource Waters (ERW) or Outstanding Resource Waters (ORW) classifications. Improve watershed and riparian land use practices to reduce nonpoint pollution and protect and restore shoreline and littoral zone habitat. Improve regulations and education regarding actions such as boat cleaning and disinfection to prevent the introduction of invasive species and slow the spread of existing populations. Continue effective treatment and regulation of industrial and municipal discharges as needed to protect water quality, public health, and local economies.
- Other opportunities related to stream management include dam removal to allow free movement of fish and other aquatic organisms; improvement of watershed and riparian land use practices to reduce nonpoint pollution; restoration of floodplain function through projects that restore and reconnect streams and floodplains wherever possible; and more effective protection and restoration of shoreline and littoral zone habitats.
- Assess adequacy of culverts at road crossing to ensure that there are no direct or indirect barriers to the free movement of native aquatic species.

Miscellaneous Opportunities: Bracken Grassland, Scattered Populations of Rare and/or Wide-Ranging Species

Bracken Grassland is a natural or semi-natural shrub- and herb-dominated community that is most often associated with frost pockets. Frost pockets are natural, dry depressions found on pitted outwash landforms (or sometimes in end moraines) that can experience growing season frosts. Frost damage can be severe enough to inhibit or even prevent the growth of trees and tall shrubs. In addition, ***allelopathy*** from species such as bracken fern (*Pteridium aquilinum*) and orange hawkweed (*Hieracium aurantiacum*) has been suspected in playing a role that keeps frost pockets treeless.

Sites with nutrient-poor soils that were severely damaged by slash fires during and after the Cutover may still be in a semi-open condition many decades later (e.g., the "stump prairies" of Upper Michigan). In ecological landscapes that historically burned with high frequency but in which fires are now suppressed and where cover of woody plants is now high, frost pockets may serve as ***refugia*** for species that require open conditions to persist (provided that they too are not frost sensitive).

Bracken Grassland is the only (more or less) native upland herb or low shrub community occurring in this part of Wisconsin. The community needs additional study as well as basic field inventory because it can provide important habitat for native species that require nonforested upland habitats. Fruit- and nut-bearing shrubs such as juneberries (*Amelanchier* spp.), blackberries (*Rubus* spp.), blueberries (*Vaccinium* spp.), and hazelnuts (*Corylus* spp.) are important and sometimes common components of Bracken Grasslands, and these can be very attractive to many species of wildlife. In some areas, Bracken Grasslands could be maintained as openings for certain wildlife species, for example, in stands that adjoin short-lived forest types such as jack pine or quaking aspen and in forests composed of longer-lived species, where increased habitat fragmentation would have potential negative impacts. Complementary forest management might include the use of periodic fire as well as creating openings at intervals that are large enough to support area sensitive animals. Nonnative (not necessarily invasive) plants are a significant part of the flora of many Bracken Grassland occurrences. Bracken Grasslands have become increasingly uncommon, or even rare, and many attempts have been made to increase their productivity by planting trees (usually conifers) in them. Success has been mixed, at best. Because of the topography associated with the extensive pitted outwash landforms present in the Northern Highland, this may be one of Wisconsin's most important ecological landscapes for this community.

Bracken Grassland, Northern Dry Forest communities, managed with prescribed fire. Johnson Lake Barrens, Vilas County. Photo by Eric Epstein, Wisconsin DNR.

Not all species of management concern are closely allied with specific communities. Some rare species occur as widely scattered, low density populations, and these must be treated on a case-by-case basis rather than as integral components of specific stands, habitats, or natural features identified above as "opportunities." Species that are wide-ranging but occur at very low densities, such as some forest raptors, need to be considered at broad scales to ensure that their habitat needs are met over time. Connectivity between patches of suitable habitat is a key consideration for some of these species, especially those with limited dispersal capabilities (some small mammals as well as herptiles and invertebrates).

Management Opportunities, Needs and Actions

- Identify and map existing Bracken Grassland communities on state and other public ownerships.
- Document vegetation, including nonvascular plants.
- Document selected fauna, e.g., terrestrial invertebrates, herptiles, and birds. Assess habitat values for these species.
- Provide Bracken Grassland habitat for native species that prefer or require upland sites in a relatively treeless condition.
- Where frost pockets and Bracken Grasslands occur, they may serve as forest openings where these are desired without the expenditures in time, effort, and dollars needed to create artificial openings on sites that quickly succeed to forest after they are cleared.
- Discontinue the attempted ***afforestation*** of frost pockets and possibly other Bracken Grasslands on state lands, at least until we have a better understanding of their origin and conservation values.
- Scattered populations of sensitive species that are not closely associated with the opportunities discussed above should be treated on a case-by-case basis. Management guidelines have been developed for some of them (e.g., forest raptors).

Socioeconomic Conditions

Socioeconomic information is summarized within county boundaries that approximate ecological landscapes unless specifically noted as being based on other factors. Economic data are available only on a political unit basis, generally with counties as the smallest unit. Demographic data are presented on a county approximation basis as well since they are often closely associated with economic data. The multi-county area used for this approximation is called the Northern Highland counties, except where otherwise noted. Iron, Oneida, and Vilas counties are included in the Northern Highland counties, because at least 25% of each county lies within the ecological landscape boundary (Figure 14.8).

Figure 14.8. *Northern Highland counties.*

Metropolitan areas or populations outside of the ecological landscape county approximation can impact the area. In the Northern Highland counties, the closest metropolitan areas that impact the county approximation are Green Bay and Wausau. Both are relatively small population centers without a wide-reaching impact. Visitors and seasonal residents from Milwaukee, Madison, and Chicago come to the ecological landscape for recreation (WDNR 2006b).

Recreation and the service sector are significant contributors to the economy of the Northern Highland counties. The clear soft waters, sandy bottoms, and shorelines of the numerous kettle lakes make them among the most desirable areas for water recreation in the state. Development of lakeshores for second and primary homes has significantly altered these natural features. As is common in northern Wisconsin, the timber industry is important in local economies. Much of the land is used for timber and pulp production, made possible by the availability of public land and the 17% of ***timberland*** owned by private forest industry. Agricultural productivity is low for most crops due to the short growing season and poor soils.

The population density of the Northern Highland counties (23 persons per square mile) is about one-fourth that of the state as a whole (105 persons per square mile), and its economy is below average. Per capita income for the Northern Highland counties is lower than statewide, although it has been increasing. The service sector employs the most people. Poverty rates for all people and for children under age 18 are higher than for the state as a whole. The Northern Highland counties each have higher unemployment rates than the state average. Iron, Oneida, and Vilas counties are all service-dependent.

History of Human Settlement and Resource Use

American Indian Settlement

The archaeology of northern Wisconsin is fragmentary and often poorly understood. Given this, there are many gaps in our understanding of the cultural evolution of early peoples in northern Wisconsin. It can be generally said that technology and traditions occurred earlier in southern Wisconsin than in northern Wisconsin. Although sporadic, there is evidence of habitation in the Northern Highland Ecological Landscape as far back as the late Paleo-Indian Tradition (7,000 to 8,000 years ago) at the Gypsy Villa and Squirrel Dam sites in Oneida County (Mason 1997). Occupation at the Squirrel Dam site persisted through the time of the middle Archaic Tradition and included artifacts that suggest a variant of the Old Copper complex (Stoltman 1997). (The Old Copper complex used to be considered its own culture but is now considered to be a technological phase associated with many cultural affiliations during the Archaic Tradition.)

There are a number of sites in the Northern Highland Ecological Landscape that show characteristics of the Woodland Tradition including the Squirrel Dam, Lake Tomahawk, and Shannon sites (Stevenson et al. 1997). These sites all included diagnostic ceramics and projectile points as well as effigy mounds of various shapes. The Lake Tomahawk site included a tapering linear mound called a "catfish effigy," which are found almost exclusively in northern Wisconsin. Wild rice was clearly a major food source among Woodland peoples in this area.

There is little clear evidence of what happened in this ecological landscape up to the time of Euro-American contact. There were several tribes that were being pushed westward, many of whom likely passed through or stayed for short periods during these times. The Santee Dakota claimed large areas of northwestern Wisconsin, but it is not clear if they claimed lands this far east. See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for further discussion of the history of American Indian settlement in Wisconsin.

Euro-American Contact and Settlement

French fur traders, missionaries, and soldiers began arriving in the region during the mid-17th century. At the time of Euro-American contact, it is unclear who claimed what is now the Northern Highland Ecological Landscape, although the Chippewa were certainly living in the area. The Lac du Flambeau Band of Lake Superior Chippewa Indians had a permanent settlement in the Northern Highland Ecological Landscape since 1745 (GLITC 2014). Lac du Flambeau, or "Lake of the Torches," takes its name from the traditional practice of spear fishing at night while using a torch to illuminate the fish. The Lac du Flambeau reservation was created as part of the treaties of 1837 and 1842 and is the only reservation in the Northern Highland Ecological Landscape.

Early Agriculture

Agriculture was late coming to the Northern Highland counties and has never been prominent economically or socially in these counties. Officially, permanent Euro-American settlement began in Oneida County around the time of its founding in 1885. Vilas and Iron counties (each founded in 1893) were settled later as the Cutover moved north (NACO 2010). As the Cutover advanced in the Northern Highland counties, farm settlements slowly increased on cut-over land generally poorly suited for agriculture. By 1900 the population of the three Northern Highland counties was officially 20,420 (ICPSR 2007). The bulk of agricultural activity (350 of the 516 estimated farms in the Northern Highland counties) was found in Oneida County in 1900, and Oneida County has remained the most populous and most agricultural Northern Highland county throughout the region's short settled history. Farm numbers slowly crept up in the Northern Highland counties during the 1920s because these were among the last areas in the state affected by the Cutover. By 1930 the number of farms had reached only 1,804 (Figure 14.9). Farm numbers remained level through the 1930s; by 1940 there were 1,808 farms in the Northern Highland counties.

During and following World War II, Northern Highland counties' farm numbers began to decline sharply as much of the marginal land proved ill-suited for intensive agriculture. Mechanization also contributed to increasing the average size of farms even as the number of farms dropped (Figure 14.9). That trend continued throughout much of the remaining 20th century. Farms in the Northern Highland counties tended to be about the same size as in the state as a whole in the early part of the 20th century, then became comparatively smaller in the 1930s and 1940s (ICPSR 2007). However, the failure of marginal farms in the Northern Highland counties caused them to be combined and consolidated, and Northern Highland counties' farm size grew larger than the state average by 1950, averaging 156 acres per farm compared to 138 acres statewide (Figure 14.10).

Total value of all crops indicates the extreme influence of the Great Depression on agriculture, even in a minor agricultural region such as the Northern Highland counties. In 1910 all crops harvested in the Northern Highland counties had an estimated total value of only $420,518, which had compounded by 1920 to $2.9 million (ICPSR 2007). However, total value of all crops in the Northern Highland counties plummeted in 1930 ($1.4 million) and fell further in 1940 ($0.6 million). Total values of crops in the Northern Highland counties comprised only 0.4% of total crop value in the state in 1940, with these crops coming from farms comprising 0.8% of all Wisconsin farm acreage. Farms in the Northern Highland counties historically have not been as productive as those in the state as a whole, in part due to the droughty, less fertile soils and shorter growing seasons than counties to the south.

Over the early part of the 20th century, Northern Highland counties' farms were much less productive for "cereals" compared to other parts of Wisconsin. The 1910 federal agricultural census listed cereals as only 15.2% of the total value of all crops harvested in the Northern Highland counties, compared to 49.3% of statewide crop value (ICPSR 2007). By 1940 cereals comprised only 6.9% of crop value in the Northern Highland counties, following a similar trend of decline statewide. Meanwhile, hay and forage, associated with livestock farming, was 30.7% of total value of crops harvested in the Northern Highland counties in 1910, about equal to 27.5% statewide. By 1940 hay and forage had risen to 46.0% of total crop value in the Northern Highland counties.

See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for further discussion of the history of agricultural settlement in northern Wisconsin.

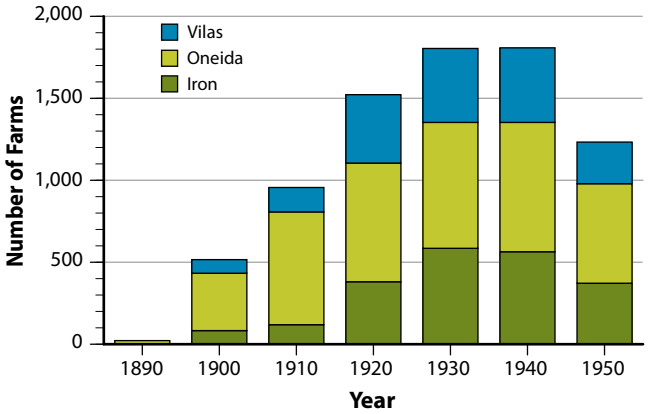


Figure 14.9. *Number of farms in the Northern Highland counties between 1890 and 1950 (ICPSR 2007).*

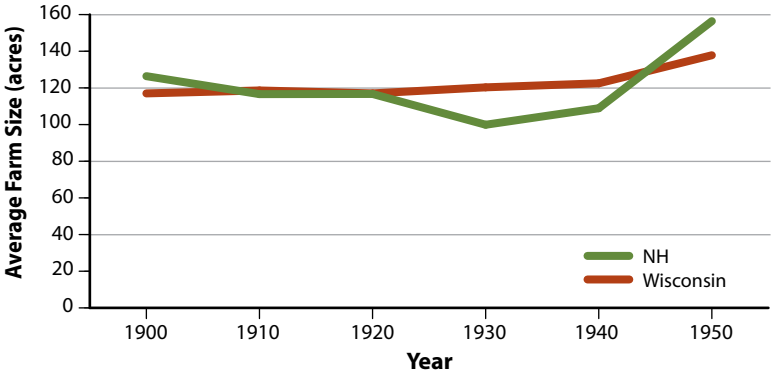


Figure 14.10. *Average farm size in the Northern Highland counties between 1900 and 1950 (ICPSR 2007).*

Early Mining

Mining has occurred in Wisconsin for thousands of years. There is some evidence to suggest this activity began in Wisconsin during the Paleo-Indian Tradition. However, there is little or no evidence of early mining in the Northern Highlands Ecological Landscape.

Early Transportation and Access

Early American Indian residents and Euro-American arrivals traveled through the region by navigating the extensive network of lakes and rivers. The Wisconsin River system, including the Squirrel and Tomahawk rivers and the Manitowish-Bear-Flambeau river systems, formed the primary water routes through this area. Villages, camps, and trading posts were built near water bodies and trail confluences.

In 1854 the Treaty of La Pointe ceded the Lake Superior Band of Chippewa Indians' lands to the United States government. In return, the tribe received reservation land, monetary payments, and supplies and services. The federal government then offered land to railroad companies at reduced prices to bring railroad lines into the region. The first rail line to reach the area was the Milwaukee, Lake Shore and Western Railroad (now the Union Pacific). The establishment of rail lines, starting in the 1880s, coincided with the timber boom and opening of iron ore mines to the north and west.

See "Statewide Socioeconomic Assessments" in Chapter 2, "Assessment of Current Conditions," for further discussion of the history of transportation in Wisconsin.

Early Logging Era

The logging industry became established in the ecological landscape in the latter half of the 19th century. Extensive fires often followed logging. The fires burned the slash and debris left from logging operations. Eastern white pine was initially the first tree of choice, and after its depletion, loggers turned to eastern hemlock and various hardwoods. Access to trees and delivery to sawmills was expedited by the network of waterways that were used to float logs to the mills. Scouring of river bottoms and deposition of bark and other woody debris changed the character of many rivers. Subsequent transportation of logs to mills was facilitated by the establishment of railroads. The timber industry attracted settlers and helped support other economic activities in the three counties, such as agriculture, mining, housing construction, and railroad building, which in turn helped support the timber industry.

Roth (1898) described forest conditions in some northern Wisconsin counties at the close of the 19th century. Roth noted that in Iron County pine had been harvested in parts of each township, with heavy removals in some areas. The county was primarily mixed hardwoods, pine, and eastern hemlock. Swamps were plentiful, especially in the southern portion of the county, and contained northern white-cedar, tamarack, and spruce. It was estimated that in the late 1800s Iron County forests contained 400 million ***board feet*** of pine and 350 million board feet each of eastern hemlock and hardwoods. Noted hardwoods were birch (*Betula* spp.), American basswood, and maple (Roth 1898). By comparison, today there are 129 million board feet of pine, 144 million board feet of eastern hemlock, and 717 million board feet of hardwood ***sawtimber*** in Iron County forests (USFS 2009).

Oneida County had experienced heavy losses of pine along the streams and railways. What remained of the pre-logging 1.2 billion board feet of pine were scattered stands that generally contained red pine. An estimated 60 million board feet of hardwoods were still standing in 1897, 40 million of which were birch and American basswood (Roth 1898). Of the other 20 million board feet, most was elm (*Ulmus* spp.) and maple; oak was in short supply. The eastern hemlock was so scattered that Roth did not bother to estimate the board feet. Fire associated with the Cutover had decimated the swamps that once consisted of tamarack, northern white-cedar, and spruce. Today there are 628 million board feet of pine, 54 million board feet of eastern hemlock, and 551 million board feet of hardwood sawtimber in Oneida County (USFS 2009).

The forests in much of Vilas County were once dominated by eastern white and red pines, with a small amount of jack pine. Eastern hemlock and various hardwoods were locally important. Timber harvest began around 1870. By 1897 pine had been harvested in nearly every township. Roth estimated 1.5 billion board feet of pine remained along with thousands of acres of saplings and young thickets (Roth 1898). Approximately 120 million board feet of eastern hemlock were scattered over the county. Hardwoods, too, were scattered. What remained was 150 million board feet of primarily birch, American basswood, and maple. Swamps, including open bogs, covered approximately 20% of the county. Fire ran through many of the swamps, though tamarack, northern white-cedar, and some spruce stood in less frequently burned areas. Fire also burned up much of the young coniferous growth (including most of the regenerating pine and eastern hemlock), leading to dominance by pioneering species such as quaking aspen and white birch. Today there are 1.3 billion board feet of pine, 183 million board feet of eastern hemlock, and 960 million board feet of hardwood sawtimber in Vilas County (USFS 2009).

In 1933 a U.S. Forest Service office was located in Rhinelander to help facilitate land acquisition in northeastern Wisconsin and act as the headquarters for the newly established Nicolet National Forest. Shortly after the initial land acquisition, the ***Civilian Conservation Corps*** began reforesting the ecological landscape with jack and red pine. Within the Northern Highland counties, there are 46,269 acres of National Forest. Wisconsin's largest state forest, the Northern Highland-American Legion, was established in 1925 to protect the headwaters of the Wisconsin, Flambeau, and Manitowish rivers. The Northern Highland-American Legion State Forest now occupies more than 225,000 acres in Vilas, Oneida, and Iron counties.

See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for a general description of the logging era in northern Wisconsin.

Resource Characterization and Use[1]

The Land

Of the approximately 1.2 million acres of land (excludes open water) that make up the Northern Highland Ecological Landscape, about 78% is forested (USFS 2009). About 57% of the forestland is privately owned, while 27% is owned by the state, 11% is owned by counties and municipalities, and 5% is federally owned.

Minerals

Nonmetallic mining, namely sand and gravel mining, occurs in each of the Northern Highland counties. In 2010 most nonmetallic mining occurred in Oneida County, with 58 nonmetallic mines on 547 acres (Oneida County 2011).

In 1990 the Lynne deposit, with an estimated volume of 5.8 million tons of zinc-lead-silver ore, was discovered on county-owned land in Oneida County. The Crandon deposit, discovered in 1975, has an estimated 55 million tons of zinc-copper-lead ore a short distance to the east in Forest County (Roe 1991). The proposed Crandon mine was the site of a complex and contentious multi-decade legal battle between environmentalists, American Indian tribes, sportfishing groups, the State of Wisconsin, and multiple large mining corporations. The purchase of the mine site in 2003 by the Sokaogon Chippewa and Forest County Potawatomi tribes marked the end of possible extraction from the Crandon deposit for the foreseeable future.

Water (Ground and Surface)

Water Supply

The data in this section are based on Wisconsin DNR's 24K Hydrography Geodatabase (WDNR 2012), which are the same as the data reported in the "Hydrology" section; however, the data are categorized differently here so the numbers differ slightly. Of the 1,956,400 acres that make up Iron, Oneida, and Vilas counties, 205,800 acres (10.5%) are surface water. There are 2,941 named lakes within the three counties, totaling nearly 192,000 acres (93% of the surface water). There are 29 lakes, including five flowages, in the Northern Highland counties over 1,000 acres in size. The headwaters of the Wisconsin, Manitowish, and Flambeau rivers originate in the Northern Highland Ecological Landscape, and large parts of the Turtle-Flambeau Flowage and Willow Flowage occur here. Groundwater from a thin (50 to 200 feet) layer of overlying glacial till provides critical base flow to rivers, streams, lakes, and wetlands. These abundant aquatic resources provide a large potential for water-based recreation and other water uses.

Water Use

Each day 43 million gallons of ground and surface water are withdrawn in the three Northern Highland counties (Table 14.3). About 73% of the withdrawals are from surface water. Of the 65,973 people that reside in these counties, 26% are served by public water sources, and 74% are served by ***private wells*** (USGS 2010). Oneida County withdraws 78% of the total with Vilas County withdrawing 19%. The largest water usage, 38%, is for thermoelectric once-through power generation with Oneida County, accounting for the bulk of this.

Recreation

Recreation Resources

Land use, land cover, and ownership patterns partly determine the types of recreation that are available to the public. For instance, in the Northern Highland Ecological Landscape, there is a higher percentage of forest, water, and wetland and a lower proportion of agricultural and grassland compared to the rest of the state (see Chapter 3, "Comparison of Ecological Landscapes," in Part 1 of this publication and/or the map of "WISCLAND Land Cover (1992) of the Northern Highland Ecological Landscape" in Appendix 14.K at the end of this chapter). The surface area in water and the proportion of that water in lakes as opposed to rivers is the highest in the state.

There are many public lands and waters in the Northern Highland Ecological Landscape owned by the county, state, and federal governments. The density of campgrounds is the highest in the state. The number of visitors to state lands and the density of multi-purpose trails are both third highest out of 16 ecological landscapes (WDNR 2006b). Acreage in natural areas is much higher than the state average, as is the number of Land Legacy sites with high recreation potential. In summary, the Northern Highland Ecological Landscape has both a significant supply and demand for recreational facilities.

Supply

Land and Water. According to Forest Inventory and Analysis, there are about 934,000 acres of forestland in the Northern Highland Ecological Landscape, 5.7% of the total acreage in the state (USFS 2009). Approximately 43% of all forestland is in public ownership (4th highest in the state) with 27% under state control, 6% federally owned, and 10% belonging to county and municipal governments. The Northern Highland Ecological Landscape comprises 3.3% of Wisconsin's total land area but 13.6% of the state's acreage in water. Lakes and reservoirs make up over 96% of the surface water area of the Northern Highland Ecological Landscape, rivers and streams make up 4% of the area (WDNR 2012). The largest rivers are the Wisconsin, Manitowish, and Tomahawk rivers. The largest reservoir is the Turtle-Flambeau Flowage, which covers almost 13,000 acres. Other large lakes include Lac Vieux Desert, Trout Lake, Fence Lake, and Tomahawk Lake and the Willow and Rainbow flowages (both impoundments).

[1]When statistics are based on geophysical boundaries (using GIS mapping), the name of the ecological landscape is followed by the term "ecological landscape." When statistics are based on county delineation, the name of the ecological landscape is followed by the term "counties."

Public Lands. Public access to recreational lands is vital to all types of recreational activity. In the Northern Highland Ecological Landscape, almost 582,800 acres, or 44% of all land and water, is publicly owned, greater than the statewide average proportion of public land (19.5%), ranking this ecological landscape third highest of 16 ecological landscapes in proportion of public ownership (WDNR 2005b). There are about 174,000 acres of public waters, 278,000 acres of state recreational lands, 47,000 acres of federally owned lands, and 83,800 acres of county forests. State-owned lands and facilities are especially important to recreation in the Northern Highland Ecological Landscape. There are over 233,000 acres of state forestlands, all within the Northern Highland-American Legion State Forest. In addition, there are 18,500 acres of state trails and wild rivers, including the Turtle Flambeau Scenic Waters Area, and about 14,300 acres of fisheries and wildlife management lands. The largest of these, Powell Marsh State Wildlife Area and Thunder Lake State Wildlife Area, each provide over 3,000 acres of recreational land.

Campgrounds. There are 86 public and privately owned campgrounds, which together provide about 4,465 campsites in the Northern Highland counties (Wisconsin DNR unpublished data). With 5% of the state's campgrounds, this ecological landscape ranks eighth (out of 16 ecological landscapes) in the number of campgrounds but first in campground density (per square mile of land).

Trails. The Northern Highland counties have about 2,200 miles of recreational trails (Table 14.4) and rank third (out of 16 ecological landscapes) in trail density (miles of trail per square mile of land). There is a higher density of mountain bikes, ATV, snowmobile, and cross-country ski trails compared to the rest of the state (Wisconsin DNR unpublished data).

Land Legacy Sites. The Land Legacy project has identified over 300 places of significant ecological and recreational importance in Wisconsin, and 11 are either partially or totally located within the Northern Highland Ecological Landscape (WDNR 2006c). Two of them, the Northern Highland-American Legion State Forest and the Turtle-Flambeau Flowage, are rated as having high recreational significance. In addition, the Border Lakes region and the Northern Highland-American Legion State Forest are rated as having the highest conservation significance.

State Natural Areas. As of 2011, the Northern Highland Ecological Landscape contained 58 state natural areas totaling 43,672 acres (Wisconsin DNR unpublished data); 98% of this acreage is publicly owned (by governments and educational institutions); 2% is owned by private or joint public-private interests (including nongovernmental organizations). The largest state natural areas in this ecological landscape include the Turtle-Flambeau Patterned Bog, within the Turtle-Flambeau Scenic Waters Area (4,855 acres, Iron County); DuPage Lake Peatlands (3,288 acres, Iron County), Big Swamp (2,914 acres, Oneida County), Rainbow Wetlands (2,357 acres, Oneida County) and Toy Lake Swamp (2,308 acres, Iron and Vilas counties). Wetlands make up the vast majority of this acreage, with the remainder consisting of small stands of older pine or eastern hemlock forest. For more information on state natural areas, see Wisconsin DNR (2014e).

Table 14.3. *Water use (millions of gallons/day) in the Northern Highland counties.*

County	Ground Water	Surface Water	Public Supply	Domestic[a]	Agriculture[b]	Irrigation	Industrial	Mining	Thermo-electric	Total
Iron	0.6	0.4	0.4	0.1	0.0	0.5	–	0.0	–	**1.0**
Oneida	8.1	25.6	1.9	1.2	2.7	3.1	8.7	0.1	16.0	**33.6**
Vilas	2.8	5.5	0.4	0.9	5.7	1.3	0.0	0.0	0.0	**8.3**
Total	**11.5**	**31.5**	**2.7**	**2.2**	**8.4**	**4.9**	**8.7**	**0.1**	**16.0**	**43.0**
Percent of total	**27%**	**73%**	**6%**	**5%**	**19%**	**11%**	**21%**	**0%**	**38%**	

Source: Based on 2005 data from the U.S. Geological survey on water uses in Wisconsin counties (USGS 2010a).
[a]Domestic self-supply wells.
[b]Includes aquaculture and water for livestock.

Table 14.4. *Miles of trails and trail density in the Northern Highland counties compared to the whole state.*

Trail type	Northern Highland (miles)	Northern Highland (miles/100 mi^2)	Wisconsin (miles/100 mi^2)
Hiking	76	2.8	2.8
Road biking	106	3.9	4.8
Mountain biking	76	2.8	1.9
ATV: summer & winter	286	10.5	9.3
Cross-country skiing	552	20.2	7.2
Snowmobile	1,098	40.3	31.2

Source: Wisconsin DNR unpublished data.

Demand

Visitors to State Lands. In 2004 there were an estimated 1.9 million visitors to the Northern Highland-American Legion State Forest in the Northern Highland Ecological Landscape (Wisconsin DNR unpublished data).

Fishing and Hunting License Sales. Of all license sales, the highest revenue producers for the Northern Highland counties were nonresident fishing licenses (44% of total sales), resident fishing licenses (26% of total sales), and resident hunting licenses (22% of total sales) (Wisconsin DNR unpublished data). Table 14.5 shows a breakdown of various licenses sold in the Northern Highland counties in 2007. Oneida County accounts for both the highest number of licenses sold and the highest revenue from sales. The Northern Highland counties accounted for about 4% of total license sales in the state. Licenses sold in the Northern Highland counties may be used in other parts of the state.

Metropolitan Versus Nonmetropolitan Recreation Counties. A research study (Johnson and Beale 2002) classified Wisconsin counties according to their dominant characteristics. One classification is "nonmetro recreation county." This type of county is characterized by high levels of tourism, recreation, entertainment, and seasonal housing. The Northern Highland counties are highly nonurban, and all are categorized as nonmetro recreation counties.

Maintaining the aesthetic integrity of natural areas for quiet sport recreation, like cross-country skiing, could have a positive impact on the local economy in the Northern Highland. Photo by John M. Touscany.

Recreational Issues

Results of a statewide survey of Wisconsin residents indicated that certain issues are causing impediments to outdoor recreation opportunities within Wisconsin (WDNR 2006b). Many of these issues, such as increasing ATV usage, overcrowding, increasing multiple-use recreation conflicts, loss of public access to lands and waters, invasive species, and poor water quality, are common across many regions of the state.

Silent Sports Versus Motorized Sports. Over the next decade, the most dominant recreation management issues will likely revolve around conflicts between motorized and nonmotorized recreation interests. From a silent-sport perspective, noise pollution from motorized users is one of the higher causes for recreation conflict (WDNR 2006b). Recreational motorized vehicles include snowmobiles, ATVs, motor boats, and jet skis. ATV use is especially contentious. ATV riding has been one of the fastest growing outdoor recreational activities in Wisconsin.

Timber Harvesting. A high percentage of statewide residents are concerned about timber harvesting in areas where they recreate (WDNR 2006b). Their greatest concern about timber harvesting is large-scale visual changes (i.e., large openings) in the forest landscape. Forest thinning and harvesting that creates small openings is more acceptable. Silent-sport enthusiasts as a group are the most concerned about the visual impacts of harvesting, while hunters and motorized users are somewhat less concerned.

Loss of Access to Lands and Waters. With ever-increasing development here by new and seasonal residents along shoreline and

Table 14.5. *Fishing and hunting licenses and stamps sold in the Northern Highland counties.*

County	Resident fishing	Nonresident fishing	Misc. fishing	Resident hunting	Nonresident hunting	Stamps	Total
Iron	2,721	3,642	105	4,284	432	1,751	12,935
Oneida	22,755	17,386	407	19,539	652	5,022	65,761
Vilas	18,732	22,587	90	9,694	635	3,186	54,924
Total	**44,208**	**43,615**	**602**	**33,517**	**1,719**	**9,959**	**133,620**
Sales ($)	**$1,016,490**	**$1,686,729**	**$13,278**	**$843,819**	**$194,216**	**$87,654**	**$3,842,186**

Source: Wisconsin DNR unpublished data.

forested properties, there has been a loss of easy access to lands and waters within this ecological landscape. This may come from the fact that new housing developments have become more concentrated around lakes and have closed large areas of shoreline once open to the casual recreation user. Another element that may also play into lost access is the difficulty with finding information on access to public lands and waters. In a statewide survey, this element was highly ranked as a barrier to increased outdoor recreation (WDNR 2006a).

Agriculture

Overall, land in farms in the Northern Highland counties has been increasing in recent years (Figure 14.11). There were 56,400 acres of farmland in the region in 1980, but by 2002, farmland acreage had increased to 73,400 acres (USDA NASS 2004). In 2002, average farm size was 232 acres, exceeding the Wisconsin average of 204 acres.

Killing frosts have occurred as late as June 6th, which is a limiting factor for crop production in the three Northern Highland counties. As would be expected, farms are better suited to cool season crops such as rye and hay.

Small amounts of oats, rye, and alfalfa hay were grown in all three counties, while growing corn and barley was attempted in only one or two counties in 2002 (USDA NASS 2004). No wheat was grown in any of the counties. The Northern Highland counties produced 10,500 tons of dry hay, which is less than 1% of the state total. All three counties had beef cattle, while dairy cattle were limited to small numbers in only Iron and Oneida counties in 2002. In 2002 the market value of all agriculture products sold in Oneida and Vilas counties was $17.7 million—87% from crop sales, and 13% from livestock sales. Data were not published for Iron County because there were not enough agricultural products sold.

Agricultural land sold and diverted to other uses resulted in a slightly lower agricultural land diversion in the Northern Highland counties than in the state as a whole. Only 143 of the 73,468 acres of agricultural land in the three counties was sold and diverted to other land uses in 2002 (USDA NASS 2004). This 0.2% loss was lower than the state loss of 0.3%. Another 645 acres of farmland in the Northern Highland counties were sold in 2002 but continued in agricultural use.

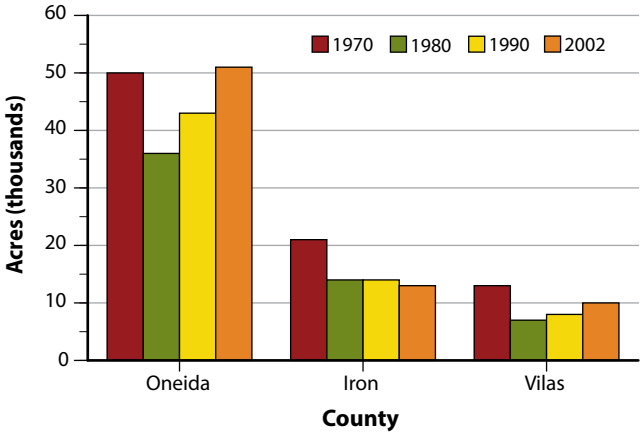


Figure 14.11. *Acres of farmland in the Northern Highland counties by county and year (USDA NASS 2004).*

Timber

Timber Supply

Timber Ownership. The total land area of the Northern Highland Ecological Landscape is approximately 1.2 million acres, with 934,746 acres (78%) classified as timberland (USFS 2009). Timberland is defined as forestland capable of producing 20 cubic feet of industrial wood per acre per year, and not withdrawn from timber utilization. Ownership greatly influences how the timberland resource is used. Figure 14.12 delineates timberland ownership within the Northern Highland Ecological Landscape. Public entities (federal, state, county, and municipal governments) own 43%, while 57% is owned by private landowners, including individuals, tribal nations, and corporate holdings (forest industry and other). In 2006, 2,986 acres of forestland in the Northern Highland counties was sold. Of this, 22%, or 658 acres, was diverted to some other use, primarily housing development (USDA NASS 2009).

Most forests within the Northern Highland Ecological Landscape are managed, usually for timber and certain types of recreation. This provides jobs for local economies and a supply of timber for the forest products industry. Photo by Paul Pingrey.

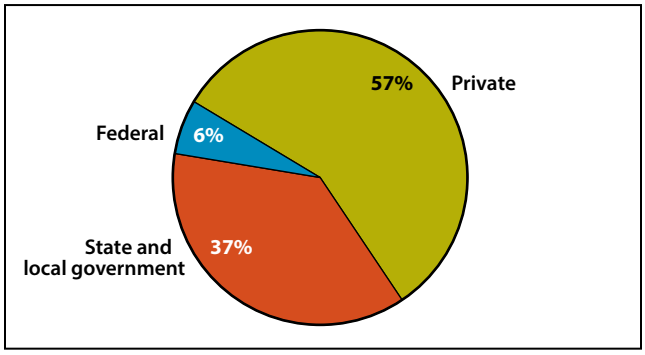


Figure 14.12. *Timberland ownership within the Northern Highland Ecological Landscape (USFS 2009).*

Growing Stock and Sawtimber Volume. There was approximately 1.2 billion cubic feet of ***growing stock*** volume in the Northern Highland Ecological Landscape in 2007 (USFS 2007) (see the "Socioeconomic Characteristics" section in Chapter 3, "Comparison of Ecological Landscapes"). Just over half of this volume (52%) was in softwoods. This is appreciably different than for the state as a whole where 74% of total growing stock volume was hardwoods. Within the growing stock volume in the ecological landscape, about 3.7 billion board feet was in sawtimber, about 69% of which was softwood. For the whole state, sawtimber hardwood volume (67%) exceeded softwood volume, a very distinct difference from this ecological landscape.

Annual Growing Stock and Sawtimber Growth. Between 1996 and 2007, this ecological landscape's timber resource experienced a net average annual growing stock increase of 27 million cubic feet (USFS 2007) (see "Socioeconomic Characteristics" in Chapter 3, "Comparison of Ecological Landscapes"). Forty-six percent of this new growth was in softwood growing stock trees. Sawtimber grew a net annual average of 83 million board feet, of which about 62% was in softwoods. As with total volumes, net growth for both growing stock and sawtimber in the ecological landscape was quite different than on a statewide basis. For the entire state, 75% of annual growing stock and 69% of annual sawtimber growth was in hardwood species.

Timber Forest Types. According to FIA data, the primary forest types in the Northern Highland Ecological Landscape classified by forestland acreage are sugar maple-beech-yellow birch (10%), black spruce (9%), red pine (8%), aspen (7%), and white birch (5%) (USFS 2009). See Appendix H, "Forest Types That Were Combined into Forest Type Groups Based on Forest Inventory and Analysis (FIA) Data," in Part 3, "Supporting Materials." Table 14.6 shows the forestland acreage in this ecological landscape by forest type.

Table 14.6. *Acreage of timberland in the Northern Highland Ecological Landscape by forest type and size class.*

Forest type[a]	Seedling/sapling	Pole-size	Sawtimber	Total
Jack pine	6,751	12,604	11,302	30,656
Red pine	5,350	14,145	57,285	76,780
Eastern white pine	7,513	2,176	51,866	61,556
Eastern hemlock	–	–	14,559	14,559
Balsam fir	15,490	12,801	4,682	32,973
White spruce	3,454	–	1,802	5,256
Black spruce	61,241	21,279	949	83,470
Tamarack	24,877	26,983	3,918	55,778
Northern white-cedar	–	7,014	14,300	21,314
Scotch pine	–	486	–	486
Eastern white pine-northern red oak-white ash	10,059	5,722	24,213	39,994
Other pine-hardwood	6,176	2,372	8,730	17,278
White oak-red oak-hickory	755	5,384	2,981	9,120
Northern red oak	7,928	4,217	31,171	43,316
Red maple-oak	–	881	3,002	3,883
Mixed upland hardwoods	2,132	1,177	–	3,309
Black ash-American elm-red maple	715	6,953	2,146	9,814
River birch-sycamore	–	–	–	–
Cottonwood	–	–	–	–
Willow	2,862	–	–	2,862
Red maple-lowland	9,506	–	–	9,506
Sugar maple-beech-yellow birch	15,186	58,226	28,556	101,969
Black cherry	4,955	–	–	4,955
Hard maple-basswood	1,551	3,577	17,763	22,891
Red maple-upland	715	9,075	5,912	15,702
Aspen	101,829	114,725	23,126	239,680
White birch	7,698	28,106	9,101	44,904
Nonstocked[b]	-	-	-	16,082
Total	**296,743**	**337,903**	**317,365**	**968,093**

Source: U.S. Forest Service Forest Inventory and Analysis (FIA) Mapmaker (USFS 2009).

[a]U.S. Forest Service Forest Inventory and Analysis (FIA) uses a national forest typing system to classify FIA forest types from plot and tree list samples. Because FIA is a national program, some of the national forest types in the above table do not exactly represent forest types that occur in Wisconsin.

[b]Nonstocked land is less than 16.7% stocked with trees and not categorized as to forest type or size class.

Timber Demand

Removals from Growing Stock. Average annual removals from growing stock for this ecological landscape were 15 million cubic feet between 2002 and 2007 (USFS 2007) (see the "Socioeconomic Characteristics" section in Chapter 3, "Comparison of Ecological Landscapes"). The majority of removals (66%) were from hardwood growing stock trees. Removals to growth ratios were 42% for softwoods, 68% for hardwoods, and 56% for total growing stock volume (Figure 14.13). On a statewide basis, the growth to removals ratio was 53% for all species.

Removals from Sawtimber. Average annual removals of the sawtimber portion of growing stock for this ecological landscape were 38 million board feet between 2002 and 2007 (USFS 2007). About 55% of this volume was from softwoods (see the "Socioeconomic Characteristics" section in Chapter 3, "Comparison of Ecological Landscapes"). Sawtimber removals to growth ratios were 40% for softwoods, 53% for hardwoods, and 45% for total volume (Figure 14.14). On a statewide basis, the growth to removals ratio was 43% for all species of sawtimber.

Price trends

Trees have varying economic values depending on the species. Northern red oak and white oak (*Quercus alba*) are the two highest priced hardwood sawtimber species in the Northern Highland counties (almost all of this is northern red oak) (WDNR 2008). Northern white-cedar is the most expensive softwood timber species, followed by eastern white

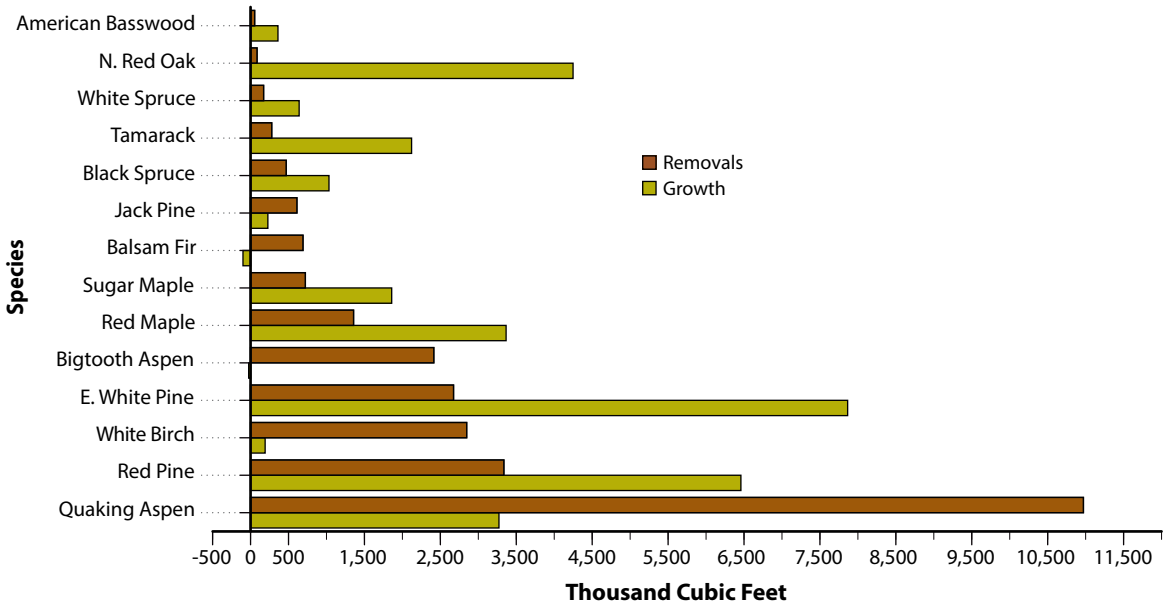


Figure 14.13. *Growing stock growth and removals (selected species) on timberland in the Northern Highland Ecological Landscape (USFS 2009).*

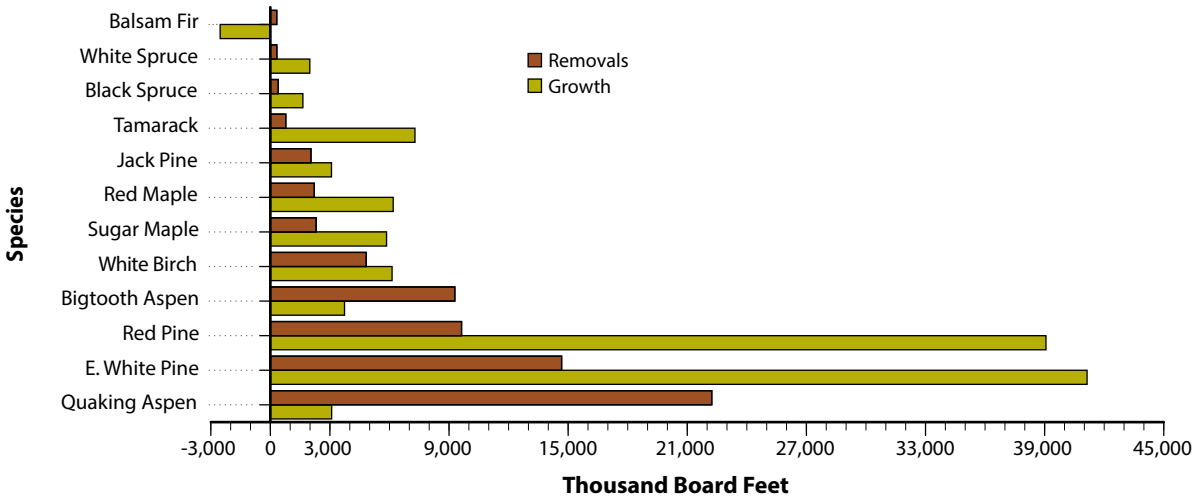


Figure 14.14. *Sawtimber growth and removals on timberland in the Northern Highland Ecological Landscape (USFS 2009).*

pine. Jack and red pine are the most valuable softwood pulpwood species, while aspen is the most valuable hardwood pulpwood species. Most sawtimber and pulpwood prices tend to be higher in the Northern Highland counties compared to Wisconsin as a whole, with a few exceptions.

Infrastructure

Transportation

The transportation infrastructure of the Northern Highland Ecological Landscape varies in comparison to the rest of the state. Road mile density is quite different in each of the counties. Compared to the state as a whole, road density is lower in Iron County, about equal to the state average in Oneida County, and higher in Vilas County (WDOT 2000). Railroad density is significantly lower in the three counties when compared to statewide (WDOT 1998). Vilas County has no railroad transportation at all. There are seven airports in the Northern Highland Ecological Landscape (WDOT 2012). Rhinelander/Oneida County Airport is the only regional airport, and there are no airports at all in Iron County. There are no commercial shipping ports in this ecological landscape. (WCPO 2010) (see Table 14.7).

Renewable Energy

Hydroelectric and wind power are the only renewable energy sources quantified by county in Wisconsin energy statistics produced by the Wisconsin Department of Administration (WDOA 2006). Some general inferences can be drawn from other sources regarding the potential for renewable energy production in the Northern Highland counties.

■ **Biomass.** Woody biomass from logging residue has some potential for development in the Northern Highland counties. The large timber supply, as noted in the "Timber" section above, could provide opportunities for energy generation. Logging residues in 2003 in Iron, Oneida, and Vilas counties were 3.5, 6.6 and 3.9 million cubic feet, respectively (USFS 2004). Residues left over from sawmill production can be used for energy. Potential for excess mill residues are more limited because there are only five sawmills that produce over 100,000 board feet of lumber per year in the three counties. Mill residues for the Northern Highland counties were 1.3 million cubic feet (USFS 2007). Much of this volume would be utilized by the mills for their own heat generation.

■ **Hydroelectric.** There are two hydroelectric power plants in the Northern Highland counties, one in Oneida County and one in Vilas County, generating 6,387 MWh and 1,517 MWh in 2005, respectively (WDOA 2006). In the entire state, there are 68 sites, owned either by utility companies or privately owned, which generate a total of 1,462 million kilowatt hours.

■ **Ethanol.** As noted in the "Agriculture" section above, corn and soybean production is very limited in the Northern Highland counties due to the short growing season. As a result, potential for growing additional corn and soybeans for ethanol production would be very limited. There are no ethanol plants in the Northern Highland Ecological Landscape (Renewable Fuels Association 2014).

■ **Wind.** There are no commercial wind facilities located in the Northern Highland counties (WWIC 2013). Mean annual power densities are less than 200 W/m^2 (watts per square meter) in this part of the state, indicating that there is poor potential for wind generation (USDE 2013).

Current Socioeconomic Conditions

The Northern Highland counties combined (Iron, Oneida, and Vilas) have a lower population density than the state as a whole. Per capita income for the region is lower than statewide, although income has been increasing in the Northern Highland counties. The poverty rate for all people and for people under age 18 is higher than for the state as a whole.

Table 14.7. *Road miles and density, railroad miles and density, number of airports, airport runway miles and density, and number of ports in the Northern Highland Ecological Landscape.*

	Northern Highland	State total	% of state total
Total road length (miles)[a]	6,770	185,487	4%
Road density[b]	3.7	3.4	–
Miles of railroads	78	5,232	1%
Railroad density[c]	4.3	9.6	–
Airports	8	128	6%
Miles of runway	6.7	95.8	7%
Runway density[d]	3.7	1.7	–
Total land area	2,081	54,807	4%
Number of ports[e]	0	14	0%

[a]Includes primary and secondary highways, roads, and urban streets.
[b]Miles of road per square mile of land. Data from Wisconsin Roads 2000 TIGER line files (data set) (WDOA 2000).
[c]Miles of railroad per 100 square miles of land. Data from 1:100,000-scale Rails Chain Database (WDOT 1998).
[d]Miles of airport runway per 1,000 square miles of land. Data from Wisconsin Airport Directory 2011–2012 web page (WDOT 2012).
[e]Data from Wisconsin Commercial Ports Association (WCPA 2010).

The Northern Highland counties each have higher unemployment rates than the state. The service sector resulting from tourism is the most important employer in the Northern Highland counties.

Demography

Population Distribution

In 2010 the population of the Northern Highland counties was 63,344 (USCB 2012). These counties are mostly rural (81.7%) and sparsely populated. Northern Highland population centers (defined by the U.S. Census Bureau as cities with populations over 2,500) include the cities of Rhinelander (7,714) and Tomahawk (3,403). Tomahawk is within the limited portion of the Northern Highland Ecological Landscape that occurs in northern Lincoln County but is not included in the data analysis that follows since the majority of Lincoln County lies outside of the Northern Highland Ecological Landscape. All other Northern Highland Ecological Landscape cities, towns, and villages have populations less than 2,500 (USCB 2009). There are no major population centers bordering the Northern Highland counties.

Population Density

The mean population density of the Northern Highland counties in 2010 was less than a quarter of that for the state as a whole. There were 23 persons per square mile in the Northern Highland counties, compared with 105 persons per square mile in the state as a whole. Iron County was the state's most sparsely populated county, with only 7.8 persons per square mile (USCB 2012).

Population Structure

Age. The residents of the Northern Highland counties are older than the state as a whole. Over 23% of the population is over 65, compared with 13.7% of the statewide population. This older population skews some of the data presented (e.g., income and poverty rates, for example) since retirees generally have lower incomes than working people. There is also a lower percentage of people under 18—18.0% of the population as compared with 23.6% statewide (USCB 2012). The median age increased from 32 to 44 years of age (WDNR 2006b). Most of this increase occurred between 1980 and 2000 as the baby boom generation began to reach older ages. However, age structure can also be impacted by migration trends. Between 1990 and 2000, these counties experienced a net loss of young adults and saw an increase in population at other age groups, especially of adults at early retirement age. The median age was projected to increase by two to three years in this area by 2010.

Minorities. The area is racially homogeneous (as defined by U.S. census reports for 2010) with a 95.2% white, non-Hispanic population compared to 93.5% statewide. Only 0.3% of the Northern Highland counties' population is African American, and 1.1% is Hispanic, compared to 6.3% and 3.6%, respectively, statewide. However, there is a much higher percentage of American Indian, 4.3%, compared to 1.0% of the statewide population (USCB 2012). The majority of the Northern Highland counties' American Indian population resides in Vilas County, whose population is 11.1% American Indian (USCB 2012).

Education. The Northern Highland counties are comparable with the rest of the state in terms of the percentage of residents 25 years old or older who have graduated from high school, with 91.5% high school graduation rate for the Northern Highland counties compared to 89.4% for the state in 2010. However, this area lags slightly in attaining higher education; 22.8% of the Northern Highland counties' residents 25 or older have bachelor's or higher degrees, compared to 25.8% statewide (USCB 2012).

Population Trends

From 1950 to 2006, the population of Northern Highland counties increased 68%, only slightly higher than the statewide population growth of 62%. Population change is not evenly distributed across the Northern Highland counties. Vilas County alone more than doubled in population during the period from 1950 to 2006, while Oneida County grew by 76% in that period. However, by 2006 Iron County had actually lost over a quarter of its 1950 population (USCB 2009).

The largest population changes in Northern Highland counties occurred from 1970 to 1980 and 1990 to 2000 (USCB 2009). The population increased substantially between 1990 and 2000 in each of the Northern Highland counties. The three counties' combined population grew by 16% during that period. However, that growth was not evenly distributed; Iron County's population grew nearly 12%, slightly exceeding the state growth rate of 10%, while Vilas County grew almost 19%. According to 2010 U.S. census data, all three counties lost population from 2000 to 2010 (less than 1% for each county) (USCB 2012).

Housing

Housing Density. To a lesser degree than population density, housing density in the Northern Highland counties reflects their isolated, rural nature. In 2010, the Northern Highland counties had a combined mean of 22.5 housing units per square mile of land, less than half of the state's average housing density (48.5 units per square mile) (USCB 2012). Seasonal and recreational homes, often clustered along lakeshores, influence the distribution of houses in the Northern Highland counties.

Seasonal Homes. Seasonal and recreational homes make up a mean of 41.6% of the Northern Highland counties' housing stock, compared to only 6.3% statewide. This indicates a high degree of tourism and high number of seasonal residents in this area. This trend is distributed somewhat unevenly through the counties. Vilas County (49%) has a greater proportion of

seasonal or recreational residences than either Iron County (42.8%) or Oneida County (35.4%) (USCB 2012).

Conversion of seasonal residences to permanent residences may result in (1) a change in community values; (2) a change in local government priorities; (3) increased cultural conflict between long-term and new residents; (4) an increase in the proportion of local residents not dependent upon jobs in the local area; and (5) increased costs to provide public and social services. As a result of the demand-driven shift in land ownership from residents to more seasonal residents (some of whom become permanent residents), local residents increasingly may not be able to afford to own rural or lakeshore property.

Housing Growth. The most rapid housing growth occurred between 1970 and 1990, when the number of houses in Vilas and Oneida counties more than doubled (increasing by 106%), adding more than 10,000 new housing units (WDNR 2006b). Housing growth has generally outpaced population growth in part because of the high proportion of seasonal-use homes in the area. The exception is in the 1990s when many seasonal houses were converted into permanent homes, and population growth and housing growth were parallel.

Housing Values. Housing values, according to the 2010 U.S. census, are generally lower in this area compared to the statewide median, but there is much variation within the Northern Highland counties. The median housing value for tourism-rich Vilas County ($193,700) is higher than the state median ($167,100) while the median housing for isolated Iron County ($102,800) is the lowest for any county in the state (USCB 2012).

The Economy

There are higher levels of service jobs based primarily on recreation and tourism in the Northern Highland counties compared with the state as a whole. Wages in the service sector tend to be lower than in other economic sectors with a higher proportion of part-time and seasonal jobs. There is lower representation of agriculture and higher paying manufacturing and technology sector jobs in the Northern Highland counties. There is a net in-migration of retirement age adults and out-migration of young adults. Relative age of the remaining population is increasing. Per capita and household incomes and average wages per job are lower in the Northern Highland counties while unemployment rates are higher than in the state as a whole. The higher percentage of retirees, with lower incomes, obviously affects income levels relative to the rest of the state.

Iron County is less populated and contributes less economically than either Oneida or Vilas counties and, further, has less than 50% of its geographical area within the Northern Highland Ecological Landscape. Meanwhile this analysis does not account for the influence of northeast Lincoln County, which is within the Northern Highland Ecological Landscape, includes the Northern Highland counties' second largest city (Tomahawk), and has more favorable economic characteristics than does Iron County. For these reasons, the economic characteristics of Oneida and Vilas counties are most representative of the economy of the Northern Highland Ecological Landscape, and economic figures cited below may err on the side of underestimating the potential of the Northern Highland Ecological Landscape as a local economy.

Income

Per Capita Income. Total personal income for the three counties in 2006 was $2.05 billion (1.1% of the state total), with Oneida County as the major contributor ($1.21 billion). Per capita income in 2006 ($31,593) was lower than the statewide average of $34,405 (Table 14.8) but ranked fifth among ecological landscape county approximations in Wisconsin (USDC BEA 2006). Among ecological landscape county approximations that do not include a major metropolitan area, the Northern Highland counties ranked behind only the Western Prairie counties (located near Minneapolis/St. Paul, Minnesota) in per capita income, which has been increasing for the Northern Highland counties. When adjusted for inflation (year 2000 dollars), per capita income for the region was $14,179 in 1970, $18,178 in 1980, $19,519 in 1990, and $25,704 in 2002 (USDC BEA 2006). In 2007 higher paying jobs in the forest products and processing industries accounted for 6.2% of employee compensation paid in the three counties (MIG 2009), but the effect of the transition from seasonal residences to permanent residences on the part of older, wealthier property owners is

Table 14.8. *Economic indicators for the Northern Highland counties and Wisconsin.*

	Per capita income[a]	Average earnings per job[a]	Unemployment rate[b]	Poverty rate[c]
Wisconsin	**$34,405**	**$36,142**	**4.7%**	**10.2%**
Iron	$25,469	$24,634	8.2%	14.5%
Oneida	$33,256	$29,132	5.8%	8.2%
Vilas	$30,622	$24,643	6.1%	9.1%
Northern Highland counties	$31,593	$27,444	6.1%	9.0%

[a]U.S. Bureau of Economic Analysis, 2006 figures.
[b]U.S. Department of Labor Bureau of Labor Statistics, Local Area Unemployment Statistics, 2006 figures.
[c]U.S. Bureau of the Census, Small Area Income and Poverty Estimates, 2005 figures.

likely the greatest factor in the Northern Highland counties' relatively favorable per capita income.

Household Income. The Northern Highland counties had much lower median household income during 2008–2012 than the statewide average ($52,627) (USCB 2012). Median household income in the Northern Highland counties ranges from Oneida County's $44,181 to Iron County's $37,112.

Earnings Per Job. Similar to "Household Income," earnings per job in the Northern Highland counties are among the lowest in the state. In 2006, average earnings per job for the three Northern Highland counties were $27,444, compared to the statewide average of $36,142. Iron County ($24,634) and Vilas County ($24,643) had considerably lower wages per job than did Oneida County ($29,132) (USDC BEA 2006). Real wages were in decline from 1970 through 1990, however, over the past decade they have increased. In 1970 the average wage was $22,156, in 1980 it was $21,749, in 1990 it was $19,028, and in 2002 it was $23,380. Per capita income includes social security and pension income while earnings per job are strictly based on wages. With the higher numbers of people over age 65 and fewer households with children in the Northern Highland counties than in the rest of the state, it is not surprising that per capita income and earnings per job do not follow the same trend.

Unemployment

The Northern Highland counties each had higher 2006 average annual unemployment rates than the state as a whole. Oneida County was lowest (5.8%) and Iron was highest (8.2%) compared to the state average of 4.7% (USDL BLS 2006) (Table 14.8). The higher unemployment rates in the Northern Highland counties may be misleading because of the significantly higher percentage of seasonal employees in the tourism industry, a heavy component of the Northern Highland counties' economy. Even though unemployment rates are seasonally adjusted using national adjustment factors, the volatility of tourism industry employment may inflate actual rates of unemployment. Unemployment rates were much higher throughout the state after 2008 but have become lower again.

Poverty

Poverty Rates. The U.S. Census Bureau estimated the Northern Highland counties' 2005 poverty rate for all people (9.0%) was lower than for the state as a whole (10.2%). Poverty rates for all people are much lower in Oneida (8.2%) and Vilas (9.1%) counties than in Iron County, whose poverty rate of 14.5% is fifth highest in Wisconsin (USCB 2009).

Child Poverty Rates. Compared to the statewide average (14%), 2005 estimates of poverty rates for people under age 18 were lower in Oneida County (11.9%) and higher in Vilas (15.8%) and Iron (19.7%) counties (USCB 2009).

Because the Northern Highland counties have relatively low income and high unemployment compared to the rest of the state, it might seem that Northern Highland counties' poverty rates should be higher than in the state as a whole. Several factors confound this logic. First it should be noted that poverty thresholds are not adjusted for regional, state, or local variations in the cost of living. So the reason for the difference cannot be variation in local cost of living.

This disparity appears to again be a result of the prevalence of an older population in Northern Highland counties. Poverty rates are based on the size of family and tax status (under or over age 65). As an example, a married couple with two children under 18 has a poverty threshold of $23,624, a married couple under 65 with no children under 18 has a poverty threshold of $15,600, and a married couple over 65 with no children under 18 has a poverty threshold of $14,081 (USCB 2014). Significantly more people are over age 65 in the Northern Highland counties (26.5% compared with 14.8% statewide), and there are fewer households with children (USCB 2012). Even with a lower per capita income, the older population would be expected to have a lower percentage of people under their lower poverty level since Social Security alone would usually put them above the minimum threshold.

Residential Property Values

Overall, Northern Highland counties' residential property values greatly exceed the statewide average ($134,021 per housing unit). Northern Highland counties' residential property values are highly variable among the counties, ranging from low values in Iron County ($112,222), to very high values in Oneida County and even higher in Vilas County (Table 14.9). Only tourist haven Door County has higher average residential property values than those in Vilas County ($252,098), reflecting the prevalence of vacation and second homes associated with the region's many lakes.

Important Economic sectors

Iron (2,800 jobs), Oneida (26,942), and Vilas (10,971) counties together provided 40,713 jobs in 2007, or about 1.1% of the total employment in Wisconsin (Table 14.10; MIG 2009). Tourism-related jobs comprise the greatest portion (16.9%) of all employment in Northern Highland counties, followed in importance by Retail Trade (15.0%), Construction (13.5%), Government (13.1%), and Health Care and Social Services (9.3%). For definitions of economic sectors, see the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013). So while Northern Highland counties constitute a minor portion of the state's economy, they are leaders in tourism and accommodation services, highly dependent upon their unique vacationland character for income.

Importance of economic sectors within the Northern Highland counties when compared to the rest of the state was evaluated using an economic base analysis to yield a standard metric called a location quotient (Quintero 2007). Economic base analysis compares the percentage of all jobs

in an ecological landscape county approximation for a given economic sector to the percentage of all jobs in the state for the same economic sector. For example, if 10% of the jobs within an ecological landscape county approximation are in the manufacturing sector and 10% of all jobs in the state are in the manufacturing sector, then the location quotient would be 1.0, indicating that this ecological landscape county approximation contributes jobs to the manufacturing sector at the same rate as the statewide average. If the location quotient is greater than 1.0, the ecological landscape county approximation is contributing more jobs to the sector than the state average. If the location quotient is less than 1.0, the ecological landscape county approximation is contributing fewer jobs to the sector than the state average.

When compared with the rest of the state, the Northern Highland counties had seven sectors with location quotients higher than 1.0 (Figure 14.15, Appendix 14.I). Three sectors in the Northern Highland counties garnered location quotients higher than in any other ecological landscape county approximation for the particular economic sector: Tourism-related, Real Estate, Rental, and Leasing, and Construction, affirming the great economic importance of recreation, tourism, and second homes to the Northern Highland counties. Retail Trade, closely tied to tourism as well, has the second highest location quotient among all sectors within the Northern Highland counties. The Forest Products and Processing sector, while contributing only 3.3% of Northern Highland counties' jobs in 2007, contributed more jobs than the state average percentage. The Other Services sector and Government sector also each provided a percentage of jobs higher in Northern Highland counties than the state average percentage. The "Other Services" sector consists primarily of equipment

Table 14.9. *Property values for the Northern Highland counties and Wisconsin, assessed in 2006 and collected in 2007.*

	Residential property value	Housing units	Residential property value per housing unit
Wisconsin	**$340,217,559,700**	**2,538,538**	**$134,021**
Iron	$680,404,400	6,063	$112,222
Oneida	$5,460,745,200	28,846	$189,307
Vilas	$6,159,765,900	24,434	$252,098
Northern Highland counties	$12,300,915,500	59,343	$207,285

Sources: Wisconsin Department of Revenue 2006–2007 property tax master file (except housing units); housing units: U. S. Census Bureau estimates for July 1, 2006.

Table 14.10. *Total and percentage of jobs in 2007 in each economic sector within the Northern Highland (NH) counties. The economic sectors providing the highest percentage of jobs in the Northern Highland counties are highlighted in blue.*

Industry sector	WI employment	% of WI total	NH counties employment	% of NH counties total
Agriculture, Fishing & Hunting	110,408	3.1%	627	1.5%
Forest Products & Processing	88,089	2.5%	1,343	3.3%
Mining	3,780	0.1%	40	0.1%
Utilities	11,182	0.3%	74	0.2%
Construction	200,794	5.6%	5,477	13.5%
Manufacturing (non-wood)	417,139	11.7%	1,017	2.5%
Wholesale Trade	131,751	3.7%	702	1.7%
Retail Trade	320,954	9.0%	6,110	15.0%
Tourism-related	399,054	11.2%	6,898	16.9%
Transportation & Warehousing	108,919	3.1%	992	2.4%
Information	57,081	1.6%	522	1.3%
Finance & Insurance	168,412	4.7%	821	2.0%
Real Estate, Rental & Leasing	106,215	3.0%	1,665	4.1%
Professional, Science & Tech Services	166,353	4.7%	821	2.0%
Management	43,009	1.2%	86	0.2%
Administrative and Support Services	166,405	4.7%	1,157	2.8%
Private Education	57,373	1.6%	574	1.4%
Health Care & Social Services	379,538	10.7%	3,772	9.3%
Other Services	187,939	5.3%	2,684	6.6%
Government	430,767	12.1%	5,331	13.1%
Totals	3,555,161		40,713	1.1%

Source: IMPLAN, © MIG, Inc. 2009 (MIG 2009).

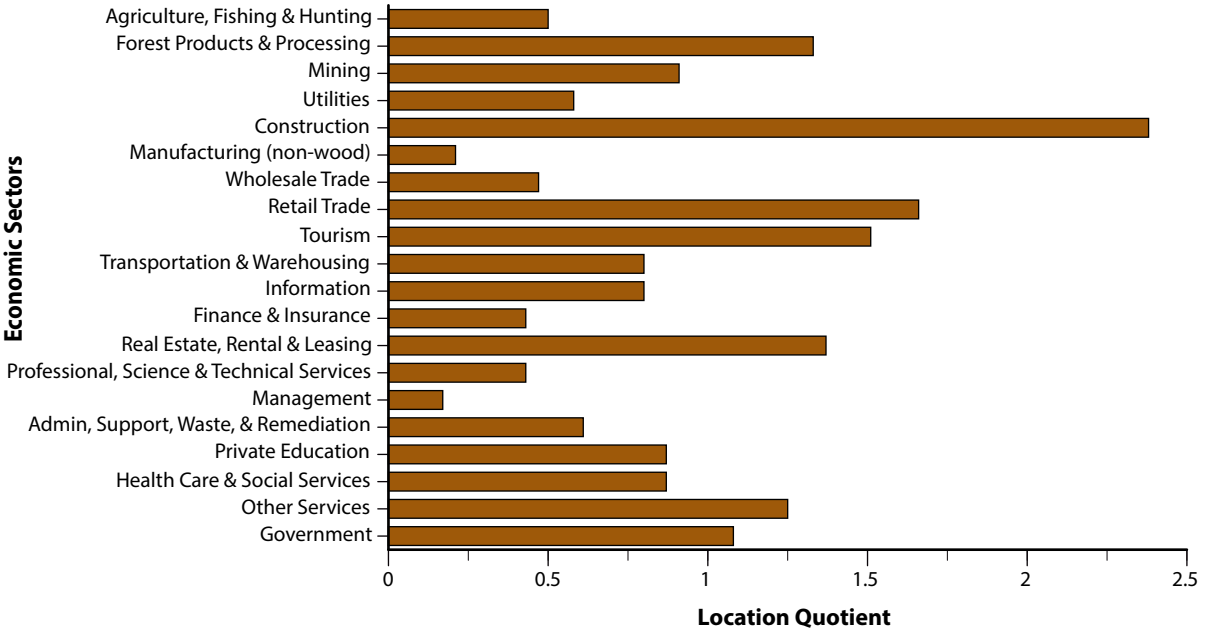


Figure 14.15. *Importance of economic sectors within the Northern Highland counties when compared to the rest of the state. If the location quotient is greater than 1.0, the Northern Highland counties are contributing more jobs to that economic sector than the state average. If the location quotient is less than 1.0, the Northern Highland counties are contributing fewer jobs to that economic sector than the state average.*

and machinery repairing, promoting or administering religious activities, grant making, advocacy, and providing dry-cleaning and laundry services, personal care services, death care services, pet care services, photo finishing services, and temporary parking services. The Tourism-related sector includes relevant subsectors within retail trade; passenger transportation; and arts, entertainment, and recreation. The Tourism-related sector also includes all Accommodation and Food Services (Marcouiller and Xia 2008). The Forest Products and Processing sector includes sectors in logging, pulp and paper manufacturing, primary wood manufacturing (e.g., sawmills), and secondary wood manufacturing (e.g., furniture manufacturing).

Urban Influence

The U.S. Department of Agriculture's Economic Research Service (USDA ERS) divides counties into 12 groups on a continuum of urban influence, with 1 representing large metropolitan areas, 2 representing smaller metropolitan areas, and the remaining classes from 3 to 12 representing nonmetropolitan counties increasingly less populated and isolated from urban influence (USDA ERS 2012b). The concept of urban influence assumes that population size, urbanization, and access to larger adjacent economies are crucial elements in evaluating potential of local economies. The Northern Highland counties are nonmetropolitan (rural) with only Oneida County (class 9) enjoying a small degree of "influence" from adjacent urban areas and the presence of the small city of Rhinelander. Iron and Vilas counties are among only three counties in Wisconsin classified as the most isolated and least populated (class 12).

Economic Types

Based on the assumption that knowledge and understanding of different types of rural economics and their distinctive economic and sociodemographic profiles can aid rural policymaking, the USDA ERS classifies counties in one of six mutually exclusive categories: farming-dependent counties, mining-dependent counties, manufacturing-dependent counties, government-dependent counties, service-dependent counties, and nonspecialized counties (USDA ERS 2012a). Oneida County was classified as service-dependent in 2004 according to the USDA ERS's economic specialization definitions. Iron and Vilas counties were classified as nonspecialized.

Policy Types

The USDA ERS also classifies counties according to "policy types" deemed especially relevant to rural development policy (USDA ERS 2012a). All three of the Northern Highland counties were classified as both "nonmetro recreation" counties and "retirement destination" counties. Nonmetro recreation counties are rural counties classified using a combination of factors, including share of employment or share of earnings in recreation-related industries in 1999, share of seasonal or occasional use housing units in 2000, and per capita receipts from motels and hotels in 1997, indicating economic dependence especially upon an influx of tourism and recreational dollars. Retirement destination counties (those in which the number of residents 60 and older grew by 15% or more between 1990 and 2000 due to in-migration) are shaped by an influx of an older population and have particular needs for health care and services specific to that population.

Integrated Opportunities for Management

Use of natural resources for human needs within the constraints of sustainable ecosystems is an integral part of ecosystem management. Integrating ecological management with socioeconomic programs or activities can result in efficiencies in land use, tax revenues, and private capital. This type of integration can also help generate broader and deeper support for sustainable ecosystem management. However, any human modification or use of natural communities has trade-offs that benefit some species and harm others. Even relatively benign activities such as ecotourism will have impacts on the ecology of an area. Trade-offs caused by management actions need to be carefully weighed when planning management to ensure that some species are not being irreparably harmed. Maintaining healthy, sustainable ecosystems provides many benefits to people and our economy. The development of ecologically sound management plans should save money and sustain natural resources in the long run.

The principles of integrating natural resources and socioeconomic activities are similar across the state. A discussion of "Integrated Ecological and Socioeconomic Opportunities" can be found in Chapter 6, "Wisconsin's Ecological Features and Opportunities for Management." That section offers suggestions on how and when ecological and socioeconomic needs might be integrated and gives examples of the types of activities that might work together when planning the management of natural resources within a given area.

Appendices

Appendix 14.A. *Watershed water quality summary for the Northern Highland Ecological Landscape.*

Watershed no.	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Very Poor/Poor/Fair/Good/Very Good/Excellent)
LS15	Montreal River	144,807	Good to Excellent; taxa richness; rare species; ERW tribs; clay soil erosion; pipeline contamination; some agr NPS; dam flux; low flows
LS16	Presque Isle River	69,151	Excellent; Crab Lake ORW; wetlands; clay sed; needs biol. survey
UC10	Upper S. Fork Flambeau River	178,549	V Good; atmospheric Hg in most and low D.O. in some lakes
UC14	Flambeau Flowage	158,196	Good to V Good; lakes mesotrophic to slightly eutrophic; many high quality, phosphorous-sensitive lakes; Hg
UC15	Bear River	93,086	Good to V Good; lakes mesotrophic to moderately eutrophic; many high quality, phosphorous-sensitive lakes; Hg
UC16	Manitowish River	171,904	Good to V Good; lakes oligotrophic to slightly eutrophic; many high quality, phosphorous-sensitive lakes; Hg
UW32	New Wood River[b]	74,070	V Good; many cold ERW; beaver dams; temp; hab; sed
UW33	Noisy and Pine creeks	114,783	Good to V Good; some ERW; cranberry NPS; beaver dams; Hilderbrand Lake – excess sed; Pickerel Lake – excess vegetation
UW34	Spirit River[b]	108,175	Good; few ERW; Spirit R. Flowage = Hg in fish, sed & agr NPS
UW35	Somo River	90,435	Good; many ERW; past industrial BOD; sed Hg; some agr NPS
UW36	Lower Tomahawk River	85,676	Good; NPS nutrients; beaver dams; sed, hab & low flow on two streams; Somo Lake & Lake Mohawksin = excess P & weedy growth
UW37	Middle Tomahawk River	149,313	Fair to Good; 12 ERW; sed, hab & low flow on eight streams; a few lakes have impaired water quality or fishery or excess weeds
UW38	Upper Tomahawk River	119,569	Good to V Good; only two ORW/ERW streams; municipal PS; cranberry NPS; many quality lakes P-sensitive; few lakes with excess weeds
UW39	Woodboro	39,671	Good to V Good; some ERW streams; past industrial BOD; sed Hg; beaver dams; flux; few lakes with excess weeds or impaired WQ
UW40	Pelican River	169,524	Fair to V Good; Landfill; Beaver dams; municipal PS; a few lakes with excess weeds or impaired WQ
UW41	Rhinelander Flowage	76,670	Fair to Good; past industrial BOD; hab; beaver dams; some quality lakes P-sensitive; a few lakes with excess weeds
UW42	Sugar Camp Creek	120,316	Good to V Good; beaver dams; cranberry NPS; some quality lakes P-sensitive; a few lakes with excess weeds
UW43	Saint Germain River	44,872	Good to V Good; beaver dams; hab; a few eutrophic lakes
UW44	Eagle River	116,286	Good to V Good; cranberry NPS; several slightly eutrophic lakes
UW45	Tamarack/Pioneer River	133,930	Good to V Good; many ERW; beaver dams; some mesotrophic lakes P-sensitive; several slightly eutrophic lakes
UW46	Deerskin River	36,403	Good to Excellent; beaver dams; mesotrophic lakes

Source: Wisconsin DNR Bureau of Watershed Management data.

[a]Based on Wisconsin DNR watershed water quality reports.

[b]Only a small fraction of this watershed lies within the ecological landscape, so overall impacts of land uses within the Northern Highland are unlikely to impact water quality within the watershed to any appreciable degree.

Abbreviations:
Agr = Agricultural.
BOD = Biochemical oxygen demand.
D.O. = Dissolved oxygen levels.
ERW = Exceptional Resource Water (very good to excellent water quality, with point source discharges).

Abbreviations continued on next page

Appendix 14.A, *continued.*

Flux = Abnormal highs and lows in stream flow fluctuation due to lack of groundwater infiltration, etc., often due to loss of forest cover, or creation of excessive impermeable surface.
Hab = Stream habitat damage.
Hg = Mercury contamination of fish, mainly deposited by coal combustion, or sometimes by industry.
NPS = Nonpoint source pollutants, such as farm or parking lot runoff, or septic system leakage.
ORW = Outstanding Resource Water (very good to excellent water quality, with no point source discharges).
P = Phosphorus.
PS = Point source pollutants, such as treated municipal and industrial wastewater.
Sed = Excess sedimentation.
Temp = Elevated temperatures in some stream reaches.
Tribs = Streams that are tributary to the stream(s) after which the watershed is named.
WQ = Water quality.

Appendix 14.B. *Forest habitat types in the Northern Highland Ecological Landscape.*

The forest habitat type classification system (FHTCS) is a site classification system based on the floristic composition of plant communities. The system depends on the identification of potential climax associations, repeatable patterns in the composition of the understory vegetation, and differential understory species. It groups land units with similar capacity to produce vegetation. The floristic composition of the plant community is used as an integrated indicator of those environmental factors that affect species reproduction, growth, competition, and community development. This classification system enables the recognition and classification of ecologically similar landscape units (site types) and forest plant communities (vegetation associations).

A forest habitat type is an aggregation of sites (units of land) capable of producing similar late-successional (potential climax) forest plant communities. Each recognizable habitat type represents a relatively narrow segment of environmental variation that is characterized by a certain limited potential for vegetation development. Although at any given time, a habitat type can support a variety of disturbance-induced (seral) plant communities, the ultimate product of succession is presumed to be a similar climax community. Field identification of a habitat type provides a convenient label (habitat type name) for a given site, and places that site in the context of a larger group of sites that share similar ecological traits. Forest habitat type groups more broadly combine individual habitat types that have similar ecological potentials.

Individual forest cover types classify current overstory vegetation, but these associations usually encompass a wide range of environmental conditions. In contrast, individual habitat types group ecologically similar sites in terms of vegetation potentials. Management interpretations can be refined and made significantly more accurate by evaluating a stand in terms of the current cover type (current dominant vegetation) plus the habitat type (potential vegetation).

Habitat types	Description of forest habitat types found in the Northern Highland Ecological Landscape.
PQE	*Pinus strobus-Quercus rubra/Epigaea repens* White pine-Red oak/Trailing arbutus
PArV	*Pinus strobus-Acer rubrum/Vaccinium angustifolium* White pine-Red maple/Blueberry
PArVAa	*Pinus strobus-Acer rubrum/Vaccinium angustifolium-Aralia nudicaulis* White pine-Red maple/Blueberry-Wild sarsaparilla
AVVb	*Acer saccharum/Vaccinium angustifolium-Viburnum acerifolium* Sugar maple/Blueberry-Maple-leaved viburnum
ATM	*Acer saccharum-Tsuga canadensis/Maianthemum canadense* Sugar maple-Hemlock/Wild lily-of-the-valley
ATD	*Acer saccharum-Tsuga canadensis/Dryopteris spinulosa* Sugar maple-Hemlock/Spinulose shield fern
AOCa	*Acer saccharum/Osmorhiza claytoni-Caulophyllum thalictroides* Sugar maple/Sweet cicely-Blue cohosh
ACaI	*Acer saccharum/Caulophyllum thalictroides-Impatiens capensis* Sugar maple/Blue cohosh-Jewelweed
ArAbCo	*Acer rubrum-Abies balsamea/Cornus canadensis* Red maple-Balsam fir/Bunchberry
TMC	*Tsuga canadensis/Maianthemum canadense-Coptis groenlandica* Hemlock/Wild lily-of-the-valley-Goldthread
ArAbVC	*Acer rubrum-Abies balsamea/Vaccinium spp.-Coptis groenlandica* Red maple-Balsam fir/Blueberry-Goldthread
Forest Lowland	Habitat types not defined

Source: Kotar and Burger (2002).

Appendix 14.C. *The Natural Heritage Inventory (NHI) table of rare species and natural community occurrences (plus a few miscellaneous features tracked by the NHI program) for the Northern Highland (NH) Ecological Landscape in November 2009. See the Wisconsin Natural Heritage Working List online for the current status (http://dnr.wi.gov, keyword "NHI").*

Scientific name (common name)	Lastobs Date	EOs[a] in NH	EOs in WI	Percent in NH	State rank	Global rank	State status	Federal status
MAMMALS								
Canis lupus (gray wolf)	2008	19	204	9%	S2	G4	SC/FL	LE
Martes americana (American marten)	2008	2	3	67%	S3	G5	END	
Napaeozapus insignis (woodland jumping mouse)	1998	1	15	7%	S2S3	G5	SC/N	
Sorex arcticus (arctic shrew)	1998	1	31	3%	S3S4	G5	SC/N	
Sorex hoyi (pygmy shrew)	1978	1	39	3%	S3S4	G5	SC/N	
Sorex palustris (water shrew)	1998	3	13	23%	S2S3	G5	SC/N	
BIRDS[b]								
Accipiter gentilis (Northern Goshawk)	2008	23	141	16%	S2B,S2N	G5	SC/M	
Ammodramus leconteii (Le Conte's Sparrow)	2006	4	22	18%	S2S3B	G4	SC/M	
Ammodramus nelsoni (Nelson's Sparrow)	1992	1	6	17%	S1B	G5	SC/M	
Anas rubripes (American Black Duck)	1993	1	2	50%	S2B	G5	SC/M	
Asio otus (Long-eared Owl)	2000	3	8	38%	S2B	G5	SC/M	
Botaurus lentiginosus (American Bittern)	2006	3	41	7%	S3B	G4	SC/M	
Bucephala clangula (Common Goldeneye)	2006	1	5	20%	S2B	G5	SC/M	
Buteo lineatus (Red-shouldered Hawk)	1992	2	301	1%	S3S4B,S1N	G5	THR	
Catharus ustulatus (Swainson's Thrush)	1992	3	18	17%	S2B	G5	SC/M	
Chlidonias niger (Black Tern)	1995	3	60	5%	S2B	G4	SC/M	
Contopus cooperi (Olive-sided Flycatcher)	2008	1	4	25%	S2B	G4	SC/M	
Coturnicops noveboracensis (Yellow Rail)	2006	4	22	18%	S1B	G4	THR	
Dendroica caerulescens (Black-throated Blue Warbler)[c]	2003	5	27	19%	S3B	G5	SC/M	
Dendroica cerulea (Cerulean Warbler)[c]	1996	3	92	3%	S2S3B	G4	THR	
Dendroica tigrina (Cape May Warbler)[c]	2008	3	26	12%	S3B	G5	SC/M	
Falcipennis canadensis (Spruce Grouse)	2008	11	33	33%	S1S2B,S1S2N	G5	THR	
Haliaeetus leucocephalus (Bald Eagle)	2007	288	1286	22%	S4B,S2N	G5	SC/P	
Oporornis agilis (Connecticut Warbler)	2003	4	27	15%	S2S3B	G4	SC/M	
Pandion haliaetus (Osprey)	2007	219	733	30%	S4B	G5	SC/M	
Picoides arcticus (Black-backed Woodpecker)	2006	7	17	41%	S2B	G5	SC/M	
Poecile hudsonicus (Boreal Chickadee)	2008	10	25	40%	S2S3B	G5	SC/M	
Wilsonia canadensis (Canada Warbler)[c]	2008	1	20	5%	S3B	G5	SC/M	
HERPTILES								
Diadophis punctatus edwardsii (northern ring-necked snake)	1996	1	23	4%	S3?	G5T5	SC/H	
Emydoidea blandingii (Blanding's turtle)	2006	1	316	0%	S3	G4	THR	
Glyptemys insculpta (wood turtle)	2007	18	262	7%	S2	G4	THR	
Hemidactylium scutatum (four-toed salamander)	2005	6	63	10%	S3	G5	SC/H	
Lithobates catesbeianus (American bullfrog)	2006	21	70	30%	S3	G5	SC/H	
Lithobates septentrionalis (mink frog)	2006	3	7	43%	S3S4	G5	SC/H	
FISHES								
Aphredoderus sayanus (pirate perch)	1977	2	39	5%	S3	G5	SC/N	
Clinostomus elongatus (redside dace)	1980	2	96	2%	S3	G3G4	SC/N	
Etheostoma microperca (least darter)	1985	1	83	1%	S3	G5	SC/N	
Fundulus diaphanus (banded killifish)	1985	2	105	2%	S3	G5	SC/N	
Lepomis megalotis (longear sunfish)	1993	1	25	4%	S2	G5	THR	

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Appendix 14.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NH	EOs in WI	Percent in NH	State rank	Global rank	State status	Federal status
Moxostoma valenciennesi (greater redhorse)	1990	4	56	7%	S3	G4	THR	
Notropis anogenus (pugnose shiner)	1990	3	49	6%	S2	G3	THR	
MUSSELS/CLAMS								
Alasmidonta marginata (elktoe)	1996	3	44	7%	S4	G4	SC/P	
Pleurobema sintoxia (round pigtoe)	1997	10	50	20%	S3	G4G5	SC/P	
BUTTERFLIES/MOTHS								
Boloria eunomia (bog fritillary)	1993	1	49	2%	S3	G5	SC/N	
Boloria freija (freija fritillary)	2004	3	20	15%	S2S3	G5	SC/N	
Boloria frigga (frigga fritillary)	1993	3	9	33%	S2	G5	SC/N	
Callophrys henrici (Henry's elfin)	2008	1	19	5%	S1S2	G5	SC/N	
Erebia discoidalis (red-disked alpine)	1980	1	8	13%	S2	G5	SC/N	
Hesperia comma (Laurentian skipper)	2002	2	15	13%	S3	G5	SC/N	
Phyciodes batesii lakota (Lakota crescent)	1995	2	24	8%	S3	G4T4	SC/N	
DRAGONFLIES/DAMSELFLIES								
Aeshna clepsydra (mottled darner)	1994	6	9	67%	S2	G4	SC/N	
Aeshna eremita (lake darner)	1994	3	15	20%	S3	G5	SC/N	
Nasiaeschna pentacantha (cyrano darner)	1996	6	14	43%	S3	G5	SC/N	
Ophiogomphus howei (pygmy snaketail)	1996	2	33	6%	S4	G3	THR	
Somatochlora cingulata (lake emerald)	1994	1	1	100%	S1	G5	SC/N	
BEETLES								
Agabus bicolor (a predaceous diving beetle)	2004	1	9	11%	S3	GNR	SC/N	
Cicindela longilabris (a tiger beetle)	2004	2	6	33%	S2S3	G5	SC/N	
Dubiraphia robusta (robust dubiraphian riffle beetle)	1994	1	2	50%	S1	G1G3	SC/N	
Lioporeus triangularis (a predaceous diving beetle)	1994	1	4	25%	S1S2	GNR	SC/N	
MISCELLANEOUS INSECTS/SPIDERS								
Banksiola dossuaria (a giant casemaker caddisfly)	1994	2	5	40%	S2S3	G5	SC/N	
Booneacris glacialis (wingless mountain grasshopper)	2005	1	8	13%	S3	G5	SC/N	
Isoperla richardsoni (a perlodid stonefly)	1994	2	3	67%	S3	G4	SC/N	
Melanoplus scudderi (Scudder's short-winged grasshopper)	2006	1	1	100%	S1S2	G5	SC/N	
PLANTS								
Arabis missouriensis var. *deamii* (Deam's rockcress)	1998	1	22	5%	S2	G5?QT3?Q	SC	
Arethusa bulbosa (swamp-pink)	2009	20	96	21%	S3	G4	SC	
Callitriche heterophylla (large water-starwort)	1996	1	3	33%	S1	G5	THR	
Calypso bulbosa (fairy slipper)	2004	4	34	12%	S3	G5	THR	
Carex gynocrates (northern bog sedge)	1993	2	31	6%	S3	G5	SC	
Carex lenticularis (shore sedge)	1996	4	18	22%	S2	G5	THR	
Carex pallescens (pale sedge)	1995	1	27	4%	S3	G5	SC	
Carex tenuiflora (sparse-flowered sedge)	2007	9	84	11%	S3	G5	SC	
Carex vaginata (sheathed sedge)	1995	3	35	9%	S3	G5	SC	
Ceratophyllum echinatum (prickly hornwort)	1996	1	61	2%	S2	G4?	SC	
Clematis occidentalis (purple clematis)	1998	6	32	19%	S3	G5	SC	
Cypripedium reginae (showy lady's-slipper)	2003	2	99	2%	S3	G4	SC	

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Appendix 14.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NH	EOs in WI	Percent in NH	State rank	Global rank	State status	Federal status
Dryopteris expansa (spreading woodfern)	1980	1	13	8%	S2	G5	SC	
Eleocharis robbinsii (Robbins' spikerush)	2007	11	28	39%	S3	G4G5	SC	
Epilobium palustre (marsh willow-herb)	2005	6	37	16%	S3	G5	SC	
Epilobium strictum (downy willow-herb)	1995	1	22	5%	S2S3	G5?	SC	
Equisetum variegatum (variegated horsetail)	1993	1	47	2%	S3	G5	SC	
Eriophorum alpinum (alpine cotton-grass)	2007	1	25	4%	S2	G5	SC	
Juncus stygius (moor rush)	1997	1	2	50%	S1	G5	END	
Littorella americana (American shore-grass)	1995	5	6	83%	S2	G5	SC	
Myriophyllum farwellii (Farwell's water-milfoil)	1995	4	60	7%	S3	G5	SC	
Ophioglossum pusillum (adder's-tongue)	1995	1	12	8%	S2	G5	SC	
Oryzopsis canadensis (Canada mountain-ricegrass)	2001	3	4	75%	S1	G5	SC	
Osmorhiza chilensis (Chilean sweet cicely)	1993	1	33	3%	S3	G5	SC	
Platanthera dilatata (leafy white orchis)	1995	2	31	6%	S3	G5	SC	
Platanthera orbiculata (large roundleaf orchid)	1996	1	78	1%	S3	G5	SC	
Potamogeton confervoides (algae-like pondweed)	1995	4	9	44%	S2	G4	THR	
Potamogeton diversifolius (water-thread pondweed)	2000	2	29	7%	S2	G5	SC	
Potamogeton vaseyi (Vasey's pondweed)	2002	3	19	16%	S2	G4	SC	
Rhynchospora fusca (brown beakrush)	2007	2	21	10%	S2	G4G5	SC	
Ribes hudsonianum (northern black currant)	2007	4	76	5%	S3	G5	SC	
Triglochin maritima (common bog arrow-grass)	1995	3	59	5%	S3	G5	SC	
Utricularia geminiscapa (hidden-fruited bladderwort)	2002	20	95	21%	S3	G4G5	SC	
Utricularia purpurea (purple bladderwort)	2008	22	55	40%	S3	G5	SC	
Utricularia resupinata (northeastern bladderwort)	2007	16	29	55%	S3	G4	SC	
COMMUNITIES								
Alder Thicket	1982	6	106	6%	S4	G4	NA	
Black Spruce Swamp	2007	6	41	15%	S3?	G5	NA	
Boreal Forest	1993	1	36	3%	S2	G3?	NA	
Boreal Rich Fen	1995	1	18	6%	S2	G4G5	NA	
Bracken Grassland	1992	2	6	33%	S2	G3	NA	
Emergent Marsh	1983	6	272	2%	S4	G4	NA	
Emergent Marsh - Wild Rice	2006	7	15	47%	S3	G3G4	NA	
Floodplain Forest	1983	1	182	1%	S3	G3?	NA	
Hardwood Swamp	1993	1	53	2%	S3	G4	NA	
Lake—Deep, Soft, Drainage	1986	2	11	18%	S1	GNR	NA	
Lake—Deep, Soft, Seepage	1997	11	49	22%	S3	GNR	NA	
Lake—Deep, Very Soft, Seepage	2005	16	29	55%	S3	GNR	NA	
Lake—Shallow, Hard, Drainage	1982	1	35	3%	SU	GNR	NA	
Lake—Shallow, Hard, Seepage	1980	1	52	2%	SU	GNR	NA	
Lake—Shallow, Soft, Drainage	2006	14	36	39%	S3	GNR	NA	
Lake—Shallow, Soft, Seepage	2004	10	87	11%	S4	GNR	NA	
Lake—Soft Bog	1982	4	52	8%	S4	GNR	NA	
Lake—Spring	1996	3	13	23%	S3	GNR	NA	
Muskeg	2007	7	45	16%	S4	G4G5	NA	
Northern Dry Forest	2004	5	63	8%	S3	G3?	NA	
Northern Dry-mesic Forest	2006	46	284	16%	S3	G4	NA	
Northern Mesic Forest	2006	42	383	11%	S4	G4	NA	
Northern Sedge Meadow	2007	22	231	10%	S3	G4	NA	
Northern Wet Forest	2007	22	322	7%	S4	G4	NA	

Continued on next page

Appendix 14.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NH	EOs in WI	Percent in NH	State rank	Global rank	State status	Federal status
Northern Wet-mesic Forest	2007	8	243	3%	S3S4	G3?	NA	
Open Bog	2008	28	173	16%	S4	G5	NA	
Patterned Peatland	2004	2	4	50%	S1	GNR	NA	
Poor Fen	2004	8	46	17%	S3	G3G4	NA	
Shrub-carr	1981	2	143	1%	S4	G5	NA	
Spring Pond	1991	10	69	14%	S3	GNR	NA	
Springs and Spring Runs, Hard	1981	1	71	1%	S4	GNR	NA	
Springs and Spring Runs, Soft	1980	1	12	8%	SU	GNR	NA	
Stream—Fast, Hard, Cold	1983	5	98	5%	S4	GNR	NA	
Stream—Fast, Hard, Warm	1981	1	10	10%	SU	GNR	NA	
Stream—Slow, Hard, Cold	1979	1	22	5%	SU	GNR	NA	
Stream—Slow, Hard, Warm	1982	2	20	10%	SU	GNR	NA	
Stream—Slow, Soft, Cold	1981	3	8	38%	SU	GNR	NA	
Stream—Slow, Soft, Warm	2006	7	14	50%	SU	GNR	NA	
Submergent Marsh	1994	2	6	33%	S4	G5	NA	
OTHER ELEMENTS								
Bird rookery	2000	4	54	7%	SU	G5	SC	

[a]An element occurrence is an area of land and/or water in which a rare species or natural community is, or was, present. Element occurrences must meet strict criteria that is used by an international network of Heritage programs and coordinated by NatureServe.
[b]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.
[c]The American Ornithologist's Union lists these birds as Black-throated Blue Warbler (*Setophaga caerulescens*), Cerulean Warbler (*Setophaga cerulea*), Cape May Warbler (*Setophaga tigrina*), and Canada Warbler (*Cardellina canadensis*).

STATUS AND RANKING DEFINITIONS

U.S. Status—Current federal protection status designated by the Office of Endangered Species, U.S. Fish and Wildlife Service, indicating the biological status of a species in Wisconsin:

LE = listed endangered.
LT = listed threatened.
PE = proposed as endangered.
NEP = nonessential experimental population.
C = candidate for future listing.
CH = critical habitat.

State Status—Protection category designated by the Wisconsin DNR:

END = Endangered. Endangered species means any species whose continued existence as a viable component of this state's wild animals or wild plants is determined by the Wisconsin DNR to be in jeopardy on the basis of scientific evidence.

THR = Threatened species means any species of wild animals or wild plants that appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered.

SC = Special Concern. Special Concern species are 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.

Wisconsin DNR and federal regulations regarding Special Concern species range from full protection to no protection. The current categories and their respective level of protection are as follows:

SC/P = fully protected;
SC/N = no laws regulating use, possession, or harvesting;
SC/H = take regulated by establishment of open closed seasons;
SC/FL = federally protected as endangered or threatened but not so designated by Wisconsin DNR;
SC/M = fully protected by federal and state laws under the Migratory Bird Act.

Global Element Ranks:

G1 = Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2 = Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state or physiographic region) or because of other factor(s) making it vulnerable to extinction throughout its range; typically 21-100 occurrences.

Status and ranking definitions continued on next page

Appendix 14.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in NH	EOs in WI	Percent in NH	State rank	Global rank	State status	Federal status

G4 = Uncommon but not rare (although it may be quite rare in parts of its range, especially at the periphery) and usually widespread. Typically > 100 occurrences.
G5 = Common, widespread, and abundant (although it may be quite rare in parts of its range, especially at the periphery). Not vulnerable in most of its range.
GH = Known only from historical occurrence throughout its range, with the expectation that it may be rediscovered.
GNR = Not ranked. Replaced G? rank and some GU ranks.
GU = Currently unrankable due to lack of data or substantially conflicting data on status or trends. Possibly in peril range-wide, but status is uncertain.
GX = Presumed to be extinct throughout its range (e.g., Passenger pigeon) with virtually no likelihood that it will be rediscovered.

Species with a questionable taxonomic assignment are given a "Q" after the global rank. Subspecies and varieties are given subranks composed of the letter "T" plus a number or letter. The definition of the second character of the subrank parallels that of the full global rank. (Examples: a rare subspecies of a rare species is ranked G1T1; a rare subspecies of a common species is ranked G5T1.)

State Element Ranks:
S1 = Critically imperiled in Wisconsin because of extreme rarity, typically 5 or fewer occurrences and/or very few (<1,000) remaining individuals or acres, or due to some factor(s) making it especially vulnerable to extirpation from the state.
S2 = Imperiled in Wisconsin because of rarity, typically 6–20 occurrences and/or few (1,000– 3,000) remaining individuals or acres, or due to some factor(s) making it very vulnerable to extirpation from the state.
S3 = Rare or uncommon in Wisconsin, typically 21–100 occurrences and/or 3,000–10,000 individuals.
S4 = Apparently secure in Wisconsin, usually with > 100 occurrences and > 10,000 individuals.
S5 = Demonstrably secure in Wisconsin and essentially ineradicable under present conditions.
SNA = Accidental, nonnative, reported but unconfirmed, or falsely reported.
SH = Of historical occurrence in Wisconsin, perhaps having not been verified in the past 20 years and suspected to be still extant. Naturally, an element would become SH without such a 20-year delay if the only known occurrence were destroyed or if it had been extensively and unsuccessfully looked for.
SNR = Not Ranked; a state rank has not yet been assessed.
SU = Currently unrankable. Possibly in peril in the state, but status is uncertain due to lack of information or substantially conflicting data on status or trends.
SX = Apparently extirpated from the state.

State ranking of long-distance migrant animals:
Ranking long distance aerial migrant animals presents special problems relating to the fact that their nonbreeding status (rank) may be quite different from their breeding status, if any, in Wisconsin. In other words, the conservation needs of these taxa may vary between seasons. In order to present a less ambiguous picture of a migrant's status, it is necessary to specify whether the rank refers to the breeding (B) or nonbreeding (N) status of the taxon in question. (e.g., S2B, S5N).

Appendix 14.D. *Number of species with special designations documented within the Northern Highland Ecological Landscape, 2009.*

Listing status	Taxa					Total fauna	Total flora	Total listed
	Mammals	Birds	Herptiles	Fishes	Invertebrates			
U.S. Endangered	1	0	0	0	0	1	0	1
U.S. Threatened	0	0	0	0	0	0	0	0
U.S. Candidate	0	0	0	0	0	0	0	0
Wisconsin Endangered	1	0	0	0	0	1	1	2
Wisconsin Threatened	0	4	2	3	1	10	4	14
Wisconsin Special Concern	5	18	4	4	21	52	30	82
Natural Heritage Inventory total	**6**	**22**	**6**	**7**	**22**	**63**	**35**	**98**

Note: Wisconsin-listed species always include federally listed species (although they may not have the same designation); therefore, federally listed species are not included in the total.

Appendix 14.E. *Species of Greatest Conservation Need (SGCN) Found in the Northern Highland Ecological Landscape.*

These SGCN have a high or moderate probability of being found in this ecological landscape and use habitats that have the best chance for management here. Data are from the Wisconsin Wildlife Action Plan (WDNR 2005c) and Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3, "Supporting Materials." For more complete and/or detailed information, please see the Wisconsin Wildlife Action Plan. The Wildlife Action Plan is meant to be dynamic and will be periodically updated to reflect new information; the next update is planned for 2015.

Only SGCN highly or moderately (H = high association, M = moderate association) associated with specific community types or other habitat types and that have a high or moderate probability of occurring in the ecological landscape are included here (SGCN with a low affinity with a community type or other habitat type and with low probability of being associated with this ecological landscape were excluded). Only community types designated as "Major" or "Important" management opportunities for the ecological landscape are shown.

Bald Eagle.
Photo by Herbert Lange.

	MAJOR												IMPORTANT										
	Coolwater Streams	Emergent Marsh	Emergent Marsh – Wild Rice	Inland Lakes	Northern Dry-mesic Forest	Northern Sedge Meadow	Northern Wet Forest	Open Bog	Submergent Marsh	Submergent Marsh – Oligotrophic	Warmwater Rivers	Warmwater Streams	Alder Thicket	Boreal Rich Fen	Bracken Grassland	Coldwater Streams	Ephemeral Pond	Impoundments/Reservoirs	Northern Dry Forest	Northern Hardwood Swamp	Northern Mesic Forest	Northern Wet-mesic Forest	Shrub-carr
Species that are significantly associated with the Northern Highland Ecological Landscape																							
MAMMALS																							
Gray wolf					H		H	M					H		H				M	M	H	H	M
Northern flying squirrel					H		H												M	M	H	H	
Water shrew	H			M			H					M	M			H				H	M	H	
Woodland jumping mouse							M										M			M	H	M	
BIRDS[a]																							
American Golden Plover		M																M					
American Woodcock													H							M	M		H
Bald Eagle				H					M		H							H					
Black Tern		H	M	M		M			M									M					
Black-backed Woodpecker							H												M				
Black-throated Blue Warbler					M																H		
Boreal Chickadee							H																
Brown Thrasher															H								
Canada Warbler					M			M						M	M						H	M	H
Connecticut Warbler							M	M						M					H				
Golden-winged Warbler					M		M	M					H						M	M	M		H
Least Flycatcher					M														M	M	H		
Lesser Scaup			M	M					H		M							M					
Northern Goshawk					M																H		
Olive-sided Flycatcher							H	M														M	
Osprey				H							H							H					
Red Crossbill					H														H				
Short-billed Dowitcher		H																M					
Spruce Grouse							H	M											M				

Continued on next page

Appendix 14.E, *continued.*

Wood turtle.
Photo by Wisconsin DNR staff.

	MAJOR												IMPORTANT										
	Coolwater Streams	Emergent Marsh	Emergent Marsh – Wild Rice	Inland Lakes	Northern Dry-mesic Forest	Northern Sedge Meadow	Northern Wet Forest	Open Bog	Submergent Marsh	Submergent Marsh – Oligotrophic	Warmwater Rivers	Warmwater Streams	Alder Thicket	Boreal Rich Fen	Bracken Grassland	Coldwater Streams	Ephemeral Pond	Impoundments/Reservoirs	Northern Dry Forest	Northern Hardwood Swamp	Northern Mesic Forest	Northern Wet-mesic Forest	Shrub-carr
Veery					M		M						H							H	M		H
Vesper Sparrow															H								
Whip-poor-will					M														M				
HERPTILES																							
Four-toed salamander	M	H				M	M	H					H			M	H			M	H	H	H
Mink frog	H	H	M	H		H		H	H	M	H	H	M	M		M	M	H					M
Wood turtle	H					M	M		H		H	H	H		H	H	M			M	H	M	H
FISH																							
Greater redhorse				M							M	H						M					
Longear sunfish				M							M	M											
Pugnose shiner				M								M											
Species that are moderately associated with the Northern Highland Ecological Landscape																							
MAMMALS																							
Eastern red bat	H	M		M	M	M	M	M	M	M	M	M	M	M		H	H		M	M	M	M	M
Moose		H		H		M	M	M	H	H	M	M	H					M		H	M	H	H
BIRDS																							
American Bittern		H				H		H															
Blue-winged Teal		H	M	M		M			M									M					
Buff-breasted Sandpiper		M																					
Canvasback			M	M					H		H							M					
Dunlin		M									M							M					
Field Sparrow															M								
Nelson's Sharp-tailed Sparrow						H																	
Northern Harrier						H			M							M							
Rusty Blackbird		M						M					M				M						M
Solitary Sandpiper	M	H						M				M				M	H						
Wood Thrush																					M		
Yellow Rail						H		H															
HERPTILES																							
Mudpuppy				H							H					M		H					
FISH																							
Lake sturgeon				H							H							H					
Least darter				M							M	M											

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 14.F. *Natural communities[a] for which there are management opportunities in the Northern Highland Ecological Landscape.*

Major opportunity[b]	Important opportunity[c]	Present[d]
Northern Dry-Mesic Forest	Northern Dry Forest	Boreal Forest
Northern Wet Forest	Northern Mesic Forest	
Black Spruce Swamp	Northern Wet-Mesic Forest	Floodplain Forest
Tamarack (Poor) Swamp	Northern Hardwood Swamp	
		Pine Barrens
Muskeg	Alder Thicket	
	Shrub-carr	Bedrock Glade
Northern Sedge Meadow		
	Bracken Grassland	
Open Bog		
Poor Fen	Boreal Rich Fen	
Emergent Marsh	Ephemeral Pond	
Emergent Marsh - Wild Rice		
Submergent Marsh	Inland Beach	
Oligotrophic Marsh		
	Coldwater Stream	
Coolwater Stream	Impoundment/Reservoir	
Warmwater River		
Warmwater Stream		
Inland Lake		

[a]See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin," for definitions of natural community types. Also see Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 ("Supporting Materials") for an explanation on how the information in this table can be used.

[b]Major opportunity – Relatively abundant, represented by multiple significant occurrences, or ecological landscape is appropriate for major restoration activities.

[c]Important opportunity – Less abundant but represented by one to several significant occurrences or type is restricted to one or a few ecological landscapes.

[d]Present – Uncommon or rare, with no good occurrences documented. Better opportunities are known to exist in other ecological landscapes, or opportunities have not been adequately evaluated.

Appendix 14.G. *Public conservation lands in the Northern Highland Ecological Landscape, 2005.*

Property name	Size (acres)[a]
STATE	
Hay Creek-Hoffman Lake State Wildlife Area[b]	1,680
Menard Island State Resource Area	2,600
Northern Highland-American Legion State Forest[b]	219,700
Powell Marsh State Wildlife Area	4,340
Thunder Lake State Wildlife Area	3,280
Turtle-Flambeau Scenic Waters Area[b]	20,040
Willow Flowage Scenic Waters Area[b]	7,720
Woodboro Lakes State Wildlife Area	2,470
Miscellaneous Lands[c]	12,740
FEDERAL	
Chequamegon-Nicolet National Forests[b]	47,100
COUNTY FOREST[d]	
Iron County Forest[b]	13,650
Lincoln County Forest[b]	8,210
Oneida County Forest[b]	25,270
Vilas County Forest[b]	35,550
TOTAL	**404,350**

Source: *Wisconsin Land Legacy Report* (WDNR 2006c).

[a]Actual acres owned in this ecological landscape.

[b]This property also falls within adjacent ecological landscape(s).

[c]Includes public access sites, fish hatcheries, fire towers, streambank and nonpoint easements, lands acquired under statewide wildlife, fishery, forestry, and natural area programs, Board of Commissioners of Public Lands holdings, small properties under 100 acres, and properties with fewer than 100 acres within this ecological landscape.

[d]Locations and sizes of county-owned parcels enrolled in the Forest Crop Law are presented here. Information on locations and sizes of other county and local parks in this ecological landscape is not readily available and is not included here, except for some very large properties.

Appendix 14.H. *Land Legacy places in the Northern Highland Ecological Landscape and their ecological and recreational significance.*

The *Wisconsin Land Legacy Report* (WDNR 2006c) identified 11 sites in the Northern Highland Ecological Landscape as important ecological (and in some cases also recreational) areas that state and other conservation entities should consider for protection over the next 50 years. Monico Forest harbors a high diversity of uncommon forest interior birds. Somo River supports a highly diverse community of aquatic organisms, while the Squirrel and Tomahawk rivers are bordered by undisturbed wetlands, feature remnant stands of old-growth white and red pines, and provide habitat for several rare animals, including two threatened species of turtle.

From an ecosystem management perspective, the best remaining conservation opportunities or higher priorities may be within the undeveloped or lightly developed "Border Lakes" area. This area has high conservation significance, substantial remaining protection opportunities, and is large in size. The Border Lakes on the northern edge of the Northern Highland Ecological Landscape (much of it is within the North Central Forest Ecological Landscape) could be an ecologically significant link between the Northern Highland and the vast forests of the Upper Peninsula of Michigan and provide important habitat for loons, ospreys, eagles, otters, and other aquatic or water-dependent species. Certain forested areas (e.g., stands of large conifers, old-growth patches) support sensitive species such as Blackburnian, Pine and Cape May Warblers, Northern Goshawk, Red-shouldered Hawk, Spruce Grouse, Boreal Chickadee, and Black-backed Woodpecker. In addition, the Land Legacy Report notes that Big Pine Creek, Tamarack Creek, Pickerel Creek and Mishonagon Creek are all worthy of consideration for additional conservation action.

Map Code	Place name	Size	Protection initiated	Protection remaining	Conservation significance[a]	Recreation potential[b]
BL	Border Lakes region	Large	Moderate	Moderate	xxxxx	xx
CN	Chequamegon-Nicolet National Forests	Large	Substantial	Limited	xxxxx	xxxxx
DK	Deerskin River	Medium	Moderate	Limited	xxx	x
MF	Monico Forest	Medium	Limited	Substantial	x	xx
NA	Northern Highland-American Legion State Forest	Large	Substantial	Limited	xxxxx	xxxxx
SO	Somo River	Medium	Moderate	Moderate	x	xx
SQ	Squirrel and Tomahawk rivers	Medium	Moderate	Moderate	xxx	xx
TM	Thunder Marsh	Medium	Substantial	Limited	xxx	x
TF	Turtle-Flambeau Flowage	Large	Substantial	Limited	xxxx	xxxxx
UW	Upper Wisconsin River	Large	Moderate	Moderate	xxx	xxx
WF	Willow Flowage	Medium	Substantial	Limited	xx	xxxx

[a]**Conservation significance.** See the *Wisconsin Land Legacy Report* (WDNR 2006c), p. 43, for detailed discussion.

- xxxxx Possesses outstanding ecological qualities, is large enough to meet the needs of critical components, and/or harbors globally or continentally significant resources. Restoration, if needed, has a high likelihood of success.
- xxxx Possesses excellent ecological qualities, is large enough to meet the needs of most critical components, and/or harbors continentally or Great Lakes regionally significant resources. Restoration has a high likelihood of success.
- xxx Possesses very good ecological qualities, is large enough to meet the needs of some critical components, and/or harbors statewide significant resources. Restoration will typically be important and has a good likelihood of success.
- xx Possesses good ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors statewide or ecological landscape significant resources. Restoration is likely needed and has a good chance of success.
- x Possesses good to average ecological qualities, may be large enough to meet the needs of some critical components, and/or harbors ecological landscape significant resources. Restoration is needed and has a reasonable chance of success.

[b]**Recreation potential.** See the *Wisconsin Land Legacy Report*, p. 43, for detailed discussion.

- xxxxx Outstanding recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet many current and future recreation needs, is large enough to accommodate incompatible activities, could link important recreation areas, and/or is close to state's largest population centers.
- xxxx Excellent recreation potential, could offer a wide variety of land and water-based recreation opportunities, could meet several current and future recreation needs, is large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to large population centers.
- xxx Very good recreation potential, could offer a variety of land and/or water-based recreation opportunities, could meet some current and future recreation needs, may be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized to large population centers.
- xx Good to moderate recreation potential, could offer some land and/or water-based recreation opportunities, might meet some current and future recreation needs, may not be large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to mid-sized population centers.
- x Limited recreation potential, could offer a few land and/or water-based recreation opportunities, might meet some current and future recreation needs, is not likely large enough to accommodate some incompatible activities, could link important recreation areas, and/or is close to small population centers.

Appendix 14.I. *Importance of economic sectors (based on the number of jobs) within the Northern Highland counties compared to the rest of the state.*

Industry	CLMC	CSH	CSP	FT	NCF	NES	NH	NLMC	NWL	NWS	SEGP	SLMC	SWS	SCP	WCR	WP	STATE
Forestry, fishing, hunting, & agr support	0.62	1.11	1.48	3.61	5.16	2.01	3.14	11.86	1.53	3.74	0.86	0.28	1.80	3.12	1.81	1.68	0.85
Mining	1.44	2.11	0.92	1.38	0.86	4.32	0.23	2.49	0.45	0.22	2.36	0.23	1.41	0.23	1.57	1.47	0.32
Utilities	1.49	0.97	0.81	0.61	0.73	0.35	1.42	0.24	1.50	1.13	0.90	1.31	0.72	1.20	1.17	0.60	1.06
Construction	1.28	0.84	0.90	0.84	0.93	0.86	1.37	0.96	1.64	1.26	1.25	0.69	0.89	1.27	0.85	1.43	0.80
Manufacturing	1.39	1.08	1.10	1.39	1.31	1.62	0.37	1.22	0.44	0.57	1.16	0.79	0.87	0.51	0.87	1.01	1.63
Wholesale trade	0.95	0.76	0.51	0.78	0.54	0.54	0.40	0.53	0.91	0.55	1.26	1.05	0.86	0.61	0.82	0.83	0.94
Retail trade	1.08	1.11	1.11	1.15	1.11	1.04	1.38	1.00	1.10	1.05	1.03	0.93	2.01	0.97	1.18	1.09	0.94
Transportation & warehousing	1.01	1.32	2.11	1.28	0.94	1.08	0.56	0.72	2.16	1.33	0.84	1.09	0.77	1.35	1.44	1.22	1.04
Information	0.71	0.42	0.78	0.80	0.48	0.45	0.65	0.36	0.70	0.65	1.23	1.30	1.31	0.67	0.79	0.52	0.74
Finance & insurance	1.07	1.42	1.10	1.11	0.64	0.48	0.44	0.46	0.41	0.40	1.01	1.34	0.71	0.43	0.70	0.63	0.95
Real estate & rental & leasing	0.96	0.78	0.63	0.63	0.86	0.39	1.10	0.62	0.78	0.95	1.20	1.45	0.54	0.83	0.80	0.90	0.57
Professional, scientific & tech services	1.02	0.67	0.55	0.62	0.55	0.50	0.46	0.48	0.58	0.60	1.14	1.28	0.70	0.50	0.66	2.87	0.57
Management	1.05	0.20	0.59	0.75	0.25	0.10	0.17	0.23	0.36	0.20	1.10	1.49	0.07	0.51	0.77	0.14	0.93
Admin., support, waste, remediation	1.08	0.48	0.44	0.51	0.51	0.17	0.47	0.24	0.69	0.49	0.94	1.49	0.49	0.89	0.80	0.83	0.64
Educational services	1.09	0.26	0.32	0.36	0.32	0.45	0.41	0.29	0.03	0.05	0.77	2.19	0.17	0.03	0.62	0.21	0.76
Health care & social assistance	0.91	0.86	1.25	1.10	0.92	1.01	1.05	0.89	0.94	0.87	0.91	1.32	1.00	0.90	1.12	0.77	0.98
Arts, entertainment & recreation	1.02	1.41	0.94	1.06	1.04	0.42	0.68	1.33	0.70	0.90	0.98	1.35	0.72	0.86	1.09	0.76	0.91
Accommodation & food services	1.09	1.51	0.95	0.98	1.05	1.22	1.63	1.04	1.38	1.45	1.04	0.98	0.89	1.28	1.20	1.22	0.90
Other services	1.04	1.10	0.97	1.00	0.77	1.16	0.80	1.17	2.43	1.51	1.10	1.08	0.97	1.60	0.86	1.09	0.96
Unclassified establishments	0.85	3.96	1.97	2.09	5.74	3.53	4.57	2.75	3.35	6.47	0.99	1.81	3.83	5.27	2.94	1.98	0.69
Government	0.68	0.98	1.05	0.92	1.09	1.14	0.89	0.83	1.06	1.14	0.87	0.76	1.21	1.16	1.02	1.11	0.99
Tourism	0.67	1.15	0.92	0.80	1.63	1.08	2.96	2.60	1.31	2.23	0.69	0.59	0.82	2.21	1.28	0.61	1.99

Source: Based on an economic base analysis using location quotients (Quintero 2007). Definitions of economic sectors can be found at the U.S. Census Bureau's North American Industry Classification System web page (USCB 2013).

Appendix 14.J. *Scientific names of species mentioned in text.*

Common name	Scientific name
Algae-like pondweed	*Potamogeton confervoides*
American basswood	*Tilia americana*
American beaver	*Castor canandensis*
American Bittern[a]	*Botaurus lentiginosus*
American black bear	*Ursus americanus*
American Black Duck	*Anas rubripes*
American bullfrog	*Lithobates catesbeianus*
American marten	*Martes americana*
American shoregrass	*Littorella uniflora* var. *americana*
American Woodcock	*Scolopax minor*
Annosum root rot fungus	*Heterobasidion annosum*
Arrow-leaved sweet-coltsfoot	*Petasites sagittatus*
Ashes	*Fraxinus* spp.
Aspens	*Populus* spp.
Bald Eagle	*Haliaeetus leucocephalus*
Balsam fir	*Abies balsamea*
Banded killifish	*Fundulus diaphanus*
Big-tooth aspen	*Populus grandidentata*
Birches	*Betula* spp.
Black ash	*Fraxinus nigra*
Blackberries	*Rubus* spp.
Black locust	*Robinia pseudoacacia*
Black spruce	*Picea mariana*
Black Tern	*Chlidonias niger*
Black-throated Blue Warbler	*Setophaga caerulescens,* listed as *Dendroica caerulescens* on the Wisconsin Natural Heritage Working List
Blanding's turtle	*Emydoidea blandingii*
Blueberries	*Vaccinium* spp.
Bluegill	*Lepomis macrochirus*
Boreal Chickadee	*Poecile hudsonicus*
Box elder	*Acer negundo*
Bracken fern	*Pteridium aquilinum*
Bronze birch borer	*Agrilus anxius*
Brook trout	*Salvelinus fontinalis*
Brown Thrasher	*Toxostoma rufum*
Bulrushes	*Scirpus* spp.
Bur oak	*Quercus macrocarpa*
Bur-reeds	*Sparganium* spp.
Canada thistle	*Cirsium arvense*
Canada yew	*Taxus canadensis*
Cape May Warbler	*Setophaga tigrina,* listed as *Dendroica tigrina* on the Wisconsin Natural Heritage Working List
Cat-tails	*Typha* spp.
Cerulean Warbler	*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List
Chestnut-sided Warbler	*Setophaga pensylvanica*
Ciscoes	*Coregonus* spp.
Common buckthorn	*Rhamnus cathartica*
Common Loon	*Gavia immer*
Common reed	*Phragmites australis*
Common tansy	*Tanacetum vulgare*
Connecticut Warbler	*Oporornis agilis*
Curly pondweed	*Potamogeton crispus*
Dame's rocket	*Hesperis matronalis*
Diplodia pine blight fungus	*Diplodia pinea*

Continued on next page

Appendix 14.J, *continued.*

Common name	Scientific name
Dogwoods	*Cornus* spp.
Dubiraphian riffle beetle	*Dubiraphia robusta*
Eastern hemlock	*Tsuga canadensis*
Eastern purple bladderwort	*Utricularia purpurea*
Eastern white pine	*Pinus strobus*
Elms	*Ulmus* spp.
Emerald ash borer	*Agrilus planipennis*
Eurasian water-milfoil	*Myriophyllum spicatum*
European earthworms	Family Lumbricidae
Evening Grosbeak	*Coccothraustes vespertinus*
Fairy-slipper orchid	*Calypso bulbosa*
Fisher	*Martes pennanti*
Forest tent caterpillar	*Malacosoma disstria*
Forget-me-not	*Myosotis scorpioides* and *M. sylvatica*
Freija fritillary	*Boloria freija*
Frigga fritillary	*Boloria frigga*
Garlic mustard	*Alliaria petiolata*
Glossy buckthorn	*Rhamnus frangula*
Golden-winged Warbler	*Vermivora chrysoptera*
Gray Jay	*Perisoreus canadensis*
Gray wolf	*Canis lupus*
Greater redhorse	*Moxostoma valenciennesi*
Green ash	*Fraxinus pennsylvanica*
Green frog	*Rana clamitans*
Gypsy moth	*Lymantria dispar*
Hazelnuts	*Corylus* spp.
Hidden-fruited bladderwort	*Utricularia geminiscapa*
Honeysuckle (nonnative)	*Lonicera morrowii, L. tatarica,and Lonicera* x *bella*
Hypoxylon fungus	*Hypoxylon* spp.
Jack pine	*Pinus banksiana*
Jack pine budworm	*Choristoneura pinus*
Japanese barberry	*Berberis thunbergii*
Japanese knotweed	*Polygonum cuspidatum*
Juneberries	*Amelanchier* spp.
Lake emerald	*Somatochlora cingulata*
Lake sturgeon	*Acipenser fulvescens*
Lake trout	*Salvelinus namaycush*
Large water-starwort	*Callitriche heterophylla*
Largemouth bass	*Micropterus salmoides*
Le Conte's Sparrow	*Ammodramus leconteii*
Leafy spurge	*Euphorbia esula*
Leafy white orchis	*Platanthera dilatata*
Least darter	*Etheostoma microperca*
Lesser wintergreen	*Pyrola minor*
Lincoln's Sparrow	*Melospiza lincolnii*
Little goblin moonwort fern	*Botrychium mormo*
Longear sunfish	*Lepomis megalotis*
Mallard	*Anas platyrhynchos*
Marsh willow-herb	*Epilobium palustre*
Moor rush	*Juncus stygius*
Mottled darner	*Aeshna clesydra*
Mourning Warbler	*Geothlypis philadelphia*
Muskellunge	*Esox masquinongy*
Nelson's Sparrow	*Ammodramus nelsoni*
North American river otter	*Lontra canadensis*

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Appendix 14.J, *continued.*

Common name	Scientific name
Northeastern bladderwort	*Utricularia resupinata*
Northern Goshawk	*Accipiter gentilis*
Northern Harrier	*Circus cyaneus*
Northern pike	*Esox lucius*
Northern pin oak	*Quercus ellipsoidalis*
Northern red oak	*Quercus rubra*
Northern Saw-whet Owl	*Aegolius acadicus*
Northern white-cedar	*Thuja occidentalis*
Norway maple	*Acer platanoides*
Oaks	*Quercus* spp.
Oak wilt fungus	*Ceratocystis fagacearum*
Orange hawkweed	*Hieracium aurantiacum*
Osprey	*Pandion haliaetus*
Palm Warbler	*Setophaga palmarum*
Peat moss	Genus *Sphagnum*
Phellinus fungi	*Phellinus* spp.
Pin cherry	*Prunus pensylvanica*
Pines	*Pinus* spp.
Pine sawfly	*Neodiprion* spp., *Diprion* spp.
Pine Siskin	*Spinus pinus*
Pirate perch	*Aphredoderus sayanus*
Pond lilies	*Nymphaea odorata* and *Nuphar* spp.
Pondweeds	*Potamogeton* spp.
Pugnose shiner	*Notropis anogenus*
Pumpkinseed	*Lepomis gibbosus*
Purple loosestrife	*Lythrum salicaria*
Pygmy snaketail	*Ophiogomphus howei*
Quaking aspen	*Populus tremuloides*
Rainbow smelt	*Osmerus mordax*
Red Crossbill	*Loxia curvirostra*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Red pine pocket mortality fungi	*Leptographium procerum* and *L. terrebrantis*
Red-shouldered Hawk	*Buteo lineatus*
Redside dace	*Clinostomus elongatus*
Reed canary grass	*Phalaris arundinacea*
Ring-necked Duck	*Aythya collaris*
Robbins' spike-rush	*Eleocharis robbinsii*
Ruffed Grouse	*Bonasa umbellus*
Rusty crayfish	*Orconectes rusticus*
Sandhill Crane	*Grus canadensis*
Scrub oak	*Quercus ellipsoidalis*
Sedge Wren	*Cistothorus platensis*
Shore sedge	*Carex lenticularis*
Showy lady's-slipper	*Cypripedium reginae*
Silver maple	*Acer saccharinum*
Smallmouth bass	*Micropterus dolomieu*
Snowshoe hare	*Lepus americanus*
Southern bog lemming	*Synaptomys cooperi*
Speckled alder	*Alnus incana*
Spotted knapweed	*Centaurea biebersteinii*
Spruces	*Picea* spp.
Spruce Grouse	*Falcipennis canadensis*
Sugar maple	*Acer saccharum*
Swainson's Thrush	*Catharus ustulatus*

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Appendix 14.J, *continued.*

Common name	Scientific name
Swamp-pink orchid	*Arethusa bulbosa*
Tamarack	*Larix laricina*
Trumpeter Swan	*Cygnus buccinator*
Two-lined chestnut borer	*Agrilus bilineatus*
Veery	*Catharus fuscescens*
Walleye	*Sander vitreus*
Watercress (nonnative)	*Nasturtium officinale*
Water-shield	*Brasenia schreberi*
White birch	*Betula papyrifera*
White oak	*Quercus alba*
White pine blister rust fungus	*Cronartium ribicola*
White spruce	*Picea glauca*
White-tailed deer	*Odocoileus virginianus*
White-winged Crossbill	*Loxia leucoptera*
Wild parsnip	*Pastinaca sativa*
Wild rice	*Zizania* spp.
Willows	*Salix* spp.
Wood Duck	*Aix sponsa*
Wood turtle	*Glyptemys insculpta*
Yellow birch	*Betula alleghaniensis*
Yellow perch	*Perca flavescens*
Yellow Rail	*Coturnicops noveboracensis*

[a]The common names of birds are capitalized in accordance with the checklist of the American Ornithologists Union.

Appendix 14.K. *Maps of important physical, ecological, and aquatic features within the Northern Highland Ecological Landscape.*

- Vegetation of the Northern Highland Ecological Landscape in the Mid-1800s
- Land Cover of the Northern Highland Ecological Landscape in the Mid-1800s
- Landtype Associations of the Northern Highland Ecological Landscape
- Public Land Ownership, Easements, and Private land Enrolled in the Forest Tax Programs in the Northern Highland Ecological Landscape
- Ecologically Significant Places of the Northern Highland Ecological Landscape
- Exceptional and Outstanding Resource Waters and 303(d) Degraded Waters of the Northern Highland Ecological Landscape
- Dams of the Northern Highland Ecological Landscape
- WISCLAND Land Cover (1992) of the Northern Highland Ecological Landscape
- Soil Regions of the Northern Highland Ecological Landscape
- Relative Tree Density of the Northern Highland Ecological Landscape in the Mid-1800s
- Population Density, Cities, and Transportation of the Northern Highland Ecological Landscape

Note: *Go to http://dnr.wi.gov/topic/landscapes/index.asp?mode=detail&Landscape=12 and click the "maps" tab.*

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