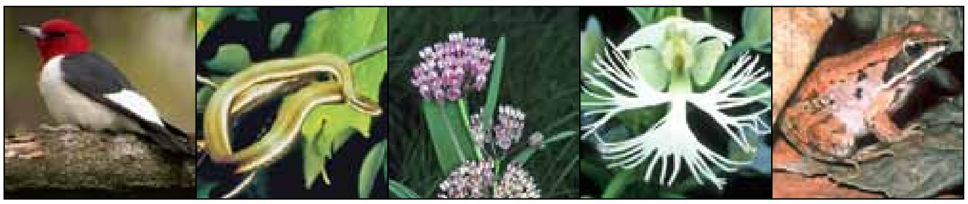
Chapter 18

Southeast Glacial Plains 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): Red-headed Woodpecker, photo by Herbert Lange; queen snake, photo courtesy of Ohio Department of Natural Resources; prairie milkweed, photo by Thomas Meyer, Wisconsin DNR; prairie white-fringed orchid, photo by Thomas Meyer, Wisconsin DNR; wood frog, photo by Dan Nedrelo.

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Cover Photos

Top left: *Prairie milkweed (*Asclepias sullivantii*) (Wisconsin Threatened) occurs almost exclusively in good quality wet-mesic prairie remnants. More populations of this prairie obligate are known from the Southeast Glacial Plains than any other ecological landscape. Photo by Thomas Meyer, Wisconsin DNR.*

Bottom left: *Oak Opening and diverse tallgrass prairie remnant. Southern Kettle Moraine region, western Waukesha County. Photo by Eric Epstein, Wisconsin DNR.*

Top right: *The floodplain of the lower Wolf River supports large stands of bottomland hardwoods, interdigitated with running sloughs, small ponds, and patches of marsh, sedge meadow, and shrub swamp. Waupaca County. Photo by Eric Epstein, Wisconsin DNR.*

Bottom right: *Mature mesic to dry-mesic hardwood forest features a canopy composed of sugar maple, American basswood, American beech, northern red oak, and white ash. Northern Kettle Moraine region, Sheboygan County. Photo by Eric Epstein, Wisconsin DNR.*


Robert H. Read

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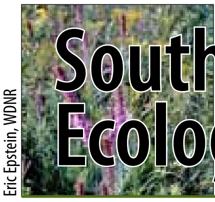


Eric Epstein, WDNR

Southeast Glacial Plains Ecological Landscape at a Glance

Physical and Biotic Environment

Size

This ecological landscape encompasses 7,725 square miles (4,943,731 acres), representing 13.8% of the area of the state of Wisconsin.

Climate

The climate is typical of southern Wisconsin; the mean growing season is 155 days, mean annual temperature is 45.9°F, mean annual precipitation is 33.6 inches, and mean annual snowfall is 39.4 inches. The climate is suitable for agricultural row crops, small grains, and pastures, which are prevalent in this ecological landscape.

Bedrock

The Southeast Glacial Plains Ecological Landscape is primarily underlain by limestone and dolomite with some sandstone and shale. The landscape is generally covered by a thick layer of glacial deposits (>50 feet). The southernmost exposures of the Silurian dolomite Niagara Escarpment occur south of Lake Winnebago.

Geology and Landforms

The dominant landforms are glacial till plains and moraines composed mostly of materials deposited during the Wisconsin glaciation, but the southwestern part of the ecological landscape consists of older, pre-Wisconsin glaciation till, and the topography is more dissected. Other glacial landforms, including drumlins, outwash plains, eskers, kames, and kettles, are also well represented. The Kettle Moraine is an area of rough topography on the eastern side of the Southeast Glacial Plains that marks the areas of contact between the Green Bay and Lake Michigan glacial lobes. Numerous excellent examples of glacial features occur and are highly visible in the Kettle Moraine.

Soils

Soils are derived from lime-rich tills overlain in most areas by a silt-loam loess cap.

Hydrology

The Southeast Glacial Plains has the highest aquatic productivity for plants, insects, other invertebrates, and fish of any ecological landscape in the state. Significant river systems include the Wolf, Bark, Rock, Fox, Milwaukee, Sugar, Mukwonago, and Sheboygan. Most riparian zones have been degraded. Several clusters of large lakes exist, including the Yahara chain of lakes in and around Madison and the Winnebago Pool system of lakes. Kettle lakes occur within end moraines, in outwash channels, and in ancient riverbeds. This ecological landscape contains some huge marshes as well as fens, sedge meadows, wet prairies, tamarack swamps, and floodplain forests. Many wetlands here have been affected by hydrologic modifications (ditching, diking, tiling), grazing, infestations of invasive plants, and excessive inputs of sediment- and nutrient-laden runoff from croplands and residential areas.

Current Land Cover

Land cover is primarily agricultural cropland (58% of the ecological landscape). Remaining forests occupy only 11% of the land area, and major cover types include maple-basswood, oak, lowland hardwoods, and conifer swamps (mostly tamarack-dominated). No large areas of upland forest exist except on the Kettle Interlobate Moraine, where the topography is too rugged to practice intensive agriculture, and the soils are not always conducive to high crop productivity. Wetlands are extensive (12% of the ecological landscape, 593,248 acres) and include large marshes and sedge meadows and extensive forested lowlands within the lower Wolf River floodplain. Forested lowlands are also significant along stretches of the Milwaukee, Sugar, and Rock rivers.

Socioeconomic Conditions

The counties included in this socioeconomic region are Calumet, Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Ozaukee, Rock, Sheboygan, Walworth, Washington, Waukesha, Waupaca, and Winnebago.

Population

The population was 2,129,491 in 2010, over one-third of Wisconsin's population (37.4%). Half of Wisconsin's residents live within 50 miles of this ecological landscape.

Population Density

223 persons per square mile

Per Capita Income

$38,934

Important Economic Sectors

Manufacturing (non-wood) (13.9%), Government (12.6%), Tourism-related (10.6%), and Retail trade (9.2%) sectors employed the most people in 2007, reflecting high non-wood manufacturing and government service. Although agriculture, residential development (and urbanization), and forestry do not have a large impact on the economy or the number of jobs, they are the sectors that have the largest impact on the natural resources in the ecological landscape (in recent years groundwater withdrawals by municipalities to accommodate urban-industrial growth have raised concerns about protecting water supplies as well as lakes, streams, and wetlands).

Public Ownership

Only 4% of the Southeast Glacial Plains is in public ownership (226,230 acres), of which 58% is wetland and 42% is upland. Major public lands include Horicon National Wildlife Refuge and Horicon State Wildlife Area and the Northern and Southern Units of the Kettle Moraine State Forest. Other state lands here are managed for fish, wildlife, natural areas, and recreation. The Cedarburg Bog, an extensive wetland complex in southeastern Wisconsin, is owned by the University of Wisconsin system and the Wisconsin DNR. County-owned lands are not extensive but include significant features, including several ecologically important stretches of the Niagara Escarpment. A map entitled "Public Land Ownership, Easements, and Private Land Enrolled in the Forest Tax Programs in the Southeast Glacial Plains" can be found in Appendix 18.K at the end of the chapter.

Other Notable Ownerships

The Nature Conservancy, in cooperation with the Wisconsin DNR and others, has a major project designed to protect the Mukwonago River watershed (including Lulu Lake) in the southeastern part of the ecological landscape. Several local land trusts have active projects aimed at protecting lands of high ecological significance. NGOs, including the Madison Audubon Society, Waukesha County Land Conservancy, Kettle Moraine Land Trust, Jefferson County Land Trust, and Friends of the Mukwonogo River, are among the groups active in local preservation efforts. NGO involvement is important statewide for many reasons but becomes especially critical in heavily developed southern Wisconsin.

View across vast Horicon Marsh, one of the most significant marsh complexes in southern Wisconsin. This site is used annually by hundreds of thousands of migratory waterbirds and provides critical nesting habitat for numerous species. Dodge County. Photo by Jack Bartholmai.

Considerations for Planning and Management

The Southeast Glacial Plains is heavily developed and highly populated. Pressure on natural resources, including ground and surface waters, is high and unlikely to diminish in the short-term. The amount of impervious surface is increasing in some watersheds, raising concerns about our ability to protect sensitive aquatic life and associated wetlands. Habitat fragmentation is severe, and isolation of native habitats is a major concern. Many invasive species are now widespread, well established, and have expanding populations here. Public ownership is limited, and partnerships between public and private partners will be essential to accomplish long-term management goals and objectives for natural resources.

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) has conducted biological inventories for the seven counties in which they have jurisdiction and identified important natural areas and sensitive species populations; all seven of the SEWRPC counties are at least partially located within the Southeast Glacial Plains Ecological Landscape. The Wisconsin DNR has also conducted biological inventory work throughout the Southeast Glacial Plains.

While in general reconnecting isolated habitat patches is a positive, and ultimately often necessary, action, when habitats lacking invasives are identified, planners and other stakeholders need to be sure that pathways for colonization by invasive species have not been created or increased and that control measures for both existing and future problems created by these species are anticipated and built into management plans and the budgeting process.

For the two units of the Kettle Moraine State Forest and at some of the larger wetland complexes (such as those at Horicon, along the lower Wolf River, Sugar, and Milwaukee rivers or in the Mukwonago River watershed), planning at large scales will have many benefits to best ensure long-term viability of the resources present because those areas offer many opportunities that smaller more isolated sites cannot.

Management Opportunities

Although large portions of the Southeast Glacial Plains Ecological Landscape are now intensively developed agricultural or urban-industrial lands, there are major opportunities to maintain natural communities and provide critical habitat for many native species. Opportunities for managing on a larger scale are limited to a few areas.

The Kettle Moraine region features the least developed uplands in the entire ecological landscape, much of it within the units of the Kettle Moraine State Forest. Collectively, the Kettle Moraine State Forest arguably comprises the largest and most ecologically important public landholding in this part of the state. The Northern Unit of the Kettle Moraine State Forest features extensive upland forests, conifer and hardwood swamps, lakes, springs, marshes, ephemeral ponds, and significant stretches of the Milwaukee River and its tributaries. This area is now southeastern Wisconsin's major breeding site for forest interior species, especially birds. There are opportunities here to develop, maintain, and enlarge blocks of contiguous forested habitat that include large patches of older mesic and oak-dominated forests, patches of young forest, dense brush, and areas where high contrast edge and associated negative impacts have been reduced.

The Southern Unit of the Kettle Moraine State Forest is a major repository of rare and diminished natural communities, especially oak savannas and woodlands, wet prairies, fens, sedge meadows, and relict bogs. Each of these is a high priority for conservation because they are rare at state or global levels, include some of the best remaining occurrences, and/or support many rare native plants and animals. Wisconsin's largest native grassland protection and restoration project, the Scuppernong River Habitat Area, is located within the Southern Unit of the Kettle Moraine State Forest. Fire suppression, successional processes, and tree planting have created blocks of forest in the Southern Unit of the Kettle Moraine State Forest that are now large enough to provide critical nesting habitat for forest interior species. Determining where to maintain such semi-natural habitats versus where to actively restore the globally rare savanna and woodland communities can be challenging and controversial, even where the protection and maintenance of biodiversity is a primary management objective.

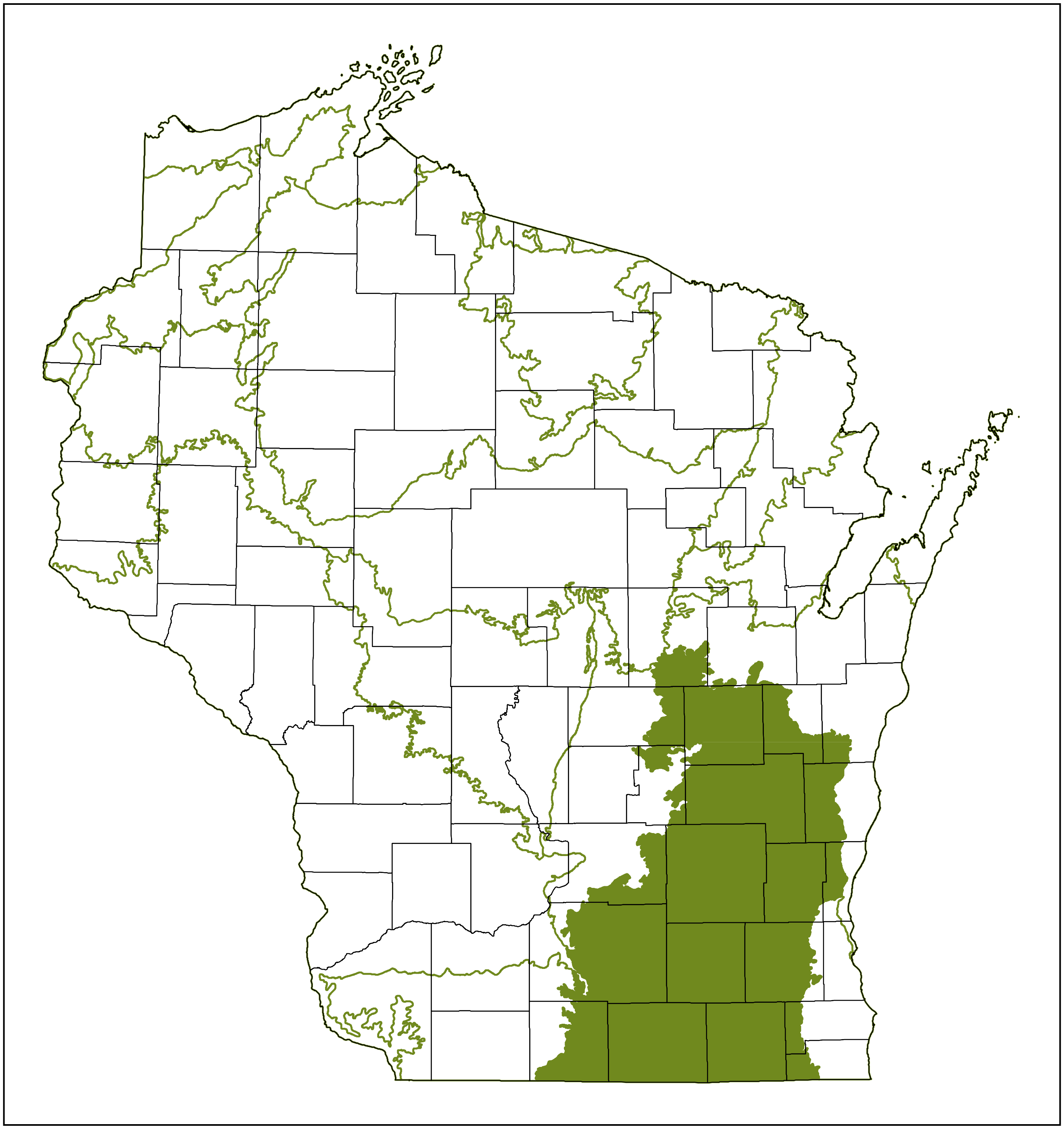
Some wetlands in the Southeast Glacial Plains are large, in good condition, and provide critical habitat for a host of sensitive species including large populations of breeding and migratory waterbirds as well as other wetland inhabitants. Emergent Marsh (including Horicon Marsh, the Upper Midwest's largest cat-tail marsh) is especially well represented, but sedge meadow, calcareous fen, wet prairie, and tamarack swamp are also important. The large complex of sedge meadow, marsh, and wet prairie associated with the White and Puchyan rivers is also outstanding in terms of size and quality. The lower Wolf River corridor features the most extensive forested floodplain in eastern Wisconsin and also one of the largest emergent marshes.

The Mukwonago River watershed is the most intact watershed in this ecological landscape because it features a spring-fed river system that supports a high diversity of fishes and aquatic invertebrates and extensive and floristically rich wetlands and because it is associated with remnant rare natural communities such as tallgrass prairie, calcareous fen, oak openings, oak woodland, and relict bogs. Many rare species have been documented here. Private and public partners are working to protect, manage, and restore many components of this watershed.

Lakes are concentrated in several areas, sometimes in association with end moraines, other times occupying glacial lakebeds and outwash channels. Shallow lakes are well represented, and some of these are associated with extensive wetlands of marsh, sedge meadow, and shrub-carr. Noteworthy warmwater streams include the Wolf, Mukwonago (some of the upper stretches are classified as "coolwater"), Rock, Crawfish, Sugar, Milwaukee, and Bark rivers. Most lakes here are now heavily developed.

Miscellaneous features of significance include southern Wisconsin's westernmost stands of mesic maple-beech forest, hardwood swamps, bog relicts, and scattered surrogate grasslands. The southern extremities of the Niagara Escarpment occur here and provide habitat for rare invertebrates and plants as well as the largest bat hibernaculum in the Upper Midwest.

Oak Opening and tallgrass prairie near Genesee, Waukesha County. Photo by Eric Epstein, Wisconsin DNR.



Southeast Glacial Plains Ecological Landscape

Drew Feldkirchner, WDNR

Southeast Glacial Plains 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 of the book, "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 of the book, "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" (see 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 the book 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 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 Characteristics

The "Environment and Ecology" and "Socioeconomic Characteristics" 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. "Southeast Glacial Plains 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 Southeast Glacial Plains Ecological Landscape covers approximately 4.9 million acres and makes up the bulk of the noncoastal land area in southeastern Wisconsin. This ecological landscape is situated entirely on glacial landforms, including till plains, interlobate moraines, and end moraines. Most of this ecological landscape is composed of glacial materials deposited during the Wisconsin glaciation, but the southwestern portion consists of older, pre-Wisconsin glaciation till, with more dissected topography. Soils are lime-rich tills overlain in most areas by a silt-loam loess cap. Agricultural and residential developments throughout the ecological landscape have significantly altered the ***historical vegetation*** and the hydrology. Many of the natural community remnants, especially the rare types, are associated with rugged moraines, wet sites, or areas where the ***Niagara Escarpment*** is at or close to the surface.

Historically, vegetation in the Southeast Glacial Plains consisted of a mix of prairie, savanna, and oak forest, with maple-basswood forests prevalent in areas less affected by wildfire. Wet and wet-mesic prairies, sedge meadows, marshes, fens, and tamarack swamps occurred in poorly drained, wetter portions of the ecological landscape. End moraines and drumlins supported prairies, savannas, and oak forest. Agricultural and urban land use practices have drastically changed the land cover of the Southeast Glacial Plains since Euro-American settlement. The current land cover is primarily agricultural cropland. The prairies and savannas are all but gone, and the remaining forests are severely fragmented and occupy only about 10% of the total land area. Important forest ***cover types*** include oak, maple-basswood, and lowland hardwoods. No large areas of contiguous upland forest exist today except on the Kettle Interlobate Moraine, which has relatively rugged topography that is ill-suited for agricultural use. In the southern Kettle Moraine, much of the historical oak savanna cover has succeeded to dense hardwood forests due to fire suppression. Only about 4% of this ecological landscape is publicly owned.

The Southeast Glacial Plains has a wide range of aquatic habitat diversity as well as relatively high levels of naturally occurring nutrients that can result in high biological productivity or biomass of plants, insects, invertebrates, and fish. It has the highest number of vertebrate Species of Greatest Conservation Need among all ecological landscapes in the state, providing major opportunities for 56 species that are significantly or moderately associated with warmwater rivers, inland lakes, and impoundments (WDNR 2005b). Significant river systems include the Wolf, Sheboygan, Milwaukee, Rock, Sugar, Mukwonago, Bark, Illinois Fox, and Green Bay Fox. Most riparian zones have been degraded when natural vegetation was removed and intensive agricultural use or urban-industrial development followed. The ecological landscape contains several large lakes, including clusters in the Madison area and in the Winnebago Pool lakes system, comprising lakes Butte des Morts, Winneconne, Poygan, and Winnebago, which is the largest inland lake in Wisconsin, covering 137,708 acres. These lakes are important to many aquatic species including the globally rare lake sturgeon. ***Kettle lakes*** are common on end moraines and in outwash channels. In addition to the huge internationally known Horicon Marsh, this ecological landscape contains other important wetlands, including other marshes, meadows, fens, tamarack swamps, and low prairies. Many of these natural communities are now rare, and they often support rare plants and animals. However, many wetlands have been altered by ditching, tiling, grazing, and infestation by invasive plants. Widespread fire suppression has facilitated the spread and increase of woody plants into oak-dominated savannas, woodlands, and forests and into rare herb-dominated communities such as fens, prairies, and sedge meadows.

Increasing the area of impermeable surface (roads, parking lots, buildings, etc.) and excessive groundwater withdrawals are major factors that have contributed to poor water quality and diminished water quantity. Impermeable surfaces tend to collect and concentrate pollutants that can quickly enter surface waters in runoff, while some pollutants can eventually filter through downslope permeable areas and contaminate groundwater. Pumping high volumes of groundwater can cause water levels to drop in lakes, streams, and wetlands. Excessive groundwater withdrawal can also increase concentrations of naturally occurring radium and other radionuclides in deep aquifers of southeastern Wisconsin (USGS 2008).

Although the Southeast Glacial Plains counties are densely populated compared to other areas of the state, agriculture is very important and constitutes the major land use throughout most of this ecological landscape. Among the ecological landscape county approximations, it ranks first in the total number of acres and third in percentage of acreage in farmland (farmland includes all land under farm ownership such as cropland, pastureland, and woodland), market value of agricultural products per acre, and milk production per acre; it ranks second in the amount of corn produced. The percentage of agricultural land sold and diverted to other uses is below average. Recreation is also important in the Southeast Glacial Plains counties. It has the highest number of fishery and wildlife areas, the second highest number of state parks and forests (though the total public land acreage is low—573,000 acres, or 11.6% of all land and water), and one of the highest ratios of water to land surface area. Per capita water use is near average. The Southeast Glacial Plains counties are economically prosperous with a well-educated and racially diverse population. The population density (223 persons per square mile) is about twice that of the state as a whole (105 persons per square mile), the second highest population density among the ecological landscape county approximations. The Southeast Glacial Plains counties have the third lowest population of older adults (over 65) while the proportion of nonwhites, especially Hispanics and African Americans, is one of the highest. The per capita income, average wage, and number of high school and college graduates are all third highest, while the rates of poverty and unemployment are both third lowest among the ecological landscape county approximations. The manufacturing sector is relatively strong, whereas farming, though a major economic activity and very productive, does not provide a large percentage of jobs.

Environment and Ecology

Physical Environment

Size

The Southeast Glacial Plains Ecological Landscape encompasses 7,725 square miles (4,943,731 acres), representing 13.8% of the state's total area. This is the third largest ecological landscape in the state.

Climate

Climate data were analyzed from 24 weather stations within the Southeast Glacial Plains Ecological Landscape (Clinton, Ripon, Afton, University of Wisconsin-Madison Arboretum, Arlington University Farm, Beaver Dam, Beloit, Brodhead, Burlington, University of Wisconsin-Madison's Charmany Farm, Chilton Sewage Plant, Fond du Lac, Fort Atkinson, Hartford, Horicon, Lake Geneva, Lake Mills, Madison, Oconomowoc, Oshkosh, Plymouth, Watertown, West Bend, and Whitewater; WSCO 2011).

The Southeast Glacial Plains has a continental climate, with cold winters and warm summers, similar to other southern Wisconsin ecological landscapes (Central Lake Michigan Coastal, Central Sand Plains, Central Sand Hills, Southern Lake Michigan Coastal, Southwest Savanna, Western Coulees and Ridges, and Western Prairie). Ecological landscapes in the southern half of the state tend to have longer growing seasons, warmer summers, warmer winters, and more precipitation than the ecological landscapes further north. Ecological landscapes adjacent to the Great Lakes generally tend to have warmer winters, cooler summers, and higher precipitation, especially snow. The Southeast Glacial Plains is more than 100 miles from south to north, and the climate varies considerably across this latitudinal gradient, along with variation in climate resulting from local topography and other factors. Overall, the climate (temperature, growing degree days, and precipitation) here is suitable for agricultural use row crops, small grains, and pastures, which are prevalent land uses in this ecological landscape (58% of the area).

With an average of 155 growing degree days (base 32°F), the Southeast Glacial Plains has the third longest growing season of any of Wisconsin's ecological landscapes. Only the Southern Lake Michigan Coastal and Central Lake Michigan Coastal ecological landscapes, both influenced by Lake Michigan, have longer growing seasons. The growing season ranges from 135 to 175 days across the ecological landscape, and it is unclear what causes this variation, although local topography may be an important factor.

The average annual temperature is 45.9°F (it varies from 44.4°F to 48.8°F). Although it is generally colder in the northern part of the ecological landscape, local topography may also influence temperatures. The average January minimum temperature is 5.7°F, 2.5 degrees higher than the mean for other southern ecological landscapes. The average August maximum temperature is 81.2°F, similar to other southern ecological landscapes (80.9°F).

Mean annual precipitation and snowfall is similar to other ecological landscapes in southern Wisconsin. Mean annual precipitation is 33.6 inches (ranging from 31.1 to 36.6 inches), and mean annual snowfall is 39.4 inches. Snowfall varies considerably among weather stations in this ecological landscape, ranging from 20.8 inches in Clinton to 61.4 inches in Plymouth. Although there are exceptions, the general trend is for more snowfall at weather stations in the northern part of the ecological landscape and less to the south. Part of this variability is likely due to observer differences and optional methods employed at some volunteer weather stations (Kunkel et al. 2007).

Bedrock Geology

The Southeast Glacial Plains Ecological Landscape is large, and many parts of its geology have not been thoroughly investigated; thus, there is not a compiled source that provides information about bedrock for the entire area. Approximately the eastern third of the ecological landscape is underlain by Silurian dolomite of the Niagara Formation, and most of the rest of the area is underlain by Ordovician dolomite (Evans et al. 2004). Some limestone, sandstone, and shale are present within these rock layers. The Niagara Escarpment is exposed as dolomite cliffs, which in this ecological landscape are especially prominent in Calumet, Fond du lac, and Dodge counties (WDNR 2002a). Cambrian sandstones, including some strata of dolomite and shale, underlie the far western edge of the ecological landscape and are exposed in the valleys of the Rock and Sugar rivers. Precambrian quartzite outcrops are localized in Dodge and Jefferson counties, and a few exposures of rhyolite and granite occur near the northwestern border of the ecological landscape (Smith 1978, Clayton 2001). Bedrock is overlain by 50 feet to more than 400 feet of glacial sediment in most of the area, and outcrops are scarce and not extensive. (Nomenclature used herein is according to the Wisconsin Geological and Natural History Survey Open-File Report *Bedrock Stratigraphic Units in Wisconsin;* WGNHS 2006.)

The oldest and deepest bedrock is Precambrian granite or quartzite that is more than a billion years old. This ancient bedrock is covered with layers of Paleozoic sedimentary rock up to 1,600 feet thick at the eastern edge of the area but is only about 280 feet thick in southern Waushara County (Summers 1965, SEWRPC 1997). The Precambrian surface slopes downward to the east and south, where its elevation is over 800 feet below sea level. Elevations are higher toward the northwestern part of the Southeast Glacial Plains where the Precambrian surface occurs at elevations of around 400 feet above sea level (and within about 400 feet below the land surface). Occasional outcrops rise to over 900 feet of elevation, so the depth to Precambrian bedrock and the thickness of the overlying Paleozoic and Silurian bedrock is highly variable within the ecological landscape. A contour map of the buried Precambrian bedrock surface is shown in Smith (1978).

Paleozoic bedrock is made up of sandstones, dolomite, siltstone, and shale, and Silurian rock is dominantly dolomite (Figure 18.1). The rock sequences were formed by cycles of marine deposition followed by erosion, occurring over approximately 80 million years. A description of these cycles and the marine conditions that led to formation of different rock types is given in LaBerge (1994, p. 207). Paleozoic bedrock is similar throughout southern Wisconsin, so the rock types discussed here are comparable to those of the Southwest Savanna and the Western Coulees and Ridges ecological landscapes (Dott and Attig 2004). In the Southeast Glacial Plains, as throughout most of southern Wisconsin, Cambrian sandstones are important aquifers.

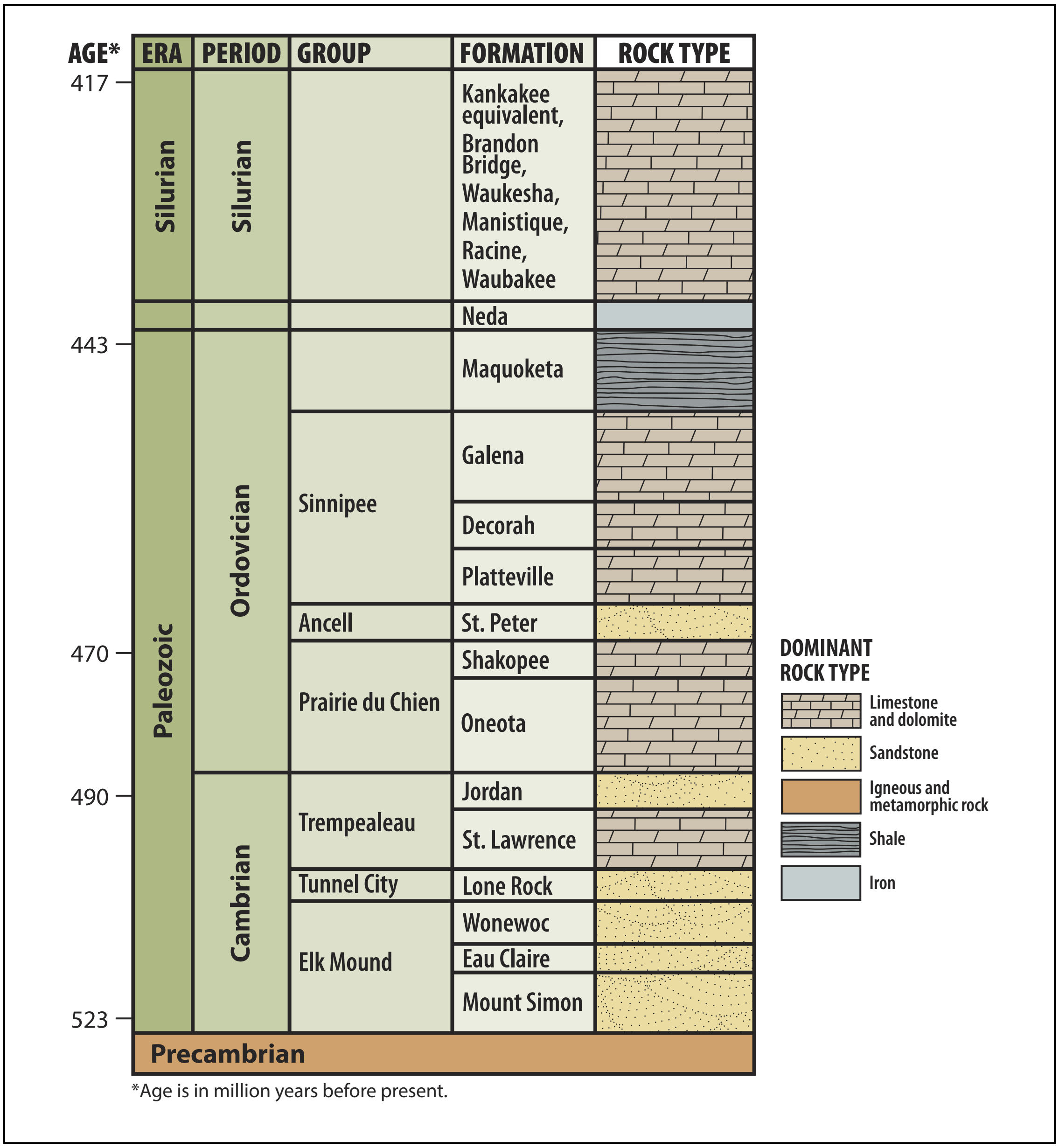


Figure 18.1. *Bedrock strata in the Southeast Glacial Plains Ecological Landscape. Diagram based on WGNHS (2006) and Evans et al. (2004).*

The oldest Paleozoic rock in the ecological landscape is Cambrian sandstone of the Elk Mound Group, deposited starting around 520 million years ago when Cambrian seas first spread into Wisconsin from the south and west. These seas eventually covered the entire state but were shallower over the ***Wisconsin Dome***, and consequently the Cambrian bedrock thins as the dome's surface rises. The Elk Mound Group includes the Mount Simon, Eau Claire, and Wonewoc formations. The Mount Simon Formation overlies Precambrian bedrock at the base of the Paleozoic sequence. It is a thick deposit beneath most of the Southeast Glacial Plains Ecological Landscape, 300 to 1,500 feet thick in Waukesha County (Clayton 2001) and up to 800 feet thick in Columbia County (Harr et al. 1978). The Mount Simon Formation is a light colored, fine- to coarse-grained, thick-bedded sandstone with some dolomite and shale. It was deposited from a shallow marine environment as Cambrian seas advanced over the area (Borman and Trotta 1975). The Eau Claire Formation overlies the Mount Simon. It was deposited in a quieter marine environment as oceans rose to a greater depth. The Eau Claire Formation is fine- to medium-grained, thin- to medium-bedded, yellow or brownish sandstone, fossiliferous, and contains shale. After this phase of deposition, the seas retreated, and the surface of the Eau Claire Formation was eroded (Schultz 2004). Above the Eau Claire Formation lies the Wonewoc Formation, deposited in nearshore environments as the seas readavanced. It is a fine- to medium-grained, thick-bedded, brownish-yellow to yellow or white sandstone, likely deposited on broad tidal flats (Thwaites et al. 1922).

Bedrock of the Elk Mound Group is up to 1,300 feet thick in central Waukesha County but thins to the northwest. Most of the thickness is made up of the Mount Simon Formation; the Eau Claire and Wonewoc formations are thinner (Clayton 2001).

The Wonewoc Formation grades gradually into the overlying Lone Rock Formation, part of the Tunnel City Group. The Lone Rock Formation is very fine- to fine-grained, glauconitic (i.e., micaceous, containing an iron silicate), thin- to medium-bedded light brown to green-brown sandstone. Fossils of trilobites and brachiopods can be found locally in this sandstone, indicating marine deposition.

The discontinuous Mazomanie Formation, occurring only in the northwestern part of the ecological landscape, is made up of very fine- to medium-grained feldspathic and quartzose sandstone and sandy dolostone. In other areas, only the Lone Rock Formation occurs (Odom 1978).

The St. Lawrence Formation, part of the Trempealeau Group, occurs in a thin layer above the Lone Rock Formation. It was formed from sand and the shells of marine organisms and includes thin-bedded sandy dolomite, dolomitic sandstone, and dolomitic siltstone. It has a variable thickness, possibly due to irregularities of the underlying surface, variable deposition, or erosion following deposition. Fossils of trilobites and brachiopods can be abundant in the St. Lawrence but are mostly fragmented from transport before settling. Again, after this phase of deposition, the seas retreated, and erosion of the surface occurred.

Jordan Formation sandstone overlies the St. Lawrence Formation. It is fine- to coarse-grained, light brown to brownish-yellow, moderately sorted, quartz, thick-bedded sandstone that ranges in thickness, likely due to uneven deposition (Thwaites et al. 1922, Evans 2003). It is not known to contain fossils, and this, along with the pattern of bedding, indicates that deposition may have occurred on a sand flat covered by water at times, with some material deposited by wind.

Cambrian rocks are thick in parts of the ecological landscape; for example, they are more than 1,000 feet thick in the southwest corner of Jefferson County (Borman and Trotta 1975). Paleozoic rocks (Cambrian and Ordovician) are approximately 1,000 feet thick beneath Dane County (Clayton and Attig 1997) and range from about 1,000 to more than 1,500 feet thick in Rock County (Zaporozec 1982) and from less than 650 to more than 1,300 feet thick in Waukesha County (Clayton 2001).

Ordovician rocks overlying Cambrian deposits include discontinuous occurrences of dolomite of the Oneota Formation of the Prairie du Chien Group. The Oneota Formation consists of fine- to medium-crystalline, thin- to thick-bedded, pale gray to light brownish-gray dolomite, sandy dolomite, and dolomitic sandstone. Its thickness in Waukesha County is reported as "a few meters" (Clayton 2001). The dolomite contains cavities in which calcite and quartz has developed, and chert is also abundant. Fossils of algal reefs (Cryptozoa) are common in the dolomite, and other fossils can be found in the chert. The Prairie du Chien's surface is dissected by erosion that occurred after this stage of deposition, and in some places the deposit was completely removed (Borman and Trotta 1975, Schultz 2004).

The Ancell Group is next in the sequence, overlying the Prairie du Chien Group (or overlying other Cambrian layers, in locations where the uppermost rock layers were completely eroded, some all the way down to the Elk Mound Group). A layer of red clay and chert residuum between the Prairie du Chien and the Ancell provides additional evidence that weathering occurred for some time before deposition resumed. The Ancell Group is mostly sandstone of the St. Peter Formation; in Waukesha County, its thickness ranges from 65 to 200 feet. The St. Peter Formation consists of fine-to-medium grained, white to yellow quartz-rich, thick-bedded sandstone with some limestone, shale, and conglomerate. It can be thick but in many areas was partially or completely eroded after deposition. Rocks of the St. Peter Formation and the Prairie du Chien group, along with smaller areas of Cambrian rock, make up the topmost bedrock layers in most of the western third of the ecological landscape.

Sinnipee Group dolomite, including the Platteville, Decorah, and Galena formations, overlies the Ancell Group. Sinnipee Group rocks are firm dolomites with some limestone and shale, overlain by the Maquoketa Formation of dolomitic shale. These groups can each be as much as 200 to 250 feet thick (Clayton 2001, Evans et al. 2004). The Neda Formation, made up of hematitic oolite (iron-rich nodules formed around sand grains or bits of fossilized shell) and dolomitic shale, forms a thin layer atop the Maquoketa in some locations (Evans et al. 2004). The Sinnipee, Maquoketa, and Neda rocks make up the topmost bedrock layers to the west of the Silurian dolomite deposits, in approximately the middle third of the ecological landscape. Sinnipee Group rocks are most commonly the topmost, as much of the Maquoketa and Neda formations were removed by erosion, and the Neda Formation may have originally been bar deposits that only formed in a few favorable locations rather than a continuous layer (Borman and Trotta 1975, Paull and Paull 1977).

The Neda Formation is locally well known for the abandoned Neda mining district in Dodge County, about 3 miles south of the town of Mayville (Paull and Paull 1977). Hematitic oolite was mined here for its iron content from 1849 until 1928. Although the Neda Formation occurs at only a few locations in eastern Wisconsin, it is up to 37 feet thick in the Neda mining area and extends northward for almost 3 miles from the former mine's main entrance. Mining was an important and profitable industry here for many years; in 1906 two smelters produced 400 tons of ore per day. Altogether, more than 3.5 million tons of ore was removed and much still remains, but the phosphorous content of the oolite makes it undesirable for the quality needed in modern steel. Today the mines are abandoned and the furnaces dismantled.

Silurian dolomite is the upper layer of the bedrock sequence in the eastern part of the Southeast Glacial Plains Ecological Landscape. It is up to 330 feet thick in east central Waukesha County. The deposit was eroded and abraded during glaciation and thus thins to the west, ending in a line that runs roughly south from Lake Winnebago (Calumet, Winnebago, and Fond du Lac counties) to the Illinois state line (Clayton 2001). Silurian outliers such as the one atop west Blue Mound signify that the Silurian seas likely covered Wisconsin and that these deposits were widespread prior to erosion. Evans et al. (2004) described the Silurian deposits as consisting of six different formations, including the Kankakee Equivalent (the oldest), Brandon Bridge, Waukesha, Manistique, Racine, and Waubakee. Each of the formations is dominantly dolomite, but there are differences in grain size, mineral content, color, and bedding. The Racine Formation is fossiliferous and well known for its many ancient reefs. The Silurian reefs are found in a ring around the Michigan basin but are most common in areas between Green Bay and Racine and south of Chicago into Indiana (Dott and Attig 2004). Reef mounds are well known in the Milwaukee area (see Chapter 19, "Southern Lake Michigan Coastal Ecological Landscape"), but smaller reefs also occur in the northeastern part of this ecological landscape (for example, reef materials are found in a quarry west of Grafton in Washington County) (also see map in Dott and Attig 2004, p. 240). The Milwaukee reefs contain fossils of over 200 different species, dominantly the spongelike stromatoporids, now extinct, along with corals and bryozoans (Dott and Attig 2004). Racine Formation dolomite from inter-reef locations has been extensively quarried to produce the attractive "Lannon stone," popular in southern Wisconsin landscaping.

Landforms and Surficial Geology

The land surface of this ecological landscape was primarily formed by glaciation, and glacial features are a highlight here because they are of global significance. A relatively rugged interlobate glacial moraine (the Kettle Moraine) runs southwest to northeast across this area. Till plains and moraines are common, and outwash features also occur, mostly in channels between morainal ridges. Interesting features like drumlins, ***kames***, and kettles are relatively common. There are nearly 1,000 drumlins in Waukesha County alone (Clayton 2001), and extensive drumlin fields also occur in Jefferson, Dodge, and Fond du Lac counties.

Most of the Southeast Glacial Plains Ecological Landscape is covered in glacial deposits originating from the Green Bay Lobe during the late Wisconsin ice advance, but the eastern portion of the land surface was deposited by the Lake Michigan Lobe, and the southwest portion is mantled in older, pre-Wisconsin till. Glacial sediment is typically less than 50 feet thick except in the eastern part of the ecological landscape, where the bedrock surface slopes downward to the Michigan Basin. Here, glacial materials are often 100 to 200 feet thick, and in ancient river valleys that preceded the Wisconsin Ice Age, sediments can be much thicker. One such valley drained parts of Waukesha, Jefferson, Dodge, and Dane counties; a portion of this valley underlies what is now Lake Koshkonong (Rock, Dane, and Jefferson counties), where glacial sediments are more than 400 feet thick (Borman and Trotta 1975). Most of the ecological landscape is overlain by a silt-loam loess cap; it can be more than 4 feet thick in parts of Dane, Columbia, and Rock counties but thins to the east and is only 0.5 to 2 feet thick in Waukesha County (Hole 1976, Clayton and Attig 1997, Blumer 2006).

Glacial ice has covered this area a number of times, as evidenced by older till in the southwest part of the ecological landscape. However, the late Wisconsin advance of the Green Bay and Lake Michigan lobes, which reached their maximum extent at about 24,000 years ago, removed most evidence of previous glaciations. The Green Bay Lobe, as the name implies, moved in a south to southwestward direction through the low-lying and softer sediments of Green Bay. This lobe expanded as far south as Janesville; its outer edge is known as the Johnstown Moraine and forms a U-shaped curve of low hills and ridges in the southern part of the ecological landscape. Meanwhile, the large Lake Michigan Lobe moved southward through the Michigan Basin and covered much of what is now Lower Michigan, Illinois, and Indiana. Its western margin bumped up against the Green Bay Lobe, creating the dramatic topography of the Kettle Moraine. South of the Kettle Moraine, the Lake Michigan Lobe built the Darien Moraine in Walworth County. By about 19,000 years ago the two lobes began to melt, and they were gone from this area by about 12,000 years ago. Approximate time frames for glacial events in this part of Wisconsin have recently been revised based on gamma radiation levels; previous carbon-14 dating had identified more recent dates for some of these events (Hooyer 2007).

There are four distinctly different geomorphic regions within the Southeast Glacial Plains. The northern portion of the ecological landscape is within the Lake Winnebago Clay Plain Subsection (222Kc), made up of a glacial lake plain surrounded by a bedrock-cored till plain; the till plain also formed islands in the glacial lake (Cleland et al. 1997; for details on Subsections, see the "Introduction" in Part 1 and the "Ecological Landscapes, NHFEU Provinces, Sections, and Subsections" map in Appendix G, "Statewide Maps," in Part 3, "Supporting Materials.") Glacial Lake Oshkosh existed in portions of this Subsection during times when ice of the Green Bay Lobe stood in the Fox River lowland between present-day Lake Winnebago and the city of Green Bay. Surface water draining northward through the lowland became ponded in front of the ice sheet until finding other outlets, either through the ancestral Wisconsin River or eastward to the Michigan basin. The ice sheet readvanced at least two times after it had fully receded from Wisconsin, so there were three stages of Glacial Lake Oshkosh during ice retreat. The lake was at its largest extent during the first stage at about 18,500 years ago; subsequent lower stages occurred at around 16,000 and 13,500 years ago (Hooyer 2007). It left behind a nearly level lake plain formed by settling of fine-grained offshore sediment, as well as beach terraces and ridges created by wave and ice action along former shorelines. As the lake dried, winds blowing unimpeded across the lake plain deposited aeolian sands and formed dunes. Material deposited by the Green Bay Lobe during its readvances is considered part of the Kewaunee Formation, with source sediments in the Lake Michigan basin. It is reddish brown and clayey or silty, reworked from fine-grained lake sediments. The Kewaunee Formation is made up of several members, including the Chilton, Kirby Lake, Glenmore, and Middle Inlet, depending on which ice readvance deposited the material (Clayton et al. 2006). Some areas of the older Horicon Member of the Holy Hill Formation are exposed in abraded upland areas; the sandier Horicon Member underlies the more recent deposits associated with readvances of the Green Bay Lobe (Hooyer 2007).

The Southern Green Bay Lobe Subsection (222Ke), named for its correspondence with the extent of the Green Bay Lobe during the late Wisconsin glaciation, occupies the central portion of the ecological landscape. Here, rolling till plains accentuated by many well-defined drumlins define the landscape. End and ***recessional moraines*** occur near the former margins of the ice sheet, and the Kettle Interlobate Moraine is a readily identifiable glacial feature along the eastern boundary. Outwash channels and lake plains are also found here.

The till plain is predominantly the Horicon Member of the Holy Hill Formation; the Horicon Member is associated with deposition by the Green Bay Lobe. The till is described as brown, gravelly, clayey, silty sand and is notable for containing dolomite pebbles scraped up as the glacier moved over dolomitic bedrock (Clayton and Attig 1997). Soils formed in this till are rich in ***calcium*** and magnesium.

Moraines along the southern and eastern borders of the Subsection have a hummocky topography resulting from ***supraglacial till*** (material on top of the ice sheet) being deposited unevenly along the ice margin and from the collapse of the landscape after buried stagnant ice melted. Glacial action at the time of deposition is thought to have been partly controlled by preglacial drainage systems and by characteristics of the underlying bedrock. Stream sediment flowing out from melting ice sheets was either deposited on solid ground, where it retains a flat topography, or it was deposited over stagnant glacial ice and collapsed as the ice melted, resulting in hummocky topography on ***pitted outwash*** plains and collapsed heads-of-outwash. Glacial lakes formed in many parts of the area when a large quantity of water melted from the ice sheets and was held back by ice dams, bedrock ridges, and/or moraines. Sediments deposited in these lakes formed nearly level lake plains in low-lying areas. One of the largest glacial lakes was Lake Scuppernong, thought to have covered most of Jefferson County and parts of adjacent counties, depositing layers of clay and silty clay in its deeper basins (Clayton 2001). Glacial Lake Yahara covered the low-lying areas of what is now the city of Madison at elevations about 15 feet higher than the current Lake Mendota (Mickelson 2007).

The Kettle Interlobate Moraine is the most significant and unusual glacial feature in this area and has long attracted the attention of geologists. The Kettle Moraine is a complex range of ridges and hills, varying in width from 1 to 30 miles and rising up to 300 feet in elevation above the surrounding landscape. The area gets its name from the "kettle" features, formed when large ice blocks were left by the receding glacier and melted away slowly to leave bowl-shaped depressions. Characteristics of the Kettle Moraine's glacial sediment and topographic features were described by Charles Whittlesey in 1851, and in the 1870s, Chamberlin developed concepts of the types of glacial activity that formed the moraine. Chamberlain described the moraine in extravagant terms: "an irregular, intricate series of drift ridges and hills of rapidly, but often very gracefully, undulating contour, consisting of rounded domes, conical peaks, winding and, occasionally, geniculated ridges, short, sharp spurs, mounds, knolls and hummocks, promiscuously arranged, accompanied by corresponding depressions that are even more striking in character" (quoted in Lasca 1970). He went on to describe the "kettles" in similar fashion, noting that although some are round, many of them are not kettle-shaped but may be oval, elliptical, or even trough-like or forming irregular winding hollows. Many have very steep sides. Chamberlain noted that all these features "give to the formation a strikingly irregular and complicated aspect."

In more technical terms, the Kettle Moraine is part of the end moraine system built at the margins of the Green Bay and Lake Michigan lobes during the late Wisconsin ice advance (Figure 18.2). This "interlobate" area between the Green Bay and Lake Michigan lobes received large volumes of meltwater and associated sediments as the glacial ice melted and shrank northward. While it contains some morainal till, the Kettle Moraine is mostly composed of sand and gravel in a sequence of outwash fans. The outwash fans are highest near the areas where the lobes met where material was deposited from both sides, but their topography is very irregular due to the collapse of sediment as buried ice blocks melted. The northern part of the Kettle Moraine features more eskers, kames, and gravelly moraine ridges, while its outwash features are narrower and more irregular than the southern kettles. Diagrams illustrating the formation of the Kettle Moraine are shown in Dott and Attig (2004, pp. 274 and 282).

The Geneva/Darien Moraines and Till Plains Subsection (222Kf) occupies the eastern portion of the ecological landscape. It was formed by the Lake Michigan Lobe and also exhibits till plains, drumlins, and outwash features. This Subsection is predominantly a till plain of the New Berlin Member of the Holy Hill Formation. The New Berlin Member was deposited by the Lake Michigan Lobe, which distinguishes it from the Horicon Member that was deposited by the Green Bay Lobe. Much of the landscape has an undulating, subglacially molded topography that includes well-defined drumlins. Braided proglacial stream sediment was either deposited on solid ground and still retains a flat topography (outwash plain) or it was deposited over stagnant glacial ice that collapsed as the underlying ice melted, resulting in hummocky topography (pitted outwash plains). Offshore glacial lake sediments formed nearly level lake plains. Postglacial stream cutting and deposition formed floodplains, terraces, and swamps along major rivers. The many swamps that occur are the result of impeded drainage caused by the underlying till and lake sediments.

In the southwest part of the ecological landscape, the Rock River Old Drift Country Subsection (222Kh) was formed in older glacial sediment of the Walworth and Zenda formations,

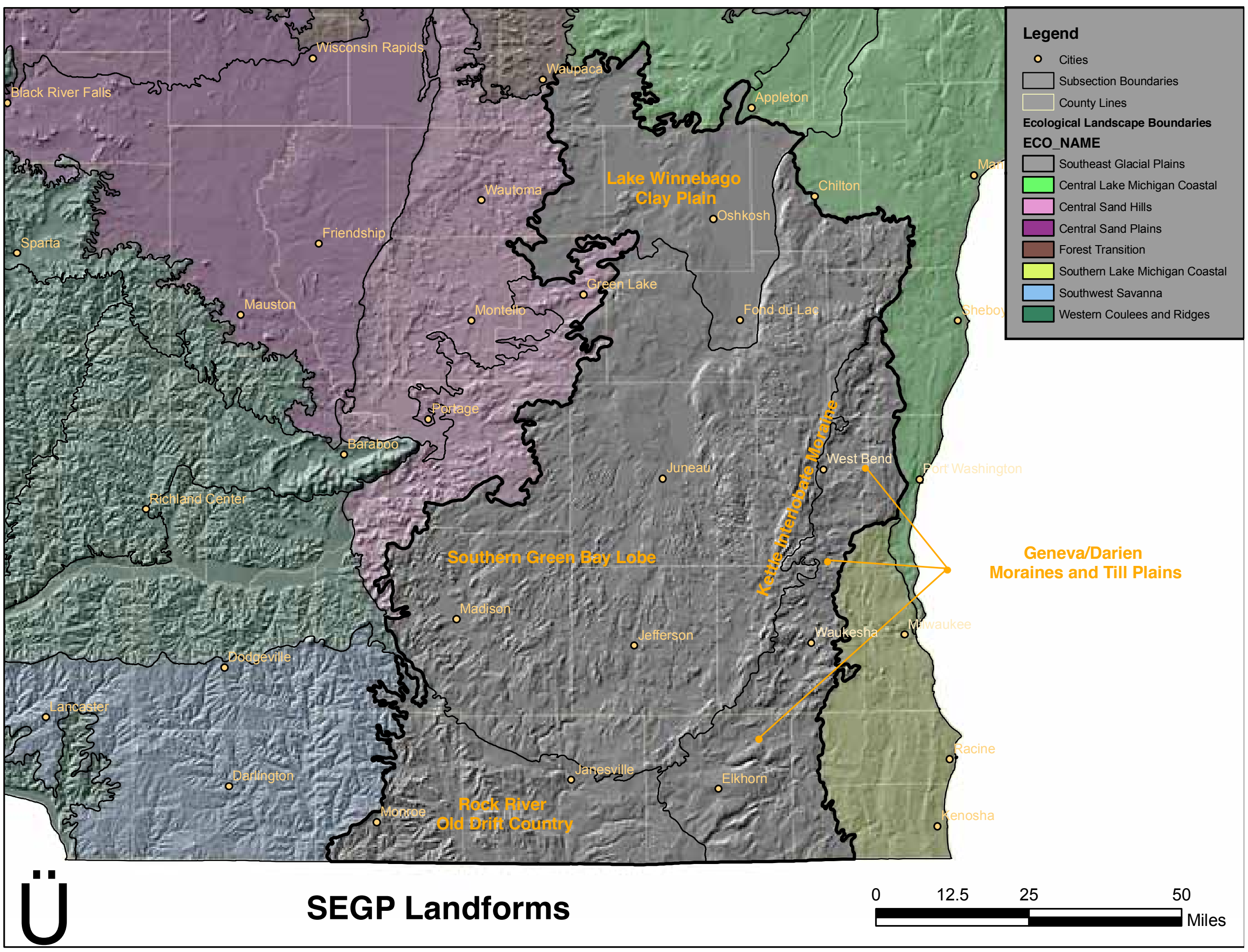


Figure 18.2. *Landform features of the Southeast Glacial Plains Ecological Landscape. Interlobate kettle moraine features are located along the boundary between the Southern Green Bay Lobe Subsection and the Geneva/Darien Moraines and Till Plain Subsection.*

which were deposited prior to the Wisconsin ice age. The glacial geology of this area has been described in some detail by Bleuer (1970). The eastern part of the Subsection has broad, flat to rolling plains (east of the Rock River), while the western portion of the area is more eroded and dissected, similar in appearance to the Driftless Area. Till plains in the eastern part of the Subsection have an undulating subglacially molded topography, while till in the western portion has rolling to hilly bedrock-controlled topography with mature erosional features. Lower portions of the area are filled with outwash deposits that originated from the Green Bay Lobe during the Wisconsin glaciation. Braided proglacial streams carried outwash material and built landforms including outwash plains, terraces, and fans. In places, offshore glacial lake sediments formed nearly level lake plains. Dissolution of bedrock by surface water or groundwater created karst topography in some areas in the western part of the Subsection (for information on karst, see Chapter 22, "Western Coulees and Ridges Ecological Landscape," and Chapter 15, "Northern Lake Michigan Coastal Ecological Landscape").

A map showing the Landtype Associations (WLTA Project Team 2002) in the Southeast Glacial Plains Ecological Landscape, along with the descriptions of the Landtype Associations, can be found in Appendix 18.K at the end of this chapter.

Topography and Elevation

Land surface elevation ranges from 686 to 1,326 feet within this ecological landscape. Topography ranges from nearly level on outwash and lake plains to undulating and rolling on till plains, to hilly and steep in the Kettle Interlobate Moraine (Figure 18.3).

Soils

Most upland soils of the Southeast Glacial Plains Ecological Landscape are brown or reddish brown calcareous glacial till ranging in texture from sandy loam to loam or clay loam. Some soils are outwash sands and gravels or lacustrine clays and sands derived from Glacial Lake Oshkosh. A mantle of silty loess, originating from wind deposition during and after glaciation, is 6 inches to more than 48 inches thick in different parts of the ecological landscape (Hole 1976). Nearly all the soils are rich in calcium carbonates derived from the underlying dolomite bedrock and are highly productive. Some of the soils have an iron content that gives them a reddish color; the iron comes from sediments transported by glaciers from the Lake Superior basin. The reddish versus brownish color of the soils is generally linked to glacial formations but is not always distinctive. The browner soils tend to be associated with the Holy Hill and New Berlin formations, while reddish ones are more typical of the Kewaunee Formation and the older Zenda Formation (Schneider 1983, Dott and Attig 2004). Upland soils range from well drained to poorly drained; they have very slow to rapid permeability and low to very high available water capacity. Most lowland soils are very poorly drained nonacid mucks, but some are silty or clayey lacustrine or loamy till soils. Soils in the larger river valleys include loamy to silty alluvium, nonacid muck, and aeolian silts over acid outwash sand and gravel. The "Soils of the Southeast Glacial Plains" map in Appendix 18.K indicates the general textures of soils in the Southeast Glacial Plains, classifying them as clayey, silty, or loamy, with many interspersed wetland soils.

Soils within the ecological landscape vary, primarily due to differences in parent materials deposited by glaciers or glacial lakes and also due to erosion and other geomorphic processes during the time since glaciation.

The Lake Winnebago Clay Plain Subsection (222Kc) has extensive areas of clayey and silty lake plain (lacustrine) deposits originating from Glacial Lake Oshkosh and some sandy deposits. The fine textures of these soils limit water drainage, so there are many wetlands in the area. The lake plains have soils formed in calcareous clayey to silty lacustrine and noncalcareous to calcareous sandy lacustrine. They range from well drained to poorly drained and generally have silty clay loam to loamy fine sand surface textures, very slow to rapid permeability, and high to low available water capacity. Most lowland soils are very poorly drained nonacid muck and clayey lacustrine. The Subsection also includes moraine uplands with soils that formed in reddish-brown calcareous sandy loam to clay loam till (soil suborder Udalfs*).* They range from well drained to somewhat poorly drained and generally have silt loam to loam surface textures, moderately slow to slow permeability, and moderate to high available water capacity. The major river valleys have soils formed in sandy to clayey alluvium or nonacid muck. River valley soils range from moderately well drained to very poorly drained and have areas subject to periodic flooding.

The Southern Green Bay Lobe Subsection (222Ke), as the name implies, was formed by the Green Bay Lobe of the Wisconsin glaciation. The dominant soils are calcareous loamy tills; there are also areas of outwash sands and gravel and silty lacustrine materials. Soils on the moraine uplands and drumlins are formed in brown calcareous sandy loam to loam till. They range from well drained to somewhat poorly drained and generally have silt loam surface textures, moderate to very slow permeability, and moderate to high available water capacity. The outwash plains have upland soils with loamy alluvium or loess surfaces over calcareous outwash sands and gravel. They range from well drained to somewhat poorly drained and generally have silt loam to loam surface textures, moderately rapid to moderate permeability, and moderate available water capacity. The lake plains have soils formed in calcareous loamy to silty lacustrine. They range from well drained to somewhat poorly drained and generally have silt loam surface textures, moderate to slow permeability, and moderate to very high available water capacity. Most lowland soils are very poorly drained nonacid muck but may also be silty and clayey lacustrine or loamy till. The major river valleys have soils formed in loamy to silty alluvium or nonacid muck; they range from moderately

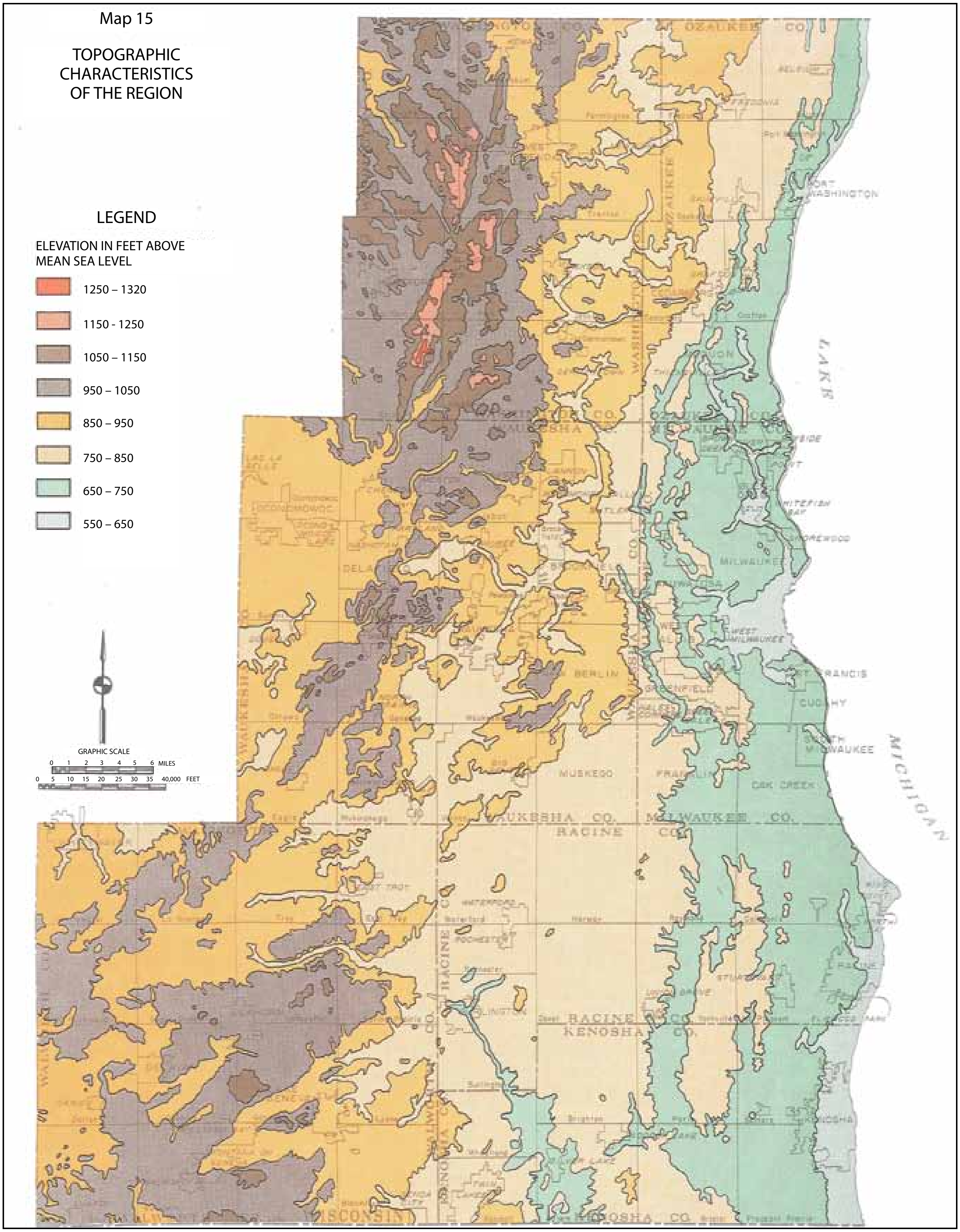


Figure 18.3. *Topographic characteristics of southeastern Wisconsin. Source: Southeastern Wisconsin Regional Planning Commission Planning Report No. 42. A Regional Natural Area and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, 1997.*

well drained to very poorly drained and have areas subject to periodic flooding.

Soils in the Geneva/Darien Moraines and Till Plains Subsection (222Kf), where the landscape was formed by the Lake Michigan Lobe, can be calcareous loamy till, outwash, or loamy lacustrine material. This area was glaciated at about the same time as the Southern Green Bay Lobe Subsection (222Ke), and landforms are similar, but the soils are slightly sandier. Moraine uplands have soils formed in brown calcareous sandy loam to loam till. They range from well drained to somewhat poorly drained and generally have silt loam surface textures, moderate to slow permeability, and moderate to high available water capacity. The outwash plains have upland soils formed in loamy alluvium or loess surfaces over calcareous outwash sand and gravel. They range from well drained to somewhat poorly drained and generally have silt loam to loam surface textures, moderately rapid to moderate permeability, and moderate available water capacity. The lake plains have soils formed in calcareous loamy to silty lacustrine. They range from well drained to somewhat poorly drained and generally have silty loam surface textures, moderate to slow permeability, and moderate to very high available water capacity. Most lowland soils are very poorly drained nonacid muck but include silty and clayey lacustrine and loamy till. The major river valleys have soils formed in loamy to silty alluvium or nonacid muck; these soils range from moderately well drained to very poorly drained and have areas subject to periodic flooding.

Landforms of the Rock River Old Drift Country Subsection (222Kh) were formed by glaciers prior to the Wisconsin ice age, and soils show the effects of erosion and other geomorphic processes that occurred during the time since glaciation (e.g., soils shallow to bedrock are found here). Also, this Subsection received outwash material that flowed from the Wisconsin glaciers, so it has more sandy soils than the rest of the ecological landscape.

Most soils formed in either calcareous loamy till or in outwash. Upland soils in the eastern part of the Subsection (to the east of the Rock River) formed in brown to reddish-brown calcareous sandy loam to loam till, in loess or loamy alluvium over calcareous outwash sand and gravel, or in calcareous silty and loamy lacustrine material. They range from well drained to somewhat poorly drained and generally have silt loam surface textures, moderate permeability, and moderate to high available water capacity. The western part of the Subsection has upland soils formed in brown to reddish-brown calcareous sandy loam to loam till, or in loamy deposits over clayey residuum over dolomite bedrock; some soils here are shallow. They range from well drained to moderately well drained and generally have silt loam surface textures, moderate to slow permeability, and moderate to high available water capacity. Soils in the major river valleys were formed in loamy to silty alluvium or aeolian material over acid outwash sand and gravel; they range from well drained to poorly drained and have areas subject to periodic flooding.

Hydrology

Information on the distribution and characteristics of water in the Southeast Glacial Plains Ecological Landscape, reported below, was distilled from a variety of sources, including U.S. Geological Survey, Wisconsin Geological and Natural History Survey, and university reports; Wisconsin DNR watershed studies, plans, and fishery reports; and historical accounts. Like the rest of the state, this ecological landscape has an abundance and wide diversity of water features.

Basins

This large ecological landscape encompasses all or parts of ten major basins: the Wolf River, Upper Fox River, Sheboygan River, Milwaukee River, Upper Rock River, Lower Rock River, Sugar-Pecatonica, the Manitowoc River subbasin of the greater Lakeshore Basin planning area, Illinois Fox River, and small portions of the Lower Wisconsin River, and the Lower (Green Bay) Fox River (see the map of "Water Basins" in "Appendix G, "Statewide Maps," in Part 3, "Supporting Materials"). Within these basins, there are 66 watersheds that lie entirely or partially within this ecological landscape. These basins drain north into the Green Bay portion of Lake Michigan, east into the main body of Lake Michigan, and southwest into the Mississippi River via the Rock and Wisconsin rivers. Invasive species, including common carp (*Cyprinus carpio*), Eurasian water-milfoil (*Myriophyllum spicatum*), and curly pondweed (*Potamogeton crispus*) are major problems in some waterbodies.

Inland Lakes

Past glaciation created hundreds of natural lakes in this ecological landscape, many of which have characteristics (e.g., size, bottom materials) that make them suitable for recreational pursuits such as fishing and boating. The glaciers deposited sand, gravel, and other firm substrates on the beds of some of these lakes, which has made many of them desirable for lakeshore home sites, marinas, and other development. The largest lakes are drainage lakes. The outlets have often been dammed to stabilize and/or raise water levels.

According to the Wisconsin DNR's 24K Hydrography Geodatabase (WDNR 2014c), the Southeast Glacial Plains has the second highest total acreage of open water of Wisconsin's 16 ecological landscapes and the second highest percentage of open water. There are 276 named lakes here occupying more than 213,000 acres as well as more than 10,000 small, unnamed lakes and ponds covering nearly 14,000 acres. Many of the large, shallow lakes in the Southeast Glacial Plains Ecological Landscape share similar hydrologic characteristics, development histories, and susceptibility to excess nutrients.

Despite heavy development pressures, a few of these lakes have retained significant natural habitat values. Others have undergone rehabilitation of both shorelines and inlet streams to improve physical habitat and water quality. Lulu Lake, a drainage lake on the Mukwonago River in Walworth County, is of particularly high ecological significance and a primary feature of the Mukwonago River watershed. Most of Lulu Lake's shoreline and stretches of the Mukwonago River and adjoining lands are within a ***state natural area*** jointly owned and managed by the DNR and The Nature Conservancy. This site supports a high diversity of fish, amphibians, and reptiles (see the "Fauna" section of this chapter for details). Lulu Lake has a mostly intact natural shoreline, a range of firm to soft bottom substrates, extensive adjoining wetlands, and a diverse aquatic invertebrate fauna.

Lake Geneva in Walworth County is a large lake with sufficient depth to support smallmouth bass (*Micropteris dolomieu*), numerous panfish, and introduced brown trout (*Salmo trutta*). It also supports the native cisco (*Coregonus artedi*), making it the southernmost "inland" lake in the Midwest to support this species. In the face of heavy development and the high recreational use attendant with being a short drive from major population centers such as Chicago, Milwaukee, and Madison, Lake Geneva remains fairly clean.

A cluster of lakes occurs in Waukesha County, northwest of the city of Waukesha. These include Okauchee, Oconomowoc, Lac La Belle, Keesus, Nagawicka, Pine, Pewaukee, and North lakes. Many of these are associated with morainal features that are generally heavily developed and intensively used. Several have good sport fish populations and are popular with anglers from across the region. Further north, in Washington County, there are additional lakes within or near a glacial moraine, including Big Cedar, Little Cedar, Silver, Pike, and others. These waterbodies are also popular as home sites and recreational destinations.

Lake Winnebago is the largest inland lake in Wisconsin, covering 137,708 acres. Occupying a portion of the bed of extinct Glacial Lake Oshkosh, Winnebago is shallow, with an average depth of only a little over 15 feet. The relatively level south and west shores are heavily developed, and several cities, including Fond du Lac, Oshkosh, and Neenah-Menasha, are located there. The more rugged, less developed east shore, runs below the Niagara Escarpment, which is marked by a strip of hardwood forest that parallels the shoreline on the steeper slopes. Lake Winnebago has been significantly impacted by urban and agricultural land uses. Lake Winnebago, along with the Winnebago Pool lakes of Poygan (Winnebago and Waushara counties), Winneconne (Winnebago County), and Butte des Morts (Winnebago County), host a large, carefully managed population of lake sturgeon (*Acipenser fulvescens*), which is a Wisconsin Special Concern species.

The Upper Winnebago Pool lakes (Butte des Morts, 8,800 acres; Winneconne, 5,400 acres; and Poygan, 14,100 acres), just above (upstream from) Lake Winnebago and the lower Fox River, were shallow basins of glacial origin that contained large riverine marshes until impoundment occurred at Neenah and Menasha on the lower Fox River in the mid-1800s to facilitate navigation between Green Bay and the Mississippi River. These extensive marshes were composed of dense stands of emergent vegetation, which, based on relatively undisturbed remnant stands fringing the lakes today, probably included bulrushes (*Schoenoplectus* spp., *Scirpus* spp., and *Bolboschoenus fluviatilis*), bur-reeds (*Sparganium* spp.), wild rice (*Zizania* spp.), arrowheads (*Sagittaria* spp.), and broad-leaved cat-tail (*Typha latifolia*). Large sedge meadows and wet prairies were among the other important wetland communities also present on the margins of the Winnebago Pool lakes. Some important remnants persist, most of them in need of restoration, management, and additional protection.

Impounding the Winnebago Pool lakes increased water depths and created large, shallow, open water lakes, greatly diminishing the extent of marshes, sedge meadows, and low prairies that were formerly abundant around these lakes. The increased water levels, coupled with wave action and extreme fluctuations due to water level management actions and further human development within the watersheds, destroyed thousands of acres of marsh, meadow, and prairie (Kahl 1993). Submergent vegetation began to expand into the newly created open water areas. These species included water-celery (*Vallisneria americana*), sago pondweed (*Stuckenia pectinatus*), other pondweeds (*Potamogeton* spp.), Canadian waterweed (*Elodea canadensis*), and coon's-tail (*Ceratophyllum demersum*). As humans converted much of the land within the watersheds to agricultural uses, the marshes, already somewhat eutrophic, became hypereutrophic. Water quality began to deteriorate, stressing the submergent vegetation. The introduction of carp in the late 1800s and early 1900s increased turbidity and further increased eutrophication by resuspending nutrient-laden sediments into the water column as carp uprooted aquatic plants as they fed. Carp also directly damaged aquatic vegetation through their feeding and spawning activities. Invasive plants such as common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*) were introduced. The combination of high water levels due to impounding, widely fluctuating water levels (especially severe flooding of extended duration during spring), external and internal nutrient loading, sedimentation, and carp drastically reduced the abundance of aquatic vegetation in all of these lakes by the 1960s. As aquatic vegetation decreased, wave action increased, becoming another factor that uprooted and decimated beds of aquatic vegetation and eroded marsh edges and shorelines (Kahl 1993).

By the early 1990s, the Upper Winnebago Pool lakes supported only small scattered stands of aquatic vegetation. Emergent species at this time included cat-tails (*Typha* spp.), common reed, hard-stem and soft-stem bulrushes (*Schoenoplectus acutus* and *S. tabernaemontani*, respectively), and stiff arrowhead (*Sagittaria rigida*). Submergent vegetation included water-celery, sago pondweed, other pondweeds, Canadian waterweed, water star-grass (*Heteranthera dubia*), coon's-tail, and Eurasian water-milfoil. Lake Poygan provided a partial exception to this pattern, supporting two large submergent beds composed mostly of wild celery covering about 500–600 hectares in the mid to late 1980s. However, by the early 1990s, one of these beds had almost completely disappeared.

Management activities on the Upper Winnebago Pool lakes have included adding riprap to shorelines and marsh edges; developing water level management plans to moderate summer water level fluctuations and reduce spring flooding; carp control; and construction of two large breakwaters to protect eroding marshes (a process referred to as "marsh recession") and submergent vegetation beds. One of the breakwaters also had several small islands constructed within it and a carp barrier at the entrance that allowed small boat passage for fishing, hunting, and other recreational activities.

Madison lies on the shore of lakes Mendota (9,740 acres) and Monona (3,274 acres), two of the four Yahara River lakes that are connected by the river; the other two (Waubesa and Kegonsa) are farther downstream. Though each lake suffers from varying degrees of eutrophication due to historical wastewater discharge and current urban and agricultural impacts, they remain heavily used by boaters, anglers, paddlers, kite boarders, ice boaters, and other recreationists. Other prominent drainage lakes in this ecological landscape include Lake Koshkonong (Jefferson, Rock, and Dane counties); Beaver Dam and Fox lakes (Dodge County); and White, Partridge Crop, and Partridge lakes (Waupaka County). Lake sturgeon have been introduced to several lakes where they were not originally found, including Big Cedar Lake in Washington County and lakes Mendota, Monona, and Waubesa in Dane County.

All of the large lakes in the Southeast Glacial Plains Ecological Landscape are heavily developed. Most of them have experienced significant water quality problems because of high sediment and nutrient loads and invasive species such as common carp, and several have been influenced and enlarged by dams. Several of these large lakes are shallow and marshy, but there has been a significant loss of wetland vegetation in many because dams have raised water levels and carp have degraded water quality by uprooting aquatic vegetation and increasing turbidity.

Some lakes here are relatively shallow and bordered by extensive wetlands, including Rush Lake (Winnebago and Fond du Lac counties), Big Muskego Lake (Waukesha County), and Horicon Marsh (Dodge and Fond du Lac counties). Several of these waterbodies are managed in part for the benefit of numerous waterfowl species and many other wetland-associated birds, mammals, amphibians, and reptiles. Big Muskego Lake has benefitted from restoration actions (e.g., in 1995, these included a drawdown and the elimination of carp, improving water quality and resulting in better fish and wildlife habitat). However, this lake is only 4 feet deep and suffers from regular winterkill of fish due to oxygen depletion. At Rush Lake, an intensive restoration effort to reestablish diverse aquatic vegetation and the fish and wildlife it supports has been ongoing in recent years (WDNR 2014e).

Lake Koshkonong was a large shallow, riverine marsh on the Rock River until impoundment in the mid to late 1800s. This large marsh supported large, dense stands of emergent vegetation, which probably included bulrushes, wild rice, cat-tail, and arrowheads. Large sedge meadows, lowland prairies, and hardwood swamps were also present.

By the early 1990s, the Lake Koshkonong watershed supported little aquatic vegetation, except in the riparian marshes. Cat-tails and some bulrushes dominated the marshy edges. Two small beds of submergent vegetation, only a few acres in size, and a few scattered plants elsewhere had managed to survive. These plants were primarily sago pondweed, coon's-tail, Canadian waterweed, and Eurasian water-milfoil. Lake Koshkonong had very high densities of common carp at this time. Lake Koshkonong management included riprapping, a water level management plan that did not control water levels successfully, and carp control by commercial fishers that did not result in the desired reductions in carp densities. For additional information, see the Lake Koshkonong Environmental Assessment (WDNR 2004).

Beaver Dam Lake's history is similar to that of lakes described above except that this glacial lake basin apparently held less permanent standing water prior to impoundment. Information on historical conditions is sketchy, and little is known about plant life for this basin. In the early 1990s, this lake supported dense stands of cat-tails along parts of the shoreline and sparse beds of sago pondweed. Aquatic vegetation was essentially nonexistent in the mid-1980s prior to a drawdown and carp and bullhead eradication project in 1986–87. Cat-tails were established along the shorelines during and after the drawdown, and the sago pondweed seed bank responded to the improved water clarity after the basin was refilled. Other management included riprapping and annual unsuccessful attempts at carp control by DNR and commercial fishers.

Urbanization has affected many of this ecological landscape's lakes during the past 50 or more years. The pressure of urbanization is ongoing, as virtually all municipalities try to attract new commercial, industrial, and residential development. Most lakes in developed areas are very fertile, eutrophic or hypereutrophic, and exhibit excessive growths of algae, often turning the water a pea green color. These developed lakes are generally very turbid and/or experience excessive aquatic plant or algae growth.

Excessively high lake fertility in the Southeast Glacial Plains Ecological Landscape is due, in part, to excess sediment and nutrient inputs from polluted runoff, which may have substantially greater initial impacts to small, shallow lakes than to larger, deeper lakes. However, lakes that are deeper and borderline mesotrophic, such as Rock Lake, Lac LaBelle, Okauchee Lake, and North Lake, may respond to additional protections to halt or at least slow water quality declines. Delavan Lake's (Walworth County) water quality was affected by excess agricultural phosphorus, carp, and nonnative vegetation but was greatly improved in the early 1990s following a water drawdown, alum treatment, and a carp eradication program. While the reintroduced game fish population remains stable and water clarity is better than in the 1980s, too much phosphorus and silt continue to enter the lake in runoff, algae blooms persist, and carp are again present, prompting calls for renewed action (Heine 2007).

Invasive plants (e.g., Eurasian water-milfoil and curly pondweed) are now impacting many lakes in this ecological landscape. See the "Invasive Species" section in this chapter.

Impoundments

The Southeast Glacial Plains has the largest area of impounded waters (including parts of the vast Horicon Marsh) of any ecological landscape in Wisconsin—234,781 acres (WDNR 2014c). There are 412 remaining dams across streams in this ecological landscape as of late 2012, while 78 former dams have been formally abandoned and removed for economic, safety, or ecological reasons over the past several decades. Another 53 former dams are documented as "informally abandoned," with no structural remnants capable of impounding a stream. A few of these dams (such as erosion control check dams) are not on streams at all (Wisconsin DNR unpublished data).

As previously mentioned, the Upper Winnebago Pool lakes (Butte des Morts, Winneconne, and Poygan) and Lake Koshkonong were large, shallow, riverine marshes until their impoundment in the mid to late 1800s. Many other riverine marshes were also converted to open water "lakes" via impoundment construction in the 1800s, and most, if not all, suffered similar, subsequent water quality problems.

The Rock, Fox, Milwaukee, Sheboygan, and Yahara are among the largest rivers in the Southeast Glacial Plains Ecological Landscape, and all are blocked by numerous large and small dams. Many of the dams on these major rivers and small streams have existed since the earliest period of Euro-American settlement, having been installed to provide power for grain mills, saw mills, and other uses. At least 30 small impoundments have been created solely for waterfowl management purposes; these were designed to help offset, in part, waterfowl losses caused by draining large natural wetlands for agriculture. However, impoundments have often caused a loss of flowing water habitat, significant loss of habitat connectivity, barriers to aquatic organisms, increases in water temperatures, and local water quality impairments. These conditions can provide spawning and other advantages to aquatic invasive species, such as the common carp and Eurasian water-milfoil.

Horicon Marsh is a huge complex of herbaceous wetland vegetation, pools, and mudflats. It is a heavily manipulated system, which is now managed to benefit migratory waterbirds and associated wildlife. Photo by Craig Wilson.

The primary water quality problems in impoundments in the Upper Rock River basin, excessive growth of algae, reduced dissolved oxygen levels, and poor water clarity (turbidity), are caused by agricultural and urban polluted runoff as well as common carp, which contribute thousands of tons of sediment and nutrients to surface waters annually (WDNR 2002b).

Lake Sinissippi (Dodge County) illustrates some of the problems with impoundments. This 2,854-acre impoundment on the Rock River, downstream from Horicon Marsh, is located in a setting dominated by wetlands. However, the peaty soils and wind effects along the shallow shoreline contributed to severe erosion that enlarged the surface water area from 2,300 acres in 1930 to its present size. The introduction of the nonnative common carp and runoff from agricultural land uses contributed to serious turbidity and eutrophication problems as well as a loss of the sport fish population. A restoration plan failed to reverse these problems in the early 1970s. As of 2012, plans for sediment removal, shoreline stabilization, and other measures to improve the lake were under consideration by the Lake Sinissippi Lake Improvement District and the U.S. Army Corps of Engineers (LSID 2012).

Rivers and Streams

The Southeast Glacial Plains Ecological Landscape is drained by 4,647 miles of perennial streams (WDNR 2014c). Due to the impacts of intensive agricultural, suburban, and urban land uses, many of the flowing waters are much more significant for their recreational, rather than ecological, values.

Based on stream surveys for aquatic invertebrates and fish, Turtle Creek (Walworth County), the Mukwonago River, the lower Wolf River, and stretches of the Milwaukee River are among the most ecologically important streams here, exhibiting a high diversity and abundance of these taxa, including many that are sensitive to degraded water quality or impaired function. Other streams prominent for fish and invertebrate diversity here include the lower Little Wolf, lower Waupaca, middle Fox, White, upper Sheboygan, Yahara, Rock, Crawfish, Sugar, and the "southeast" or "Illinois" Fox rivers. The precise ecological status of some of the smaller streams cannot be determined at this time due to the lack of systematic monitoring data for stream invertebrates and sensitive fish species (W.A. Smith, Wisconsin DNR, personal communication).

Many of the more than 1,400 springs here serve as cold water sources for scores of coldwater streams. Most of the coldwater streams with suitable habitat are designated as trout streams and are distributed throughout the eastern and southwestern portions of this ecological landscape. Notable coldwater streams in the eastern part of the Southeast Glacial Plains include Bluff (Walworth County), Mason, Genesee, Scuppernong and Paradise Springs (Waukesha County), and Palmer (Kenosha County) creeks; Brandy and Spring brooks (Waukesha County); and the upper ***reaches*** of the Mukwonago and Scuppernong rivers. High quality coldwater streams in the southwest part of this ecological landscape include upper Black Earth (Dane County), Sylvester (Green County), Story (Green County), Spring, Allen and Raccoon (Rock County) creeks, and the upper Little Sugar (Green County) and West Branch of the Sugar (Dane County) rivers. Nichols Creek (within the Nichols Creek State Wildlife Area in Sheboygan County), in the upper Milwaukee River watershed, exhibits a level of invertebrate diversity and native brook trout reproduction that is characteristic of very healthy cold streams for its first 2 miles; downstream, habitat is degraded by an impoundment and agricultural land uses that negatively impact water quality. Pond construction on headwaters springs results in increased water temperatures and a loss of trout habitat. Examples of streams where this has occurred include Gill and Irish creeks (Dodge County) in the watershed of the East Branch of the Rock River.

Several clear, coolwater streams with fast currents, including the South Branch of the Little Wolf River and the Waupaca River, support populations of rare dragonflies such as the Wisconsin Threatened pygmy snaketail (*Ophiogomphus howei*), a species occurring in streams with high water quality. The headwaters of Black Earth Creek, a well-known trout stream near Madison, originate in springs. This stream is highly vulnerable to impacts from manure spills because of the intensive agricultural practices within the watershed. This stream should be surveyed periodically for aquatic invertebrate species to monitor for changes in its habitat values. Other coolwater streams in this ecological landscape have been degraded as a result of intensive agriculture, channelization, and wetland drainage.

The upper parts of some watersheds of warmwater rivers in the northern portion of the ecological landscape are partially forested, in some cases extensively and in others only along a narrow riparian corridor, but agriculture dominates land uses in most of the Southeast Glacial Plains. Most rivers here are strongly influenced by agricultural and urban development. Siltation, channelization, loss of floodplain habitat, loss of forest cover, wetland losses, soil erosion from row crop fields, and urban stormwater runoff all degrade water quality and physical habitat and can increase water temperature. A number of the warmwater streams in the eastern half of this ecological landscape may have been coolwater streams prior to experiencing the above impacts. Large-scale removal of forest cover has been common in the eastern part of this ecological landscape and may have played a role in water temperature increases (W.A. Smith, Wisconsin DNR, personal communication).

Despite a large proportion of agricultural land and increasing levels of urbanization, there are some high quality warmwater streams in this ecological landscape, especially in areas where land cover tends to be forested or wetland dominated. Some of these streams support suites of fish and mussel species of high regional significance (see the "Fauna" section).

The lower Wolf River flows for about 20 miles through this ecological landscape, from the Waupaca-Outagamie county line to Lake Poygan. Here, the Wolf is a low-gradient, deep stream with prominent floodplain forest and a huge emergent marsh. This portion of the Wolf River approaches the lower Wisconsin and Mississippi rivers in fish and aquatic insect richness and supports important populations of Species of Greatest Conservation Need (see the "Fauna" section of this chapter). Stone riprapping by private and public land owners for sturgeon spawning and other purposes has made portions of the Wolf River less suitable for certain invertebrates and degraded the river's aesthetic values.

The middle and lower reaches of the Mukwonago River in southern Waukesha County is another outstanding example of a warmwater system. This stream consistently exhibits an index of biotic integrity (IBI) (Lyons 1992) rating of "excellent." With 32 to 40 fish species identified by sampling immediately below Phantom Lake in the village of Mukwonago (Waukesha County), this stream represents the highest fish species richness of any comparably sized stretch of stream in the state (J. Lyons, Wisconsin DNR, unpublished data). A reach of this stream is a major feature of the Lulu Lake State Natural Area, a joint watershed-scale protection and management effort of The Nature Conservancy, the Wisconsin DNR, and other partners. These lands protect an extensive area of wetlands and adjoining uplands vital to the health of the river.

Like many other watersheds in the state, the Mukwonago River watershed is threatened by increasing development and suburban sprawl. Located adjacent to metropolitan Milwaukee, Waukesha County is one of the fastest growing areas in the state. Over the last 20 years, major new residential and commercial areas have been established in this watershed, particularly in the vicinity of the village of Mukwonago. These new developments have the potential to diminish or degrade the Mukwonago River through altered hydrology (e.g., loss of springs, lowered base flows, more frequent and severe floods), reduced water quality (e.g., greater runoff of sediment, nutrients, and toxic substances) because of land use and the marked increase in impermeable surfaces within the watershed, and loss of habitat due to sedimentation and the elimination of natural riparian and in-stream vegetation (Wang et al. 1997). As of 2008, annual sampling has not revealed any measurable decline in habitat quality (J. Lyons, Wisconsin DNR, unpublished data), but there is concern over the recent presence of nonnative invasive zebra mussels (*Dreissena polymorpha*) in Lower Phantom Lake, an impounded drainage lake on the Mukwonago River.

The upper ("Green Bay") Fox River passes through this ecological landscape only in northern Green Lake, extreme southeastern Waushara, and Winnebago counties where it empties into Lake Butte des Morts. In the 1840s, naturalist Increase Lapham described the Fox as follows: "From the portage to Lake Winnebago, through which this river passes, it winds about among extensive marshes covered with tall-grass and wild rice. Below the lake there is a succession of rapids…" (WHS 2009). The Fox River valley was a desirable place to settle. Many people arrived to farm the rich, relatively level soil or to use the river for industrial power and transportation, so most of the Fox River has since been greatly altered by agricultural and urban land uses as well as navigational locks and impoundments.

The Scuppernong River originates in the Southern Kettle Moraine State Forest. The upper section is a spring-fed cold-water trout stream, which was partially restored by removing an impoundment that had been increasing water temperatures beyond the tolerance limits for trout reproduction. Scuppernong Creek (Waukesha County) is still negatively impacted by ditching and runoff from agricultural activities downstream.

Polluted runoff, hydrological modifications, and dams continue to threaten many streams and associated riparian habitats in the Southeast Glacial Plains Ecological Landscape. Streams such as Lomira, Kummel, Irish, and Gill creeks (Dodge County) and Limestone Creek and the Kohlsville River (Washington County) in the Upper Rock River watershed are negatively affected by polluted stormwater runoff, streambank grazing, erosion, channelization and other hydrologic disruptions, fragmentation by dams, and destruction of cold headwater spring flows through the excavation of headwaters ponds. As of 2013, Kummel, Irish, and Gill creeks all have approved ***total maximum daily load*** (TMDL) nutrient guidelines as part of an effort to restore diminished water quality.

Springs

There are 1,472 mapped springs in the Southeast Glacial Plains (Macholl 2007) supporting the more than four dozen coldwater trout streams and spring ponds that remain here despite high levels of urban and agricultural land use. The coldwater flow from these springs is critical for maintaining the low temperatures and high dissolved oxygen content that are vital to the health of coldwater streams, including those that support trout. These springs help support a few populations of native brook trout as well as invertebrates that cannot tolerate warm water temperatures.

Pond construction on headwaters springs has resulted in increased water temperatures on some streams and a loss of habitat for coldwater species. In addition, new urban and light industrial development is having a negative impact on many springs. There is concern that losses of coldwater flows combined with the current trend of rising global temperatures could eliminate some coldwater communities here (J. Lyons, Wisconsin DNR, unpublished data).

Wetlands

Wetlands are abundant in the Southeast Glacial Plains, with over 713,500 acres of wetlands (WDNR 2010b) covering approximately 14.4% of the surface area. Of the total wetland acreage, over 246,400 acres are forested (34.5%), approximately 126,000 are shrub dominated (17.7%), and over 330,000 are composed of herbs (46.3%) (e.g., marsh, wet meadows). Compared with Wisconsin's other ecological landscapes, this is the second largest number of wetland acres; in terms of wetland percentage, the Southeast Glacial Plains ranks 10th out of the 16 ecological landscapes). Regionally rare wetland communities such as calcareous fens, low prairies, and conifer swamps of tamarack (*Larix laricina*), northern white-cedar (*Thuja occidentalis*), and/or black spruce (*Picea mariana*) are of particular significance in this ecological landscape.

However, the current acreage, though large, represents a major loss of wetlands compared to their extent prior to Euro-American settlement. In this highly agricultural region, wetlands have been impacted by extensive ditching, tiling, channelization, and dam construction. Runoff is laden with excess agricultural and urban sediments, nutrients, and other contaminants. Large areas of wetlands were drained to provide tillable agricultural lands and create buildable real estate. The remaining wetlands provide valuable functions by maintaining stream flows and protecting the quality of both surface and ground water. Extensive wetlands are found on public lands such as Horicon Marsh, Theresa Marsh, Kettle Moraine State Forest, Lima Marsh, Rush Lake, White River Wildlife Area, Puchyan Marsh, Mud Lake (Dodge County), and several properties that comprise the Lower Wolf River Bottomlands Natural Resources Area. In addition to the general information presented below, see the "Natural Communities" section of this chapter for more detailed information about wetlands in this ecological landscape.

Open wetlands are represented by some very large (though often altered by past drainage attempts) examples of Emergent Marsh, including Horicon Marsh, the mouth of the Wolf River, and a number of other sites now managed to benefit waterfowl and other species. Some of Wisconsin's largest and least disturbed examples of Wet and Wet-mesic Prairie, Southern Sedge Meadow, and Calcareous Fen occur in the Southeast Glacial Plains.

This complex wetland mosaic includes floodplain forest, shrub swamp, sedge meadow, marsh, and numerous riverine lakes, ponds, and sloughs. Lower Wolf River, Waupaca County. Photo by Eric Epstein, Wisconsin DNR.

Shrub-dominated wetlands (mostly Shrub-carr in this ecological landscape) have increased compared with their historical abundance due to the effects of ditching and fire suppression in wet meadows, marshes, and low prairies. Although the extent of the shrub-dominated wetlands has increased, community condition is seldom high, invasive plants are often a serious problem, and future successional changes are likely to occur at many sites.

Forested wetlands are generally not extensive, though important stands occur along the Wolf River above Fremont, along the Milwaukee River in the northern Kettle Moraine, at scattered locations along the Rock River and its tributaries, Avon Bottoms along the Sugar River, and several sites along the northern margin of the Southeast Glacial Plains. Stands of forested floodplain along the lower Sugar River are contiguous with similar habitats along the Sugar in northern Illinois, presenting not only an important ecological management opportunity but an opportunity to partner across state lines.

Conifer swamps are usually dominated by tamarack or northern white-cedar and are sometimes associated with stands of lowland hardwoods, including ashes (*Fraxinus* spp.), elms (*Ulmus* spp.), red maple (*Acer rubrum*), and silver maple (*Acer saccharinum*). The organic peat and muck soils are typically saturated for most of the growing season, due to high water-retaining capacity and moving groundwater. Tamarack (or rarely, black spruce) is the dominant conifer on more acid peats and mucks, while northern white-cedar is more commonly dominant where groundwater and soils are relatively alkaline and provide more nutrients. Common and widespread in northern Wisconsin, conifer swamps are relatively rare and highly localized in southeastern and southwestern Wisconsin (this is generally true south of the ***Tension Zone***, including throughout the Southeast Glacial Plains. But the Central Sand Hills, and especially, part of the Central Sand Plains, are significant exceptions).

Tamarack Swamps were historically common in some areas, where they were often associated with areas of extensive glacial outwash or with the "kettles" found within rough, morainal deposits. The kettles, such as those found within the Kettle Moraine region, were formed as blocks of ice buried in glacial debris melted as the glaciers retreated. Following glacial retreat, the resulting depression—provided that it intersected the water table—became a lake, a marsh, or a bog-like wetland. Boggy wetlands, in which plant material decomposes more slowly than it accumulates, have been found in topographic settings as varied as the base of alluvial terraces or outwash deposits, along valley walls where sand and gravel deposits occur between glacial tills, sand and gravel deposits within abandoned stream channels, and in glacial kettle (Eslick 2001). These depressions eventually filled with partially decomposed vegetation, and a continuous layer of mosses became dominant (usually the "peat," or sphagnum, mosses), covering the surface, which supported a growth of plants now much more typical of wetlands in northern Wisconsin but rare in the southern parts of the state (FPDCC 1966).

Tamarack swamps throughout southern Wisconsin declined greatly due to logging, drainage, grazing, and ultimately, conversion to agricultural uses, especially muck farming

Intact tamarack swamp just east of the Wolf River, Waupaca County. Photo by Eric Epstein, Wisconsin DNR.

Filling this large ditch played a key role in restoration of wet prairie, sedge meadow, and fen communities in the Scuppernong River basin. Southwestern Waukesha County. Photo by Eric Epstein, Wisconsin DNR.

This muck farm was the former site of a tamarack swamp, which was drained, cleared, and converted to agricultural production. Jefferson County. Photo by Eric Epstein, Wisconsin DNR.

(Curtis 1959). In recent years, many of southern Wisconsin's remaining tamarack swamps appear to be in serious decline due to the combined impacts of hydrological disruption, insect attack, altered successional processes, and infestations of invasive plants such as glossy buckthorn (*Rhamnus frangula*) and reed canary grass. Deciduous saplings (e.g., elms, ashes, and red maple) are now common in some stands where they are replacing the conifers.

The other types of wetlands remaining here have often been affected by hydrological disruption, diminished water quality (due to sedimentation and manure and chemical runoff from agricultural uses), infestations of invasive species, lack of fire, and fragmentation. Small scattered wetlands are becoming increasingly isolated by development and are in danger of losing some of their functional values as well as irreplaceable ***ecosystem services***, such as providing habitat for fish and wildlife, retaining storm water (which can help to ameliorate floods), and serving as groundwater recharge areas.

Groundwater

Groundwater withdrawals are already a problem in parts of the Southeast Glacial Plains (Annin 2006). The intensive pumping of groundwater for industrial, commercial, and residential uses in the heavily urbanized parts of this ecological landscape has created substantial groundwater drawdown zones. This is especially prominent in Waukesha, Milwaukee, and Dane counties. The depth to water table in some of these areas has increased dramatically, to a depth of more than 450 feet in some places. This has greatly increased pumping costs passed on by water utilities and has raised concerns regarding obtaining adequate fresh water for current and projected future populations.

In Waukesha County, the lowered groundwater levels have also caused increased concentrations of radium and other radionuclides to enter the drinking water. Several ***municipal wells*** here exceed the federal drinking water standard of 15 picocuries per liter (pCi/L) for gross alpha activity due to radium (WGCC 2008). There is a concern that pursuing alternative municipal groundwater supplies would draw more water from the shallow groundwater formations, cause a reduction in stream flows and lake recharge, and dry out wetlands (Hunt et al. 2001).

In intensively developed areas, excessive groundwater withdrawal has stopped or reversed the natural recharge of lakes and streams by groundwater flows. In Dane County, numerous freshwater springs that previously supplied clean groundwater to lakes and streams have stopped flowing completely. Lake Mendota, bordering the northern and eastern parts of Madison in Dane County, used to receive plentiful groundwater. Now, the flow has reversed, and lake water is being drawn through the bedrock into the groundwater layer by ***high capacity well*** operation, posing a risk to drinking water by contamination from farm and lawn chemicals, pet wastes, agricultural nutrients, and other substances that wash into the lake. There was a short-term change in groundwater flow during the summer of 2008 in response to the heavy precipitation, but the long-term trend is as described above. Simulations show that the increase in pumping from 2000 to 2030 will have a significant effect on base flow in the county in addition to the reductions that have already occurred (Dane County Regional Planning Commission 2004).

Water Quality

A variety of threats to water quality in lakes and streams exist. Most pressing among these are agricultural and urban runoff and associated sediments and excess nutrients (sometimes from sanitary sewer overflows), elevated temperatures, ditching, channelization, industrial point source discharges, dams, hydrologic modification, construction site erosion, and gravel pits. Many lakes, in addition, are affected by invasive species such as Eurasian water-milfoil and/or zebra mussels, heavy recreational use, intensive shoreline development, and loss of habitat due to shoreline modifications and the removal of native vegetation.

For streams, many of the same threats exist as those listed above. However, wetlands adjoining streams have helped to protect water quality in some areas. In the larger river systems, water quality remains mixed. Some streams have been improving due to the cleanup or cessation of industrial discharges, while other lakes and streams continue to be negatively impacted by construction, nonpoint runoff from developed areas, and from agricultural activities. Smaller streams, however, are more vulnerable to and affected by local land uses, and many suffer from excessive siltation and nutrient runoff from row-crop fields or barnyards that may not be well managed or that lack vegetated ***buffers***, by discharges from sewage treatment plants that need upgrading, and by nonpoint runoff from impervious surfaces.

Outstanding Resource Waters (ORW) and ***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 as well as placement of structures, dredging, and other activities regulated under Chapter NR 30, Wisconsin Administrative Code. Both designations have regulatory restrictions, with ORWs being the most restricted. These designations are intended to meet federal Clean Water Act obligations and prevent lowering of water quality or degradation of aquatic habitats in these waters. They also can serve as guidelines for land use changes and human activities near these waters, to the extent that these activities can affect water quality.

Despite growing populations and stresses on water resources, several waters in this ecological landscape have been recognized as ORWs or ERWs. The ORWs here and their watersheds and counties (in parentheses) include Spring Lake (Middle Fox River, Waukesha County); Lulu Lake (Mukwonago River, Walworth County); Potawatomi Creek (White River/Nippersink Creeks, Walworth County); and Van Slyke

Creek (White River/Nippersink Creeks, Walworth County). The ERWs include Genesee Creek (Middle Fox River, Waukesha County) and the Mukwonago River (Mukwonago River in Waukesha County). Spring and Lulu lakes are designated ORW waters, being somewhat isolated and protected from some negative land use impacts and influenced beneficially by a combination of spring flows, adjoining wetlands, and partially protected uplands. A complete list of ORWs and ERWs in this ecological landscape can be found on the Wisconsin DNR's website (WDNR 2013).

Waters designated as impaired on the ***U.S. Environmental Protection Agency (EPA) 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 EPA 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. A number of waters in the Southeast Glacial Plains Ecological Landscape are 303(d) impaired waters. As of 2012, these include 140 streams, 29 inland lakes and impoundments, and 13 inland lake beaches. Most of these waters are impaired by atmospheric mercury contamination, and some streams suffer from point source contamination and physical habitat degradation.

Examples of streams in this 303(d) category include Silver (Fond du Lac and Green Lake counties), Cedar (Ozaukee and Washington counties), Honey (Green County), Van Dyne (Fond du Lac and Winnebago counties), Dorn and Starkweather (Dane County), Lannon, Poplar and Spring creeks (Waukesha County), and the Neenah (Winnebago County), Rat, Lower Wolf, South Branch of the Rock, and (southeast, or "Illinois") Fox rivers. The Pewaukee River, Sussex Creek, and a number of their tributaries (all Waukesha County) are degraded by problems that include agricultural nutrient and sediment runoff, streambank erosion, construction site erosion, ditching, and dams. Several stretches of the (Illinois) Fox River and a number of its tributaries (Poplar, Zion, and Frame Park creeks in Waukesha County) are degraded by nonpoint and point source pollution as well as physical habitat degradation (due to channelization and bank erosion caused by excessive high flows). Siltation in the (southeast) Fox River (Waukesha, Racine and Kenosha counties) prevents many organisms from thriving in its waters, despite it having fair to good water quality.

Lakes designated as 303(d) impaired include such well-known waters as Winneconne, Butte des Morts, Poygan, Mauthe (Fond du Lac County), Elkhart (Sheboygan County), Fox, Sinissippi, Lac La Belle, Monona, Mendota, Koshkonong, Whitewater (Walworth County), Winnebago, Beaver Dam, and Horicon Marsh. Most of these waters are impacted by atmospheric deposition of mercury. Some are affected by excess phosphorous and PCBs in sediments. Lake Koshkonong and Lower Barstow Impoundment are impaired by nonpoint runoff pollution. Whitewater Lake is also listed for *E. coli* contamination, The complete list of 303(d) impaired waters and criteria can be viewed at the Wisconsin DNR's impaired waters web page (WDNR 2010a). Little Muskego Lake (Waukesha County) and Wind Lake (Racine County) are impaired by nonpoint runoff pollution. Numerous other lakes in this ecological landscape also have high nonpoint source pollutant loadings. Several stretches of the (Illinois) Fox River and a number of its tributaries (Poplar, Zion, and Frame Park creeks) are degraded by nonpoint and point source pollution as well as physical habitat degradation (due to channelization and bank erosion caused by excessive high flows). Siltation in the (Illinois) Fox River prevents many organisms from thriving in its waters, despite it having fair to good water quality.

Susceptibility of streams, lakes, and groundwater to nonpoint source pollution varies significantly among watersheds. However, as of April 2006, every watershed in the Southeast Glacial Plains had a "High" susceptible rating for groundwater pollution (WGAC 2006). This is related in part to the interaction of the soils and geology of these watersheds with the agricultural, suburban, and urban land uses dominant across this ecological landscape (see Appendix 18.A at the end of this chapter).

Biotic Environment

Vegetation and Land Cover

Historical Vegetation

Several sources were used to characterize the historical vegetation of the Southeast Glacial Plains, 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 for 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). For a more detailed interpretation of the historical vegetation, especially the distribution of oak savanna and open oak woodland in seven southeastern Wisconsin counties, see Leitner's treatment in SEWRPC (1997). Additional inferences about vegetative cover were sometimes drawn from information on land capability, climate, disturbance regimes, the activities of native peoples, and various descriptive narratives. 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 (Finley 1976), the Southeast Glacial Plains Ecological Landscape in the mid-1800s contained a mixture of upland forest, oak openings, prairie, and various wetlands. Oak and mesic hardwoods (maple-basswood or, rarely, maple-beech) forest covered nearly 50% of the area; however, there was little or no coniferous forest other than tamarack and very small amounts of northern white-cedar and black spruce in the lowlands (Figure 18.4). The Southeast Glacial Plains contained one of three large blocks of mesic hardwood forest south of the Tension Zone (one of the other two large hardwood blocks was entirely within the Western Coulees and Ridges Ecological Landscape and the other straddled the Western Coulees and Ridges and Western Prairie ecological landscapes). Based on maps using tree density from PLS data, a good portion of the area Finley typed as oak forest in this ecological landscape was likely oak savanna (e.g., Rhemtulla et al. [2009] and unpublished data from D. Mladenoff). Wetlands covered approximately 17% of the ecological landscape.

The PLS information has been converted to a database format, and relative importance values (RIV) for tree species were calculated based on the average of tree species density and ***basal area*** (He et al. 2000). The sum of the RIVs for each of the individual species is 100%. Based on this analysis, oak species dominated the ecological landscape, accounting for an aggregate RIV of 71.5%. Bur oak (*Quercus macrocarpa*) (RIV of 32.3%), white oak (*Quercus alba*) (RIV of 21.9%), and black oak (*Quercus velutina*) (RIV of 13.5%) had the highest RIVs of all tree species found here. Sugar maple (*Acer saccharum*) at 6.4% was the only other tree species with an RIV higher than 5%. See the map "Vegetation of the Southeast Glacial Plains in the Mid-1800s" in Appendix 18.K for a spatial representation of these data.

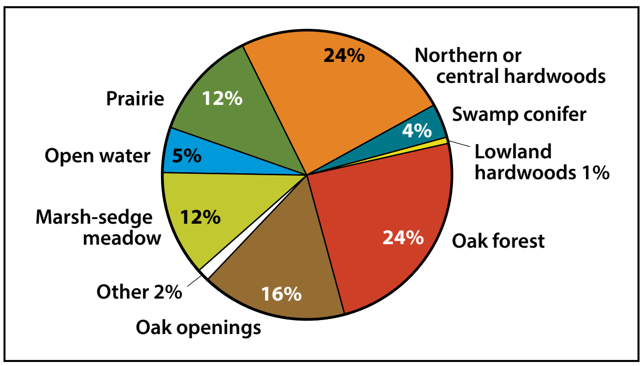


Figure 18.4. *Vegetation of the Southeast Glacial Plains Ecological Landscape during the mid-1800s as interpreted by Finley (1976) from federal General Land Office public land survey information.*

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 USDA Forest Service's Forest Inventory and Analysis (FIA), and the National Land Cover Database (NLCD) were used. Results among these data sets often differ, as 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."

Based on the most recent (1992) available satellite-derived data from WISCLAND, approximately 58% of the ecological landscape was in agricultural use at that time (WDNR 1993) (see Figure 18.5). Note that the 11% classified as "grassland" was not prairie but pasture or other (mostly) nonnative upland cover types. The Southeast Glacial Plains Ecological Landscape has the largest number of acres in agricultural use (2.8 million acres) than any ecological landscape, while it has the third highest percentage of its land in agricultural use. Nearly 26% of Wisconsin's agricultural lands are in the Southeast Glacial Plains. Agriculture now comprises the ***matrix*** land cover of most portions of the ecological landscape and often has major influences over remnant patches of other vegetation types as well as on aquatic resources.

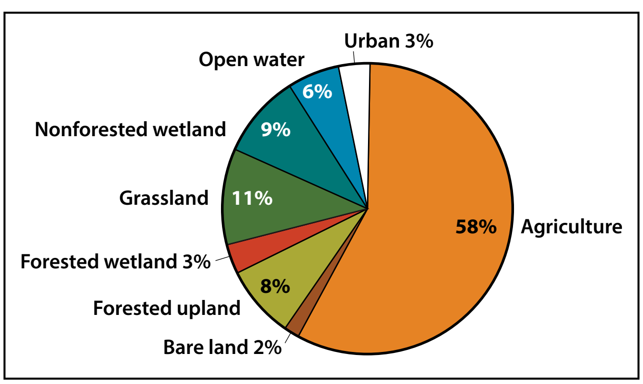


Figure 18.5. *WISCLAND land use/land cover data showing categories of land use classified from 1992 LANDSAT satellite imagery for the Southeast Glacial Plains Ecological Landscape (WDNR 1993).*

Lands in the Southeast Glacial Plains are highly productive, and agricultural use is intensive. In many areas, habitat fragmentation and isolation are severe. Photo by Eric Epstein, Wisconsin DNR.

The Wisconsin Wetlands Inventory offers a more specific assessment of wetlands than WISCLAND, but it has other limitations that result from relying primarily on air photo interpretation. According to the Wisconsin Wetlands Inventory, wetlands comprise 14.5% of the ecological landscape, or around 713,561 acres (WDNR 2010b). Emergent/wet meadow is the most abundant wetland category (this includes marshes, sedge meadows, and disturbed areas dominated by reed canary grass or common reed), covering more than 330,000 acres, followed by forested wetlands (both hardwood and coniferous) that cover approximately 246,000 acres. Shrub/scrub wetlands occur across approximately 126,000 acres. Aquatic beds occupy approximately 11,000 acres. 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." Some of the important animals associated with wetlands are also discussed in the "Fauna" section.

The U.S. Forest Service's Forest Inventory and Analysis (FIA) program is a continuous on-the-ground forest census from which point samples can be compiled, analyzed, and projected to assess the timber resources of a given area. FIA contains more information on specific forest types than WISCLAND and can be generalized for entire ecological landscapes. Because they use different sampling methods at different points in time and each has different sources of error, estimates from FIA and WISCLAND do not always agree. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information.

According to FIA data summarized in 2004, forests cover only 12% of the land area in the Southeast Glacial Plains (USFS 2004). The predominant forest cover type group is northern and central hardwoods (28% of the forested area) followed by lowland hardwoods (26%) and oak-hickory (25%). All other forest types each occupy less than 10% of the forested land area (Figure 18.6).

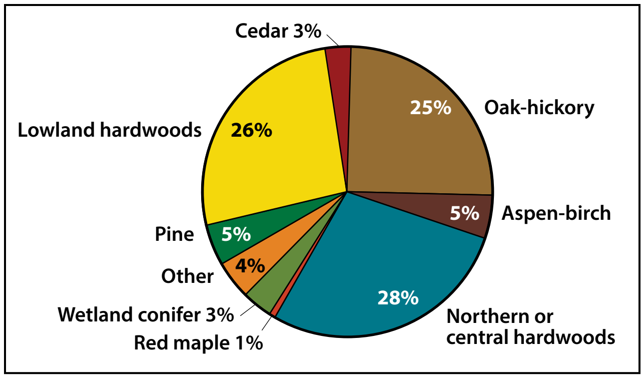


Figure 18.6. *Forest Inventory and Analysis (FIA) data (USFS 2004) showing forest type as a percentage of forested land area for the Southeast Glacial Plains Ecological Landscape. Only about 12% of the landscape is classified as forest (greater than 17% crown cover). The "pine" category includes eastern white and red pine. The "cedar" category is northern white-cedar. The "wetland conifer" category also includes northern white-cedar and other wetland conifers. See Appendix C, "Data Sources Used in the Book," in Part 3, "Supporting Materials," for more information about the FIA data.*

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 or suppressing fires). Although data are limited to a specific snapshot in time, they provide valuable insights into Wisconsin's ecological capabilities. Maintaining or restoring some lands to more closely resemble historical systems 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 be restored to historical conditions as this is not possible and not 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."

As previously noted, the total amount of forested acreage in this ecological landscape has decreased substantially as a result of conversion to agriculture and other land uses. The places where forests occur now are correlated with areas that were wet or otherwise difficult to farm (examples of the latter include the relatively extensive forests in the rough and droughty terrain of the Kettle Moraine region in the eastern part of the ecological landscape and areas along the Niagara Escarpment) or in isolated wood lots now surrounded by crop land. This likely explains at least some of the differences in species composition between today's forest and the forest of the mid-1800s in this ecological landscape. Today's remaining forested areas (based on FIA) are now primarily hardwood species (32.3% of RIV), oak species (16.2%), and elm species (10.6%) (Figure 18.7). Oak species have declined dramatically from historical levels (from 71.5% to 16.2% of RIV), while northern hardwood species have doubled (from 16.0% to 32.3% of RIV). Red maple has increased (from 0.3% to 7.4%), as have elm species (from 4.3% to 10.6%).

Because the soils, topography, and climate of the Southeast Glacial Plains made much of the area suitable for agriculture, the loss of formerly abundant and widespread natural communities was significant. Prairies have been reduced to small, scattered remnants, most of them on sites that are either too dry and infertile or too wet to practice row crop agriculture. Tallgrass prairies occupied mostly mesic sites of high fertility and very few occurrences remain. Oak savannas were historically abundant here but have declined tremendously for reasons that include conversion to cropland, prolonged periods of intensive grazing, fire suppression, and residential development.

Wetlands have decreased due to ditching, diking, tiling, and channelization. Sedge meadows and lowland prairies

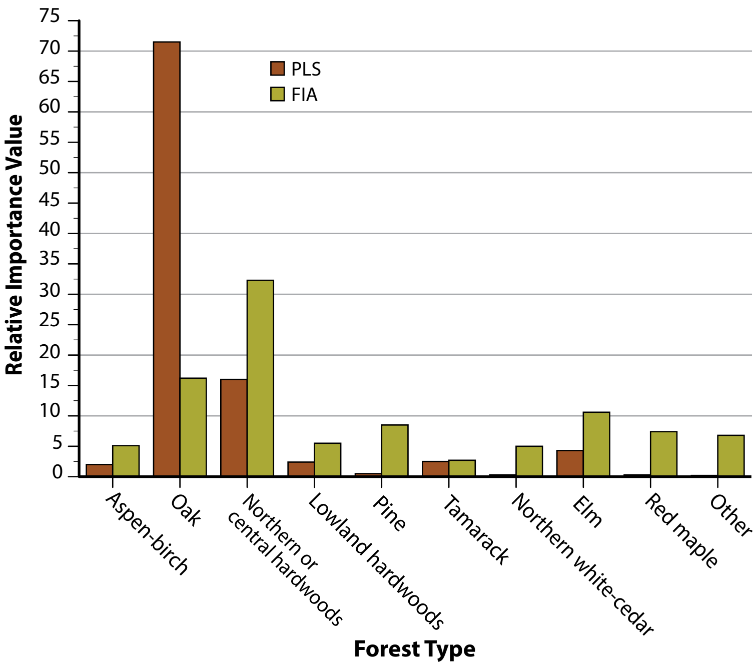


Figure 18.7. *Comparison of tree species' relative importance value (average of relative dominance and relative density) for the Southeast Glacial Plains Ecological Landscape during the mid-1800s, when the federal General Land Office public land survey (PLS) data were collected, with 2004 estimates based on 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.*

have been especially hard hit as they have been more amenable to cropland conversion when drained. These and other types of wetlands such as (wooded) swamps and marshes have been altered significantly by excessive sediment and nutrient inputs, grazing, successional processes accelerated by drainage activities, and increases in exotic, often invasive, species. In parts of the Southeast Glacial Plains, it was common to drain and clear tamarack swamps and use those areas to grow vegetables or sod.

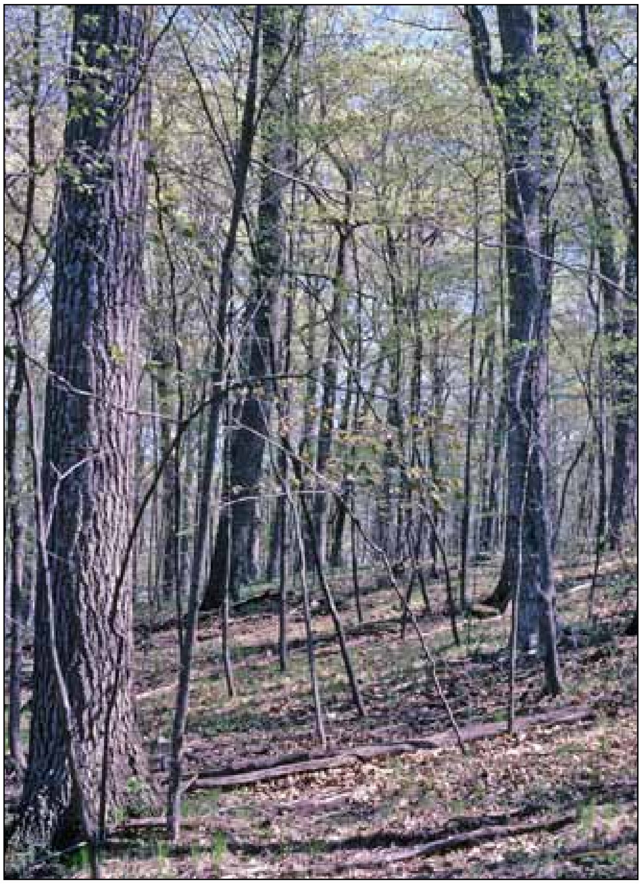
Natural Communities

This section summarizes the abundance and importance of major physiognomic (structural) natural community groups in this ecological landscape. Some of the 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 Southeast Glacial Plains Ecological Landscape, see Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin." Information and references on invasive species can be found in the "Natural and Human Disturbances" section of this chapter.

Forests. Prior to the mid-1800s, mesic to dry-mesic hardwood forests of sugar maple-basswood, sugar maple-beech, and red oak-white oak covered much of the northeastern part of the Southeast Glacial Plains, especially east of the Crawfish and Rock rivers and north of the Bark River (see the map "Vegetation of the Southeast Glacial Plains in the Mid-1800s" in Appendix 18.K). With the arrival of large numbers of Euro-American immigrants, most of this ecological landscape's upland hardwood forests were cleared and converted to farms, and the remnant woodlots are generally small and often isolated. The larger remaining blocks of upland forest occur in the more rugged and generally less fertile Kettle Moraine, where natural community types (and habitat types) occur on sites that vary from mesic to very dry. "Rich" mesic hardwood forests are not common in the Kettle Moraine nor are they currently well represented anywhere in the Southeast Glacial Plains. Nevertheless, there are excellent opportunities to maintain extensive forests of northern red and white oak as well as some maple-basswood, especially in the north. American beech (*Fagus grandifolia*) is present but restricted to areas in the northeastern portion of the ecological landscape. Eastern white pine (*Pinus strobus*) becomes a canopy component near the northern end of the Kettle Moraine and also occurs naturally in the adjacent forests to the east in the Central Lake Michigan Coastal Ecological Landscape.

Pine plantations are common throughout the Kettle Moraine where they often occupy lands that were cleared, farmed for a while, then abandoned due to steep slopes, low fertility, and drought susceptibility. Red pine (*Pinus resinosa*) and eastern white pine were the species most commonly planted, but plantations of Scots pine (*Pinus sylvestris*) and exotic spruces occur in a few areas. Many conifer plantations in this ecological landscape now have dense understories dominated by tall shrubs, especially the highly invasive exotic buckthorns (*Rhamnus cathartica* and *R. frangula*) and honeysuckles (e.g., *Lonicera morrowii, L. tatarica*, and the hybrid *Lonicera* x *bella*), which, once established, are extremely difficult to control.

In the warmer, drier, more fire-prone South Kettle Moraine, much of what is now "forest" was historically oak savanna with bur oaks dominant and white oak, black oak, and shagbark hickory (*Carya ovata*) among the important associates. In the absence of frequent low-intensity groundfires, the former savannas have now become choked with shrubs and saplings—the latter typically of species other than oaks. Oak forests were often limited to sites with more protection from wildfire and cooler, more moist northern or eastern exposures of the moraine or on the leeward sides of extensive wetlands or large waterbodies. Oak forest was most abundant in the southern and western parts of the Southeast Glacial Plains



This mature dry-mesic hardwood forest is dominated by northern red oak, white oak, shagbark hickory, American beech, sugar maple, and American basswood. Northern Kettle Moraine Region. Photo by Eric Epstein, Wisconsin DNR.

where it adjoined or was sometimes interspersed with woodland, savanna, and prairie communities. Extensive mesic forests were generally found farther east and north.

Along the lower Wolf River between Fremont and New London (and even beyond, into the Central Lake Michigan Coastal Ecological Landscape), floodplain forests are extensive and highly significant to specialized forest interior wildlife. Lowland hardwood forests also occur in (usually) small stands at scattered locations along the North Branch of the Milwaukee River and on floodplains of a few of the other larger rivers here.

Conifer swamps, usually dominated by tamarack, were locally common in poorly drained areas—even in the southernmost part of the ecological landscape. Many of these swamps were drained, converted to vegetable production, and later became sod farms. Some of these drained swamps are no longer producing crops and are being "restored" as wetlands. However, the trajectory and ultimate end points of such restorations are far from certain due to oxidation and erosion of muck soils. Several large swamps, e.g., the 8,000-acre Sheboygan "Marsh" (includes both the Sheboygan County Park and Sheboygan Wildlife Area), now exhibit huge areas of dead tamarack in which virtually no regeneration is occurring. A large tamarack swamp of around 400 acres persists at White River Marsh Wildlife Area as part of the White River Prairie/Tamarack State Natural Area.

There are a few stands of black spruce and a few wet-mesic conifer swamps of northern white-cedar in this ecological landscape. These conifers and some of their associated understory plants occur here at or very near their southern range extremities. Such outliers of northern vegetation support many plants and some animals that are regionally rare, and a subset of these should be monitored as they may be especially sensitive to climate change. They will continue to be affected by the drastic changes on the surrounding landscape.

Savannas. Oak savannas, especially the now globally imperiled Oak Opening community, were abundant in the Southeast Glacial Plains prior to Euro-American settlement and covered vast areas south of the Bark River and west of the Rock and Crawfish rivers. Open-grown bur oaks, which exhibited distinctive limb architecture and had the capability of growing to great size and age, were especially characteristic of sites on the edges of the extensive prairies that formed the dominant cover over fire-prone portions of the ecological landscape.

Following Euro-American settlement, the oak openings were quickly converted to cropland or pasture. The widespread implementation of fire suppression policies has allowed deciduous shrubs and saplings to overwhelm and choke the understories beneath and between the canopy oaks. Grazing may maintain stand structure, at least at some locations for awhile, but can also cause the decrease or loss of sensitive understory plants and some associated animals. When discontinued, the proliferation and spread of woody plants—especially invasive shrubs—can be extremely rapid.

Savanna restoration requires a great deal of time, effort, and expense, and the outcomes are uncertain. Frequent fires of low intensity are thought to have maintained this community in the past. The southern portion of the Kettle Moraine region offers some of the best protection, restoration, and management opportunities for savanna communities anywhere in the state and, probably, the Upper Midwest. The magnitude of the opportunity is due to the existence of a substantial public land base that contains good quality remnants (or remnants that are thought to be restorable because of their structure or composition) and the interest of local managers, natural historians, and advocates for the representation of native plant communities on the Wisconsin landscape.

The native eastern red-cedar (*Juniperus virginiana*) can be a serious invader of oak savannas and prairies, but it also occurs as a component of cliffs or "glades" or other rocky, stony, or sandy sites. On at least some sites, for example, along the face of the Niagara Escarpment, the management goal should consider the accommodation of an eastern red-cedar component and, given local site conditions, perhaps some more mesophytic trees as well.

Shrub Communities. Shrub swamps are common on the margins of open wetlands and along lake and stream borders. Most of the shrub-dominated wetlands here are of the Shrub-carr type, with dogwoods (*Cornus* spp.) and willows (*Salix* spp.) most often the dominant plants. Shrub swamps dominated by speckled (or "tag") alder (*Alnus incana*) occur in the northern portions of the Southeast Glacial Plains Ecological Landscape, but these are not common this far south. Extensive ditching and the implementation of wildfire suppression policies have contributed to an increase in shrub cover in formerly more open grasslands, including native communities such as prairies, sedge meadows, and some fens.

Although management efforts to maintain grasslands often target all woody plants for removal, native shrub communities are well adapted to certain site conditions and provide habitat for many native plants and animals, including some that are on Wisconsin's list of Species of Greatest Conservation Need. Maintenance of shrub communities where appropriate is a valid conservation and management goal and may be critical for at least a few species.

A diverse shrub-carr community borders this ecologically important stretch of the East Branch of the Milwaukee River. Northern Kettle Moraine region, Fond du lac County. Photo by Eric Epstein, Wisconsin DNR.

Herbaceous Communities. Prairies, wet meadows, and emergent marshes were historically abundant here. All have been reduced in area, especially the tallgrass prairies, of which only a few 1/100ths of 1% of their former acreage remains. Many sedge meadows have been altered by ditching, grazing, and the encroachment of woody plants, but one of Wisconsin's largest and least disturbed sedge meadow, marsh, and prairie complexes persists along the White and Puchyan rivers in the northern part of the ecological landscape.

Scuppernong "Marsh," a part of the southern Kettle Moraine that harbors remnant native grasslands of exceptional quality, has been the object of an ambitious and successful restoration project. Several thousand acres of prairie, meadow, fen, marsh, and old field "surrogate grassland" have been opened up via prescribed burning and brushing, and this site now represents one of Wisconsin's most important grassland management projects. Hydrologic restoration is also occurring, and the open wetlands will ultimately grade into oak savanna and oak woodland and then to closed canopy oak-dominated hardwood forest. This is one of only a few sites in the Midwest where restoration of these globally rare communities is occurring at such a large scale.

Wet-mesic prairie remnants in the Scuppernong River basin support an exceptionally rich assemblage of native plants and animals. Waukesha County. Photo by Drew Feldkirchner, Wisconsin DNR.

Some of the large, shallow drainage lakes formerly supported vast stands of wild rice. For example, in 1850, Lake Koshkonong, a widening on the Rock River, covered an area approximately 8 miles long that averaged over 2.5 miles in width. At that time, wild rice was described as growing abundantly over almost its entire surface, "giving to it more the appearance of a meadow than a lake" (Lapham 2001). Horicon Marsh, also situated on the Rock River, was described as a "broad and shallow lake extending 12 miles, with an average breadth of five miles." Wild rice was also abundant there, prior to the massive hydrological disruptions that occurred in the early 20th century. The lake's depth at the time of Lapham's

Extensive emergent marshes dominated by cat-tails occur along the lower stretches of the Rat River near its confluence with the Wolf River at Lake Poygan. Winnebago County. Photo by Eric Epstein, Wisconsin DNR.

observation was estimated to have been 4 feet lower than it is at the present time. Other extensive wild rice marshes were described along portions of the upper and middle Fox River and at some locations in lakes Butte des Morts, Winneconne, and Poygan. Restoring rice to the lakes and low-gradient streams in the southeast has proven difficult because of excessive fertility, altered hydrology, the activity of common carp, and mechanical disturbance from powerboats (R. Kahl, Wisconsin DNR, personal communication).

Wild rice is no longer a dominant plant in the large marshes of the Southeast Glacial Plains. Cat-tails and bulrushes are more often the prevalent species, and sometimes even these have been replaced, often by aggressive invasive plants such as common reed, reed canary grass, or the nonnative narrow-leaved cat-tail (*Typha angustifolia*) and hybrid cat-tail (*Typha* x *glauca*). Dams have raised water levels in many of the shallow lakes and marshes, creating extensive areas of open water that now support relatively little emergent vegetation.

Miscellaneous Natural Communities and Terrestrial Habitats. Cliffs and ***talus slopes*** are rare in this ecological landscape and are most common in association with the dolomite outcroppings of the Niagara Escarpment, especially in Fond du Lac and Dodge counties. Many of the escarpment's cliff faces, which tend to face west, are dry and support plants and animals adapted to xeric conditions. However, in a few areas, springs and seepages provide microhabitats that enable the survival of additional specialists. Niagara Escarpment conservation efforts need to account for and protect local hydrology to ensure that the habitat needs of those species requiring constant supplies of moisture are met over time. Remnant vegetation above the escarpment includes some of the better remaining stands of mesic maple-beech forest in the Southeast Glacial Plains. Such remnants are now quite rare and merit protection. They can receive heavy use by migratory birds.

Some parts of the escarpment have been mined and quarried. The Ordovician Neda Formation formerly produced oolitic hematite ore (Paull and Paull 1977) and is intimately associated with the Niagara Escarpment. The abandoned Neda Mine (now Neda Mine State Natural Area) is now the site of a major ***bat hibernaculum*** that annually hosts almost 150,000 bats (D.N. Redell, Wisconsin DNR, personal communication).

Surrogate grasslands include some of the abandoned and fallowed fields that occur throughout the ecological landscape. These can provide valuable, even critical, habitat for species dependent on large grasslands, especially in those areas in which intensive agriculture are now practiced. Grassland birds, including waterfowl, are among the major benefactors of surrogate grassland protection.

Forest Habitat Types

As noted throughout this chapter, the Southeast Glacial Plains Ecological Landscape is extensively developed and most of the land farmed. Most of the region is covered by loess-derived soils that are nutrient rich and well drained. Forest habitat types reflect the limited site variability. Common habitat type groups are dry-mesic to mesic, mesic, and wet-mesic to wet (Table 18.1). In addition, mesic to wet-mesic sites, although minor in occurrence, often harbor forest patches here.

Dry-mesic to mesic sites are typically associated with loamy soils that are well drained and nutrient rich. Forest stands are most commonly dominated by northern red oak (*Quercus rubra*) and white oak, often with sugar maple, white

Table 18.1. *Forest habitat type groups and forest habitat types[a] of the Southeast Glacial Plains Ecological Landscape (SEGP EL).*

Southern forest habitat type groups[b] common within the SEGP EL	Southern forest habitat types common within the SEGP EL	Southern forest habitat types minor within the SEGP EL
Dry-mesic to mesic (DM-M) (Includes phases)	ATiFrVb ATiFrVb (Cr)	AFrDeO AFrDe(Vb) AFrDe
Wet-mesic to wet (WM-W)	Forest lowland (habitat types not currently defined)	
Mesic (M) (Includes phases)		ATiFrCa(O) ATiFrCa AFAs AFAs-O
Southern forest habitat type groups minor within the SEGP EL		
Mesic to wet-mesic (M-WM)		Undefined Wet-mesic

Source: Kotar and Burger (1996).

[a]Forest habitat types are explained in Appendix 18.B ("Forest Habitat Types in the Southeast Glacial Plains 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.

ash (*Fraxinus americana*), and American basswood (*Tilia americana*). Frequent associates and occasional dominants include black cherry (*Prunus serotina*), shagbark hickory, bitternut hickory (*Carya cordiformis*), elms, red maple, and aspen (*Populus* spp.). Potential late-successional dominants are sugar maple, American basswood, and white ash.

Mesic sites are typically associated with loamy soils that are well to moderately well drained and nutrient rich. Forest stands can be dominated by any mix of northern red oak, white oak, sugar maple, American basswood, white ash, black cherry, shagbark hickory, and elms. Potential late-successional dominants are sugar maple, American basswood, and white ash.

Mesic to wet-mesic sites are typically associated with loamy soils that are somewhat poorly drained and nutrient rich to medium. Most forest stands are dominated by any mix of red maple, ashes, American basswood, and swamp white oak (*Quercus bicolor*).

Wet-mesic to wet forested lowlands occur on poorly drained soils. Most sites are dominated by swamp hardwoods composed of any mix of red maple, green ash (*Fraxinus pennsylvanica*), black ash (*Fraxinus nigra*), and swamp white oak. Swamps dominated by conifers are relatively rare.

Flora

Factors contributing to the diverse flora of the Southeast Glacial Plains Ecological Landscape include its diverse soils and landforms, strong representation of natural communities and habitats that have become or always were rare, and the ecological landscape's large size. This area has also had a long history of botanical exploration and collecting. Because the Southeast Glacial Plains is heavily populated and intensively developed, many native plants are now in need of conservation attention. Appendix 18.C at the end of this chapter contains a tabular representation of all rare vascular plant (and animal) occurrences in the Southeast Glacial Plains archived by the Wisconsin Natural Heritage Inventory within the past 30 years (WDNR 2009).

One hundred and nine vascular plant species on the Wisconsin Natural Heritage Working List (WDNR 2009) have been documented in the Southeast Glacial Plains Ecological Landscape within the past 30 years (these are considered "nonhistorical" records). Of these 109 species, 10 are listed as Wisconsin Endangered, 28 as Wisconsin Threatened, and 71 as Wisconsin Special Concern.

Globally rare plants occurring here include earleaf foxglove *(Tomanthera auriculata,* listed as *Agalinus auriculata* on the Wisconsin Natural Heritage Working List*),* forked aster (*Aster furcatus*), kitten's-tails (*Besseya bullii*), prairie bush-clover (*Lespedeza leptostachya*), prairie white-fringed orchid (*Platanthera leucophaea*), and Hall's bulrush (*Schoenoplectus halii,* listed as *Scirpus hallii* on the Working List). Prairie bush-clover and prairie white-fringed orchid are globally rare plants listed as Wisconsin Endangered. Both are also listed as U.S. Threatened.

Species restricted in Wisconsin to this ecological landscape tend to be ultra-rarities, with only one or two state populations. Examples include Hall's bulrush, Wilcox's panic grass (*Dicanthelium wilcoxianum*), Swan's sedge (*Carex swanii*), and Torrey's sedge (*Carex torreyi*). Earleaf foxglove was thought to have been extirpated from Wisconsin before its 1999 rediscovery at Scuppernong Prairie in Waukesha County by Southeastern Wisconsin Regional Planning Commission (SEWRPC) botanist Lawrence Leitner.

Native grasslands such as prairies, sedge meadows, and fens provide habitat for many plant species with very limited distributions that cannot persist indefinitely on degraded sites. Over 50% of the rare plants found in this ecological landscape are associated with these habitats, despite their currently limited acreage and the intensively developed nature of most of the ecological landscape. The Scuppernong complex in the south Kettle Moraine is one of the few places where prairies and savannas can be not only restored but expanded. Even small, isolated, somewhat disturbed prairie, meadow, and fen remnants are worth protecting here to maintain local genotypes and assemblages of species that may not exist elsewhere in the Southeast Glacial Plains.

Kitten's-tails (Wisconsin Threatened) is more common in Wisconsin than any other place in the world, and it is more common in the southern Kettle Moraine region of the Southeast Glacial Plains than anywhere else in Wisconsin. Photo by Robert H. Read.

The globally rare prairie white-fringed orchid (U.S. Threatened and Wisconsin Endangered) is a tallgrass prairie obligate that is better represented in the Southeast Glacial Plains than anywhere else in Wisconsin. Photo by Thomas Meyer, Wisconsin DNR.

Bedrock habitats are rare and highly localized features in the Southeast Glacial Plains. They are most often associated with exposures of the Niagara Escarpment or with small outcroppings of other rock formations that occur along several of the larger rivers near the eastern edge of the ecological landscape. The dolomite cliffs and talus slopes of the Niagara Escarpment support rare habitat specialists such as rock whitlow-grass (*Draba arabisans*), Laurentian bladder fern (*Cystopteris laurentiana*), and rock stitchwort (*Arenaria stricta*).

Although forest acreage has undergone a severe decline throughout much of this ecological landscape, some of the forest remnants provide habitat for sensitive species, including rarities such as forked aster, American gromwell (*Lithospermum latifolium*), and reflexed trillium (*Trillium recurvatum*).

Three rare tree species have been documented here. The Southeast Glacial Plains contains one of only two known locations for Wisconsin Threatened blue ash (*Fraxinus quadrangulata*), the only Wisconsin tree with statutory protection.

The Wisconsin distribution of forked aster (Wisconsin Threatened) is limited to the southeastern counties. It is globally rare and an inhabitant of hardwood forests. Waukesha County. Photo by Robert H. Read.

Significant Flora in the Southeast Glacial Plains Ecological Landscape

- Globally rare plants for which this ecological landscape is especially important include kitten's-tails, earleaf foxglove, forked aster, prairie bush-clover and prairie white-fringed orchid. Wisconsin's only population of Hall's bulrush occurs here.
- Prairie bush-clover and prairie white-fringed orchid are listed as U.S. Threatened by the U.S. Fish and Wildlife Service. Both are Wisconsin Endangered.
- Rare wetland communities such as Calcareous Fen, Wet-mesic Prairie, and Southern Sedge Meadow are represented here by multiple occurrences of good quality. Numerous rare plant species are associated with the habitats these natural communities provide.
- Oak Openings and upland prairies supply critical habitat for rare plants, including kitten's-tails, yellow gentian, pale purple coneflower, prairie parsley, rough rattlesnake root, and yellow giant hyssop.
- Recent research has shown that forests in southern Wisconsin are demonstrating increases in exotic species and habitat generalists at the expense of more sensitive native plants.
- The key to protecting populations of many of these rare species is to ensure that the natural communities they depend on are managed appropriately and in ways that can accommodate short-term environmental change.
- Habitat and population isolation, coupled with the spread and explosive increase in invasive species pose major threats to the native flora of the Southeast Glacial Plains.

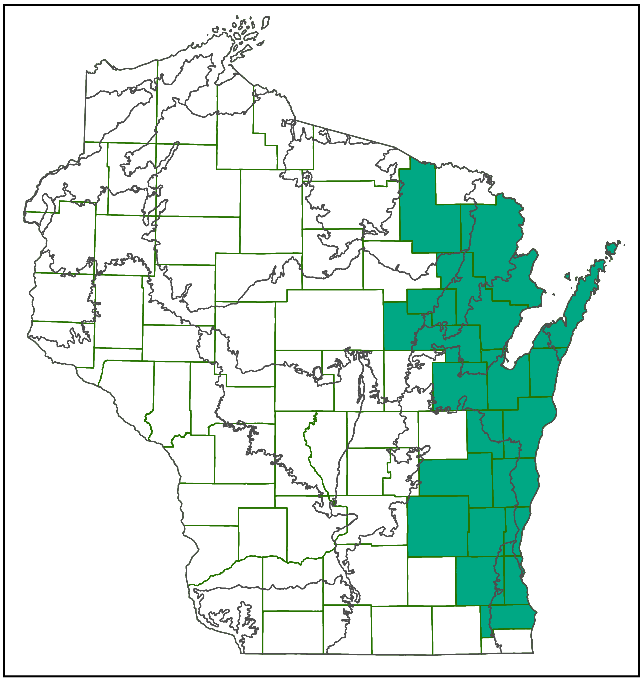


Figure 18.8. *Range of American beech in Wisconsin.*

Kentucky coffee-tree (*Gymnocladus dioicus*) and American sycamore (*Platanus occidentalis*) are Wisconsin Special Concern species that have been found here. American sycamore occurs in floodplain forests along the Sugar River in the southwestern part of the ecological landscape and is also known from a few Wisconsin stations farther west. American beech is not rare but has a restricted Wisconsin range that ends abruptly near the eastern edge of the Southeast Glacial Plains (Figure 18.8).

The Southeast Glacial Plains Ecological Landscape possesses a rich flora, which is highly threatened by the destruction, isolation, and degradation of habitat needed by native plants. Ecological stressors such as development and exurban sprawl, the spread of invasive plants, hydrologic disruption, and high numbers of white-tailed deer (*Odocoileus virginianus*) continue to affect remnant natural communities with profound impacts. In addition to those plants recognized on official state lists as "rare" via special designations (such as endangered, threatened, or special concern), many other components of the landscape's flora warrant monitoring and conservation attention. Recent research has documented significant shifts in the understory composition of forests throughout southern Wisconsin with an overall decrease in native species diversity (Rogers et al. 2008). In particular, there is a region-wide increase of habitat generalists and weeds at the expense of species that are more sensitive and highly specialized.

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 as having occurred in the Southeast Glacial Plains Ecological Landscape. Of those, this review is limited to those 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).

Historically, the vegetation of the Southeast Glacial Plains Ecological Landscape was dominated by maple-basswood forest in the northeast and oak forest, oak openings, prairie, savanna, and wetlands in the west and south. The ecological landscape was important for a mixture of wetland, grassland, and southern forest species, including American bison (*Bos bison*), elk (*Cervus canadensis*), Greater Prairie-Chicken (*Tympanuchus cupido*), Sharp-tailed Grouse (*Tympanuchus phasianellus*), Northern Bobwhite (*Colinus virginianus*), Wild Turkey (*Meleagris gallopavo*), and Passenger Pigeon (*Ectopistes migratorius*). However, wildlife populations changed dramatically following Euro-American settlement in the mid-1800s when grasslands were plowed and forests cleared for agriculture, and wildfires were suppressed and controlled.

There are many historical accounts of bison in this ecological landscape, and they are thought to have occupied the prairie areas of the state (Figure 18.9) south of Lake Winnebago and in the western and southern parts of the ecological landscape where prairie and oak openings were common. The Buffalo Lake region in Marquette County was once a great American bison range (Schorger 1937). Although evidence is scarce, American bison are thought to have disappeared from this area in the early 1800s. A current hypothesis is that American bison preferred short to mid-grass prairies, and marginal bison habitat east of the Mississippi along with hunting pressure from early American Indians prevented them from moving east of the Mississippi River (R.A. Henderson, Wisconsin DNR, personal communication). When American Indian populations declined during the 1600s and 1700s as a result of disease and social disruption upon the arrival of Euro-Americans, bison populations were able to increase and expand. Later, when American Indian tribes from the eastern United States were forced west by Euro-American settlers, the bison population in Wisconsin came under heavy hunting pressure by American Indians for food. The American bison population had already been reduced to small numbers by the time the state was settled by Euro-Americans.

Elk were found throughout Wisconsin but flourished in open woodlands and oak openings, which often occur at the border of grasslands and forests (Figure 18.10). They were most numerous and abundant in the southern and western parts of the state (Schorger 1954) and were likely abundant here because many elk antlers have been found in lake bottoms and marshes of the Southeast Glacial Plains. Although still abundant during the early 1800s, elk were scarce here by 1850. Attempts have been made to restore elk in Wisconsin, although not in the now heavily developed Southeast Glacial Plains (see the "Fauna" section of Chapter 22, "Western Coulees and Ridges Ecological Landscape," for detailed description of elk restoration).

White-tailed deer were found statewide but were likely more abundant in southern Wisconsin at the time of Euro-American settlement (Schorger 1953). They were reported as plentiful in this ecological landscape until around 1850. However, as settlers arrived in southern Wisconsin, they depended on venison for food, and professional market hunters sent tons of venison to the large cities of the eastern U.S. The combination of subsistence harvest and market hunting likely reduced the state's deer population to its lowest level late in the 19th century. Deer populations remained low, and deer were considered uncommon throughout southern Wisconsin from 1900 through the 1960s. However, since the early 1980s, deer have become very abundant here (Figure 18.11). Like many other species, white-tailed deer are an important animal for recreation but cause crop damage, vehicle accidents, and damage to forest regeneration and plant communities. ***Chronic wasting disease*** (CWD) was discovered in this ecological landscape along the Illinois border in 2002 (Figure 18.12). Since then, special hunting seasons and regulations have been implemented to attempt to reduce the deer herd and contain the disease. Testing for CWD is currently ongoing in portions of the Southeast Glacial Plains to monitor for the incidence and potential spread of the disease and inform hunters of infected deer they may have shot.

The gray wolf (*Canis lupus*) was commonly found in this ecological landscape but declined quickly after Euro-American settlement. Living primarily on deer and rabbits, the gray wolf declined gradually throughout the state due to loss of food sources, shooting, trapping, and poisoning. Gray wolves were killed in Dane and Waukesha counties in 1871, and a wolf was killed in Jefferson County as late as 1880 (Schorger 1942a). No gray wolf packs are known from this ecological landscape as of this writing, but individuals are occasionally documented as transients.

American black bears (*Ursus americanus*) were once found throughout the ecological landscape. They were more abundant in the more wooded areas in the east than in the prairie and oak opening regions to the west and south (Schorger 1949). However, during certain years,

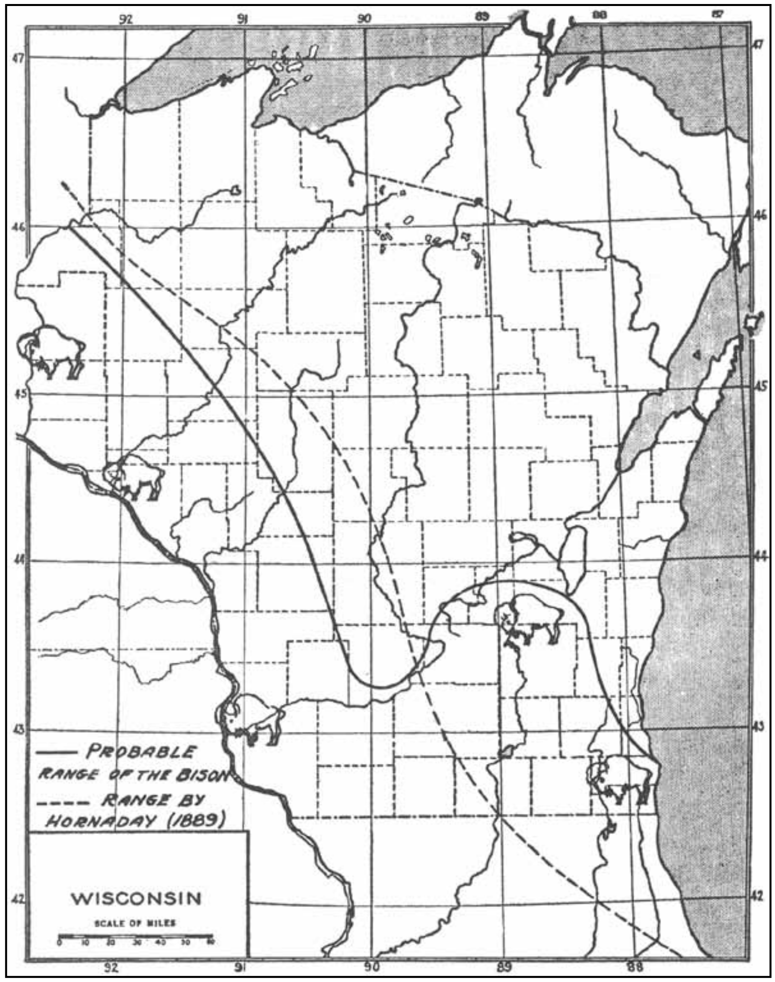


Figure 18.9. *Probable range of the American bison in Wisconsin prior to Euro-American settlement. Figure reproduced from Schorger (1937) by permission of the Wisconsin Academy of Sciences, Arts and Letters.*

bears moved in large numbers to many parts of the ecological landscape including the less heavily forested west and south, possibly as a result of mast failure. American black bear sightings here are now rare and come mostly from the northern portions of the ecological landscape.

The American beaver (*Castor canadensis*) was historically present along the streams, rivers, and inland lakes of the Southeast Glacial Plains but declined quickly in the early 1800s as the fur trade and human settlement increased. Milwaukee was a trading and shipping center for beaver pelts from the area south and east of the Wisconsin and Fox rivers. The last recorded shipment of beaver pelts from Milwaukee was 21.5 pounds in 1822 (Schorger 1965). Today the American beaver still occupies some of this ecological landscape's rivers and inland lakes where suitable habitat exists.

The North American river otter (*Lontra canadensis*) was present at the time of Euro-American settlement and was thought to be as abundant here as the American beaver, if not more abundant. The otter typically inhabited streams, rivers, and inland lakes and was considered plentiful throughout the ecological landscape in the mid-1880s. As had occurred with American beaver, North American river otter numbers declined as trapping pressure and settlement increased. Pelts were traded and sold in Milwaukee from at least 1760 to 1840 (Schorger 1970). The North American river otter is

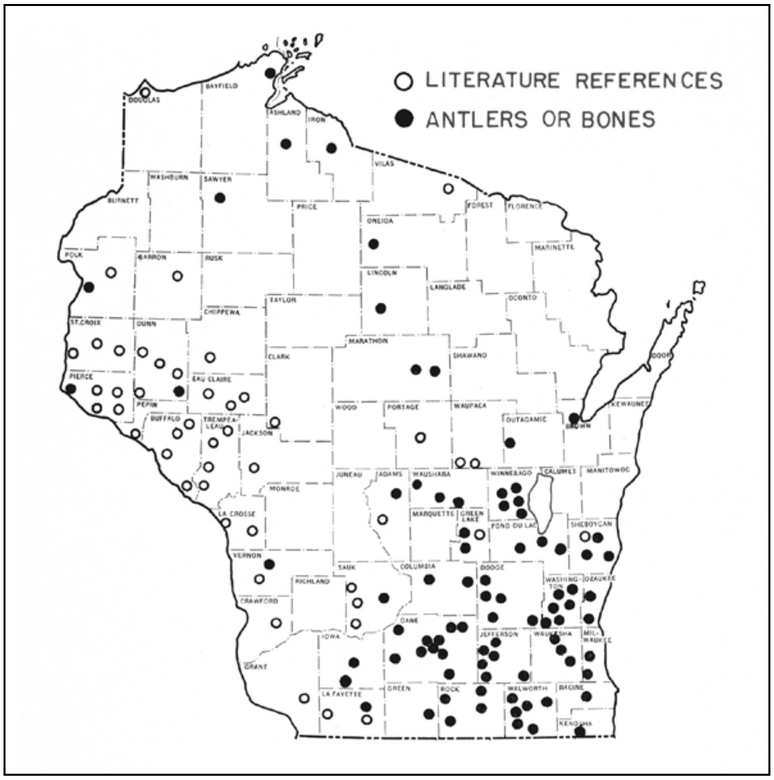


Figure 18.10. *Historical records of elk in Wisconsin. Figure reproduced from Schorger (1954) by permission of the Wisconsin Academy of Sciences, Arts and Letters.*

still present, and today populations are increasing along rivers and streams with suitable fish populations and riparian habitat.

The Passenger Pigeon's (*Ectopistes migratorius*) former distribution has been described as covering the eastern half of North America (Schorger 1946), but its nesting was limited by the presence and abundance of mast (primarily beech nuts and acorns). Schorger (1946) reported from newspaper accounts and interviews that the Passenger Pigeon nested by the millions in Wisconsin. Although central Wisconsin was usually thought to be its prime nesting area, it undoubtedly nested here as well, since acorns and beech nuts, two of its favorite foods, were plentiful in some areas. Indiscriminate hunting and trapping on the nesting grounds and sale of the Passenger Pigeon at city markets across the eastern part of the country caused the extinction of this species from the wild by 1899. See Chapter 10, "Central Sand Plains Ecological Landscape," for a more detailed discussion of the Passenger Pigeon.

Historically, the Wild Turkey occurred in Wisconsin south of a line from Green Bay to Prairie du Chien (Schorger 1942b; Figure 18.13), and they were abundant in the Southeast Glacial Plains. For example, in 1837 it was reported that "bears and wild turkeys were very plentiful for a few years after the first settlers came" in the town of Verona (Schorger 1942b), located along the westernmost edge of this ecological landscape. Due to persistent hunting by settlers for food, reduced habitat availability, and the severe winter of 1842–1843, the Wild Turkey was rare here by the late 1840s. This species is now established in all 16 ecological landscapes in Wisconsin and is abundant in parts of the Southeast Glacial Plains. (See the "Fauna" section of Chapter 22, "Western Coulees and Ridges Ecological Landscape," for a discussion of Wild Turkey introductions).

The Sharp-tailed Grouse was considered widely distributed in the state in open and brushy habitats prior to Euro-American settlement, and it was likely very common in the extensive prairies and oak openings of the Southeast Glacial Plains (Schorger 1943). Kumlien and Hollister (1903) reported that the Sharp-tailed Grouse was "extremely abundant" in southern Wisconsin in 1840. It was considered more common than the Greater Prairie-Chicken. They probably expanded into some areas following Euro-American settlement since young trees temporarily provided brushy habitat with the cessation of fire. Later, they declined as brushy oak openings grew up into dense forests and intensive agriculture became widespread. Today the Sharp-tailed Grouse does not occur in this ecological landscape and listed as a Species of Greatest Conservation Need.

The Greater Prairie-Chicken was found throughout southern Wisconsin before Euro-American settlement, and it was abundant in the open parts of the Southeast Glacial Plains Ecological Landscape. There are reports of the Greater Prairie-Chicken being brought into Milwaukee in 1842 "by the sleigh load" for the market, and it was considered "common fare" on the table (Schorger 1943). Great numbers of Greater Prairie-Chicken were shipped to Chicago and large eastern cities such as New York and Washington via rail. By 1852, laws were passed to protect the Greater Prairie-Chicken from hunting and trapping during January through August. Although it remained abundant through the early 1850s, Greater Prairie-Chicken numbers began plummeting by 1857 after a series of severe winters and wet cold springs and continued market hunting and trapping. Later, succession and other habitat changes caused by the lack of fire and plowing of the prairies for agriculture further contributed to the decline of the Greater Prairie-Chicken here. At first, agriculture seemed to cause the Greater Prairie-Chicken population to increase, but populations declined as agricultural methods became more intensive and habitat became less suitable. The range of the Greater Prairie-Chicken was eventually forced north as prairies were plowed for agriculture in the south while forests were cleared in central and northern Wisconsin. Later, as forests became reestablished in the north, the Greater Prairie-Chicken's range was constricted. Currently, this species is mostly limited to a set of managed wildlife areas in central Wisconsin and is not found anywhere in the Southeast Glacial

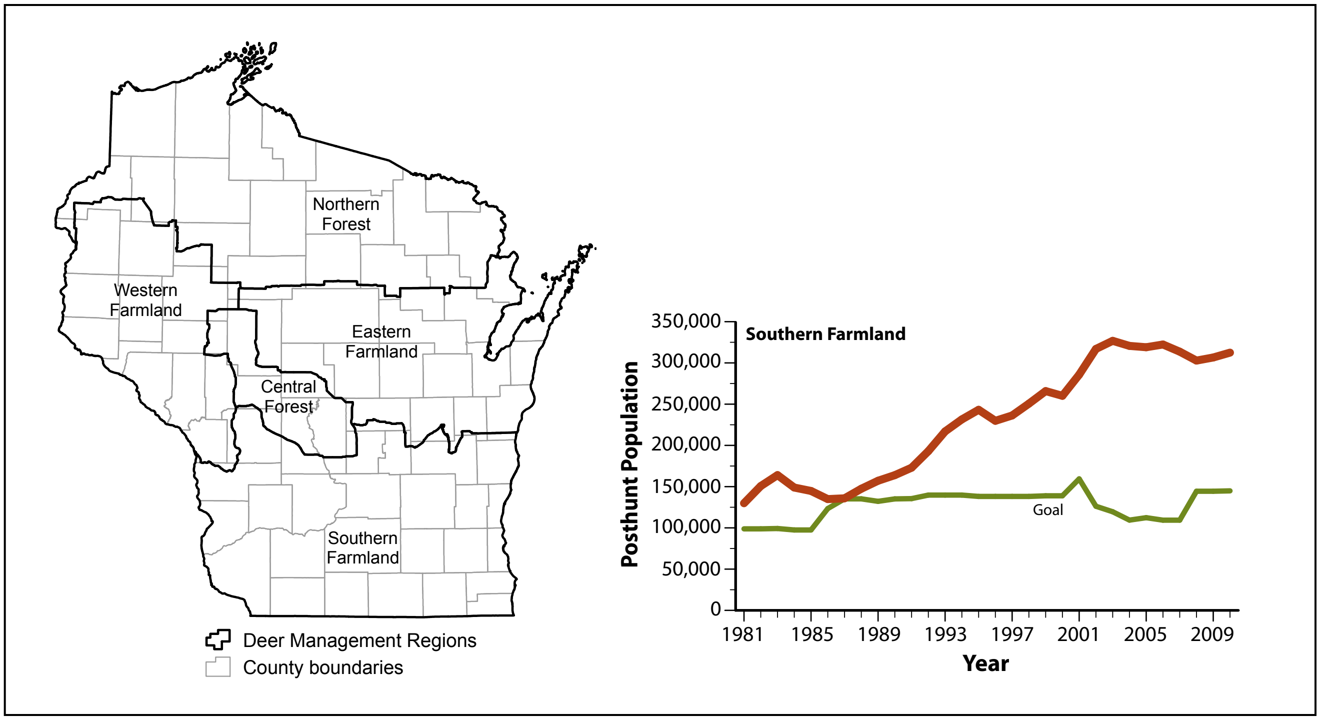


Figure 18.11. *White-tailed deer population size in relation to population goals in the southern farmland deer management region, 1981–2010.*

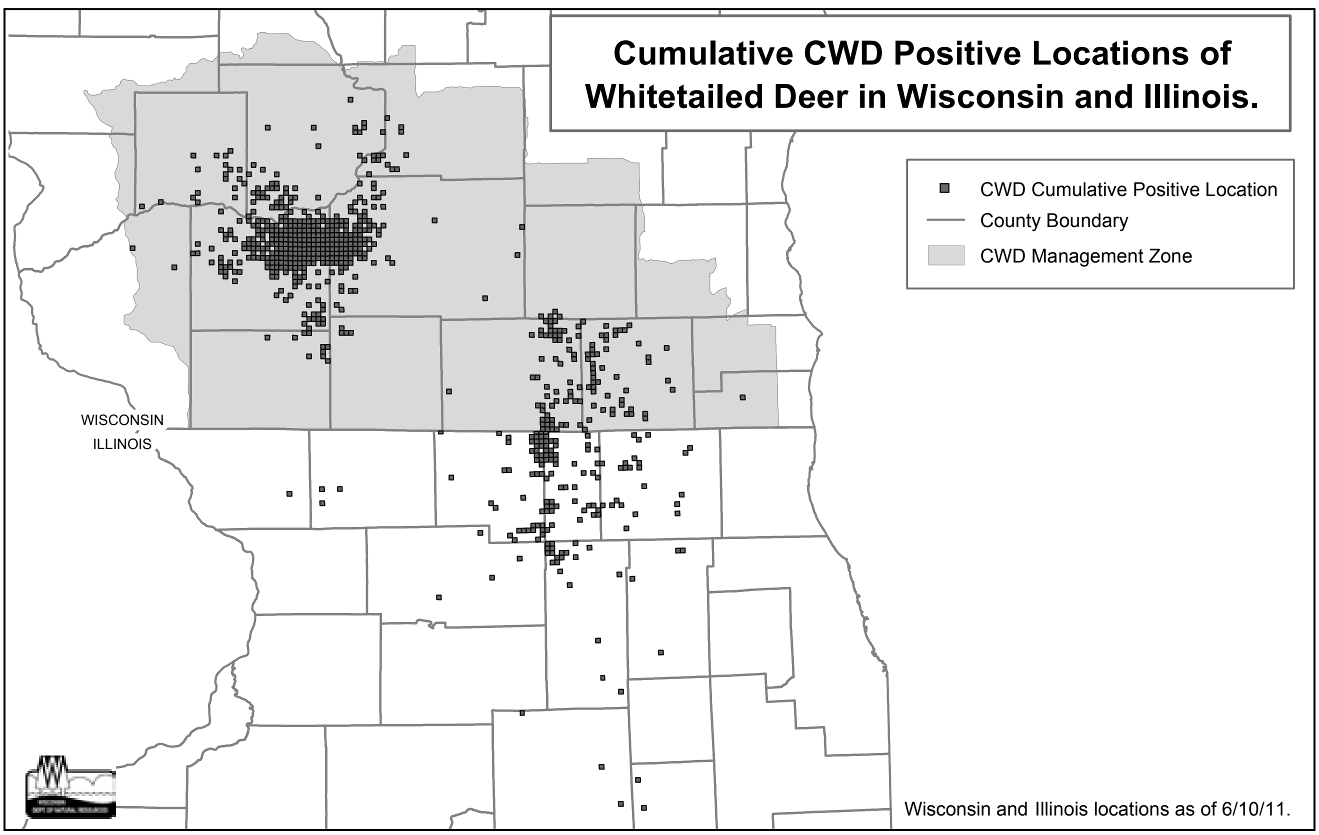


Figure 18.12. *Cumulative locations of CWD-positive white-tailed deer in Wisconsin and Illinois, 2002–2011.*

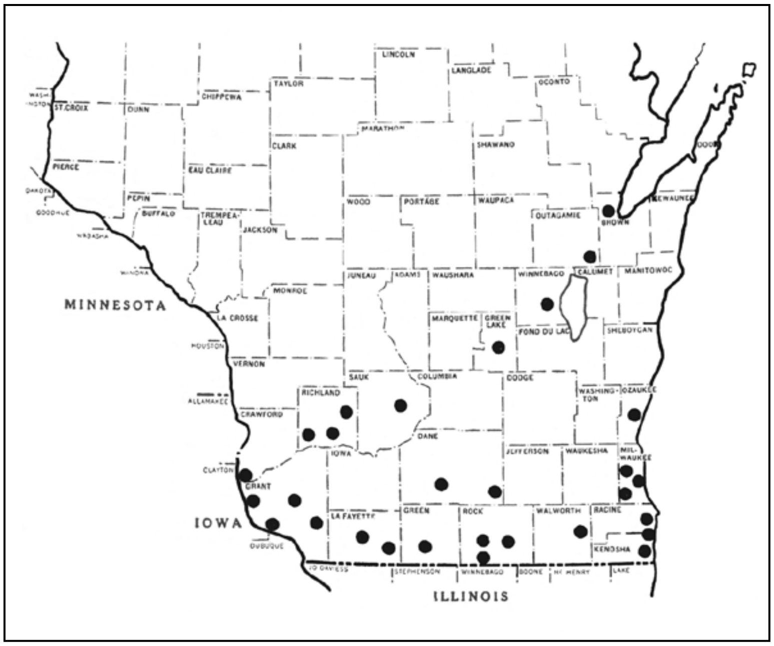


Figure 18.13. *Historical Wild Turkey range in Wisconsin. Figure printed with the written permission of The Wilson Ornithological Society, from Schorger, A.W. 1942. The Wild Turkey in early Wisconsin.* Wilson Bulletin *54:173–182.*

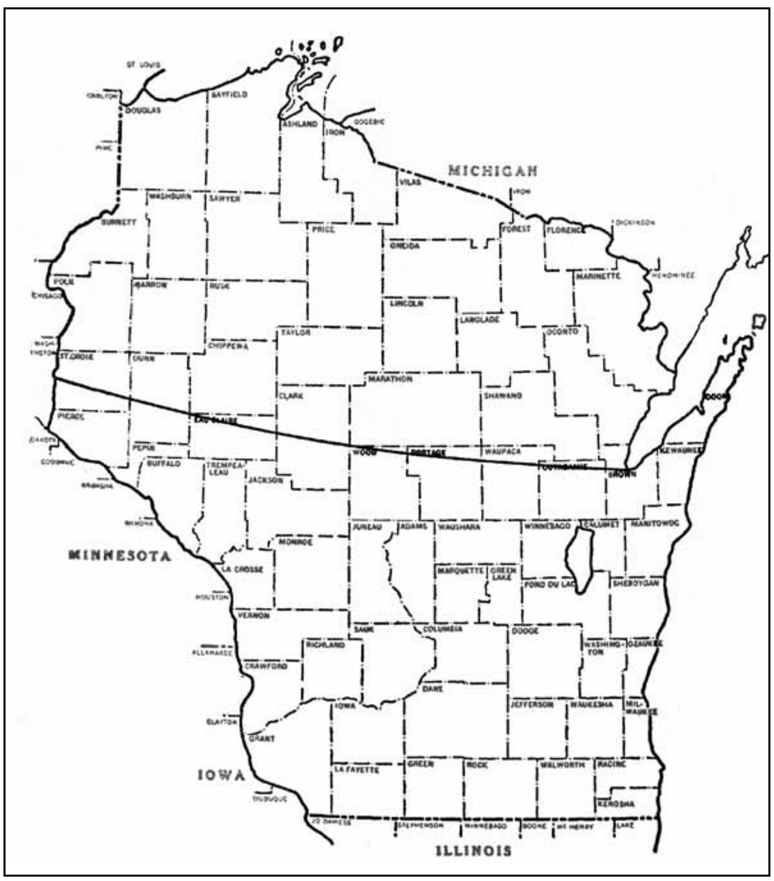


Figure 18.14. *Historical Northern Bobwhite range in southern Wisconsin. Figure reproduced from Schorger (1944) by permission of the Wisconsin Academy of Sciences, Arts and Letters.*

Plains. The Greater Prairie-Chicken is listed as Wisconsin Threatened and a Species of Greatest Conservation Need.

The Northern Bobwhite is thought to have been formerly widely distributed throughout the more open areas of the state (Schorger 1944; Figure 18.14), with populations fluctuating widely depending on winter severity. They were very abundant in the Southeast Glacial Plains Ecological Landscape, especially during a succession of mild winters from 1846 to 1857. Peak numbers were reached in 1854. In Madison during this time, it was said that a good shot could "readily bag 50 to 75 in a day" (Schorger 1944). Shipments of quail from Beloit to the eastern cities amounted to 12 tons in 1854–1855. A shipment of 20,000 Northern Bobwhite from Janesville was received in Philadelphia in 1856. Northern Bobwhite declined quickly thereafter due to unregulated trapping and adverse weather. Although the winters of 1854–1855 and 1855–1856 were severe, trapping continued with "tons of quail and other game hanging in the yard of the Capitol House in Madison," and the population was much reduced by the fall of 1857 compared to former years. Although the population recovered through the 1860s, it never again reached the 1854 level. From 1870 to the 1940s the Northern Bobwhite population remained mostly stable, but since then populations have decreased dramatically due changes in land use and other causes (see the "Fauna" section of Chapter 22, "Western Coulees and Ridges Ecological Landscape," for efforts to improve Northern Bobwhite populations). While still found in parts of this ecological landscape, they remain

Formerly widespread and abundant in much of the Southeast Glacial Plains, the Northern Bobwhite is now uncommon and local. Photo by Jack Bartholmai.

uncommon today. The Northern Bobwhite is a Wisconsin Special Concern species as well as a Species of Greatest Conservation Need.

Several races (Mongolian, Chinese, and English) of the Ring-necked Pheasant (*Phasianus colchicus*) were introduced in this ecological landscape beginning in the 1890s. In 1895 the Wisconsin legislature passed a law making it illegal to "take, catch, or kill any Mongolian, Chinese, or English Pheasants, or any other variety of pheasant for a period of five years" to provide protection while establishing populations (Schorger 1947). Many early releases were unsuccessful, but the Ring-necked Pheasant eventually became established in this ecological landscape because of favorable habitat conditions. Pheasant hunting became an important activity for Wisconsin hunters. In the 1940s, the Ring-necked Pheasant population began to decline due to habitat reduction, more "clean" farming practices, and urbanization. Because of a continually declining pheasant population, there have been numerous efforts to improve pheasant habitat to provide hunting opportunities, including the creation of a "pheasant stamp" in 1992. Hunters are required to buy a Ring-necked Pheasant stamp to hunt this species, with the revenue supporting Ring-necked Pheasant habitat management. Habitat projects funded by the pheasant stamp revenues and partner dollars have managed, preserved, and restored thousands of acres of nesting and winter habitat. In addition, the Wisconsin DNR has been raising pheasants for many decades at a state-operated game farm at Poynette and releasing them on numerous hunting grounds within the Southeast Glacial Plains Ecological Landscape to provide hunter recreation.

Up to 1850, the Sandhill Crane (*Grus canadensis*) was a common breeding bird in this ecological landscape and the rest of the state (Schorger 1942a) where suitable wetlands occurred. The largest numbers occurred in the more extensive prairies and "marshes." Habitat loss, nest predation, disturbance by man, and hunting led to dramatic declines, and by the early 1950s, the total population of Sandhill Cranes in Wisconsin was estimated to be 25 breeding pairs. Since then, the Sandhill Crane has made a remarkable comeback and is again a common breeding bird here and in much of the state.

Trumpeter Swans (*Cygnus buccinator*) nested in large marshes in all but the forested regions of northeastern Wisconsin until the 1880s (WDNR 2013h), but by 1900 the Trumpeter Swan was extirpated and widely thought to be extinct. Fortunately, a small nonmigratory population survived in remote mountain valleys of Montana, Idaho, and Wyoming. Since then, there has been a concerted effort to restore the species to its former range. In 1987, a restoration effort was begun with a goal of establishing a self-sustaining migratory population by the year 2000 (see the "Fauna" section of Chapter 10, "Central Sand Plains Ecological Landscape," for discussion of this restoration program). Although most of the restoration efforts have been in Wisconsin's central and northern ecological landscapes, some Trumpeter Swans were released in the Southeast Glacial Plains. By 2008 there were 120 nesting pairs statewide, with over 600 Trumpeter Swans total in the Wisconsin population. Trumpeter Swans were taken off Wisconsin's threatened and endangered species list in 2009.

After decades of persecution and habitat destruction, the eastern massasauga (*Sistrurus catenatus catenatus*) is now very rare and uses marshy areas, lowland prairies, floodplain forests, and streams in a few locations in southern and central Wisconsin. The eastern massasauga is sensitive to habitat changes and has been listed as Wisconsin Endangered since the mid-1970s. It is also a candidate for federal listing. There were a few records prior to 1999 for the eastern massasauga in the Southeast Glacial Plains, but the species has not been found here since then due to continued habitat loss and human persecution.

This ecological landscape has the largest lake sturgeon population in the state. The lake sturgeon is one of the largest freshwater fish in the world and is considered a living fossil because it has survived virtually unchanged for over 100 million years. Lake sturgeon can grow to a weight of hundreds of pounds and can live to be nearly 200 years old. An 82-year-old lake sturgeon caught in Lake Winnebago in 1953 is the oldest lake sturgeon recorded in Wisconsin. A 152-year-old, 215-pound lake sturgeon was caught in Lake of the Woods, Ontario, in the same year (WDNR 2014b). The lake sturgeon is highly vulnerable to pressures of overfishing, pollution, and habitat degradation because of their slow growth and infrequent spawning. Female lake sturgeon do not reach sexual maturity until they are 24 to 26 years of age, and they spawn only once every four to six years. Lake sturgeon will travel great distances over their lifetimes but will always return to the streams in which they hatched to spawn. At one point, lake sturgeon were very plentiful in the Great Lakes. In the late 1800s, due to over-fishing and the destruction and pollution of their spawning beds, lake sturgeon populations in the Great Lakes crashed. Lake sturgeon is a Wisconsin Special Concern species and a Species of Greatest Conservation Need. The DNR released a management plan for lake sturgeon in 2000 (WDNR 2000).

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 the state. To ensure that all species are maintained somewhere in the state, "significant wildlife" includes both common species and species that are considered "rare." Four categories of species are discussed: rare species, Species of Greatest Conservation Need, responsibility species, and socially important species (see definitions in text box). Because the conservation of wildlife communities and habitats is the most efficient and cost effective way to manage and benefit a majority of species, we also discuss management of different wildlife habitats in which significant fauna occur.

Rare Species. In this publication, "rare" includes all of those species that appear on the Wisconsin Natural Heritage Working List (WDNR 2009) and are classified as "endangered," "threatened," or "special concern" by the state or federal governments. (See Appendix 18.C for a comprehensive list of the rare animals known to exist in the Southeast Glacial Plains Ecological Landscape). As of November 2009, the Natural Heritage Working List documented 131 rare species within the Southeast Glacial Plains, including 2 mammals, 34 birds, 7 herptiles, 12 fishes, and 76 invertebrates (see the Wisconsin DNR's Natural Heritage Inventory web page for the current status; WDNR 2009). These include two species listed as U.S. Endangered, one species being considered for federal listing, 12 Wisconsin Endangered species, 21 Wisconsin Threatened species, and 98 Wisconsin Special Concern species. See Appendix 18.D at the end of this chapter for the number of species per taxa group with special designations documented within the Southeast Glacial Plains by the Natural Heritage Inventory program.

Federally Listed Species: Two animals listed as U.S. Endangered occur here although they are more abundant in other ecological landscapes in the state. One of these is the Hine's emerald dragonfly (*Somatochlora hineana*), also listed as Wisconsin Endangered. The other animal listed as U.S. Endangered is the Karner blue butterfly (*Lycaeides melissa samuelis*), also listed as a Wisconsin Special Concern species. One species that occurs here, the eastern Massasauga rattlesnake, is being considered for federal listing. The formerly U.S. Threatened Bald Eagle (*Haliaeetus leucocephalus*) occurs here in increasing numbers. After it was delisted in 2007, the Bald Eagle remained federally protected, with monitoring for five years to ensure that the population did not decline. The Bald Eagle is protected under the U.S. Bald and Golden Eagle Protection Act and Migratory Bird Treaty Act. The Bald Eagle is now listed as a Wisconsin Special Concern species.

Categories of Significant Wildlife

- **Rare species** are those that appear on the Wisconsin Natural Heritage Working List as U.S. or Wisconsin Endangered, Threatened, or Special Concern.
- **Species of Greatest Conservation Need (SGCN)** are described and listed in the Wisconsin Wildlife Action Plan (WDNR 2005b) 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: No Wisconsin Endangered mammals are known to occur in this ecological landscape. Eight Wisconsin Endangered birds are found here: Yellow-throated Warbler *(Setophaga dominica,* listed as *Dendroica dominica* on the Wisconsin Natural Heritage Working List), Worm-eating Warbler (*Helmitheros vermivorum*), Loggerhead Shrike (*Lanius ludovicianus*), Red-necked Grebe (*Podiceps grisegena*), Caspian Tern (*Hydroprogne caspia,* listed as *Sterna Caspia* on the Natural Heritage Working List), Forster's Tern (*Sterna forsteri*), Common Tern (*S. hirundo*), and Barn Owl (*Tyto alba*). Seven Wisconsin Endangered herptiles occur here, including Northern cricket frog (*Acris crepitans),* slender glass lizard (*Ophisaurus attenuatus*), queen snake (*Regina septemvittata*), eastern massasauga rattlesnake, ornate box turtle (*Terrapene ornata*), western ribbonsnake (*Thamnophis proximus*), and eastern ribbonsnake (*Thamnophis sauritus*). Four fish are listed in the NHI database as Wisconsin Endangered, including gravel chub (*Erimystax x-punctatus*), starhead topminnow (*Fundulus dispar*), striped shiner (*Luxilus chrysocephalus*), and slender madtom (*Noturus exilis*), but the striped shiner records from the Southeast Glacial Plains Ecological Landscape are very old. Recent surveys have not found

In Wisconsin the queen snake (Wisconsin Endangered) is restricted to the southeastern counties, where it is associated with clear, fast-flowing, rock-bottomed warmwater streams. Photo courtesy of the Ohio Department of Natural Resources.

the striped shiner here, and it is now considered extirpated from this ecological landscape. Three Wisconsin Endangered mussels—purple Wartyback (*Cyclonaias tuberculata*), snuffbox (*Epioblasma triquetra*), and rainbow shell (*Villosa iris*)—and eight Wisconsin Endangered invertebrates—a land snail, the Midwest Pleistocene vertigo (*Vertigo hubrichti*); three butterflies, the swamp metalmark (*Calephelis muticum*), regal fritillary (*Speyeria idalia*), and powesheik skipperling (*Oarisma powesheik*); the Silphium borer moth (*Papaipema silphii*); two dragonflies, the Hine's emerald and warpaint emerald (*Somatochlora incurvata*); and the red-tailed prairie leafhopper (*Aflexia rubranura*)—are found here.

■ ***Wisconsin Threatened Species:*** There are no Wisconsin Threatened mammals documented in this ecological landscape. Ten Wisconsin Threatened birds have been documented within the Southeast Glacial Plains Ecological Landscape, including Henslow's Sparrow (*Ammodramus henslowii*), Great Egret (*Ardea alba*), Red-shouldered Hawk (*Buteo lineatus*), Cerulean Warbler (*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List), Acadian Flycatcher (*Empidonax virescens*), Yellow-crowned Night-heron (*Nyctanassa violacea*), Kentucky Warbler (*Geothlypis formosa,* listed as *Oporornis formosus* on the Working List), Greater Prairie-Chicken, Bell's Vireo (*Vireo bellii*), and Hooded Warbler (*Setophaga citrina,* listed as *Wilsonia citrina* on the Working List). Three Wisconsin threatened herptiles occur here, including wood turtle (*Glyptemys insculpta*), Blanding's turtle (*Emydoidea blandingii*), and Butler's gartersnake (*Thamnophis butleri*), along with six Wisconsin Threatened fish, including longear sunfish (*Lepomis megalotis*), redfin shiner (*Lythrurus umbratilis*), river redhorse (*Moxostoma carinatum*), greater redhorse (*Moxostoma valenciennesi*), pugnose shiner (*Notropis anogenus*), and Ozark minnow (*Notropis nubilus*). Five Wisconsin Threatened mussels—slippershell mussel (*Alasmidonta viridis*), monkeyface (*Quadrula metanevra*), salamander mussel (*Simpsonaias ambigua*), buckhorn (*Tritogonia verrucosa*), and ellipse (*Venustaconcha ellipsiformis*)—and one insect (pygmy snaketail) have been documented here.

■ ***Wisconsin Special Concern Species:*** Wisconsin Special Concern species include 2 mammals, 20 birds, 3 herptiles, 7 fish, and 66 invertebrates.

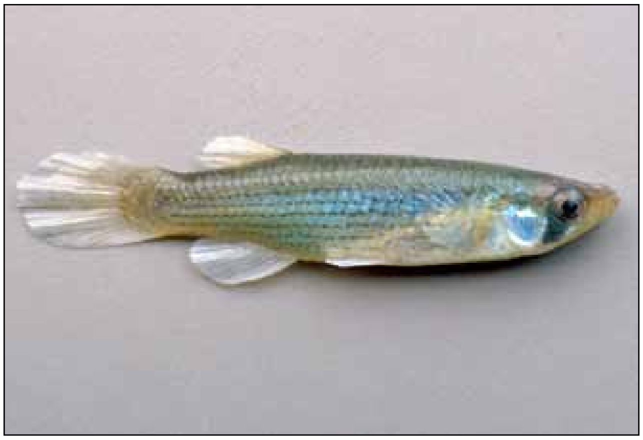
■ **Species of Greatest Conservation Need.** Species of Greatest Conservation Need (SGCN) appear in the Wisconsin Wildlife Action Plan (WDNR 2005b) and include species already recognized as endangered, threatened, or special concern on Wisconsin or federal lists along with nonlisted species that meet the SGCN criteria. There are 7 mammals, 57 birds, 10 herptiles, and 16 fish species listed as SGCN for the Southeast Glacial Plains (see Appendix 18.E at the end of this chapter for a complete list of Species of Greatest Conservation Need and the habitats with which they are associated).

Significant Wildlife in the Southeast Glacial Plains Ecological Landscape

- Many wetland fauna such as ducks, geese, rails, herons, egrets, terns, and herptiles use the abundant wetlands as breeding areas.
- Large concentrations of Canada Geese, Tundra Swans, and other waterfowl, as well as shorebirds, use aquatic sites as migration stopover areas.
- Large Great-blue Heron, Great Egret, and Forster's Tern nesting colonies occur in this ecological landscape.
- Rare birds, herptiles, and invertebrates requiring prairie, sedge meadows, and fen habitats are found here.
- Many declining grassland birds as well as ducks (upland nesters) and Ring-necked Pheasants use surrogate grasslands, especially larger sites.
- Animals associated with rare oak savanna habitats are found here.
- Regionally significant breeding populations of "southern" forest interior birds occur in both units of the Kettle Moraine State Forest and in the Lower Wolf River bottoms.
- Fauna more typical of northern Wisconsin are found in the conifer swamps.
- Large numbers of bats use Neda Mine as a hibernaculum, which is one of Wisconsin's largest.
- Rare land snails inhabit the Niagara Escarpment.
- Large numbers of lake sturgeon use the lower Wolf River, its tributaries, and the Winnebago pool lakes.
- Diverse aquatic life occurs in rivers, streams, and lakes such as the Mukwonago system.

■ **Responsibility Species.** The largest population in the United States of the globally rare lake sturgeon occurs in the lower Wolf River system and the Winnebago Pool lakes. During the spring spawning run, lake sturgeon move into the lower Wolf River to spawn and are very vulnerable to poaching while in the shallow waters. They are protected by a system of volunteer "sturgeon guards" who watch the fish day and night to help law enforcement personnel protect the species. Shoreline management along the lower Wolf ensures that adequate spawning habitat is available for the species. There is a spearing season for lake sturgeon each winter, but the harvest is controlled by a quota and registration system that prevents overharvest of the population of this slow growing and late maturing fish.

A high diversity of fish and other aquatic life occurs in the rivers and streams of the Southeast Glacial Plains. Rare fish species that occur primarily in this ecological landscape are the gravel chub and slender madtom and perhaps the redfin shiner



The Wisconsin Endangered starhead topminnow is at its northernmost range extremities in southern Wisconsin. It is one of the many rare or otherwise sensitive aquatic organisms occurring in the Mukwonago River system. Photo by John Lyons, Wisconsin DNR.

(although more survey work should be done for this species). Rare fish species that occur here but are more numerous elsewhere in the state are the starhead topminnow, pugnose shiner, and Ozark minnow. Rare mussels occurring primarily in streams of the Southeast Glacial Plains are the snuffbox, rainbow shell, slippershell mussel, and ellipse mussel.

A large bat hibernaculum occurs at Neda Mine State Natural Area (Dodge County), a large abandoned iron mine near the southernmost exposure of the Niagara Escarpment (before it dips below the earth's surface just to the south). An estimated 150,000 bats of four species—little brown bat (*Myotis lucifugus*), northern long-eared bat (*M. septentrionalis*), eastern pipistrelle (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus)*—use the mine as a winter hibernaculum, migrating there from all over the Midwest (D.N. Redell, Wisconsin DNR, personal communication). Very few bats use the mine during summer, but bats return to the mine in August. They make nightly feeding flights from September to November to build fat reserves for hibernation, so the habitat around Neda Mine is very important as a feeding site for a significant number of bats from all over the Midwest. The discovery of "white-nose fungus" (*Geomyces destructans*) in the eastern United States has been linked to the deaths of over two million bats since 2007 and threatens to cause the extinction of several bat species (D.N. Redell, Wisconsin DNR, personal communication). In 2010, the Wisconsin Natural Resources Board moved to formally list *Geomyces destructans* as a prohibited invasive species and listed four bat species (big brown bat, little brown bat, eastern pipistrelle, and northern long-eared bat) as threatened in Wisconsin. The four Wisconsin "cave" bats are especially vulnerable because they may travel great distances and spend time together in confined spaces, hibernating over the winter in caves and mines where they can become infected with the fungus that causes white-nose syndrome. Some hibernacula have experienced mortality rates greater than 98%.

Globally rare land snails occur on the Niagara Escarpment, including the Wisconsin Endangered midwest Pleistocene vertigo snail. The Niagara Escarpment is a prominent geologic feature that runs north-south across the eastern part of this ecological landscape. Exposures of dolomite bedrock harbor rare plants and animals.

Large concentrations of Canada Geese (*Branta canadensis*), Tundra Swans (*Cygnus columbianus*), ducks, and other waterfowl as well as shorebirds, wading birds, gulls, and terns use wetlands in this ecological landscape as migration stopover areas. Horicon Marsh and its "satellite" areas (Eldorado Marsh and Theresa Marsh) are well known for large concentrations (>100,000) of Canada Geese in the fall.

Diving ducks such as Canvasback (*Aythya valisineria*), Greater Scaup (*A. marila*), Lesser Scaup (*A. affinis*), Ruddy Duck (*Oxyura jamaicensis*), and other waterbirds used shallow water lakes such as lakes Koshkonong, Poygan, Winneconne, Butte des Morts, and Winnebago as habitat during their migrations. Deterioration of beds of submergent and emergent aquatic vegetation has occurred in these lakes from high water levels, activities of common carp, and excessive sediment and nutrient inputs. The food used by diving ducks during migration has been reduced, and these shallow lakes now receive much less use by diving ducks than they did formerly (R.B. Kahl, Wisconsin DNR, personal communication).

There are some very large wetlands of global or regional significance here, such as Horicon Marsh, White River Marsh, and Rush Lake. The easternmost population of nesting Redhead Ducks (*Aythya americana*) occurs at Horicon Marsh. Other rare birds breed in wetlands here, including Red-necked Grebe, King Rail (*Rallus elegans*), Forster's Tern, Black Tern (*Chlidonias niger*), Great Egret, and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). Black Tern, Forster's Tern, and Yellow-headed Blackbird were documented more often in this ecological landscape than anywhere else in the state during Wisconsin's breeding bird atlas project (Cutright et al. 2006). Other rare species using wetlands of the Southeast Glacial Plains Ecological Landscape include the Wisconsin Threatened Blanding's turtle.

This ecological landscape is important for colonial nesting birds that use marshes and shallow lakes, including Great Blue Heron (*Ardea herodias*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Great Egret, Double-crested Cormorant (*Phalacrocorax auritus*), Black Tern, and Forster's Tern. Great Blue Heron, Great Egret, and Black-crowned Night-Heron (both the Great Egret and the Black-crowned Night-Heron are considered rare) have rookeries on a number of these wetlands (e.g., Horicon Marsh, Eldorado Marsh, and Fox Lake). Double-crested Cormorants also nest in some of these heron and egret colonies. The Black Tern and Forster's Tern have nesting colonies at Horicon Marsh and Rush Lake.

Savanna species such as Red-headed Woodpecker (*Melanerpes erythrocephalus*), Eastern Bluebird (*Sialia sialis*), Orchard Oriole (*Icterus spurius*), Eastern Whip-poor-will (*Antrostomus vociferus*), gophersnake (*Pituophis catenifer*), and western fox snake (*Elaphe vulpina*) occur in the southern unit of the Kettle Moraine State Forest as well as in other parts of the ecological landscape. The southern unit of the Kettle Moraine State Forest is one of the best sites in the Upper Midwest at which to restore the globally imperiled Oak Openings (oak savanna) community used by these species.

Southern forest interior birds such as the Wisconsin Threatened Acadian Flycatcher, Cerulean Warbler, and Hooded Warbler have well-established breeding populations in both the southern and the northern units of the Kettle Moraine State Forest. Conifer stands within both units of this property support forest dwelling species that are generally found farther north. Collectively, the Kettle Moraine properties provide significant habitat for forest interior birds in a landscape otherwise dominated by agriculture. They are also extremely important as migratory stopover habitat for a variety of birds (Steele 2007). The Kettle Moraine provides habitat of statewide significance for the Acadian Flycatcher, Hooded Warbler, and other upland mesic forest birds (Cutright et al. 2006). The extensive lowland hardwood forests along the lower Wolf River also provide high-quality habitat for forest interior species, including the Wisconsin Threatened Red-shouldered Hawk and Cerulean Warbler as well as Yellow-billed Cuckoo (*Coccyzus americanus*) and Prothonotary Warbler (*Protonotaria citrea*), both Wisconsin Special Concern species.

Though still widespread and locally common in southern and central Wisconsin, Red-headed Woodpecker populations have experience worrisome declines in recent decades. This species is strongly associated with oak savannas. Photo by Herbert Lange.

Nonforested natural communities such as marshes, sedge meadows, fens, and prairies support rare birds here, including American Bittern (*Botaurus lentiginosus*) and Northern Harrier (*Circus cyaneus*), along with herptiles such as the Wisconsin Threatened Blanding's turtle. Large notable wetlands include the White River Marsh and Puchyan Prairie. Rare butterflies and moths, including swamp metalmark, silphium borer moth, regal fritillary, and powesheik skipperling, all Wisconsin Endangered, have been documented in prairie and fen habitats in this ecological landscape, and the poweshiek skipperling may be restricted to the Southeast Glacial Plains. Numerous other rare invertebrates are found here in open habitats, including the red-tailed prairie leafhopper and warpaint emerald dragonfly (both Wisconsin Endangered) as well as the Hine's emerald dragonfly, a species that is currently listed as Wisconsin Endangered and U.S. Endangered.

Socially Important Fauna. Species such as the Canada Goose, many species of ducks, white-tailed deer, Wild Turkey, and the introduced Ring-necked Pheasant are all important for hunting and wildlife viewing in this ecological landscape.

The Wisconsin Threatened Cerulean Warbler breeds in large stands of older hardwood forests. Important sites for this bird in the Southeast Glacial Plains include the Kettle Moraine State Forest and Lower Wolf River Bottoms. Photo by Dennis Malueg.

*The Wisconsin Endangered swamp metalmark is now extremely rare in the state. It occurs in calcareous fens and other alkaline wetlands that support swamp thistle (*Cirsium muticum*), the larval food plant. Photo by William Bouton.*

Horicon Marsh attracted 160,000–180,000 visitors in both 1986 and 1987 (Craven 1988) and spent over $2 million in the area to see large concentrations of migrating geese and other waterfowl. Birdwatching, in general, is popular here at several locations. Lake Winnebago has an important fishery and is the only place in the state that has a spearfishing season for lake sturgeon. Elsewhere in the ecological landscape, the many lakes support important populations of game fish such as walleye (*Sander vitreus*), smallmouth bass, largemouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*), yellow perch (*Perca flavescens*), crappie (*Pomoxis* spp.), and other panfish sought by anglers.

Wildlife Habitats and Communities. The diverse habitats of the Southeast Glacial Plains Ecological Landscape support a variety of fauna, especially those using wetlands, aquatic systems, southern forest, oak savanna, and grasslands. It is also important to southern forest, oak savanna, and surrogate grassland species. The Niagara Escarpment and Neda Mine provide specialized habitats required by several species of bats. Finally, 11 Important Bird Areas have been designated within or partially within the Southeast Glacial Plains Ecological Landscape (Steele 2007).

Open wetlands (marshes, sedge meadows, low prairies, and fens) are abundant in this ecological landscape at sites such as Lima Bog State Natural Area, Rush Lake, Horicon Marsh, White River Wildlife Area, Puchyan Marsh, the Scuppernong River basin, Kettle Moraine State Forest, and Mud Lake (Dodge County) as well as the multiple state properties comprising the lower Wolf River Bottomlands Natural Resources Area. Some of these wetlands are very large, are regionally or globally significant, and are known for their rich biota (e.g., Horicon Marsh, White River Marsh, Scuppernong River watershed, and Rush Lake). Many wetlands here have been drained or have been degraded by excessive inputs of sediments and nutrients. Common carp have reduced water quality, and invasive plants such as reed canary grass, narrow-leaved cat-tail, common reed, and glossy buckthorn have overtaken native vegetation and reduced the diversity of plants and animals using wetlands. However, even the degraded wetlands provide habitat for some native marsh and wetland species. The ***Wetland Reserve Program*** has restored many wetlands in this ecological landscape, including Zeloski Marsh (Jefferson County), Turtle Valley (Walworth County), Jefferson Marsh (Jefferson County), and Duffy's Marsh (Marquette County). Some wetlands that have water control structures have been managed recently to provide habitat specifically for migrating shorebirds (e.g., Theresa Marsh State Wildlife Area in Dodge and Washington counties).

Horicon Marsh is a huge marsh and shallow, highly altered lake on the Rock River that now supports populations of American White Pelican (*Pelecanus erythrorhynchos*), Redhead, Mallard (*Anas platyrhynchos*), Blue-winged Teal (*Anas discors*), American Bittern, Least Bittern (*Ixobrychus exilis*), American Coot (*Fulica americana*), Pied-billed Grebe (*Podilymbus podiceps*), Yellow-headed Blackbird, Black Tern, a variety of heron species, and many other waterbirds. It was designated as a "wetland of international importance" by the Ramsar Convention on Wetlands in 1990 (Ramsar Convention on Wetlands 1990) and as one of the 100 Wisconsin wetland "gems" by the Wisconsin Wetlands Association (WWA 2009). The northern two-thirds of Horicon Marsh is managed by the U.S. Fish and Wildlife Service as a national wildlife refuge, and the southern one-third is a state wildlife area managed by the Wisconsin DNR.

Rush Lake (Winnebago County) is the largest prairie-pothole lake east of the Mississippi River. The formerly lush and extensive beds of emergent vegetation have been reduced and degraded by artificially high water levels, agricultural runoff, and common carp. Restoration of the emergent vegetation is currently underway. This site is important to many wetland wildlife species (e.g., American and Least Bitterns, Common Gallinule (*Gallinula galeata*), American Coot, Forster's and Black Terns, Redhead, Ruddy Duck, King Rail, Virginia Rail

*Wilson's Phalarope (*Phalaropus tricolor*) (Wisconsin Special Concern) is a rare nesting bird in Wisconsin's marshes and sedge meadows. Photo by Dominic Sherony.*

The productive marshes of the Southeast Glacial Plains include important breeding sites for the Redhead, highly localized in Wisconsin. Photo by Donna Dewhurst.

(*Rallus limicola*), Sora (*Porzana carolina*), Black-crowned Night-Heron, Northern Harrier, Sedge Wren (*Cistothorus platensis*), American White Pelican, Double-crested Cormorant, Red-necked Grebe, and many other wetland and grassland birds (Steele 2007). Wisconsin's largest population of Red-necked Grebes nest at this site.

Other open wetlands, which are numerous in this ecological landscape, support species such as Pied-billed Grebe, Canada Goose, Mallard, Blue-winged Teal, Redhead, Ruddy Duck, Sora, Virginia Rail, American Coot, Common Gallinule, Green Heron (*Butorides virescens*), Least Bittern, Marsh Wren (*Cistothorus palustris*), Yellow-headed Blackbird, and Blanding's turtle.

Shallow water lakes provide habitat for fish as well as foraging and resting habitat for migrating waterfowl and other waterbirds during both spring and fall. These lakes (and some impoundments) support beds of aquatic plants, macroinvertebrates, and fish, and these are used by migrating waterfowl and other waterbirds. Many lakes have been impounded at their outlets, raising water levels and causing loss of wetland habitat for wildlife. Though many waterbodies have been degraded by industrial and agricultural runoff and important wetland habitat has been lost due to artificially elevated water levels and turbid water, they still provide habitat for many aquatic species.

The Winnebago Pool lakes, comprising lakes Winnebago, Butte des Morts, Winneconne, and Poygan, historically provided especially important habitat for colonial and other wetland nesting birds (e.g., Forster's Tern, Black Tern, Least Bittern) as well as for resident and migrant waterfowl (e.g., Canvasback, Lesser Scaup, and Ruddy Duck). These species still use the lakes today but to a reduced extent. Poor water quality (turbidity, excess nutrients) and the significant loss of emergent and submergent aquatic plants have led to declining populations or, in some cases, the loss of nesting marsh birds. Few Canvasbacks now use these lakes during migration; however, other diving ducks such as the Lesser Scaup and Ruddy Duck stop for a brief period during migration but do not stay long because of limited food availability (A.F. Techlow, Wisconsin DNR, personal communication). Common Tern, Forster's Tern, American White Pelican, Double-crested Cormorant, Great Blue Heron, Bald Eagle, Osprey (*Pandion haliaetus*), and Yellow-headed Blackbird populations continue to nest at some locations (A.F. Techlow, Wisconsin DNR, personal communication). These lakes also support an important sport fishery, especially for lake sturgeon (see the "Responsibility Species" section above for discussion of lake sturgeon and walleye).

Lake Koshkonong, on the Rock River, once provided habitat for many species of nesting and migratory waterfowl and other waterbirds, including Black and Forster's Terns. However, for many years artificially high water levels have made this lake too deep to support the aquatic vegetation needed as nesting habitat for these species. In 2005 there was still a large Black Tern colony at Lake Koshkonong (Wisconsin DNR unpublished data), and marshes on the lake's margins supported populations of Least Bittern and King Rail.

Several important breeding colonies of the Wisconsin Endangered Forster's Tern occur within the Southeast Glacial Plains. Nesting occurs in productive emergent marshes with open water nearby, where the terns forage for small fish and invertebrates. Photo by Len Blumin.

The Wisconsin Special Concern Black Tern has declined over much of its North American range. Marshes in the Southeast Glacial Plains provide important breeding sites for this elegant bird. Photo by Jack Bartholmai.

The Madison lakes (Mendota, Monona, Waubesa, and Kegonsa) and Fox and Beaver Dam lakes provide habitat for noteworthy populations of game fish, panfish, forage fish, and aquatic invertebrates. Mud Lake (Columbia County) is a shallow, muddy lake that supports a number of marsh birds, including Least Bitterns.

Lake Geneva in Walworth County supports smallmouth bass, numerous panfish, introduced brown trout, and other coolwater species. It also supports the native cisco, which is the southernmost inland lake in the Midwest to support this species. Lulu Lake, drained by the species-rich Mukwonago River in Walworth County, is of particular ecological significance because it holds a high diversity of fishes, amphibians, and reptiles (see Mukwonago River system below). It supports the threatened pugnose shiner, longear sunfish, Blanding's turtle, and pickerel frog (*Rana palustris*).

Rock Lake in Jefferson County, although under urban development pressure, supports sensitive species such as the Wisconsin Threatened pugnose shiner, Wisconsin Special Concern least darter (*Etheostoma microperca*), and Wisconsin Special Concern common mudpuppy (*Necturus maculosus maculosus*). Butler Lake, in the northern unit of the Kettle Moraine State Forest in Sheboygan County, is home to a population of the rare unicorn clubtail dragonfly (*Arigomphus villosipes*) that requires excellent water quality. Nearby Mauthe Lake, on the East Branch of the Milwaukee River, is relatively undisturbed and merits a systematic aquatic invertebrate survey.

Despite the widespread negative impacts of intensive agricultural, suburban, and urban land uses, some rivers and streams in this ecological landscape continue to support a diverse aquatic biota. Most of the rivers and streams are warmwater types, but coolwater and coldwater streams occur in the eastern and southwestern parts of the ecological landscape (see the "Hydrology" section of this chapter).

The Mukwonago River has good water quality and a diverse aquatic and wetland biota. Thirty-two to forty species of fish were found in the river immediately below Phantom Lake in a given year, which is "the highest fish species richness of any comparably sized stretch of stream in the state and includes several Wisconsin Threatened and Endangered fish and mussel species as well as numerous game fish and panfish species" (J. Lyons, Wisconsin DNR, unpublished data). This stream supports a population of the Wisconsin Endangered starhead topminnow and the Wisconsin Threatened longear sunfish, which are among the largest remaining populations of these species in the state (J. Lyons, Wisconsin DNR, unpublished data). The Mukwonago River also supports the Wisconsin Special Concern lake chubsucker (*Erimyzon sucetta*), Wisconsin Special Concern banded killifish (*Fundulus diaphanus*), Wisconsin Threatened pugnose shiner, and Wisconsin Threatened greater redhorse.

The "Illinois" Fox River near Waterford and Burlington supports a population of Wisconsin Threatened river redhorse, and the upper reaches in Waukesha County have small numbers of Wisconsin Threatened longear sunfish and Wisconsin Endangered starhead topminnow. Aquatic invertebrates in this river, especially mussels, may warrant more thorough study.

The upper Milwaukee River has diverse substrate, including limestone and cobble, and supports a diversity of fish, sensitive mussels, and dragonflies. It contains one of the state's best remaining populations of the Wisconsin Threatened greater redhorse plus a few Wisconsin Threatened longear sunfish and Wisconsin Threatened redfin shiner. Water quality improvements have helped restore a population of smallmouth bass, a game fish favored by many regional anglers.

The portion of the Wolf River that flows through this ecological landscape is similar to the lower Wisconsin and Mississippi rivers in species richness (fish, mussels, and other aquatic invertebrates), and the river and its complex floodplain support important populations of many SGCN species (Epstein et al. 2002), including the greater redhorse, lake sturgeon, river redhorse, western sand darter (*Etheostoma clarum*), four-toed salamander (*Hemidactylium scutatum*), wood turtle, Great Egret, American Bittern, and Blue-winged Teal. Other species supported by this portion of the lower Wolf River include mussels such as the elktoe (*Alasmidonta marginata*), round pigtoe (*Pleurobema sintoxia*), and snuffbox; dragonflies such as the elegant spreadwing (*Lestes inaequalis*), elusive clubtail (*Stylurus notatus*), pygmy snaketail, and Stygian shadowdragon (*Neurocordulia yamaskanensis*); predacious diving beetles, including *Agabus bicolor, A. inscriptus, Copelatus glyphicus, Ilybius discedens, I. incarinatus, Lioporeus triangularis, and Rhantus sinuatus*; White River crayfish (*Procambarus acutus*); Mississippi grass shrimp (*Palaemonetes kadiakensis*); and other invertebrates. The floodplain forest supports numerous vertebrate species including Black Duck, Black-billed Cuckoo (*Coccyzus erythropthalmus*), Least Flycatcher (*Empidonax minimus*), Prothonotary Warbler, Red-shouldered Hawk, and eastern red bat (*Lasiurus borealis*). Large, open marshes occur where the Wolf River empties into Lake Poygan; this section of the lower Wolf and Lake Poygan support many rare and SGCN species, including banded killifish, lake chubsucker, lake sturgeon, least darter, starhead topminnow, Blanding's turtle, common mudpuppy, pickerel frog, Black Tern, Canvasback, Forster's Tern, Redhead, and ellipse and slippershell mussels.

The lower Sugar River, in Green and Rock counties, supports the Wisconsin Endangered gravel chub, Wisconsin Threatened river redhorse, Wisconsin Threatened redfin shiner, mucket (*Actinonaias ligamentina*), and other mussels as well as rare or uncommon mayflies and other invertebrate species. The forested floodplain of the Sugar River is one of few known locations that support the Wisconsin Endangered Yellow-throated Warbler and several other forest interior species. Nest boxes placed along portions of the lower Sugar River have been shown to successfully provide habitat for the Prothonotary Warbler.

The Bark (Waukesha and Jefferson counties) and Oconomowoc (Washington and Waukesha counties) rivers are the only places in the state that still have viable populations of the Wisconsin Endangered slender madtom. The Bark, Oconomowoc, and Mukwonago (Walworth and Waukesha counties) rivers are clear, fast streams that contain rare mussels, including the State-listed ellipse, rainbow shell, and slippershell. The White River (Walworth County) flowing from Lake Geneva also supports a population of the Wisconsin Special Concern ellipse mussel.

Turtle Creek has Wisconsin's best remaining population of the Wisconsin Endangered gravel chub. This creek also supports the Wisconsin Threatened greater redhorse and Wisconsin Threatened Ozark minnow. Turtle Creek supports the fragile forktail (*Ischnura posita*), a species of dragonfly for which southern Wisconsin is the northern edge of its range, as well as the Wisconsin Endangered queensnake and other SGCN species.

Pheasant Branch Creek, flowing into the west shore of Lake Mendota, is home to a population of the Wisconsin Special Concern swamp darner (*Epiaeschna heros*), one of the largest dragonflies in the U.S.

Scuppernong Springs (Waukesha County) in the Southern Kettle Moraine supports rare damselflies, including the highland dancer (*Argia plana*) and other invertebrates. Springs and seeps emanating from tamarack and hardwood swamps, oak openings, fens, sedge meadows, and low prairies in this ecological landscape support pollution-intolerant populations of aquatic invertebrates.

Floodplain Forest occurs on the floodplains of rivers and larger streams of the Southeast Glacial Plains and provides important habitat for many species, including numerous rare species. Often, these forested stream corridors provide some of the only contiguous forested habitat over large distances. Red-shouldered Hawk, Yellow-billed Cuckoo, Prothonotary Warbler, Cerulean Warbler (all SGCN), and many other birds and herptiles rely on these habitats. Riverine lakes and ponds within these forested floodplains provide important habitat for many fish. Among the river systems with significant amounts of Floodplain Forest habitat are the lower Wolf (Outagamie, Waupaca, and Winnebago counties), Sugar (Green and Rock counties), Milwaukee (Sheboygan, Washington and Ozaukee counties), and Fox (Winnebago County).

Shrub swamps occur along river and lake margins. They also occur in poorly drained basins where fire suppression, ditching, and tiling may have accelerated the conversion of open wetlands such as sedge meadows, wet prairies, and shallow marshes to shrub swamps. Shrub swamps provide habitat for species such as Black-billed Cuckoo, Willow Flycatcher (*Empidonax traillii*), Yellow Warbler (*Setophaga petechia*), and Common Yellowthroat (*Geothlypis trichas*).

Remnant tamarack and northern white-cedar swamps occur at scattered locations within this ecological landscape. Many stands have been degraded or destroyed by hydrologic disruptions, infestations of invasive plants, and the conversion of native vegetation on adjoining upland to farmland or residential uses. Regeneration of conifers is often poor or nonexistent. Some of the better remnants provide suitable breeding habitat for regional rarities such as Northern Saw-whet Owl (*Aegolius acadicus*), Hermit Thrush (*Catharus guttatus*), Northern Waterthrush (*Parkesia noveboracensis*), Veery (*Catharus fuscescens*), Nashville Warbler (*Oreothlypis ruficapilla*), Canada Warbler (*Cardellina canadensis,* listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List), White-throated Sparrow (*Zonotrichia albicollis*), and Red-breasted Nuthatch (*Sitta canadensis*) (Bielefeldt et al. 2003). Other animals keying in on conifer swamps here include eastern ribbonsnake, four-toed salamander, and red-backed vole (*Clethrionomys gapperi*). Historically, snowshoe hare (*Lepus americanus*) inhabited conifer swamps as far south as Milwaukee County. Many of the common mammals found in southern Wisconsin (including popular game species) also use the conifer swamps.

Both the northern and southern units of the Kettle Moraine State Forest provide habitat for "southern" forest interior birds, and the northern unit also provides habitats for birds with more northern habitat affinities. These are, by far, the two largest blocks of upland forest remaining in the Southeast Glacial Plains Ecological Landscape and when combined are the largest area of public land in southeast Wisconsin. The upland forests here provide important habitat for species such as Acadian Flycatcher, Cerulean Warbler, Hooded Warbler, Red-shouldered Hawk (all Wisconsin Threatened) and several other forest interior species, many of which have experienced significant population declines in Wisconsin and throughout their regional ranges. These properties are also important migratory bird corridors, and the northern unit contains abundant ephemeral ponds that provide critical habitat for a number of vertebrate and invertebrate species, including Red-shouldered Hawk, Blue-winged Teal, American Woodcock (*Scolopax minor*), Blanding's turtle, pickerel frog, wood frog (*Lithobates sylvaticus*), and eastern red-backed salamander (*Plethodon cinereus*) (Hyde et al. 2010, WDNR 2011).

Native prairie remnants in this ecological landscape are mostly small and isolated. However, the southern unit of the Kettle Moraine State Forest contains good quality prairie remnants that are sometimes embedded within other open habitats such as marsh, sedge meadow, fen, and surrogate grassland. In other cases, the remnants are adjacent to Oak Openings or Oak Woodlands, both very rare natural communities. This property offers some of the Upper Midwest's most significant opportunities to expand, restore, and manage these fire-dependant natural communities, several of them globally rare, at multiple scales.

Surrogate grasslands include old fields, most CRP (Conservation Reserve Program) grasslands, green space, and other herb-dominated uplands composed mostly of nonnative grasses and forbs. Partial prairie plantings occurred on some state wildlife areas to aid attempts to boost turkey, duck, and pheasant production. Some of these partial prairie plantings have been planted to switchgrass, Indian grass, big and little bluestems, and limited numbers of forb species as well as plantings of nonnative cool season grasses. The Wisconsin DNR's prairie seed farm can provide local native prairie seed and help managers design appropriate seed mixtures for their sites. In addition, appropriate sites need to be selected to avoid compromising other management priorities. The Glacial Habitat Restoration Area, a landscape-scale project near the center of the Southeast Glacial Plains, was conceived and designed to restore grasslands and wetlands across an 800-square-mile area. To date, a net gain of 7,100 acres of grassland has been achieved, and almost 6,500 acres of wetlands have been restored. Most of the grassland and wetland restorations have been in small patches (less than

Because of the statewide loss of prairie, the Wisconsin Threatened Henslow's Sparrow is one of many native grassland birds that is now largely dependent on surrogate grasslands to provide adequate breeding habitat. Photo by Tom Schultz.

100 acres in size) scattered across the entire project area. The Southeast Glacial Plains' surrogate grasslands provide nesting, foraging, and migration habitat for many grassland birds, including Eastern Meadowlark (*Sturnella magna*), Bobolink (*Dolichonyx oryzivorus*), Henslow's Sparrow, Grasshopper Sparrow (*Ammodramus savannarum*), and Savannah Sparrow (*Passerculus sandwichensis*), as well as waterfowl and pheasants. This ecological landscape contains several areas that were designated as "Priority Landscapes" for grassland birds by Sample and Mossman (1997).

Natural and Human Disturbances

The Southeast Glacial Plains Ecological Landscape was once dominated by prairie, wetlands, oak savanna, oak forest, and maple-basswood forest but has been greatly changed by Euro-American settlement and related human disturbances. Agriculture, which now occurs on approximately 58% of this ecological landscape, and urban development have extensively altered the vegetation types, cover, and patterns, and there have also been major changes to the hydrology and natural disturbance regimes.

Fire, Wind, and Flooding

The western and southern portion of this ecological landscape was historically dominated by tallgrass prairie, bur oak-dominated savannas, and white-black-bur oak forest interspersed with wetlands (Finley 1976). The patterning and composition of vegetation here was largely due to fire regimes that existed for 5,000–6,000 years (Bray 1960). Fires are known to be essential to maintain tallgrass prairie and savanna vegetation, but there is disagreement about how frequently and intensely they burned prior to Euro-American settlement. Prairies may have burned at intervals of one to five years (Curtis 1959) and savannas at approximately 16-year intervals (Leitner et al. 1991). Activities of American Indians led to the ignition of many fires that maintained these community types, both in Wisconsin and throughout the Upper Midwest. Early Euro-American surveyors and travelers described extensive fires set by American Indians that were particularly common in late fall. Although lightning strikes are also known to have started fires and were more common here than in any other ecological landscape, these would likely have been too few to account for the large areas burned (Dorney 1981) under Wisconsin's climate regime. Fires starting from passing trains may have maintained a more frequent fire regime from the 1870s to around 1920. (See the "Fire, Wind, and Flooding" sections in Chapter 19, "Southern Lake Michigan Coastal Ecological Landscape," and Chapter 22, "Western Coulees and Ridges Ecological Landscape," for further discussion of fire disturbance.)

The historical fire regime is missing from today's highly modified landscape, except in a few areas where prescribed fire is used by land managers attempting to maintain open lowland prairie or savanna vegetation. In most areas, fire exclusion has allowed the saplings of shade-tolerant trees and shrubs (including aggressive and highly invasive species such as the nonnative buckthorns and honeysuckles to become abundant in both forest understories and formerly open areas. These species produce litter that does not carry fire nearly as well as oak leaves and prairie grasses and make it more difficult to use fire as a management tool.

Wet prairies, sedge meadows, and marshes were historically common in the Southeast Glacial Plains Ecological Landscape. Fire was important to maintain these communities in an open condition, especially for the wet prairies and sedge meadows. Cessation of fire after Euro-American settlement, along with ditching and lowering of the water table, has resulted in the succession of many wet prairies and sedge meadows to shrub swamps.

This remnant oak opening has been altered by many decades of fire suppression and heavy grazing. The native understory is gone, replaced by nonnative shrubs such as Eurasian honeysuckles and buckthorns, multiflora rose, and Japanese barberry. The dominant herb is the exotic Canada bluegrass. Waukesha County. Photo by Eric Epstein, Wisconsin DNR.

The northeastern quarter of the ecological landscape has a rougher, more dissected topography featuring drumlins and morainal ridges. A more mesic forest dominated by sugar maple and American basswood developed in this area, and this part of the ecological landscape contained one of the few large blocks of mesic hardwood forest present in southern Wisconsin at the time of Euro-American settlement in the mid-1800s.

The dominant disturbances in the forests in the northeastern part of the Southeast Glacial Plains would have been due to wind, creating small forest gaps at relatively frequent intervals (gap phase dynamics). Canham and Loucks (1984) reported that large-scale catastrophic windthrow was not a significant disturbance factor in southern Wisconsin. However, ***downbursts*** and tornadoes occasionally affect upland forests, and larger gaps created by windthrow or fire would have been necessary to initiate the oak component that is present in many areas. Windthrow also occurred in floodplain forests along rivers and streams where the high water table limited tree root depths.

Floodplain Forests and Hardwood Swamps along lakes, rivers, and streams and in poorly drained basins were also disturbed by periodic episodes of high water. Vegetative composition was affected by the timing and severity of flooding. Disturbances included scouring and direct damage by water, ice, and debris, sediment deposition, and periods of saturation or inundation interspersed with very dry conditions. Flood regimes have since been affected by dam construction in many parts of the ecological landscape (see the map entitled "Dams of the Southeast Glacial Plains" in Appendix 18.K), as well as by wetland drainage and filling, channelization, streambank stabilization, replacement of riparian vegetation and wetlands with agricultural fields, development of transportation infrastructure, and large increases in the area of impervious surfaces locally.

Dams have raised the water levels of many rivers and streams, creating deep water marshes and lakes (e.g., Lake Koshkonong, Lake Sinissippi, Rush Lake). In many cases, this has resulted in the inundation of shallow marshes and sedge meadows, greatly reducing the extent of emergent vegetation. These alterations, along with sedimentation, addition of nutrients, and the introduction of carp, have resulted in major changes to the vegetation in these communities and to the character of the lakes and streams with which these plant communities are associated.

Forest Insects and Diseases

Forests of the Southeast Glacial Plains Ecological Landscape are generally dominated by oaks, maple-basswood, and floodplain forest species such as silver maple, green ash, and river birch (*Betula nigra*). Each of these trees is associated with particular insects and diseases, including pests that periodically affect forests here.

Ash can be a major canopy species in floodplain forests, is often present and sometimes common in upland hardwood forests, and has been planted as a street tree in many cities in this ecological landscape. Emerald ash borer (*Agrilus planipennis*), an exotic insect native to Asia, has been confirmed in 35 Wisconsin counties as of 2015, including most counties of the Southeast Glacial Plains: Calumet, Columbia, Dane, Dodge, Fond du Lac, Green, Jefferson, Ozaukee, Rock, Sheboygan, Walworth, Washington, Waukesha, and Winnebago (WDATCP 2015). Affected counties have been placed under quarantine to limit the inadvertent spread of the emerald ash borer, which may be present in ash nursery stock, ash firewood and timber, or other articles that could spread emerald ash borer into other parts of Wisconsin or other states. Attempts to contain infestations in Michigan by destroying ash trees in areas where emerald ash borer was found have been unsuccessful, perhaps because the insect was already well established before it was found and identified. The emerald ash borer typically kills a tree within one to three years. Emerald ash borer has also been shown to feed on some shrub species (e.g., nonnative ornamentals such as privets and lilacs) in greenhouse tests, but it is still unknown as to whether shrub availability will contribute to its spread under field conditions. See the Wisconsin Emerald Ash Borer website (WDATCP 2015) for up-to-date information on its current distribution.

Asian longhorned beetle (*Anoplophora glabripennis)* has not been found in Wisconsin as of 2015 but would have major consequences if it were to become established. It is a major pest of maple species: sugar, silver, red, and Norway maple (*Acer platanoides*), and although it prefers maples, it will attack other hardwoods. Asian longhorned beetle was discovered in the Chicago area in 1998, and additional infestations have since been found in North America and Europe. The insect is believed to have entered North America inside wood packing materials and was likely introduced several times. The insect has, thus far, been contained in the Chicago area by destroying all susceptible trees in areas where it had been found, but a monitoring and eradication program has occasionally discovered new occurrences. Because containment efforts have been successful to date, there is hope that this insect may not become established in Wisconsin.

Dutch elm disease is caused by the fungus *Ophiostoma ulmi*, which is transmitted by two species of bark beetles or by root grafting. American elm (*Ulmus americana*) is more seriously affected than other elm species, but all of our native elm species are somewhat susceptible, as is the nonnative Siberian elm (*Ulmus pumila*). American elm has essentially been eliminated as a component of the forest overstory, but it can be a significant part of the understory and seedling layers. Its life span is typically now about 30 years before it succumbs to Dutch elm disease. The loss of American elm as a ***supercanopy*** or dominant tree in habitats such as floodplains has impacts on associated wildlife species such as Wood Duck (*Aix sponsa*) and, along with invasion of reed canary grass following opening of the forest canopy, may be a factor in regeneration problems currently encountered in bottomland forests.

Gypsy moth (*Lymantria dispar*) is now established in this ecological landscape. Populations are expected to increase occasionally, in the way a native insect would become more common at times. Impacts are expected to be variable, with some defoliations limited in extent and others affecting larger areas. New England states are seeing a 30–40 year (but highly variable) outbreak interval on average. Typically, drought precedes or coincides with gypsy moth outbreaks. Egg masses can be monitored to determine when a population increase large enough to produce defoliation is imminent.

Oak wilt is a vascular disease of oaks caused by the fungus *Ceratocystis fagacearum,* a species believed to be native to North America and known to occur in 21 states in the eastern and central U.S. The fungus plugs water-conducting vessels, causing leaves to wilt and fall, often killing the tree. All species of oak are susceptible, but species in the red oak group such as northern red, black, and northern pin oak (*Quercus ellipsoidalis*) are most readily killed. Once infected, they can die within a few weeks. Oaks in the white oak group (white, swamp white, and bur) can be infected, but mortality occurs less frequently and more slowly. The fungus spreads from an infected tree to adjacent susceptible trees via root grafts, causing a progressively larger patch of oak forest to succumb to oak wilt. Sap-feeding beetles (Nitidulidae family) and small oak bark beetles (*Pseudopityophthorus* spp.) can also carry spores to nearby healthy trees.

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

Invasive Species

Due in part to the large scale and pervasive impacts of human disturbances in the Southeast Glacial Plains, there are many nonnative invasive species that have become major problems here. Nonnative invasive plants and animals can outcompete native species and may eventually completely dominate a community, decreasing the abundance and diversity of native species, and disrupting ecosystem function.

In forested community types, glossy buckthorn and common buckthorn (*Rhamnus cathartica*), nonnative honeysuckles, garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), Dame's rocket (*Hesperis matronalis*), multiflora rose (*Rosa multiflora*), Norway maple, and black locust (*Robinia pseudoacacia*) already pose serious problems. These species may initially colonize disturbed areas and edges but once established can spread and continue to invade surrounding habitats without human "assistance." Many of the species mentioned above can also invade savanna habitats, and several are also problematic in shrub swamps. In grassland communities, problem invasives include crown vetch (*Coronilla varia*), cut-leaved teasel (*Dipsacus laciniatus*), bird's-foot trefoil (*Lotus corniculata*), white and yellow sweet clovers (*Melilotus alba* and *M. officinalis*), wild parsnip (*Pastinaca sativa*), autumn olive (*Elaeagnus umbellata*), multiflora rose, and spotted knapweed (*Centaurea biebersteinii*). Nonnative grasses such as smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and Canada bluegrass (*Poa compressa*) are problems in some native prairie remnants; however, in the appropriate context, they can also be important components of valuable habitat for rare and declining grassland birds and in surrogate grasslands should not necessarily be viewed as "invasive." Site values and management priorities need to be assessed on a case-by-case basis.

In aquatic and wetland ecosystems, the primary problem nonnative species are Eurasian water-milfoil, curly pondweed, rusty crayfish (*Orconectes rusticus*), common carp, common reed, purple loosestrife (*Lythrum salicaria*), and reed canary grass. The common carp continues to cause major problems in shallow lakes in the Southeast Glacial Plains by destroying native aquatic plant beds and suspending fine sediments and associated nutrients. Suspension of sediments increases turbidity and allows less light to reach plants in deeper waters, limiting growth. Large amounts of money and effort have been spent to control carp here, most recently using whole-lake poisoning to kill all of the carp and replace them with more desirable native species. In most cases, this method only temporarily reduces the carp population and kills many of the other native organisms that occur in the waterbody.

The exotic Mute Swan (*Cygnus olor*) breeds in this ecological landscape and has been documented as a nester in Waukesha, Walworth, Jefferson, Washington, Columbia, Dane, and Winnebago counties. This species poses a threat due to its mobility, ability to establish new populations, and ability to aggressively drive off some native waterfowl competitors. Mute swans also consume large quantities of submerged vegetation. There is an active statewide effort to control this species.

The Southeast Glacial Plains is highly vulnerable to additional introductions of invasive species. Human travel is a major vector for transport of a variety of invasive species, and the combination here of a large human population, many different types of transportation, and a highly disturbed landscape make it a likely location for additional introductions. In addition, many invasive species are adapted to be highly competitive on disturbed sites, of which there are many due to continuing agricultural, residential, and industrial uses and various development projects. Some ornamental plants used in landscaping can spread and become invasive in native communities, a problem because landscaping is a relatively large industry in the heavily populated Southeast Glacial Plains. For more information on invasive species, see the Wisconsin DNR's invasive species web page (WDNR 2014d).

Land Use Impacts

Historical Impacts. There have been dramatic changes in land use and land cover. Settlers plowed the prairies, drained the wetlands, and cut the forests for lumber and to make way for farmland. Following Euro-American settlement in the western and southern parts of the Southeast Glacial Plains

Ecological Landscape, land cover changed quickly from predominantly prairie, wetland, and oak savanna to agricultural fields interspersed with small scattered woodlots and wetlands that were too difficult to drain. In the northeastern part of the ecological landscape, the extensive forests were mostly cleared to make way for more farming. Only in the more rugged and difficult to farm terrain of the Kettle Moraine did the remnant forests remain relatively extensive.

Current Impacts. Current disturbances in the Southeast Glacial Plains Ecological Landscape are largely due to human activities, primarily agriculture, water level manipulations, and cessation of fire. Human disturbances also include the long-term conversion of land cover to houses, roads, agriculture, impoundments, and utility corridors, all of which are now prevalent here. Many of these changes are effectively permanent. Other disturbances, such as forest ***high-grading*** and recreational pursuits such as improper all-terrain vehicle use, can change the composition, structure, and function of a habitats to something less desirable.

In addition to direct impacts, human-caused land use changes also indirectly impact ecosystem structure and function by altering natural disturbance regimes. Forests in the Southeast Glacial Plains have been dramatically reduced in extent from what they were before Euro-American settlement, but the effects of wind disturbance on remaining forests have likely increased from historical conditions because woodlots, especially those that are small or linear within a matrix of agricultural land, now have more direct exposure to winds. Although peak flows of rivers here do not show increasing or decreasing trends (USGS 2009), there is more peak flow variability in recent times. Variability of peak flows may have been increased because of extensive wetland drainage, stream channelization, expanding urbanization, and/or by cropping lands that were historically prairie, savanna, or forest (which generally held water better). Construction of dams has disrupted the natural flood regimes of wetlands adapted to periodic flooding, and that has led to changes in species composition and stand structure as well as to function. Raising and then stabilizing water levels in shallow basins has resulted in the loss of aquatic and wetland vegetation, making these waterbodies more prone to destructive wind action, increasing the resuspension of solids, and accelerating eutrophication.

Fire suppression has reduced fire frequency and intensity, leading to dramatic changes in species composition, stand structure, and landscape patch structure of formerly extensive fire-dependent vegetation. Fire suppression has frequently led to the conversion of sedge meadow, prairie, oak savanna, and oak woodland into shrub thickets or dense forests.

Changes in Hydrology. The extensive surface waters of the Southeast Glacial Plains Ecological Landscape have been modified since Euro-American settlement. The construction of dams, locks, channel modifications, ditches, and dikes and

A long history of fire suppression and heavy grazing has allowed the understory of this oak opening to become choked with shrubs and saplings. The historical disturbance regime of periodic wildfire would have favored an open understory composed of native grasses and forbs. Photo by Eric Epstein, Wisconsin DNR.

the creation of institutions such as drainage districts have combined to alter hydrology and change water levels and flow characteristics, and these have often had negative impacts to water quality and other aquatic ecosystem attributes such as habitat and connectivity.

Prior to settlement of this area by Euro-Americans, wetlands were abundant in the Southeast Glacial Plains, covering approximately one-quarter of the ecological landscape, or about 1,235,750 acres. Roughly 70% of these wetlands (or 865,025 acres) were open (marsh, sedge meadow, and low prairie), making this ecological landscape very important for waterfowl and other wetland organisms. Almost one-half of the wetlands here were drained for agricultural, residential, and industrial purposes after Euro-Americans settled the region. While such activities were initially viewed as having obvious social benefits with little or no downside, they impaired, damaged, or destroyed many wetlands and some waterbodies by lowering or raising water tables, channeling water, and fragmenting formerly connected habitats. This has damaged or diminished the amount of most native wetland ecosystems such as sedge meadows, low prairies, and shallow marshes. Ditching alters hydrology by lowering the water table, which can damage or destroy native wetland plant communities and associated wildlife habitat. The loss of wetlands has led to many unforeseen consequences that can affect society in different ways and on a much larger scale than the local habitat losses and other impacts of any given ditch or check dam. Straightening stream channels (channelization) increases stream velocity, ultimately contributes to increased bank erosion, and can exacerbate flooding downstream. Channelized streams are poor habitat for most aquatic organisms.

Today wetlands cover about 13% of the Southeast Glacial Plains Ecological Landscape (3.3% forested and 9.2% nonforested). Some of the larger wetlands here are Horicon Marsh;

Eldorado Marsh; the White River-Puchyan marsh, meadow, and prairie complex; Scuppernong River watershed; the lower Wolf River (above Lake Poygan); and the Rush Lake wetlands. However, many of these wetlands continue to be degraded by excessive runoff of sediments, nutrients, herbicides, pesticides, and other pollutants from agricultural and urban lands, changed hydrologic conditions, and the impacts of carp and other invasive species (especially reed canary grass, common reed, and purple loosestrife).

In addition to widespread wetland drainage, some wetlands in the Southeast Glacial Plains Ecological Landscape have also been flooded to provide waterfowl habitat. Converting wetland habitat from one type to another, such as changing a sedge meadow to a marsh, is not necessarily an improvement and can diminish or eliminate habitat for species dependent on the "converted" habitat. While it is still a wetland, it may have fewer or different functional values than the original wetland (WDNR 2001) and will support a somewhat different group of species. At the ecological landscape level, all native wetland types should be maintained in an appropriate range of patch sizes and contexts and protected from direct or indirect damaging activities that diminish their extent, quality, and function. Broadscale assessments are needed to ensure that native habitats are not lost or damaged due to deliberate conversion. Changing wetland hydrology by lowering the water table, especially when combined with the elimination of periodic fire, can cause sedge meadows, low prairies, and fens to succeed to shrub or hardwood swamps.

Dams were constructed to generate power, mill grains, facilitate water transportation, and create recreational opportunities. Dams limit the movement of aquatic organisms, including game fish such as lake sturgeon, walleye, and smallmouth bass. The impounded waters behind dams are warmed, allowing ***rough fish*** such as carp to flourish while eliminating habitat for more desirable native species. Changes in hydrology, including those that restore more natural conditions, cause changes in stream habitat. For example, following removal of the Woolen Mills Dam on the Milwaukee River, stream habitat improved, populations of carp declined, and native fish increased (Kanehl et al. 1997).

As of 1989, a three-step plunge pool ***fishway*** *constructed at the Eureka Dam site enables sturgeon and other species to continue upstream on the Fox River. The dam had acted as a barrier to fish migration for 112 years. Quarried limestone was added below the spillway to fill the scour pool and minimize the negative impact (entrapment) upon smaller fish from the undertow current immediately below the dam. Photo by Ron Bruch, Wisconsin DNR.*

This ecological landscape has many large, shallow lakes. Examples include Rush Lake, Lake Koshkonong, and the Winnebago Pool lakes of Winnebago, Poygan, Winneconne, and Butte des Morts. Shallow water lakes are generally less than 20 feet in depth and do not experience thermal ***stratification*** (WDNR 2001). Many were created in part as impoundments, with water levels controlled by a dam. Although impoundments can and do provide valuable habitat for fish and wildlife, they can cause ecological damage to the streams, lakes, and wetlands they have affected. From historical accounts, some of these lakes formerly teemed with plants and animals. Years of attempted lake level stabilization have disrupted the natural cycles of high and low water needed to maintain aquatic and wetland habitats over time. In some "stabilized" aquatic systems, the loss of aquatic plant life can permit the suspension of sediments and the subsequent release of nutrients from these suspended sediments, which causes algae blooms. Habitat is then lost or damaged, and water quality and clarity are reduced.

Many of the shallow lakes are disrupted by common carp, a nonnative fish formerly prized as food by Euro-American settlers. This fish impacts aquatic plants by uprooting them, an activity that disturbs and suspends bottom sediments and the nutrients stored in them. The suspended sediments increase turbidity to the detriment of aquatic plant life and can bury the spawning beds of native fish, reducing their populations. Increasing the availability of nutrients can lead to algae blooms. When algae blooms occur, they reduce the amount of dissolved oxygen present in the water upon which aquatic organisms depend. Where water is already impounded and it is an option, water level management can be a relatively inexpensive method of regenerating emergent and submergent vegetation and the animals it supports. However, drawdowns often have low social acceptability because this reduces opportunities for some water-based recreation short-term while lake rehabilitation is occurring.

When water levels cannot be addressed, restoration of shallow lake ecology becomes difficult and very expensive. For instance, on Lake Butte des Morts, one of the Winnebago Pool lakes in east-central Wisconsin, the Wisconsin DNR instituted a project known as the Terrell's Island Breakwall. This project enclosed more than 600 acres within a rock breakwall to reduce the erosive effects of wave action, limit carp access, and thereby restore aquatic habitat. This effort, while successful, cost almost 2 million dollars, and the ecological response is much less than what could have been achieved by lowering water levels. For some of these shallow lakes and impoundments, the best management option to restore habitat and associated fish and wildlife populations is to restore natural fluctuations in water levels or, at a minimum, manage water levels in a manner that more closely mimics natural fluctuations.

Agriculture. Prior to settlement by Euro-Americans, the vegetation of the Southeast Glacial Plains Ecological Landscape was characterized by a ***mosaic*** of prairie, oak savanna, hardwood forest, sedge meadow, and marsh. Almost all of the prairie and oak savanna, many of the sedge meadows, and much of the forest has been converted to agricultural uses because of the favorable climate, relatively level topography, and rich soils. Currently, farming occurs on approximately 60% of all land in this ecological landscape.

Widespread and intensive agriculture in the ecological landscape has created a matrix of farm fields, with small, scattered, isolated patches of forest and wetland. This benefits common and widely distributed species such as white-tailed deer and Wild Turkey but does not provide habitat for rare area-sensitive grassland or forest interior species. Because of the intensive agriculture and urban/rural residential land uses, grassland bird habitat is now largely restricted to idle nonnative grasslands on publicly owned properties and on unfarmed, privately owned grasslands such as wet meadows. Large-scale grassland-wetland management sites include Scuppernong River watershed, White River Marsh, Rush Lake, and the Glacial Habitat Restoration Area. Many habitat specialists dependent on relatively undisturbed vegetation have also declined or disappeared.

Groundwater contamination via agricultural use can be an issue in areas near the Niagara Escarpment because the highly fractured dolomite bedrock is close to the surface, which allows agricultural chemicals and polluted surface waters to quickly leach into the groundwater.

This unprotected creek runs through a barnyard, where it picks up sediments, nutrients, and other contaminants. Photo by Dean Tvedt.

The Wetland Reserve Program has enrolled thousands of acres in this ecological landscape, taking formerly farmed land out of crop production and restoring wetland conditions. Usually adjacent lands are restored into permanent grass cover. The combination of restored wetlands and permanent grass cover benefits wetland and grassland birds and protects soils and water quality, although these wetlands do not typically support the same levels of plant and animal diversity as intact, undisturbed native wetlands.

Forest Management. One land cover change in the Southeast Glacial Plains has been the loss of oak in upland forests. Oak is no longer a significant forest component in much of the ecological landscape except in the less developed Kettle Moraine region. Currently, we are living on the legacy of fires that occurred over one hundred years ago and produced and maintained the oak forests, woodlands, and savannas. In part because of the cessation of periodic fire, when oak is logged today, it is often replaced by other tree species, especially on the richer sites.

The practice of high grading has been common in many forested areas and when used to remove large oaks often results in a conversion to less ecologically and economically desirable trees such as basswood, red maple, ironwood, and box elder. Shrubs and saplings of other tree species often have a significant competitive edge over the oaks under current disturbance scenarios that do not include periodic prescribed fire. The introduction and spread of invasive species (especially the Eurasian honeysuckles and buckthorns and garlic mustard) have also contributed to oak regeneration failures. More research is sorely needed to develop oak regeneration techniques that restore and maintain not only the oak trees (very difficult on mesic and even dry-mesic sites) but maintain entire oak-dominated communities. Increased use of prescribed fire as a silvicultural tool may be productive in combination with mechanical brush control, herbicide use, and underplanting. At the present time, many of the techniques in use to manage oak either have limited (or no) success or are prohibitively expensive, especially for private owners of small woodlots.

Lack of regeneration within bottomland hardwood forests (which includes both floodplain forest and hardwood swamp) could be another significant future land cover problem. Following the major destruction caused by Dutch elm disease and the loss of almost all mature elms, the disruption of hydrologic regimes, the continued spread and introduction of invasive species, and potential for damage caused by the emerald ash borer may make regeneration of lowland forests difficult. Due to altered hydrology, many lowland forests are apparently on new successional trajectories.

Outright destruction of forest has also been one of the major and pervasive changes to the land cover of the Southeast Glacial Plains. This problem is exacerbated by the poor regeneration now demonstrated by virtually all tree species that are adapted to disturbance regimes of periodic wildfire or flooding or species that are dependent on intact site hydrology in areas where maintaining native forest communities is an objective.

Swamp conifers such as tamarack and northern white-cedar are failing to regenerate at many sites in the ecological landscape. At some locations, the canopy trees, especially tamarack, are dying. Hydrologic disruptions appear to be a major cause of this mortality, and for northern white-cedar, excessive deer browse is at least partly responsible for the lack of tree regeneration. Suppression of fire, the increase in tall shrubs and deciduous saplings, excessive nutrient and sediment inputs from surrounding agricultural lands, changes in landscape context, and climate change may also be contributing factors to the decline of native conifers here, but more definitive answers to the question of why these communities are apparently no longer able to maintain themselves are not available now. Research is needed to determine the cause of decline and lack of regeneration of these two community types and to develop practical and effective means of addressing the underlying problems. The negative changes appear to be happening rapidly, so there is an element of urgency associated with this problem.

■ **Residential Development.** Dispersed residential development has occurred and is increasing throughout the ecological landscape, especially near the larger cities (e.g., Madison, Waukesha, and those parts of the Fox River valley in the Southeast Glacial Plains Ecological Landscape). Dispersed development creates permanent and widespread changes that alter large areas within the ecological landscape. It results in not only the direct destruction of forests and grasslands but in habitat fragmentation and the loss of habitat connectivity.

A trend in some rural areas has been the construction of large homes, often with huge lawns, at low densities. Depending on what is in the surrounding area, this can present opportunities as well as problems. Photo by Eric Epstein, Wisconsin DNR.

Heavy development of lake and stream shorelines has had major negative impacts, such as loss of habitat and reduced water quality, that has affected native aquatic plants and animals, including fish, herptiles, and invertebrates. Such impacts have occurred statewide, but they have been especially dramatic and well documented in the lakes of the Southeast Glacial Plains Ecological Landscape (Jennings et al. 1999, Marshall and Lyons 2008). Special attention is needed to clarify ***cumulative impacts*** on local site conditions and on overall watershed condition.

Management Opportunities for Important Ecological Features of the Southeast Glacial Plains

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 of one or more community types;
- 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 other important management considerations;
- accommodate species needing large areas or those requiring more than one type of 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 consideration 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 in 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 Southeast Glacial Plains include

- the Kettle Moraine;
- Mukwonago River watershed;
- the lower Wolf River;
- Niagara Escarpment;
- marshes, meadows, fens and shallow lakes;
- other inland lakes;
- conifer swamps: tamarack, black spruce, northern white-cedar;
- warmwater rivers and streams; and
- miscellaneous features: scattered, sometimes isolated forest, savanna, and prairie remnants; springs; surrogate grasslands; lakes; shrub swamp (alder thicket).

Natural communities, community complexes, and important habitats for which there are management opportunities in the Southeast Glacial Plains Ecological Landscape are listed in Table 18.2. Examples of some locations where these important ecological places may be found within the ecological landscape are shown on the "Ecologically Significant Places within the Southeast Glacial Plains Ecological Landscape" map in Appendix 18.K at the end of this chapter.

The Kettle Moraine

The Kettle Moraine is an area of relatively rough, topographically distinctive terrain that resulted from contact between two glacial lobes, the Green Bay Lobe and the Lake Michigan Lobe (see Figure 18.3 in the "Physical Features" section). The land in the Kettle Moraine is generally less developed than in areas with more level terrain and richer soils. This is one of the few areas in southern Wisconsin with substantial public ownership in an ecological landscape that is 96% privately owned,

Outstanding Ecological Opportunities in the Southeast Glacial Plains Ecological Landscape

- The Southeast Glacial Plains offers some of the Upper Midwest's best opportunities to restore and manage globally rare natural communities such as oak savannas, tallgrass prairies, sedge meadows, and fens.
- The Kettle Moraine is a major repository of biodiversity, including natural communities, aquatic features, and rare and declining species.
- The Kettle Moraine State Forest offers a regionally rare opportunity to manage uplands associated with wetlands at large scales.
- The southern Kettle Moraine contains some of Wisconsin's best and most viable examples of oak savanna, oak forest, prairie, fen, and marsh.
- The northern Kettle Moraine features extensive upland hardwood forests, hardwood swamps, conifer swamps, open wetlands, and ephemeral ponds.
- Wetlands are common here and include large fertile marshes and sedge meadows that provide habitat for numerous resident and migratory animals, especially waterbirds.
- The Mukwonago River watershed supports exceptional aquatic biodiversity and occurs within a mosaic of highly significant wetlands, prairie, oak savanna, and oak forest.
- Other significant warmwater ecosystems include the Wolf, Bark, Oconomowoc, Sugar, and Milwaukee rivers as well as smaller streams such as Turtle Creek.
- The Niagara Escarpment supports rare plants and globally rare invertebrates and contains a regionally significant bat hibernaculum.
- Calcareous till and groundwater have made the Southeast Glacial Plains a state stronghold for alkaline streams, lakes, marshes, meadows, and calcareous fens. All of these habitats support rare species.
- Large-scale grassland/wetland restoration projects that are up and running include the Glacial Habitat Restoration Area and Scuppernong Marsh.
- The Wetland Reserve Program has restored and can continue to restore many wetlands on private lands using federal dollars.
- Small prairie remnants occur throughout the southern Kettle Moraine and at scattered locations in the southern and western parts of the ecological landscape.
- Large shallow lakes are important for lake sturgeon, other sensitive fish, herptiles, invertebrates, and waterbirds.
- Some of North America's best and most publicized examples of glacial landforms occur within the Southeast Glacial Plains. Associated "ecological opportunities" include community mosaics that were strongly shaped by these landforms and are not repeated elsewhere.

Table 18.2. *Natural communities, aquatic features, and selected habitats associated with each ecological feature within the Southeast Glacial Plains Ecological Landscape.*

Ecological features[a]	Natural communities,[b] aquatic features, and selected habitats
Kettle Interlobate Moraine – includes the Northern, Southern, Middle Kettle Moraine	Northern Wet-Mesic Forest Northern Hardwood Swamp Black Spruce Swamp Southern Dry Forest Southern Dry-mesic Forest Southern Hardwood Swamp Southern Mesic Forest Southern Tamarack Swamp Floodplain Forest Oak Opening Oak Woodland Alder Thicket Bog Relict Shrub-carr Dry Prairie Mesic Prairie Wet Prairie Wet-Mesic Prairie Surrogate Grassland Calcareous Fen Emergent Marsh Submergent Marsh Northern Sedge Meadow Southern Sedge Meadow Coldwater Stream Ephemeral Pond Inland Lake Springs and Spring Runs Warmwater River
Mukwonago River Watershed	Southern Dry-mesic Forest Southern Sedge Meadow Southern Tamarack Swamp Oak Opening Oak Woodland Shrub-carr Wet-mesic Prairie Calcareous Fen Emergent Marsh Submergent Marsh Ephemeral Pond Impoundment/Reservoir Inland Lake Springs and Spring Runs Warmwater River Warmwater Stream
Lower Wolf River	Northern Hardwood Swamp Floodplain Forest Tamarack Swamp Alder Thicket Shrub-carr Northern Sedge Meadow Southern Sedge Meadow Surrogate Grassland Emergent Marsh Submergent Marsh Warmwater River

Continued on next page

Table 18.2, *continued***.**

Ecological features[a]	Natural communities,[b] aquatic features, and selected habitats
Niagara Escarpment	Southern Mesic Forest Southern Dry-mesic Forest Oak Woodland Cedar Glade Dry Cliff Moist Cliff Bat Hibernaculum Springs and Spring Runs
Marshes, meadows, and shallow lakes	Southern Hardwood Swamp Shrub-Carr Wet Prairie Wet-mesic Prairie Southern Sedge Meadow Surrogate Grassland Calcareous Fen Emergent Marsh Submergent Marsh Inland Lake
Scattered conifer swamps	Northern Wet-Mesic Forest Black Spruce Swamp Southern Tamarack Swamp Alder Thicket Shrub-carr Inland Lake
Warmwater rivers and streams	Floodplain Forest Wet Prairie Wet-Mesic Prairie Southern Sedge Meadow Emergent Marsh Submergent Marsh Warmwater River Warmwater Stream

[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" in Part 1 for definitions of natural community types.

and it is heavily used for recreation. The Kettle Moraine also contains the only extensive areas of upland forest in the Southeast Glacial Plains. Remnant natural communities in the Kettle Moraine tend to be less isolated than at most other locations within this ecological landscape, a factor that enhances many management opportunities. There are also significant opportunities to expand and/or connect remnant natural communities and other habitats here.

Worthy of special mention are the high number of rare species persisting here. Many of these are associated with habitats that are themselves rare, such as tallgrass prairies, oak openings, calcareous fens, large blocks of unbroken upland hardwood forest, and ***relict*** stands of lowland conifers.

South Kettle Moraine

Outstanding features of the southern Kettle Moraine include a regionally significant concentration of rare natural communities, including remnant Oak Openings, Oak Woodland, Calcareous Fen, Wet-mesic Prairie, Southern Sedge Meadow, and Southern Tamarack Swamp. The southern Kettle Moraine is one of only a few locations in the state where it will be possible to protect, manage, and restore the full continuum of fire-dependent natural communities characteristic of ecological landscapes south of the Tension Zone at a large scale. A major grassland-savanna restoration project is well underway within the southern unit of the Kettle Moraine State Forest in southwestern Waukesha County's Scuppernong River watershed.

The Scuppernong River basin contains some of Wisconsin's best and largest examples of globally rare natural communities such as tallgrass prairies and oak savannas. Numerous rare plants and animals have been documented here. Waukesha County. Photo by Eric Epstein, Wisconsin DNR.

Undisturbed ephemeral pond in rough interlobate moraine, embedded within mature dry-mesic hardwood forest of oaks and maples. Photo by Eric Epstein, Wisconsin DNR.

Oak Woodland features high canopy closure, but the dominant oaks retain distinctive limb architecture. Such vegetation is transitional between oak forest and oak savanna and can be managed at appropriate scales and in the right settings to benefit some forest interior species along with other species requiring or preferring more open conditions. Jefferson County. Photo by Drew Feldkirchner, Wisconsin DNR.

Extensive forests now occur in some parts of the southern Kettle Moraine, mostly consisting of overgrown savannas and woodlands, some oak forest, and plantations of white and red pine. While the plantations are not natural habitats, they can increase the effective size of some of these forests and provide habitat for species that otherwise would likely not be present. Some of these forest patches are large enough to support rare forest interior birds such as the Cerulean Warbler, Hooded Warbler, and Acadian Flycatcher. Planning, wherever large forested areas occur, will best be conducted by an interdisciplinary group where the opportunities for maintaining or increasing forest interior conditions are weighed against the feasibility and need for oak savanna and grassland restoration. These two objectives need not be incompatible or in conflict if the planning unit is large enough and if sufficient data have been collected and analyzed at local and landscape scales.

North Kettle Moraine

This portion of the Kettle Moraine is characterized by extensive hardwood forests, lakes, ephemeral ponds, and streams with their associated wetlands—lowland forests of cedar, tamarack, and ash, and shrub swamps composed of willow, dogwood, and alder. Floodplain Forest, sedge meadows, and spring seeps are relatively minor in terms of acreage but important for their context and for the distinctive assemblages of dependent species they support. The prairie and savanna elements that characterize the southern Kettle Moraine are, for the most part, scarce or absent. This area includes the northern unit of the Kettle Moraine State Forest.

This is one of the very few places in the Southeast Glacial Plains that will potentially sustain populations of species dependent on forest interior conditions. Managers should seek opportunities to expand the area of forest and fill gaps. This would give planners and managers more flexibility to include patches of early successional forest and native upland shrub habitats into management scenarios, thereby enhancing rather than compromising the large blocks of interior forest and populations of species requiring those conditions.

Middle Kettle Moraine

In this part of the interlobate Kettle Moraine, the vegetation is more fragmented by agricultural lands and residential developments than in areas to the north or south where larger blocks of public ownership occur. Consequently, opportunities to reconnect some of the now disjunct areas may be difficult and expensive. The cultural features responsible for this fragmentation include the Interstate 94 corridor, several other major travel corridors, scattered businesses, and

This stand of mature mesic hardwood forest has a canopy composed of large sugar maple, American basswood, American beech, and northern red oak. Most forest remnants of this type occur within the northeastern part of the Southeast Glacial Plains. Kettle Moraine State Forest – Northern Unit. Photo by Christina Isenring, Wisconsin DNR.

a number of upscale subdivisions. At locations where the separation between patches of natural or semi-natural habitat is not effectively permanent, a "stepping stone" approach to conservation design might be used. (In heavily developed landscapes, or in areas where land prices are extremely high, it is not always possible to connect the remnant habitat patches. The next best option might be to protect what's left in configurations that keep their proximity as close as possible. Sometimes it may be feasible to incorporate undeveloped green spaces into some of the areas between more inherently valuable habitat remnants). Within such areas, site-by-site assessments of ecological opportunities are needed to establish site quality, document management needs, and clarify the factors that would better ensure long-term site viability.

An example of one of the better opportunities to enlarge, connect, and enhance the conservation of native ecosystems in the middle Kettle Moraine exists at sites along the Oconomowoc and Little Oconomowoc rivers in southwestern Washington and northern Waukesha counties. This area includes the Loew Lake unit of the Kettle Moraine State Forest, Monches Woods, and the privately owned Zinn Preserve. Extensive undeveloped wetlands occur to the north of Loew Lake. Partnerships with other conservation organizations, including local land trusts, will need to be pursued and developed in this ecological landscape.

While a majority of future acquisitions and expansions might be directed at the southern and northern parts of the Kettle Moraine, additional opportunities to work with private landowners and organizations between the northern and southern areas should be sought. It should be remembered that recreational pressures to use those areas now in public ownership will increase, and the current land base may prove to be quite limited in its ability to provide adequate protection for the many unique natural features here.

Management Opportunities, Needs, and Actions

- The South Kettle Moraine contains outstanding examples of globally rare natural communities such as Wet-mesic Prairie, Calcareous Fen, Oak Woodland, and Oak Openings.
- Numerous rare species are associated with and sometimes dependent on these rare communities. Expanded monitoring of some rare or declining species is needed, especially where management needs and responses are uncertain and potential conflicts may exist.
- Both the southern and northern portions of the Kettle Moraine offer large blocks of upland hardwood forest that provide critical habitat for forest interior species. The southern Kettle Moraine must also accommodate grassland and savanna restoration priorities. In the north, forests could be expanded, creating additional management flexibility.
- Both the northern and southern parts of the Kettle Moraine offer opportunities to manage at large scales and maintain populations of area-sensitive species that have seriously declined or disappeared elsewhere in this ecological landscape. Many habitat specialists can be accommodated here.
- The Kettle Moraine is one of only a few places in this entire ecological landscape where habitat isolation can potentially be overcome, patch size can be increased, and ecological connectivity can be maintained or reestablished. This is especially true for the upland habitats, although there are also excellent wetland opportunities.
- The middle Kettle Moraine is more fragmented and offers contextual challenges to managers owing to the number of developments already present and the absence of large blocks of unbroken habitat such as those found to the north and south. Major considerations include reducing habitat isolation and edge and protecting water quality (e.g., by using river and wetland corridors, developing buffers where needed, and working with key private landowners to accomplish defined ecological goals that cannot be accomplished within single ownerships).

Mukwonago River Watershed

The Mukwonago River system supports a wealth of native aquatic and wetland species, including rare fish, mussels, butterflies and moths, and dragonflies and is associated with extensive wetlands of good quality and significant biodiversity values. Among the important wetland communities are Emergent Marsh, Southern Sedge Meadow, Calcareous Fen, and Wet-mesic Prairie. Southern Tamarack Swamp is present at several locations, and small patches of Wild Rice Marsh occur where conditions are suitable.

A dam on the Mukwonago River within the city of Mukwonago has created 118-acre Phantom Lake, which features a large Emergent Marsh that is home to uncommon animals such as Black Tern and Blanding's turtle. Maintaining necessary water quantities in the Mukwonago, its tributaries, feeder springs, and seepages may become problematic because the demand for access to greater amounts of water is increasing and groundwater withdrawals are now occurring as a result of this increased demand.

The stretch below the Mukwonago Dam has an especially rich diversity of fish. J. Lyons (Wisconsin DNR unpublished data) reported up to 40 fish species within this stretch of river using annual surveys from 2003 through 2008; five of these were rare (lake chubsucker, pugnose shiner, greater redhorse, longear sunfish, and starhead topminnow). The populations of starhead topminnow and longear sunfish are among the largest remaining in the state. The Mukwonago also has a diverse sport fishery of 10–12 species (J. Lyons, Wisconsin

The diverse natural community mosaic along the Mukwonago River between Eagle Springs and Phantom lakes includes wild rice marsh, sedge meadow, tamarack swamp, springs and seepages, and oak woodland. Walworth and Waukesha counties. Photo by Eric Epstein, Wisconsin DNR.

The canopy of this oak woodland bordering the Mukwonago River is composed of large oaks (white, northern red, bur, and a few black) and some shagbark hickory. The Wisconsin Field Office of the Nature Conservancy manages this site and is using prescribed fire and mechanical removal of shrubs and saplings to restore structure and improve conditions for native understory plants. Photo by Eric Epstein, Wisconsin DNR.

DNR, unpublished data). The river has relatively little protection from adjoining land use impacts here because the floodplain is narrow and the surrounding lands are now under heavy development pressure. Maintaining water quality, water quantity, and the sensitive biota the river now supports will be major challenges for managers in the near future, especially below Mukwonago where increasing development is accompanied by increases in impervious surface. The Mukwonago River joins the (Illinois) Fox River approximately 2 miles below the dam.

The uplands bordering the river also afford significant conservation opportunities. Toward the headwaters, remnant Oak Openings, Oak Woodland, and Southern Dry-mesic Forest communities occur, with scattered small patches of native prairie. Project managers from The Nature Conservancy and the Wisconsin DNR have reintroduced fire to the oak-dominated uplands to restore characteristic structural and compositional features of the now very rare Oak Openings and Oak Woodland communities.

Partners engaged in various aspects of watershed protection for this area include the Wisconsin DNR, The Nature Conservancy, the Friends of the Mukwonago River, the Waukesha County Land Conservancy, the Kettle Moraine Land Trust, and many private citizens.

Management Opportunities, Needs, and Actions

- Protecting site hydrology is of paramount importance and is no mean task in an area that is so heavily populated and developed and growing rapidly.
- Impacts of the Eagle Springs Lake Dam on the extensive wetlands upstream are not adequately understood. Cattails and a few other emergent macrophytes appear to be increasing at the expense of species associated with meadows and fens. Wetlands here need to be monitored, using series of aerial photos taken over time to complement on-the-ground vegetation transects.
- Continue efforts to control and reduce invasive species.
- Monitor impacts of burning, especially in forested areas and restored savannas.
- Lands bordering the river below the Mukwonago Dam need additional protection.
- A watershed scale effort to update and expand information on the locations of rare plants and animals dependent on various components of the Mukwonago River system is needed.
- Continue working with The Nature Conservancy, the Friends of the Mukwonago River, Kettle Moraine Land Trust, the Waukesha County Conservancy, other NGOs, Southeastern Wisconsin Regional Planning Commission (SEWRPC), and private individuals to protect the aquatic features, natural communities, plants, and animals of the Mukwonago River watershed.

Lower Wolf River

Between New London and Fremont, the Wolf River's gradient is low, and the floodplain is up to several miles wide. The extensive forested lowlands along this stretch of the Wolf River provide critical habitats that occur at few other locations within this ecological landscape and support many area-sensitive forest interior birds. There is a diverse fishery with at least 69 fish species found between Lake Poygan and the Shawano Dam, seven of which are rare. Efforts to restore and enhance lake sturgeon habitat and maintain self-sustaining populations in the lower Wolf River and its connecting lakes should continue. This is important for the future health of lake sturgeon populations, but there are other sensitive aquatic species and habitats also requiring attention on the lower Wolf River.

Several natural lakes, Partridge, Partridge Crop, and Cincoe (Waupaca County), occur along the river just above Fremont, and these are associated with extensive marsh, meadow, and shrub swamp habitats.

Problematic invasive species in the river and marshes include common carp, reed canary grass, common reed, and purple loosestrife, although common reed beds have been used by Forster's Terns (Wisconsin Endangered) as substrate for nesting in recent years (A.F. Techlow, Wisconsin DNR, personal communication). Restoring marshes composed primarily of native emergent plants remains a desirable goal here. The exotic flowering rush (*Butomus umbellatus*) is established in backwaters and in marshes along the lower Wolf River and should be watched carefully because it has the potential to displace native marsh species. The exotic emerald ash borer could become a serious problem in the lowland hardwood forests along the lower Wolf in the future.

To provide secure, viable habitat over time for some of the forest interior birds, it is desirable to establish several large blocks of older forest with high canopy closure. Where feasible and appropriate, designation of natural areas, use of ***old-growth*** and ***old forest*** management guidelines (WDNR 2006a), and extended rotations are among the means by which such habitat could be established and maintained. Creating or maintaining connections between such blocks and upland forests is also an important management consideration for these exceptionally valuable forests.

Conifer swamps are uncommon along the lower Wolf River, but there is an extensive area of hydrologically intact tamarack swamp on the margins of the river's floodplain a few miles north of Fremont. This community and the habitats it provides for wildlife and plants are neither well represented nor well protected along the lower Wolf, although there are some more isolated stands of swamp conifers that occupy insular basins away from the river and outside of its floodplain (e.g., Hortonville Bog State Natural Area).

An extensive sedge meadow north of Lake Winneconne supports many species that are scarce in or absent from in the more marshy wetlands directly associated with the lower Wolf River.

Extensive marshes, with scattered riverine lakes and ponds, occur within the Wolf River floodplain above Lake Poygan. Photo by Eric Epstein, Wisconsin DNR.

Much of the floodplain of the Lower Wolf River between Shaw's Landing and Fremont is forested. Riverine ponds, sloughs, and marshes are also shown here. Waupaca County. Photo by Eric Epstein, Wisconsin DNR.

Uplands bordering the vast marshes along the lowermost stretches of the Wolf River below Fremont are predominantly a mix of active agricultural lands, fallow fields, and CRP (Conservation Reserve Program) lands. Protection of these open uplands adjacent to the river can increase the effective size of open marsh and meadow habitats, provide additional niches for open country upland species that are in increasingly short supply, and protect the wetlands and the river from sediment and nutrient inputs that would eventually degrade habitat quality in the river and wetlands and downstream in the Winnebago Pool lakes.

Water quality in the lower Wolf River is maintained to a substantial degree by the extensive wetlands that are protected under public ownership, and more of these valuable filters should be protected under existing wildlife property and natural area plans and by working with local groups and private landowners.

Management Opportunities, Needs, and Actions

- Protection of the extensive, mature lowland forests of the lower Wolf River is a priority here because no comparable alternative to conserve connected forested floodplains at this scale exists anywhere else in eastern Wisconsin.
- "Marsh recession" is occurring at the mouth of the lower Wolf River due to the artificially elevated levels of the Winnebago Pool lakes. If lake levels can't be lowered (this will be difficult because of the heavy recreational use of these lakes by powerboats and the high degree of residential development on the shorelines), then some other means of protecting these critical marshlands must be identified, assessed, and implemented. Past structural fixes have proven to be extremely costly and may cause unintended consequences or unforeseen problems in other parts of the system.
- Restoring meanders and reconnecting the main stem of the Wolf River to some of its smaller tributaries, e.g., those used for spawning by some of the native fish present, would improve habitat diversity and conditions for some of the native species now present.
- Protect undeveloped upland habitats bordering the river and its floodplain, especially where it is possible to enlarge the amount of protected open landscape and any place where upland forest might be protected adjacent to lowland forest.
- In addition to the more characteristic marsh, meadow, and floodplain forest communities along the lower Wolf River, there are good examples and potentially important opportunities to protect less common types such as Tamarack Swamp and Northern Sedge Meadow. Follow-through via the public agencies or locally active NGOs is needed to achieve this protection.
- Certain invasive plants, such as narrow-leaved cat-tail and common reed, should be watched carefully because they are now present in many areas and will almost certainly spread.

Niagara Escarpment

The Niagara Escarpment is a prominent geological feature composed of Silurian dolomite that arcs across the western and northern sides of Lake Michigan and the north side of Lake Huron as far east as New York state. The southwesternmost exposures of the Niagara Escarpment occur in the Southeast Glacial Plains Ecological Landscape, most dramatically on the east side of Lake Winnebago and south and west of the village of Oakfield along the eastern edge of the vast Horicon Marsh.

The landscape around the southern outliers of the Niagara Escarpment was historically vegetated with prairie, oak savanna, and hardwood forest (elsewhere, including farther north in Wisconsin, the escarpment was embedded within extensive mixed conifer-hardwood forests). Presently, the escarpment is situated within an area that is almost entirely devoted to agriculture. At several locations, springs and seepages feed the escarpment forests, and in a few areas these remnants support regionally rare "northern" species such as Canada yew (*Taxus canadensis*).

An abandoned iron mine (now Neda Mine State Natural Area) in the escarpment is used as a hibernaculum by 150,000 bats of four species (D.N. Redell, Wisconsin DNR, personal communication), making this one of the most significant sites for bats in the Upper Midwest.

Most of the land on and around the escarpment is privately owned. In a few places, narrow strips of hardwood forest occur on and above the escarpment, and these provide a source of shade and litter for rare land snails as well as resting and foraging areas for migratory birds. American beech is a canopy component of several forest remnants above the escarpment, some of which also contain Ephemeral Ponds. High Cliff State Park and several county parks have been established to showcase the escarpment, but additional protection is needed to combat invasive plants and vandalism. Residential development has been encroaching on all of these "protected" sites.

Management Opportunities, Needs, and Actions

- Conduct surveys for bats, rare terrestrial gastropods, rare plants, and high quality community remnants as needed to improve conservation decisions and adequately protect these rare features.
- Work with appropriate units of government, planning commissions, NGOs, and private landowners to protect portions of the escarpment known to harbor natural features of significance.
- Determine the best ways to protect escarpment hydrology and increase the viability and utility of the escarpment forests for resident and migratory wildlife. The escarpment features are currently subject to impacts from adjacent land uses and to the presence of developments that have fragmented and isolated remnant escarpment forests.
- Continue to monitor bat use of the abandoned mine, their phenology, and foraging patterns.
- Monitor the bat population at Neda Mine for white-nose syndrome. Maintain vigilance on the status of white-nose syndrome, which is decimating bat populations in eastern North America. Determine whether any mitigation techniques will prevent the spread of or control the disease to prevent bat mortality.
- Industrial wind farms are beginning to appear in this area (several are up and running as of early 2009), creating potential hazards for birds and bats. Because the footprint of each turbine is quite large, the potential to damage sensitive habitats or alter hydrology and affect springs or seepages needs to be addressed.

Marshes, Meadows, Fens, and Shallow Lakes

Areas of poorly drained ground moraine and outwash are common in the Southeast Glacial Plains Ecological Landscape, and these sites often support wetland communities such as Emergent Marsh, Southern Sedge Meadow, Calcareous Fen, and Shrub-carr. Southern Hardwood Swamps, and, less frequently, conifer swamps of tamarack or northern white-cedar, also occupy some of these poorly drained areas, but the vast majority of them have been badly degraded by ditching, grazing, logging, insect infestations and diseases (especially Dutch elm disease), and invasions of exotic plants and animals.

Some of the wetlands in the Southeast Glacial Plains are very large, such as 32,000-acre Horicon Marsh, 12,000-acre White River Marsh (this site contains one of southern Wisconsin's largest and least disturbed sedge meadows as well as emergent marsh and several diverse prairie remnants of excellent quality), and a bird-rich marsh of several thousand acres around the confluence of the Wolf and Rat rivers just north of the Winnebago Pool lakes in northwestern Winnebago County. Each of these sites supports significant resident wildlife populations and hosts major concentrations of migratory waterbirds.

Calcareous Fen, a globally rare wetland community, is more common here than in any other ecological landscape. These fens support numerous rare plants and invertebrates and several rare herptiles. While fens in the Southeast Glacial Plains Ecological Landscape are concentrated in the southern part of the Kettle Moraine, not all of them are associated with end or interlobate moraine landforms. They are widely distributed in the Southeast Glacial Plains, large parts of which are underlain by calcareous till or bedrock. In all cases, however, the site-specific and cumulative effects of manipulating water levels—even to attempt the restoration of a pre-existing condition—merit more attention, study, analysis, deliberation, and understanding than they have received in the past.

Some wetlands, especially sedge meadows and low prairies, that have been highly disturbed by ditching, tiling, excess inputs of sediments and nutrients or prolonged periods of heavy grazing are often dominated by monotypes of the exotic and highly invasive reed canary grass, which has far lower ability to support native plants and animals than less disturbed grassland vegetation. Once established, reed canary grass monotypes have the ability to spread, and they are also quite successful at preventing recolonization of wetlands by many of the more disturbance-sensitive native species.

A number of shallow lakes, such as Winnebago, Poygan, Butte des Morts, Rush, Sinissippi, and Koshkonong, were once important staging and resting areas for migrating waterfowl and other waterbirds as well as important nesting areas for many species. Restoration efforts to again provide better habitat for migrants and residents have been undertaken on some of these lakes, but much remains to be done. Recent and ongoing restoration efforts on these lakes and their associated wetlands should be assessed to determine how well native plant communities, as well as feeding and nesting habitat for birds and others, have been restored.

Management Opportunities, Needs, and Actions

- Unprotected wetlands, especially those that are large, hydrologically intact, relatively free of invasives, and that provide habitat for sensitive species, are conservation priorities.
- Sedge meadows remain inadequately protected, support many species that marshes do not, and merit additional conservation attention, especially unusual types (e.g., because of their size or because of at least partial dominance by "wire-leaved" sedges) such as the meadows north of Lake Winneconne or several of those in southwestern Washington County.

Large sedge meadow and marsh complex of good quality occupies this basin just north of Lake Winneconne, Winnebago County. Photo by Eric Epstein, Wisconsin DNR.

One of Wisconsin's largest and least disturbed southern sedge meadows occurs along the White River in Green Lake County. Photo by Eric Epstein, Wisconsin DNR.

- Identify opportunities to manage open upland habitats adjacent to marshes and sedge meadows, emphasizing large sites (e.g., those of over 100 acres) associated with good quality natural community remnants.
- Promote incentives that will better protect wetlands and improve or maintain water quality in lakes of the Southeast Glacial Plains Ecological Landscape. Work with local governments and lake districts to try and manage water levels so that wetlands and wetland-dependent wildlife are not adversely affected.
- Focus conservation efforts on shallow lakes and associated wetlands that are known to support sensitive aquatic organisms to maintain habitat for these species and see that water quality does not decline.
- Implement a marsh bird monitoring program that will yield information that cannot be obtained from most of the standard bird survey methods currently used in Wisconsin and elsewhere.
- Monitor wetland vegetation selected either for its high ecological values or for their representative condition via examination of air photos taken over time coordinated with more intensive field sampling.
- Restore and enhance wetlands and upland cover important for waterfowl and other shallow lake bird species. Continue research to address critical information needs for declining habitats and species.
- Continue to protect wetlands by various means, including education, working with local conservation groups and landowners, establishing zoning where needed, and enforcing permit regulations.
- Identify and protect critical spawning, reproductive, and nursery habitat in lakes with major sport fisheries and populations of rare species. Identify, prioritize, and protect critical aquatic habitat for endangered or threatened species to maintain a diverse fish community. Develop criteria to identify and recommend protection needs to maintain existing self-sustaining fisheries and include these recommendations in basin plans.
- Existing efforts at restoring and enhancing sturgeon habitat and self-sustaining sturgeon populations in Lake Winnebago and the Upper Winnebago Pool lakes (Poygan, Winneconne, and Butte des Morts) are vital for the future health of Wisconsin's population of lake sturgeon. Although lake sturgeon are a Wisconsin Special Concern species, ensure that lake sturgeon management does not destroy habitat for other rare fish and invertebrate species. Continue to implement the statewide Lake Sturgeon Management Plan, adjusting as appropriate. Preserve and enhance existing naturally reproducing populations. Reestablish populations in waters within their original range consistent with their genetic origins.
- Protect waters and shoreline habitat through focused educational initiatives and, as necessary, legal efforts. Utilize enforcement mechanisms for habitat restoration.
- Identify opportunities to protect, enhance, or restore threatened ecosystems. Protect critical habitat by establishing an acquisition project designed to purchase, in fee, high quality wetland habitat in lake basins. State and local conservation-oriented NGOs will all play roles in this effort.
- Identify and implement strategies to buffer the negative effects of nonpoint source pollution adjacent to critical habitat.

Other Inland Lakes

Many lakes in this ecological landscape still support a representative diversity of aquatic life (including lake trout [*Salvelinus namaycush*] and ciscoes in a few of the larger and deeper lakes), but most are vulnerable to negative land use impacts and diminished water quality in this highly agricultural and substantially urbanized part of Wisconsin. As explained earlier in this chapter, high lake fertility is due, in part, to polluted runoff, the excess sediments and nutrients coming from bare croplands, construction sites, failing septic systems, and impervious surfaces. Polluted runoff may have substantially greater, or more immediate, impacts to small, shallow lakes than to larger, deeper lakes. However, deeper lakes that are borderline mesotrophic, such as Rock Lake, lakes Mendota and Monona, Lac La Belle, Okauchee Lake, and North Lake, merit additional attention and protection to halt or least slow water quality declines. There are high quality kettle lakes here that provide important habitat for aquatic plants, freshwater sponges, and diverse assemblages of odanates (dragonflies and damselflies). Mudflats develop seasonally along the shores of some of these lakes when water levels are right and can attract large numbers of migrating shorebirds. An experiment in Lake Wingra in the Yahara River watershed showed there is a potential for restoring native lake vegetation by eliminating carp, even though the resultant improved water clarity also benefitted invasive Eurasian water-milfoil (Lathrop et al. 2010, NTLL-TER 2010).

Lakes with coldwater cisco and lake trout populations, notably Lake Geneva, are very rare in southern Wisconsin. The recharge areas of springs that feed these lakes need to be protected against conversion to impervious surfaces.

Rush, Wind, and Big Muskego are examples of shallow lakes in this ecological landscape that have been partially rehabilitated through drawdowns to kill nonnative aquatic plants and fish and to compact soft, silty, nutrient laden sediments. Beaver Dam and Fox lakes have been the subject of rehabilitation plans, and progress of the proposed actions there should be evaluated for actions that succeeded or that need to be refined. Other opportunities to rehabilitate shallow lakes should be identified and implemented. Significant progress in dealing with poor lake condition is unlikely to be achieved unless the root causes of the evident problems are also treated in a manner that is coordinated with the lake treatment proper.

Most of the deeper lakes here have been heavily developed, and many are suffering from habitat and water quality degradation. Efforts to work with lake associations and other interested parties need to continue in order to implement effective actions to restore and protect lake water quality, habitat values, and aesthetic considerations.

Management Opportunities, Needs, and Actions

- Work with lake management districts and the internal Wisconsin DNR exotics team to develop further research and strategies to minimize exotic species that are present in this ecological landscape's lakes and rivers (e.g., zebra mussel, Eurasian water-milfoil, rusty crayfish, purple loosestrife, curly pondweed, reed canary grass, common carp). Identify sites that may be designated as sensitive areas to preserve critical and unique habitat from manipulations that would result in functional losses.
- Protect groundwater and work with local units of government to further protect ***shorelands*** and guide shoreline development to protect public and private benefits from clean and abundant water and unimpaired wetland ecosystems.
- Focus fish health assessments on perturbed ecosystems where toxicants or pathogens are the factors most likely contributing to system unsustainability and explore methods to correct the cause of these problems.
- Use planning and management methods that address the connection between pollution problems on land, in water, and in air. Regulate and manage public and private shorelands and shallows in a consistent fashion to protect biodiversity and water quality. Promote sustainable practices on urban and rural land through technical assistance and incentives including the U.S. farm bill and other state and federal programs and grants.
- Encourage landowners in priority watersheds to apply for nonpoint source grants to install pollution abatement techniques. Continue to encourage municipal water systems to practice water conservation measures and implement wellhead protection programs.
- Protect native fish species and their habitat. Species that use wetlands, riparian zones, and littoral zones for spawning should receive special attention. Focus protection and restoration efforts on those habitat types and upon threatened and endangered species and their habitat. Further inventory ***nongame*** fish species, including forage fish, as integral components of aquatic ecosystems. Encourage and support research regarding interspecies relationships. As appropriate, implement ecosystem-based management strategies to ensure populations of nongame fish species are maintained to promote biodiversity.

Conifer Swamps: Tamarack, Black Spruce, Northern White-Cedar

Natural stands of "northern" conifers are uncommon and highly localized this far south. Some natural community types, such as Black Spruce Swamp, are extremely rare. Northern white-cedar swamps are also scarce here and occur at only a few locations in the eastern part of the ecological landscape. Tamarack Swamps are (or were) more common and widespread, but tamarack is faring poorly at many sites, where it appears to be undergoing replacement by dense thickets of deciduous shrubs and saplings.

Cedarburg Bog, in Ozaukee County in the eastern part of the Southeast Glacial Plains, is managed as a field station by the University of Wisconsin-Milwaukee and Wisconsin DNR. This large wetland complex is centered on a "string bog" (a "patterned peatland," of a type that is unusual anywhere in Wisconsin but is extremely so in the southern part of the state) and "forested fen," and associated with a large shallow lake, emergent marsh, and extensive ash-dominated hardwood swamps. Jefferson Marsh Tamarack Swamp, Jackson "Marsh" (it's not a marsh), Lima Bog, Beulah Bog, Lulu Lake, and Spruce Lake Bog are other important sites for conifer swamps in this ecological landscape.

Severe infestations of the highly invasive tall shrub glossy buckthorn are already established here and may totally prevent regeneration of the light-demanding tamarack. Some northern white-cedar stands are now choked with buckthorn as well. In the late summer of 2008, the emerald ash borer, was first discovered in Wisconsin just a few miles away from Cedarburg Bog. Because ashes are common and sometimes dominant in some of the lowland forests in the vicinity of this discovery, it is likely that there will be both direct and indirect impacts on nearby swamps due to ash mortality and possibly due to efforts to control this serious pest.

Ecologists Owen Boyle and Christina Isenring examining old-growth wet-mesic forest dominated by northern white-cedar. Most northern white-cedar swamps in southern Wisconsin occur in the easternmost part of the Southeast Glacial Plains. Sheboygan County. Photo by Eric Epstein, Wisconsin DNR.

Southern outliers of "northern" vegetation types, including stands of swamp conifers, may be highly vulnerable to climate change in addition to hydrological disruption. Conifer swamps should be monitored across this ecological landscape to detect changes at the community level (shifts in species composition or stand structure). Selected plant and animal species that reach their southern range limits in this ecological landscape may also be good candidates for detecting changes due to or correlated with climate change or other environmental factors.

Management Opportunities, Needs, and Actions

- Conduct surveys and document the condition of conifer swamps across the Southeast Glacial Plains and other southern Wisconsin ecological landscapes.
- Conduct research and clarify the reasons for the decline of conifers, especially tamarack.
- Develop effective methods to restore damaged stands, maintain those that are now healthy, and stall the further deterioration of declining stands.
- Essential knowledge includes better understanding of site hydrology, historical factors, and impacts related to landscape context. What is needed to maintain or restore hydrological integrity? (Do the successional trajectories these communities are now on resemble anything that occurred in the past?)
- Monitor conifer swamps using repeatable methods to detect changes in community composition and structure.
- Identify and endeavor to protect stands that appear viable due to intact hydrology, minimal infestation by invasive species, and compatible land uses in the surrounding landscape and watershed.

Rivers and Streams

The lower Wolf and the Mukwonago river systems have been discussed above because of the outstanding and specific ecosystem management opportunities they afford. Many other rivers in this ecological landscape also have significant conservation values because they are important reservoirs of biological diversity and provide many social benefits. The current status of these varies from streams that need protection now against various types of degradation to those that are would benefit from efforts at restoration of habitat and/or water quality. Rivers that fit one or both of these overlapping categories include the Bark, (Illinois) Fox, East and North Branch of the Milwaukee, Oconomowoc, Rock, Scuppernong, Des Plaines, White (Walworth County), Waupaca, (Green Bay) Fox, Sugar, and Yahara rivers and Turtle Creek.

Warmwater rivers and their floodplains provide critical habitat for waterbirds, herptiles, fish, invertebrates, and other species. The associated wetlands also serve a vital flood control function by storing flood waters and reducing stream velocities. They also function as sediment and nutrient traps.

This glacial kettle contains a boggy wetland that includes a seepage lake, sedge meadow, and healthy stand of tamarack. The surrounding uplands are vegetated with a badly degraded but potentially restorable oak savanna. Walworth County. Photo by Eric Epstein, Wisconsin DNR.

The vegetation mosaic along the upper Mukwonago River is complex and includes emergent marsh, calcareous fen, southern sedge meadow, wet-mesic prairie, and oak woodland. The Mukwonago is considered by many to be southeastern Wisconsin's exemplary stream. Walworth County. Photo by Eric Epstein, Wisconsin DNR.

Important coolwater streams include Raccoon Creek (e.g., for redside dace [*Clinostomus elongatus*]), Allen Creek (least darters), Norwegian Creek (Green County), and Hefty Creek (Green County). Care must be taken to avoid stocking nonnative trout in streams supporting rare fish vulnerable to predation by stocked fish.

There is an excellent opportunity to improve water quality and reduce suspended sediment loading in the Southeast Glacial Plain's larger rivers by providing riparian buffers around all streams here, especially those that flow through cropland or other areas with runoff concerns. This would greatly reduce the sediment and nutrient loads carried into these rivers by their many tributaries. Stormwater management programs should also be expanded in order to reduce nutrient, contaminant, and thermal pollution to rivers in this ecological landscape.

While a great deal of progress has been made in protecting and restoring water quality and habitat values, there remains a strong need to continue the progress in achieving goals for water resource management. For example, there are opportunities to combine land use planning, nonpoint pollutant source reduction, and habitat restorations to benefit a wide range of aquatic species while meeting flood minimization goals and recreational needs.

Management Opportunities, Needs, and Actions

- Identify and protect critical habitat in the upper Fox River and Milwaukee River basins through basin planning and monitoring processes in concert with the actions and interests of local citizen groups and other partners. Although clean-up efforts over the past 30 years have resulted in better water quality in many stretches of these rivers, continue to monitor and study the Fox and Milwaukee rivers and their tributaries to determine the need for additional water quality and habitat improvements.
- Promote and implement the state's Rivers Grants program to help address habitat and water quality needs for rivers. Among the streams in the Southeast Glacial Plains, the Sugar, Oconomowoc, Rock, Genesee, Bark, Mukwonago, (Illinois) Fox, White, and lower Wolf rivers and Turtle Creek have the greatest potential for protection of existing ecological values and restoration of degraded values.
- Continue to work with local units of government to further protect shore lands, provide assistance, and help guide shoreline development.
- Reduce habitat loss within and adjacent to intermittent and perennial streams, including stream order and wetlands. Emphasize protection and restoration of native fish populations and their habitat.
- Limit the spread of exotic aquatic plants and animals within high quality watersheds."
- Assure effective implementation of the Wisconsin Pollutant Discharge Elimination System (WPDES) wastewater and stormwater permitting programs. Implement total maximum daily loads (TMDLs) where needed on impaired waters on the 303(d) impaired waters list to quantify needed reductions in both point and nonpoint pollutants.
- Sport fishing is a popular use of streams here, and improvements in sport fish habitat can benefit nongame fish and other aquatic species. Identify critical habitat sites for stream bank protection, in-stream habitat restoration, and restoration of wetland and riparian habitat that has been lost. Evaluate the impact of harvest and regulations on sport fish population in large rivers.
- Document opportunities to reconnect disjointed portions of environmental corridors.
- Continue to inventory and upgrade road and stream crossings, including improperly placed culverts that impede movements of fish and other aquatic organisms.
- Dams remain that fragment habitat for many stream species. Assess the impacts of existing dams on waterways and ditches. Where negative impacts are occurring, encourage the improved operation or removal of dams. Continue to support the study of fish passage technology at hydroelectric and other dams and implement those technologies where appropriate to reduce habitat fragmentation.
- Encourage municipalities that are not under a municipal stormwater permit to apply the practices outlined in the U.S. Environmental Protection Agency's Model Post-Construction Stormwater Zoning Ordinance (USEPA 2012). Identify noncomplying industrial facilities in the scrap metal processing and auto dismantling industries and work to bring them into compliance with industrial stormwater regulations.
- Many streams have not been thoroughly surveyed here for the presence of aquatic invertebrates. However, aquatic invertebrate data have been gathered during water quality evaluations and are housed in the Wisconsin DNR SWIMS (Surface Water Integrated Monitoring System) database (WDNR 2014g) and can be used in assessing the status of waters in this ecological landscape. Water quality and quantity data need to be summarized and the most important waters identified for management.

Miscellaneous Opportunities

These "miscellaneous opportunities" are meant to encompass scattered, usually small, and often isolated remnants of natural communities that are relatively undisturbed and support habitat that is now scarce for species that would otherwise be absent in the local or regional landscape.

Wetland mosaic at the western end of Lake Beulah includes tamarack swamp, a dense stand of water-willow (bright red in photo), and a marsh dominated by floating-leaved species such as water-lilies. Walworth County. Photo by Eric Epstein, Wisconsin DNR.

This Wet-mesic Prairie remnant in Jefferson County supports a rich native flora. The land stewards have spent thousands of hours on basic biological inventories, invasives control, and restoration of hydrology. Allen Creek Prairie. Photo by Eric Epstein, Wisconsin DNR.

Also worthy of consideration are relatively intact complexes of upland forest, grassland, and various wetland communities that are not separated by roads, residential developments, or agricultural fields. These still occur at a few locations and may be especially important conservation opportunities for species that are not restricted to or dependent on a single habitat. Additional field survey is needed to establish the ecological content and condition of such sites.

Prairies and Savannas (Scattered Remnants)

Scattered prairie and savanna remnants still occur at a few locations outside of the Kettle Moraine, and they are important to ensure a broader representation of native plant communities and associated physical features across the ecological landscape. Though these are often of limited size and isolated, even small remnants have value if they can be maintained to provide habitat for disturbance-sensitive plants and animals that might otherwise disappear from large portions of the Southeast Glacial Plains. The conservation of native soil types and soil biota is another potentially important benefit of protecting prairie and savanna remnants.

Hardwood Forest

While the Kettle Moraine area has the best opportunities to protect and manage large blocks of forest, good examples of mesic maple-beech and maple-basswood forest should still be sought in the eastern and northern parts of this ecological landscape, as should intact stands of oak-dominated forest in the south and west. The regeneration of oaks on mesic and many dry-mesic sites has proven to be difficult and success uncertain here (as elsewhere in southern Wisconsin), and decisions on where to attempt oak regeneration versus where to maintain stands composed of large trees with the high canopy closure that many sensitive species require or prefer will sometimes be difficult.

Hardwood swamps (these are distinct from the riverine Floodplain Forests) composed of ashes, elms, soft maples, and others are mostly absent from public and private conservation lands throughout this and most other ecological landscapes in eastern Wisconsin. Good examples should be actively sought and, when found, considered for protection status. Virtually all known existing stands are in poor condition owing to hydrological disruption, direct and secondary impacts of past logging and grazing, the ravages of Dutch elm disease, and serious infestations of invasive plants such as reed canary grass. Any good quality examples would be of high conservation value. The discovery of emerald ash borer in Wisconsin can only make the conservation of this already decimated natural community even more difficult.

Ephemeral Pond

Ephemeral Pond was only recently added to the Wisconsin Natural Heritage Working List as a distinct community element, so at this time they are not well represented in the Natural Heritage Inventory database. Ephemeral Ponds are most characteristic of sites with intact hydrologies, with fine-textured soils that impede drainage, and where a forest canopy has persisted. There are high concentrations of these features in some parts of the Kettle Moraine area due to topography, drainage patterns, and soils, and they can support important components of biodiversity such as amphibians and specialized invertebrates, especially in hardwood forests.

Additional work on the characterization and definition of Ephemeral Ponds is still needed. New sites containing Ephemeral Ponds are being identified through volunteer efforts of the Wisconsin's Citizen-based Water Monitoring Network and by Wisconsin DNR biologists (Bernthal et al. 2009), and there are efforts to include isolated wetlands (which may include Ephemeral Ponds) in the Wisconsin Wetland Inventory. Even where intensive agriculture has completely removed the natural vegetation, low spots may still hold water in the spring and offer habitat, at least temporarily, to migrating waterfowl, shorebirds, and others.

Surrogate Grasslands

The widespread destruction and loss of prairies and other native open upland habitats throughout Wisconsin has meant that surrogate grasslands now provide much of the critical nesting habitat needed by many species of declining grassland birds and others. Upland grass situated in proximity to other open habitats, such as sedge meadows and marshes, has the highest potential to accommodate the greatest number of grassland species, including those that are area sensitive. This habitat is already part of several large-scale prairie and savanna restoration efforts, such as the Scuppernong River watershed project within the southern unit of the Kettle Moraine State Forest (this site now includes several state natural areas, focused on some of Wisconsin's best quality prairie and savanna remnants). Surrogate grasslands also exist away from the Kettle Moraine, and at some locations there are opportunities to manage open uplands in concert with meadows, marshes, and perhaps even prairie remnants.

Horicon Marsh, the White and Puchyan River complex, and the lower Wolf River also offer such opportunities.

The Glacial Habitat Restoration Area is a large landscape-scale project that is restoring scattered wetlands and grasslands across an 800-square-mile area of agricultural land. The goal is to restore 38,600 acres to grassland and 11,000 acres to wetlands at locations scattered throughout a matrix of agricultural lands. These surrogate grasslands and wetlands will have benefits to many nesting grassland and wetland birds. To date, a net gain of 7,100 acres of grassland have been established, and almost 6,500 acres of wetlands have been restored.

Springs

More than 1,400 identified springs are widely distributed across this water-rich ecological landscape, and they contribute to the sustained flow and habitat values of streams and the water supplies of some lakes. Protection of groundwater recharge areas that supply these springs is critical to maintaining habitat values and water quality within streams and in spring-fed lakes. The location and value of these springs should be used to inform local land use planning and groundwater use decisions since springs are integral parts of the aquatic ecosystems from which humans derive many aesthetic, spiritual, and recreational benefits and values.

Concentrations of springs occur in some parts of the Kettle Moraine, along the Mukwonago River, and in association with the Niagara Escarpment. In other parts of the Southeast Glacial Plains, further definition of the ecological and socioeconomic roles of springs is needed, as is the determination of the best means of protecting these features.

Lakes

The Southeast Glacial Plains is highly populated and intensively used. Even though lakes are relatively common here (and include Wisconsin's largest "inland" lake and the deepest inland lake), most of them are heavily developed and receive a lot of use. The few undeveloped lakes remaining in semi-natural condition are generally small and often shallow with soft bottoms. Problems include eutrophication from excessive nutrient inputs, sediment inputs from croplands and construction sites, water level manipulations, algal blooms, contaminants, loss of shoreline habitats and aquatic plant beds, and continued incursions from successive waves of invasive species. Undisturbed lakes are protection priorities because restoration, or as is often the case here, rehabilitation, have uncertain outcomes, are expensive, and are unlikely to return the affected waterbodies to a previous "pristine" state.

Shrub Swamps

The vast majority of shrub-dominated wetlands in the Southeast Glacial Plains are classified as Shrub-carr, with willows and dogwoods the dominant woody plants. Shrub-carr (and areas dominated by weedy, often invasive shrubs such as non-native honeysuckles and buckthorns, multiflora rose, Japanese barberry, and the native common prickly-ash [*Zanthoxylum americanum*]) may have increased in the Southeast Glacial Plains Ecological Landscape since Euro-American settlement due to fire suppression, ditching, and tiling and under certain livestock grazing regimes.

Shrub swamps dominated by speckled alder (Alder Thicket) occur in relatively few areas here. For example, Alder Thicket occurs in and around the northern Kettle Moraine in the vicinity of Cedarburg Bog and along the northern boundary of the ecological landscape. Alder Thicket has the potential to support Species of Greatest Conservation Need and should be protected where appropriate and feasible.

In situations where speckled alder has replaced forest (most often northern white-cedar or black ash) due to heavy logging and/or hydrological change (e.g., "swamping"), a site-specific assessment is needed to evaluate the feasibility of either maintaining the alder or restoring a forest.

Management Opportunities, Needs, and Actions

- Water level, sediment, and nutrient management are major issues throughout the Southeast Glacial Plains Ecological Landscape. Sound planning and management can help enhance lakes for desired habitat and plant community goals, including promoting wild rice and other plant communities as appropriate that offer optimal habitat for waterfowl, aquatic mammals, or other priority biotic elements identified during planning processes. Protecting strategically located wetlands is one effective way to improve water quality in shallow lakes.
- Impounded waters might be drawn down at certain times of the year to provide stopover habitat for shorebird. See NRCS (2001) or national and regional shorebird conservation plans (Helmers 1992, Skagen et al. 1999, de Szalay et al. 2000) for guidelines on managing shorebird habitat.
- Shoreline protection or enhancement incentive grants are sometimes available for restoration of natural plant communities, stormwater control, and erosion control, which can benefit not only a variety of species but also enhance property values.
- Embed remnant wetland communities such as marshes, sedge meadows, low prairies, and shrub swamps into grassland protection and management opportunities where possible.

Socioeconomic Characteristics

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 the approximation of the Southeast Glacial Plains Ecological Landscape is called the Southeast Glacial Plains

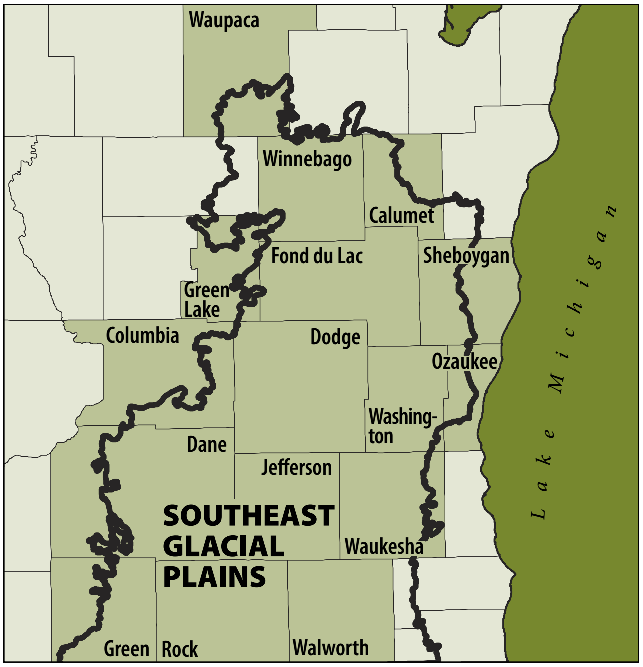


Figure 18.15. *Southeast Glacial Plains counties.*

counties (Figure 18.15). Calumet, Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Ozaukee, Rock, Sheboygan, Walworth, Washington, Waukesha, Waupaca, and Winnebago are included in the Southeast Glacial Plains counties because at least 25% of each county lies within the ecological landscape boundary.

History of Human Settlement and Resource Use

American Indian Settlement

There is evidence from several sites within the Southeast Glacial Plains Ecological Landscape that this area was occupied possibly as early as 11,000 years ago (Mason 1997). While more investigation is needed to find the exact time of first colonization of Wisconsin, there is clear evidence of early Paleo-Indian occupation continuing in southern Wisconsin until approximately 10,000 years ago. See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," in Part 1 of the book for a description of the Paleo-Indian Tradition and other traditions mentioned below.

During the Archaic Period, copper artifacts from copper mined from lava flows around Lake Superior have been found all over the eastern half of the state, with several large areas of concentrations within the Southeast Glacial Plains. Indeed, one of the most famous "Old Copper complex" cemeteries was found at the Reigh site in Winnebago County (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.

The Woodland Tradition marks the first time that agriculture occurs in Wisconsin, and the rich soils of the Southeast Glacial Plains were well known to these people, based on the numbers of sites found in this ecological landscape dating from this period. Effigy mounds are also diagnostic of the Late Woodland Tradition, and many effigy mound clusters have been found in Dodge, Dane, and Jefferson counties, among others (Stevenson et al. 1997).

Between 800 A.D. and 1000 A.D., the Mississippian Culture had made its way into Wisconsin, radiating out from the city-state of Cahokia in Southern Illinois. This culture generally lived in large permanent villages, although the type of structure has not yet been determined (Ritzenthaler 1970). The most famous archaeological site in Wisconsin is Aztalan, (near present day Lake Mills), which was a large ceremonial center and fortified village occupied between 800 A.D. and 1200 A.D (Goldstein and Freeman 1997). It demonstrates clear influence from Cahokia, including several large platform mounds but also mixes Late Woodland traditions more representative of indigenous Wisconsin peoples (The Wisconsin Cartographers' Guild 1998).

A number of different tribes settled in this region during the Iroquois wars of the turbulent 17th century. Among these were the Sauk and Fox, two tribes that are often mistaken for one people. While these two tribes are closely related and were joined in very close alliance, they are in fact separate and distinct cultures (Mason 1988). The word Sauk is a derivation from the Sauk or Sac language meaning "people of the outlet," which refers to their original homeland on Saginaw Bay in Michigan. The Fox actually called themselves the Mesquakie, meaning "the red earths," describing their original homeland, also referred to as "Outagamie," thought to be in southeastern Michigan. The French later mistook a clan name meaning "fox" for the entire tribe.

Around 1600 A.D., both tribes occupied the eastern half of Lower Michigan between Detroit and Saginaw Bay (Mason 1988). During the 1640s, the Fox and Sauk were driven from their homeland. The Fox subsequently settled in central Wisconsin, whereas the Sauk found temporary refuge at the headwaters of the Wisconsin River northwest of Green Bay.

Historically, the Ho-Chunk people made their home in this region. The Ho-Chunk, called Winnebago by the French, were at Green Bay in the mid-1600s but had gradually moved inland to Lake Winnebago by 1700 A.D. (The Wisconsin Cartographers' Guild 1998). This tribe gradually built their economy through the fur trade of the 1600s and are today one of the most economically successful tribes in the state. See the "Statewide Socioeconomic Assessments" in Chapter 2, "Assessment of Current Conditions," in Part 1 for further discussion of the history of human settlement and resource use in Wisconsin.

While this region has historically been populated with a wide variety of tribes, there are currently no tribal lands or significant American Indian populations in the area.

Euro-American Contact and Settlement

During the 17th century, French fur traders, soldiers, and missionaries began arriving here. As a result of Euro-American contact with American Indians, trading posts, missions, and forts along river routes and lakes were established. During the 1800s, however, the tribes began ceding large areas of land to the U.S. government, and permanent Euro-American settlement began in earnest.

While Dutch, French, Polish, Italian, and Swiss immigrants also settled in this area, the largest settler groups were the Germans and the Norwegians. The first Norwegian settlements began to spring up around 1838. By 1850, however, large Norwegian communities had been established at Jefferson Prairie and Rock Prairie in Rock County, Muskego in Waukesha County, and Koshkonong in Jefferson County (The Wisconsin Cartographers' Guild 1998).

Early Agriculture

Permanent Euro-American settlement began in the Southeast Glacial Plains counties well before 1850, when the first federal agriculture census data became available. Several of the Southeast Glacial Plains counties were among the first established in the state in 1836, including Calumet, Dane, Dodge, Fond du Lac, Green, Jefferson, Rock, Walworth, and Washington counties (National Association of Counties 2010). Agriculture has been a prominent component of local economies in the Southeast Glacial Plains counties since their inception. In 1850 there were already 14,828 established farms in the Southeast Glacial Plains counties, comprising nearly three-quarters of all farms in the state (ICPSR 2007). By 1860 the number of farms in the Southeast Glacial Plains counties had nearly tripled, totaling 41,249 farms. The number of farms in the Southeast Glacial Plains counties reached its maximum in 1900, with 53,824 farms, while the population of the Southeast Glacial Plains counties had reached 580,987. The population in the Southeast Glacial Plains counties has continued to grow in each subsequent decade. However, farm numbers gradually declined in the Southeast Glacial Plains counties after the turn of the century, as some smaller marginal farms were driven out of production and others were consolidated (Figure 18.16).

Average farm size in the Southeast Glacial Plains counties followed a trend of slightly smaller acreages than the state as a whole. In 1950 the average Southeast Glacial Plains county farm was only 122 acres compared to 137.8 acres statewide (Figure 18.17). Following World War II, a combination of the failure of many smaller marginal farms, subsequent consolidation, and mechanization increased the average size of farms in the Southeast Glacial Plains counties, much as it did in the state as a whole. That trend continued throughout much of the remaining 20th century.

Total value of all crops indicates the extreme influence of the Great Depression on agriculture. In 1910 all crops harvested in the Southeast

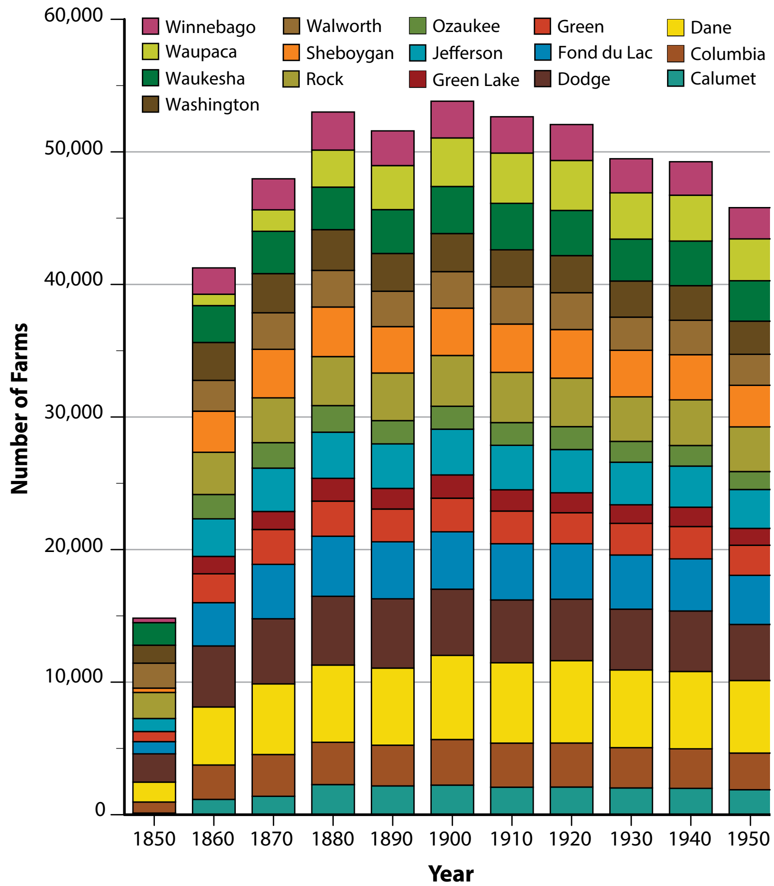


Figure 18.16. *Number of farms in the Southeast Glacial Plains counties between 1850 and 1950 (ICPSR 2007).*

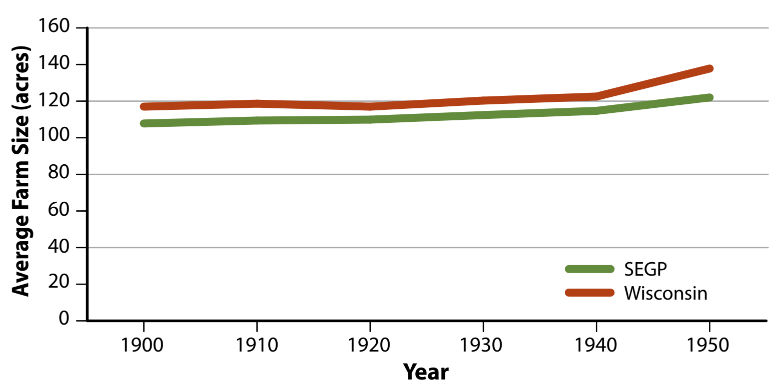


Figure 18.17. *Average farm size in the Southeast Glacial Plains counties between 1900 and 1950 (ICPSR 2007).*

Glacial Plains counties had an estimated total value of $55.6 million, which had nearly tripled by 1920 ($151 million) (ICPSR 2007). However, total value of all crops in the Southeast Glacial Plains counties plummeted in 1930 ($80 million) following the onset of the Great Depression and fell further in 1940 ($59.2 million). The Southeast Glacial Plains counties historically have had among the state's most productive farms. Total values of crops in the Southeast Glacial Plains counties comprised 35.2% of total crop value in the state in 1940, and these crops came from farms comprising only 24.1% of all Wisconsin farm acreage (ICPSR 2007).

Over the early part of the 20th century, the type of farming in the Southeast Glacial Plains counties underwent some fundamental shifts as the dairy industry was established here and Wisconsin became a national dairy leader. As time went on, farms in the Southeast Glacial Plains counties increasingly grew "hay and forage" crops and grew less "cereal" crops as farms matured; the opposite had previously been the case. The 1910 federal agricultural census listed "cereals" as 57.1% of the total value of all crops harvested in the Southeast Glacial Plains counties, but cereals comprised as little as 33.1% of total crop values in 1930, recovering only to 40.8% by 1940 (ICPSR 2007). Meanwhile, "hay and forage," associated with livestock farming, was only 23.5% of total value of crops harvested in the Southeast Glacial Plains counties in 1910 but had risen to 43.3% of total crop value by 1940, surpassing cereal crops as the most valuable type of crop grown. See the "Statewide Socioeconomic Assessments" section in Chapter 2, "Assessment of Current Conditions," for further discussion of the history of agricultural settlement in Wisconsin.

Early Mining

Mining has occurred in Wisconsin for thousands of years. There is clear evidence of copper mining in and around the Lake Superior basin, during the Middle Archaic Stage (possibly 8,000 until 3,000 years ago) with copper artifacts from that area found all over the eastern half of Wisconsin (Wittry 1957, Stoltman 1997). Iron and copper, among other minerals and metals, drew large groups of settlers to Wisconsin during the 19th and early 20th centuries. Cornish and Finnish immigrants, possessing extensive mining experience from work in Europe, were among the first to be recruited.

Iron mining began in the Southeast Glacial Plains counties in 1849 in Dodge County (Austin 1948). A portion of the Southeast Glacial Plains counties made up the eastern edge of the Wisconsin "lead district." More specifically, "the diggings" included western Dane and Green counties. By 1825 lead production had reached a total of more than 440,000 pounds; by 1828, however, this number had soared to over 12 million pounds.

Early Transportation and Access

In 1673 Marquette and Jolliet established the first route across Wisconsin from Green Bay to the Mississippi River via the Fox and Wisconsin rivers, through the northern end of the Southeast Glacial Plains Ecological Landscape. This route proved to be particularly important to the economic development of the Fox River Valley, which was partially in the Southeast Glacial Plains Ecological Landscape, and to the state as a whole. During the 1850s, the Fox and Wisconsin Improvement Company built locks and dams on the Fox River and also completed a canal between the Fox and Wisconsin rivers at Portage, providing access to an important transportation route for residents of the Southeast Glacial Plains Ecological Landscape (Wisconsin Cartographers' Guild 1998).

In the early 19th century, an extensive network of American Indian trails existed throughout the territory. Following the end of the Black Hawk War in 1832 and the rapid Euro-American settlement that followed, these trails were widened into roads suitable for ox carts and wagons (Davis 1947). A system of military roads was developed in Wisconsin around the same time, connecting key cities and forts with one another. One such road connected the Rock River with the Wisconsin River in the Southeast Glacial Plains Ecological Landscape. Another connected Janesville with Racine. By 1870, however, the importance of railroads had caused these relatively primitive roadways to become of secondary value.

As early as the late 1850s, the Milwaukee and Waukesha Railroad Company had already finished construction on a line stretching from Janesville to Fond du Lac to Oshkosh. Other lines connected Milwaukee with Janesville, Waupun, and Madison as well as Racine and Kenosha with Beloit. Janesville was also connected through another line with Watertown, Fond du Lac, Oshkosh, and Waupun (Austin 1948). In addition, the Baraboo Air Line (a railroad) connected Madison with Lodi, Baraboo, Elroy, and La Crosse.

Early Logging Era

Sawmills were first built along rivers in areas containing large stands of timber. Where there were obstacles in rivers that made it difficult to float logs, lumbermen built mills as close to the cutting area as possible, while on trouble-free rivers, sawmills were generally more centralized (Ostergren and Vale 1997). Wisconsin also had the advantage of an extensive network of waterways flowing south from the northern timber region. Wisconsin lumber production reached its peak at more than 4 billion ***board feet*** in 1892 (The Wisconsin Cartographers' Guild 1998). Sawmills caused towns to spring up all over the state. Important mills in the Southeast Glacial Plains region of the state included those at Oshkosh, which had exclusive control over the Wolf River tributaries, much of which bordered on forests with a significant pine component (Ostergren and Vale 1997) as well as a heavy concentration of mills elsewhere around Lake Winnebago. These mills mainly harvested stands of southern Wisconsin hardwood forests and oak savanna (The Wisconsin Cartographers' Guild 1998).

Resource Characterization and Use[1]

The Southeast Glacial Plains Ecological Landscape is one of Wisconsin's largest ecological landscapes with 7,726 square miles of total area (4,943,731 acres), 7,283 square miles of land, and 443 square miles of water. It has the highest population, almost two million people, and one of the highest population densities in the state. This ecological landscape has the largest area in surface water, almost 6% of the total area. The vast majority of this water, 93%, is in lakes, with Lake Winnebago making up almost half of this total.

In terms of current and potential recreational use, the Southeast Glacial Plains Ecological Landscape has the second highest proportion of surface area in water, and most of this is in lakes. The amount of public land, the density of private and public campgrounds, and density of multi-purpose trails are all about average for the state. However, the number of visitors to state properties is the highest in the state. Both the acreage in natural areas and the number of legacy sites are quite high. This ecological landscape has the highest number of land legacy sites with high recreation potential (WDNR 2006c).

Agriculture is a major factor in the economy of the Southeast Glacial Plains Ecological Landscape. This ecological landscape ranks third (out of 16 ecological landscapes) in the percentage of land area in agriculture while it ranks first in total land area in agriculture. It also is third in net income per farmed acre and has the highest corn production and second highest milk production in the state.

Forestry, on the other hand, is not nearly as important to the economy. The Southeast Glacial Plains ranks 15th out of all 16 ecological landscapes in percentage of land in forest and below average in timber volume per acre. However, it ranks about average as far as volume harvested due to the large size of the ecological landscape. Along with a very high population density, the Southeast Glacial Plains Ecological Landscape has one of the highest densities of roads, railroads, and airport runways. It has the most airports (31) of all regions but no ports.

Although the Southeast Glacial Plains Ecological Landscape uses a lot of energy for its high population, it is not a major producer of either hydroelectric power or woody biomass. This ecological landscape does, however, rank highest in the amount of wind energy produced and second highest in the number of new wind permits granted in 2008 (RENEW Wisconsin 2009). In addition, six of the nine ethanol plants in the state were located here as of 2013 (Renewable Fuels Association 2013).

[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."

The Land

Of the 4.66 million acres of land (not including the area of open water) that make up the Southeast Glacial Plains Ecological Landscape, only 13% is forested. About 85% of all forested land is privately owned while 15% belongs to the state, counties, or municipalities (USFS 2009).

Minerals

Of the 16 counties, only eight have full disclosure of mining revenues due to the small number of mining firms per county. Dane, Green, Green Lake, Fond du Lac, Rock, Sheboygan, Washington, and Waukesha counties are involved in the production of nonmetallic minerals (excluding fuels). In 2007, there were 73 mining establishments in the Southeast Glacial Plains counties. Employment in Green Lake, Fond du Lac, Calumet, Rock, and Washington counties totaled 822 people, with wages of $36 million (WDWD 2009).

Frac sand mining is increasing dramatically in some areas of Wisconsin due to the increased use in oil and gas extraction. As of December 2011, there was one frac sand mining or processing plant active or in development in the Southeast Glacial Plains Ecological Landscape.

Water (Ground and Surface)

Water Supply

The data in this section are based on the Wisconsin DNR's 24K Hydrography Geodatabase (WDNR 2014c), which are the same as the data reported in the "Hydrology" section of this chapter; however, the data are categorized differently here so the numbers will differ slightly. Surface water covers 282,680 acres in the Southeast Glacial Plains counties, or 5.7% of the total area. There are over 2,514 lakes that are at least 1 acre in size, totaling 263,325 acres or 93% of total surface water. There are 33 lakes over 500 acres and 22 that are over 1,000 acres in size. The largest are Lake Winnebago (131,871 acres), Lake Poygan, Lake Koshkonong, Lake Mendota, Lake Butte des Morts, Beaver Dam Lake, Lake Winneconne, Lake

This active gravel mine is situated within the northern part of the kettle interlobate moraine. Sheboygan County. Photo by Eric Epstein, Wisconsin DNR.

Monona, and Lake Kegonsa. There are 19,331 acres of streams and rivers, of which the Rock, Fox, Wolf, and Crawfish rivers are the largest. There are 412 dams that impound 234,781 acres of water (WDNR 2014c).

Water Use

Each day 984 million gallons of ground and surface water are withdrawn in the 16 Southeast Glacial Plains counties (Table 18.3). About 69% of the withdrawals are from surface water. Of the 1.98 million people that reside in these counties, 70% are served by public water sources and 30% are served by ***private wells*** (USGS 2010). Dane and Ozaukee counties account for 61% of all water used. The largest water usage, 61%, is for thermoelectric power generation with Ozaukee (the power plants here are along Lake Michigan in the Central Lake Michigan Coastal Ecological Landscape) and Dane counties accounting for 86% of this (USGS 2010).

Recreation

Recreation Resources

Land use, land cover, and ownership patterns partly determine the intensity and types of recreation that are available to the public. For instance, in the Southeast Glacial Plains Ecological Landscape, there is a higher percentage of agricultural and urban land and a much lower proportion of forest compared to the rest of the state (see Chapter 3, "Comparison of Ecological Landscapes," in Part 1 and/or the map "WISCLAND Land Cover [1992] of the Southeast Glacial Plains" in Appendix 18.K). According to Forest Inventory and Analysis (FIA) data, there are 590,580 acres of forestland, which is 3.6% of the total acreage in the state (USFS 2009). This ecological landscape has the second highest proportion of surface area in water among ecological landscapes, and most of this is in lakes.

There is a moderate amount of public land and water in the Southeast Glacial Plains (573,000 acres), but the percentage of public land and water in this large ecological landscape (11.6%) is less than the percentage of public land and water in the state as a whole (19.9%; Wisconsin DNR unpublished data). The density of private and public campgrounds and multi-purpose trails is also about average. However, the number of visitors to state properties is the highest in the state. Both the acreage in natural areas and the number of land legacy sites are quite high. This ecological landscape has the highest number of Land Legacy sites with high recreation potential (WDNR 2006c).

Supply

■ **Land and Water.** The Southeast Glacial Plains Ecological Landscape comprises 13.5% of Wisconsin's total land area but 22.2% of the state's acreage in water (see Chapter 3, "Comparison of Ecological Landscapes," for comparison of ecological landscape sizes). Streams and rivers make up 7% of the surface water area of the Southeast Glacial Plains Ecological Landscape whereas lakes and reservoirs account for 93% (WDNR 2014c).

■ **Public Lands.** Public access to recreational lands is vital to all types of recreational activity. In the Southeast Glacial Plains Ecological Landscape, almost 573,000 acres or 11.6% of all land and water, is publicly owned (WDNR 2005a). This is less than the statewide average of 19.9% public ownership.

Table 18.3. *Water use (millions of gallons/day) in the Southeast Glacial Plains counties.*

County	Ground-water	Surface Water	Public Supply	Domestic[a]	Agriculture[b]	Irrigation	Industrial	Mining	Thermo-electric	Total
Calumet	5.3	2.0	4.5	0.6	1.2	0.4	0.7	0.0	–	5.3
Columbia	9.9	18.3	3.4	1.3	1.4	1.7	1.6	0.3	19.0	9.9
Dane	68.7	229.3	50.1	5.0	4.9	6.2	3.6	1.6	227.0	68.7
Dodge	12.9	2.7	6.3	1.6	2.4	0.6	2.1	0.6	2.0	12.9
Fond du Lac	13.1	0.4	6.9	1.7	2.2	0.9	1.5	0.4	–	13.1
Green	10.7	0.3	2.7	0.8	1.8	5.0	0.6	0.1	–	10.7
Green Lake	8.6	0.8	1.3	0.5	2.4	2.7	1.0	1.6	–	8.6
Jefferson	27.9	2.9	5.8	1.6	4.5	10.1	6.0	0.2	3.0	27.9
Ozaukee	8.8	293.0	5.8	2.3	0.6	0.6	0.6	0.4	291.0	8.8
Rock	45.4	50.6	21.6	2.7	0.9	16.7	3.1	0.8	50.0	45.4
Sheboygan	5.2	3.3	2.4	0.8	1.9	0.2	3.1	0.1	–	5.2
Walworth	15.6	1.8	8.0	2.1	1.5	2.4	0.8	2.6	–	15.6
Washington	13.6	0.2	8.2	2.8	0.8	1.1	0.2	0.8	–	13.6
Waukesha	34.5	1.9	24.4	5.7	0.3	1.9	1.6	2.6	–	34.5
Waupaca	17.6	1.7	5.8	1.6	1.3	8.7	1.7	0.3	–	17.6
Winnebago	10.1	66.5	17.4	2.7	0.7	0.5	44.8	0.2	10.0	10.1
Total	**307.9**	**675.7**	**174.7**	**33.8**	**28.8**	**59.7**	**73.0**	**12.6**	**602.0**	**984.0**
Percent of total	**31%**	**69%**	**18%**	**3%**	**3%**	**6%**	**7%**	**1%**	**61%**	

Source: Based on 2005 data from the U.S. Geological survey on water uses in Wisconsin counties (USGS 2010).

[a]Domestic self-supply wells.

[b]Includes aquaculture and water for livestock.

State-owned facilities are especially important to recreation in the Southeast Glacial Plains. There are approximately 57,000 acres of state forest (Kettle Moraine State Forest, northern and southern units), 27,000 acres in parks and recreation areas, and 163,400 acres managed for wildlife and fisheries (WDNR 2005a). The largest state parks are High Cliff State Park with 1,675 acres and Pike Lake State Park with 830 acres. The Southeast Glacial Plains also contains 25,262 acres of state natural areas, many of which are within other public lands.

Trails. Although the Southeast Glacial Plains counties have about 5,300 miles of recreational trails (Table 18.4), this area ranks 10th (out of 16 ecological landscapes) in trail density (miles of trail per 100 square miles of land). Compared to the rest of the state, there is a higher density of hiking, biking, ATV, and cross-country ski trails (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 34 are either partially or totally located within the Southeast Glacial Plains Ecological Landscape (WDNR 2006c). Eleven of the Land Legacy sites are considered as having the highest recreation significance, and five are considered as having the highest conservation potential. In addition, the Kettle Moraine State Forest and the Niagara Escarpment are rated as having both the highest recreation and conservation significance.

Campgrounds. There are 204 public and privately owned campgrounds that provide about 18,840 campsites in the Southeast Glacial Plains counties (Wisconsin DNR unpublished data). With 11% of the state's campgrounds, the Southeast Glacial Plains Ecological Landscape ranks third (out of 16 ecological landscapes) in terms of the number of campgrounds and seventh in campground density (campgrounds per square mile of land).

State Natural Areas. The Southeast Glacial Plains Ecological Landscape has 25,262 acres of state natural areas, of which 78% is publicly owned (including government and educational institutions), 11% is owned by private interests (including NGOs), and 11% is owned by joint public-private entities (Wisconsin DNR unpublished data). The largest state natural areas here include White River Sedge Meadow (Wisconsin DNR, 2,936 acres, Green Lake County), Chub and Mud Lake Riverine Marsh (Wisconsin DNR, 1,988 acres, Dodge County), Lulu Lake (Wisconsin DNR-NGO, 1,846 acres, Walworth and Waukesha counties), Cedarburg Bog (University of Wisconsin, 1,770 acres, Ozaukee and Washington counties), and the Jefferson Tamarack Swamp (private, 1,594 acres, Jefferson County). For more information regarding state natural areas, see the Wisconsin DNR's state natural areas web page (WDNR 2014f).

Demand

Visitors to State Lands. In 2006 there were an estimated 3.4 million visitors to state recreation areas, parks, and forests in the Southeast Glacial Plains Ecological Landscape (Wisconsin DNR unpublished data). The majority, 58%, visited the state forests, namely the northern and southern units of the Kettle Moraine State Forest, and 42% visited the state parks, mainly High Cliff State Park.

Fishing and Hunting License Sales. Of all license sales, the highest revenue producers for the Southeast Glacial Plains counties were resident hunting licenses (53% of total sales), resident fishing licenses (29% of total sales), and nonresident fishing (8% of total sales) (Wisconsin DNR unpublished data). Table 18.5 shows a breakdown of various licenses sold in the Southeast Glacial Plains counties in 2007. Dane County accounts for both the highest number of licenses sold and the highest revenue from sales. This ecological landscape accounts for about 21% of total license sales in the state. Persons buying licenses in the Southeast Glacial Plains counties may travel to other parts of the state to use them.

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. Two of the 14 Southeast Glacial Plains counties are categorized as nonmetro recreation: Green Lake and Walworth counties.

Table 18.4. *Miles of trails and trail density in the Southeast Glacial Plains counties compared to the whole state.*

Trail type	Southeast Glacial Plains (miles)	Southeast Glacial Plains (miles/100 mi^2)	Wisconsin (miles/100 mi^2)
Hiking	592	6.2	2.8
Road biking	820	8.6	4.8
Mountain biking	181	1.9	1.9
ATV: summer and winter	20	0.2	9.3
Cross-country skiing	758	7.9	7.2
Snowmobile	2,927	30.7	31.2

Source: Wisconsin DNR unpublished data.

Tale 18.5. *Fishing and hunting licenses and stamps sold in the Southeast Glacial Plains counties.*

County	Resident fishing	Nonresident fishing	Misc. fishing	Resident hunting	Nonresident hunting	Stamps	Total
Calumet	10,404	340	2,132	13,767	24	4,205	30,872
Columbia	9,532	3,033	760	14,656	274	4,043	32,298
Dane	45,549	4,003	2,603	62,821	758	22,413	138,147
Dodge	13,499	983	847	23,931	315	7,692	47,267
Fond Du Lac	16,052	1,214	3,009	25,373	161	8,403	54,212
Green	4,283	576	103	7,168	241	2,310	14,681
Green Lake	4,974	3,375	394	7,165	124	2,919	18,951
Jefferson	10,200	1,157	500	15,387	90	4,361	31,695
Ozaukee	5,614	370	1,427	6,975	45	4,906	19,337
Rock	20,516	5,846	558	29,283	1,491	9,236	66,930
Sheboygan	16,631	1,176	4,282	25,346	181	14,625	62,241
Walworth	10,773	9,579	258	9,566	290	3,801	34,267
Washington	33,470	1,452	1,812	51,008	393	18,146	106,281
Waukesha	41,077	2,344	1,586	51,130	254	18,397	114,788
Waupaca	17,570	5,027	779	29,244	214	8,102	60,936
Winnebago	23,666	3,449	2,573	32,686	148	10,084	72,606
Total	**283,810**	**43,924**	**23,623**	**405,506**	**5,003**	**143,643**	**905,509**
Sales ($)	**$6,431,152**	**$1,775,529**	**$454,226**	**$11,779,367**	**$693,274**	**$1,200,330**	**$22,333,878**

Source: Wisconsin Department of Natural Resources unpublished data, 2007.

Recreational Issues

Results of a statewide survey of Wisconsin residents indicated that a number of current issues are affecting outdoor recreation opportunities within Wisconsin. 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 (WDNR 2006b).

■ **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. Many ATV riders feel there is a distinct lack of ATV trails and are looking primarily to public lands for places to expand their riding opportunities.

■ **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 are 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 the ever-increasing development along shorelines and continued fragmentation of forestlands, there has been a loss of readily available access to lands and waters within this ecological landscape. This may be due to the expansion of housing developments and associated closure of access to large areas of shoreline once open to the casual recreational user. Another element that may play into the perception of reduced access is a lack of information about where to go for recreational opportunities. This element was highly ranked as a barrier to increased outdoor recreation in a statewide survey (WDNR 2006b).

Agriculture

Farm numbers in the Southeast Glacial Plains counties have decreased 34% since 1970 (USDA NASS 2004). There were approximately 30,990 farms in 1970 and 20,811 in 2002. Between 1970 and 2002, average farm size increased from 164 acres to 190 acres, lower than the statewide average of 201 acres. The overall acreage in farms has steadily decreased since the 1970s (Figure 18.18). In 1970 there were about 5.1 million acres of farmland in these counties. By 2002 there were only 4.0 million acres, a decrease of 21%. For the 16 counties, the percentage of land in farms ranged from 26% to 82%, averaging 61%. The counties with the highest percentage of land in agricultural use were Green with 82%, Rock with 74%, and Dodge and Fond du Lac, both with 70%.

Agriculture is a very important part of the economy of the counties in the Southeast Glacial Plains. In 2002, net cash farm income totaled $430 million, or an average of $109 per agricultural acre, much higher than the statewide average of $91 per acre (USDA NASS 2004). Also in 2002, the market

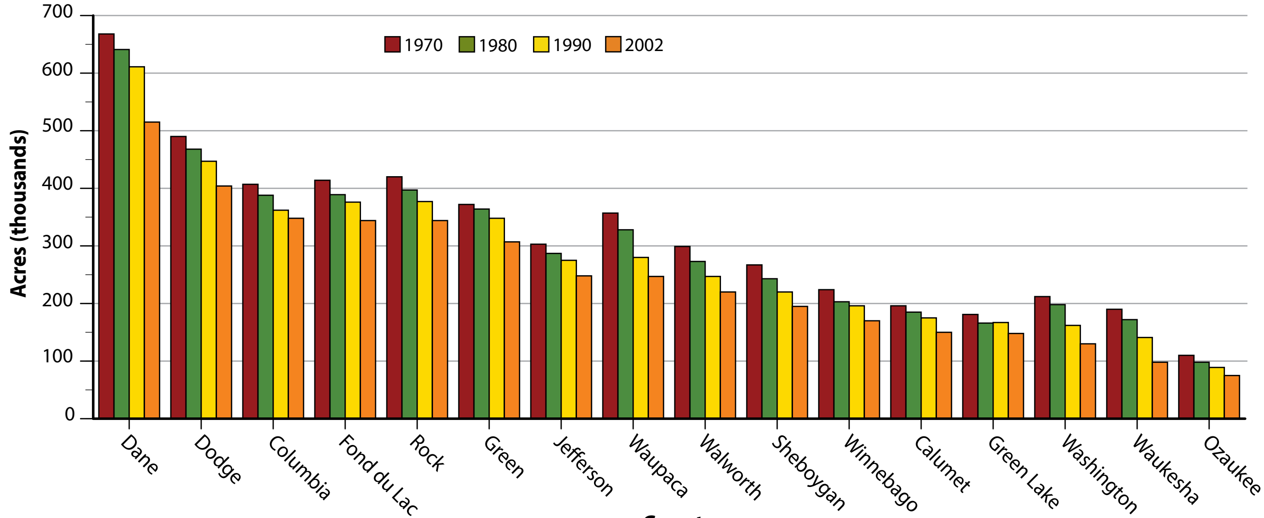


Figure 18.18. *Acreage of farmland in the Southeast Glacial Plains counties by county and year (USDA NASS 2004).*

value of all agriculture products sold in the Southeast Glacial Plains counties was $1.72 billion (21% of state total); 33% of this amount came from crop sales, while the remaining 67% was from livestock sales. Net cash farm income is very high for Dane, Fond du Lac, Dodge, and Sheboygan counties. Corn and other crops are important for Dane, Jefferson, Columbia, Dodge, and Fond du Lac counties. Dairy is important for Dane, Fond du Lac, Dodge, and Sheboygan counties.

In 2007, 29,169 acres of farmland had been sold, of which 85% stayed in agricultural use at an average selling price of $6,088, and 15% was diverted to other uses at an average sale price of $247,339 per acre (USDA NASS 2009). Southeast Glacial Plains counties not only have one of highest land diversion rates but have the highest price for diverted land and the second highest price for agricultural land in the state.

Timber

Timber Supply

Based on 2009 Forest Inventory and Analysis (FIA) data, 13% (590,779 acres) of the total land area for the Southeast Glacial Plains Ecological Landscape is forested (USFS 2009). This is less than 4% of Wisconsin's total forestland acreage. Forestland is defined by FIA as land having a certain minimal canopy cover currently and in the past, with the potential to be forested in the future. This definition is problematic in ecological landscapes such as the Southeast Glacial Plains because ecologists have characterized much of the woody cover here in the past, and to a lesser degree at present, as oak savanna rather than forest. Structurally and functionally, savannas represent distinctive and very different vegetation types from forests. There are also compositional elements unique to each.

Timber Ownership. According to FIA data, 85% of all ***timberland*** within the Southeast Glacial Plains Ecological Landscape is owned by private landowners (USFS 2009). The remaining 15% is owned by state and local governments (Figure 18.19). Timberland is defined as forestland capable of producing 20 cubic feet of industrial wood per acre per year that is not withdrawn from timber utilization (see glossary in Part 3, "Supporting Materials," for a more detailed description of "timberland").

Growing Stock and Sawtimber Volume. There was approximately 724 million cubic feet of ***growing stock*** volume in the Southeast Glacial Plains Ecological Landscape in 2007, or 4% of total volume in the state (USFS 2007). Most of this volume, 87%, was in hardwoods, higher than the proportion of hardwoods statewide, which was 74% of total growing stock volume. Hardwoods made up a similar percentage of ***sawtimber*** volume, 87%, in this ecological landscape. In comparison, statewide hardwood volume was 67% of total volume.

Annual Growing Stock and Sawtimber Growth. Between 1996 and 2007, the timber resource in the Southeast Glacial Plains Ecological Landscape increased by 173 million cubic feet or 31% (USFS 2007). Approximately 82% of this increase occurred in hardwood volume. Sawtimber volume increased

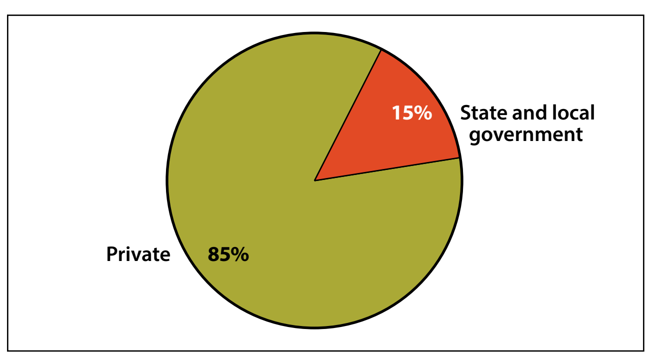


Figure 18.19. *Timberland ownership in the Southeast Glacial Plains Ecological Landscape (USFS 2009).*

by 604 million board feet or 36%, again mostly in hardwoods. This change was partly a result of a 17% increase in timberland acreage from 498,325 acres in 1996 to 585,276 acres in 2007. Statewide, timberland acreage increased by 3% during the same time period.

Timber Forest Types. According to FIA data (USFS 2009), the predominant forest type groups in the Southeast Glacial Plains Ecological Landscape in terms of acreage are oak-hickory (30%), maple-basswood (29%), and bottomland hardwoods (23%), with much smaller amounts of spruce-fir, aspen-birch, and white, red, and jack pines (Table 18.6) (see Appendix H, "Forest Types That Were Combined into Forest Type Groups Based on Forest Inventory and Analysis (FIA) Data," in Part 3 of the book, "Supporting Materials"). Timberland acreage is predominantly in the sawtimber and pole-size classes (49% and 35%, respectively), with only 12% in seedling and sapling classes.

Table 18.6. *Acreage of timberland in the Southeast Glacial Plains Ecological Landscape by forest type and size class.*

Forest type[a]	Seedling/sapling	Pole-size	Sawtimber	Total
White oak-red oak-hickory	2,881	26,224	57,123	86,229
Sugarberry-hackberry-elm-green ash	5,449	33,968	31,291	70,709
Hard maple-basswood	4,289	7,916	41,890	54,095
Mixed upland hardwoods	2,818	14,071	23,773	40,661
Sugar maple-beech-yellow birch	–	18,318	21,428	39,746
Elm-ash-locust	13,832	12,954	11,369	38,154
Black ash-American elm-red maple	2,814	23,019	4,235	30,069
Black cherry	8,873	12,109	2,922	23,904
Nonstocked[b]	–	–	–	21,921
White oak	2,075	121	14,771	16,967
Tamarack	5,243	10,640	–	15,884
Aspen	3,880	5,594	5,064	14,538
Cherry-ash-yellow-poplar	–	3,510	10,968	14,477
Silver maple-American elm	–	348	11,635	11,982
Eastern white pine	–	4,875	5,948	10,823
White birch	4,092	2,961	3,467	10,520
Sycamore-pecan-American elm	2,834	6,214	-	9,048
Red pine	41	3,309	5,335	8,685
Northern white-cedar	–	2,349	6,273	8,623
Northern red oak	–	–	8,522	8,522
Post oak-blackjack oak	–	4,230	4,059	8,289
Bur oak	–	–	6,279	6,279
Willow	1,276	2,802	2,057	6,135
White pine-red oak-white ash	2,624	1,789	1,373	5,786
Exotic softwoods & hardwoods	–	–	–	2,915
White spruce	2,899	–	–	2,899
Red maple-oak	–	–	2,854	2,854
River birch-sycamore	–	–	2,779	2,779
Cottonwood-willow	–	2,512	–	2,512
Jack pine	–	2,097	–	2,097
Other pine-hardwood	–	2,093	–	2,093
Black locust	–	2,082	–	2,082
Black walnut	443	–	1,328	1,771
Cottonwood	1,228	–	–	1,228
Total	**67,591**	**206,104**	**286,745**	**585,276**

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. For example, neither post oak nor blackjack oak occur to any great extent in Wisconsin, but since there is no "black oak forest type" in the FIA system, black oak stands in Wisconsin were placed in the "post oak-blackjack oak" category in this table.

[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. The Southeast Glacial Plains Ecological Landscape has about 3.5% of the total growing stock volume of timberland in Wisconsin. Average annual removals from growing stock were 12 million cubic feet, or about 3.5% of total statewide removals (349 million cubic feet) between 2000 and 2002 and between 2005 and 2007 (USFS 2007; see the "Socioeconomic Characteristics" section in Chapter 3, "Comparison of Ecological Landscapes," in Part 1 of the book). Average annual removals to growth ratios vary by species, as can be seen in Figure 18.20 (major species shown). Removals exceed growth for northern red oak, sugar maple, bur oak, American beech, aspen, and white birch (*Betula papyrifera*).

Removals from Sawtimber. The Southeast Glacial Plains Ecological Landscape has about 3.8% of the total sawtimber volume on timberland in Wisconsin (USFS 2007). Average annual removals from sawtimber were about 53 million board feet or 5.1% of total statewide removals (1.1 billion board feet) between 2000 and 2002 and 2005 and 2007. Average annual removals to growth ratios vary by species as can be seen in Figure 18.21 (only major species shown). Sawtimber removals exceeded growth for northern red oak, sugar maple, American beech, black cherry, bur oak, and aspen.

Price Trends

In the counties of the Southeast Glacial Plains, black walnut (*Juglans nigra*), black cherry (*Prunus serotina),* sugar maple,

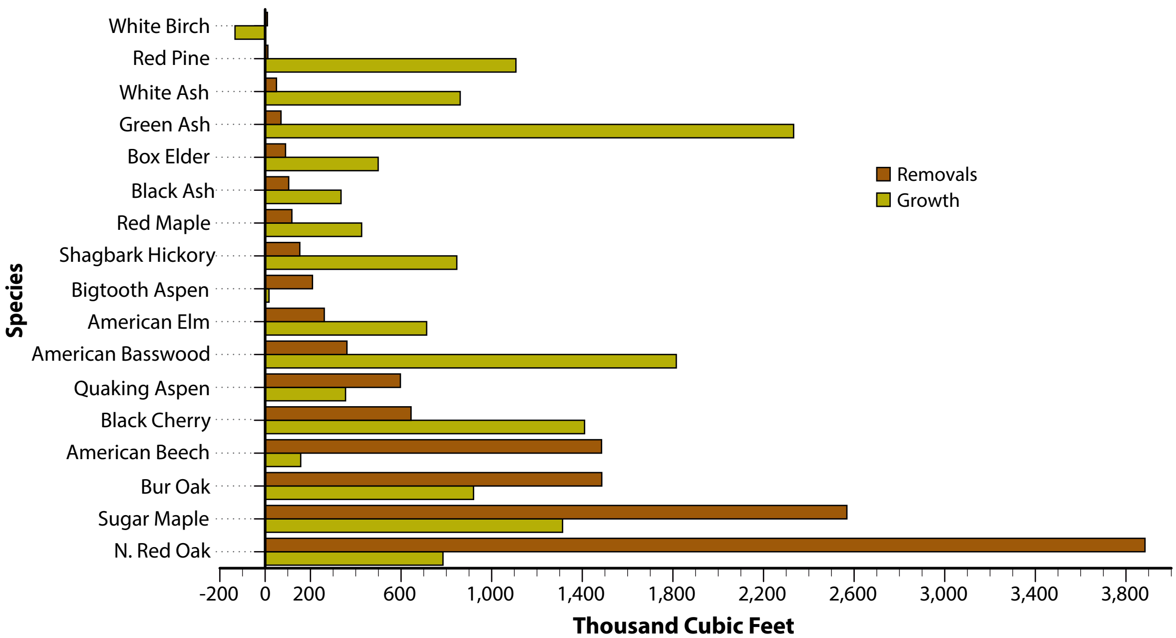


Figure 18.20. *Growing stock growth and removals (selected species) on timberland in the Southeast Glacial Plains Ecological Landscape (USFS 2009).*

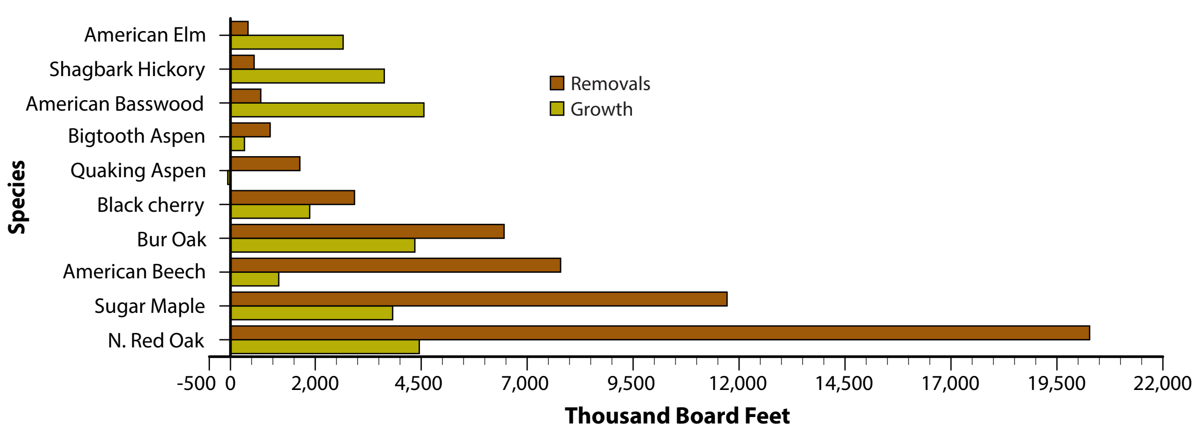


Figure 18.21. *Sawtimber growth and removals (selected species) on timberland in the Southeast Glacial Plains Ecological Landscape (USFS 2009).*

and northern red oak were the highest priced hardwood sawtimber species in 2007 (WDNR 2008). Northern white-cedar, red pine, and eastern white pine were the most valuable softwood timber species. Sawtimber prices for 2007 were generally much higher for softwoods and about the same for hardwoods compared to the rest of the state. For pulpwood, red pine is the most valuable. Pulpwood values in the counties of the Southeast Glacial Plains Ecological Landscape were generally lower for softwoods compared to the statewide average.

Infrastructure

Transportation

The transportation infrastructure of the Southeast Glacial Plains Ecological Landscape is much more developed than the rest of the state. For instance, road mile density is 26% higher (WDOA 2000), railroad density is 69% higher (WDOT 1998), and airport runway density is 76% higher (WDOT 2012) than the state as a whole. There is one primary regional airport (Dane County Regional Airport in Madison) and three reliever airports (Brookfield, Waukesha, and West Bend). There are no shipping ports in the Southeast Glacial Plains (WCPA 2010) (Table 18.7).

Renewable Energy

Hydroelectric and wind turbine 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 counties of the Southeast Glacial Plains Ecological Landscape. Due to corn-based ethanol production and wind power generation, the Southeast Glacial Plains Ecological Landscape has strong potential to produce a significant amount of renewable energy. The Southeast Glacial Plains Ecological Landscape has 4% of all woody biomass in Wisconsin, generates 1.4% of the hydroelectric power, and produces 25% of the state's corn crop. This ecological landscape had six ethanol plants and five wind generating facilities as of 2013 (WWIC 2013).

■ **Biomass.** Woody biomass is Wisconsin's most-used renewable energy resource, and the Southeast Glacial Plains Ecological Landscape produces 39.8 million oven-dry tons of biomass, or 4% of total production (USFS 2009). The forested land base, currently at 13%, has increased by 87,000 acres or 17% in the last decade.

■ **Hydroelectric.** There is only one hydroelectric power site, which generates 20.5 million kilowatt hours (kWh) (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.** The Southeast Glacial Plains counties produced 146.5 million bushels of corn in 2002, or about 25% of total corn production in the state. Acreage in agriculture, at 61% of the land base, decreased by 23% between 1970 and 2002 (USDA NASS 2004). Increasing ethanol from corn production will depend on converting land to corn. Six of the nine ethanol plants in the state are located in this ecological landscape, in Cambria, Friesland, Jefferson Junction, Milton, Monroe, and Oshkosh. They produce a total of 367 million gallons per year or 74% of the state's total ethanol production (Renewable Fuels Association 2013).

■ **Wind.** In 2013 there were five commercial wind facilities in the Southeast Glacial Plains Ecological Landscape, rated at 397 MW (megawatts) of power (WWIC 2013). Mean annual power densities are generally between 200 and 300 W/m^2 (watts/square meter) in this part of the state, with parts of Winnebago and Calumet counties having power densities of

Table 18.7. *Road miles and density, railroad miles and density, number of airports, airport runway miles and density, and number of ports in the Southeast Glacial Plains Ecological Landscape.*

	Southeast Glacial Plains	State total	Percent state total
Total road length[a] (miles)	31,392	185,487	17%
Road density[b]	4.3	3.4	–
Miles of railroads	1,193	5,232	23%
Railroad density[c]	16.4	9.7	–
Airports	31	128	24%
Miles of runway	22.7	95.7	24%
Runway density[d]	3.1	1.8	–
Total land area (square miles)	7,283	54,087	13%
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).

Industrial wind facilities are now up and running at several locations in the Southeast Glacial Plains Ecological Landscape. Poorly sited turbines may create hazards for wildlife, especially birds and bats. Locally, such developments generate controversy over issues that include human health, property values, and effects on our carbon footprint. Photo by Bill Borchardt.

300–400 W/m^2 (USDE 2013). For this reason, there is a good potential for wind generated power in this part of the state.

Current Socioeconomic Conditions

Demography

The Southeast Glacial Plains counties have undergone considerable change over the past few decades, transitioning from agricultural to suburban, with the exception of the northernmost counties in the region. Population growth exceeds that of the state, especially in more urban Southeast Glacial Plains counties. Southeast Glacial Plains counties have slightly younger populations, are more diverse racially than rural Wisconsin counties, and have education levels among the highest in the state.

Population Distribution

The U.S. Census Bureau estimated the combined 2010 population of the 16 Southeast Glacial Plains counties was 2,129,491 (USCB 2012b), or 37.4% of the state total population. Apart from the Southern Lake Michigan Coastal county approximation (with urban Milwaukee, Racine and Kenosha counties), the Southeast Glacial Plains counties are collectively the most urban among any other ecological landscape county approximation in the state. Only 26.8% of the population in Southeast Glacial Plains counties can be classified as rural population, compared to 31.7% statewide. Madison in Dane County (population estimate of 228,775 in 2007) is the largest urban center within the Southeast Glacial Plains counties (USCB 2009). Four other cities in Southeast Glacial Plains counties have populations over 60,000: Appleton on the northern edge of the ecological landscape (70,017), Waukesha in Waukesha County (66,762), Oshkosh in Winnebago County (64,592), and Janesville in Rock County (63,012). Dane County (2007 estimated population of 476,785) and Waukesha County (379,333) together comprise over 40% of the total population in Southeast Glacial Plains counties. Ten Southeast Glacial Plains counties were classified as "metropolitan" by the USDA Economic Research Service in 2004 (USDA ERS 2012b). Green Lake, Waupaca, and Green counties are the Southeast Glacial Plains counties classified as having the least metropolitan influence.

Population Density

In 2010 the population density of the Southeast Glacial Plains counties (223 persons per square mile) was more than double that in Wisconsin as a whole (105 persons per square mile). Among Southeast Glacial Plains counties, Waukesha County (709) has the highest population density, followed by Dane (408), Winnebago (384), and Ozaukee (370) counties. Green Lake (54) and Green (63) counties have the lowest population densities among Southeast Glacial Plains counties (USCB 2012b).

Population Structure

■ **Age.** The age structure of the population in the Southeast Glacial Plains counties is very similar to the state as a whole but is composed of slightly less people of retirement age (13.3% of the 2010 population in Southeast Glacial Plains counties is 65 or older, compared to 13.7% statewide) and slightly less people under the age of 18 (23.2% in Southeast Glacial Plains counties compared to 23.6% statewide) (USCB 2012b). The median age is higher than the statewide figure of 36 years old in 11 Southeast Glacial Plains counties, ranging from 36.6 years in Washington County to 40.9 years in Green Lake County (USCB 2009). However, heavily populated Dane County has a median age of 33.2 years, and four Southeast Glacial Plains counties have median ages clustered between 35 and 36 years.

■ **Minorities.** The Southeast Glacial Plains counties are less racially diverse than the state as a whole but more diverse than most rural ecological landscapes. Ninety-one percent of the 2010 population in Southeast Glacial Plains counties is white, non-Hispanic, compared to 86.2% statewide. Southeast Glacial Plains counties are 4.9% Hispanic/Latino, led by 10.3% in Walworth County, compared to 5.9% statewide. Southeast Glacial Plains counties are 2.5% Black/African American, led by 5.2% in Dane County, compared to 6.3% statewide (USCB 2012b).

■ **Education.** Residents of Southeast Glacial Plains counties 25 years of age or older have relatively high education levels compared to the state as a whole, especially in terms of higher education. According to the 2010 census, 91.7% of Southeast Glacial Plains counties' residents 25 or older have graduated from high school, compared to 89.4% statewide. The Southeast Glacial Plains counties' residents have a high post-secondary education attainment (30.8% of Southeast Glacial Plains counties' residents have received a bachelor's degree or higher, compared to 25.3% statewide). The most urban Southeast Glacial Plains counties have significantly higher education attainment levels than other Southeast Glacial Plains counties. Dane County (with 94.3% of residents graduated from high school and 45.4% having attained a bachelor's degree or higher) leads the state in education attainment, followed closely by Ozaukee County (95.1% and 43.1%, respectively) and Waukesha County (95.0% and 39.2%) (USCB 2012b).

Population Trends

Over the extended period from 1950 to 2006, Southeast Glacial Plains counties' combined population has more than doubled (125.7% population growth, twice the rate of the state's population growth (63%) (USCB 2009). The greatest population growth occurred in counties surrounding Milwaukee County, reflecting the growth of the Milwaukee suburbs and movement out of the city center. Waukesha County's population boomed to more than four times its 1950 size by 2006. Populations of Washington and Ozaukee counties more than tripled over the same time period. Meanwhile, Dane, Walworth, and Calumet counties experienced well over 100% population growth over the period from 1950 to 2006.

Population growth in Southeast Glacial Plains counties combined has outflanked statewide growth from decade to decade since 1950, though the relative rate has slowed continually over time. From 1950 to 1960, Southeast Glacial Plains counties (25.8% population growth) grew nearly twice as fast as the state as a whole (15.1%). From 1960 to 1970, Southeast Glacial Plains counties' combined population growth (23.9%) continued well ahead of statewide numbers (11.8% population growth). By the period from 1970 to 1980, population growth in Southeast Glacial Plains counties (11.9%) had slowed but remained ahead of statewide growth (6.5%). From 1980 to 1990, population growth in Southeast Glacial Plains counties (7.1% growth, compared to 4% statewide) continued to slow. The period from 1990 to 2000 saw increased growth, both in Southeast Glacial Plains counties and statewide (14.6 and 9.6%, respectively), but the gap continued to narrow (USCB 2009). Suburban Milwaukee counties have experienced relatively slowed growth in the past two decades, while counties with small cities (Dane, Calumet, Washington, Jefferson, and Walworth counties) have led the Southeast Glacial Plains counties population growth.

Housing

Housing Density. The Southeast Glacial Plains counties' combined housing density in 2010 (97 housing units per square mile of land) is roughly twice the state's housing density (48.5 units per square mile). Similar to population density, housing density is highest in Waukesha County (293 units per square mile), followed by Dane (180), Winnebago (169), and Ozaukee (156). Rural Southeast Glacial Plains counties such as Green (27), Green Lake (30), Columbia (34) and Waupaca (34) have comparatively low housing densities. The remaining Southeast Glacial Plains counties have housing densities ranging from Dodge County's 42 units per square mile to Washington County's 127 units per square mile (USCB 2012a).

Seasonal Homes. Seasonal and recreational homes made up only 2.9% of housing stock in the Southeast Glacial Plains counties in 2010, compared to the statewide average of 6.3%. Of Southeast Glacial Plains counties, only Green Lake (16.8%), Walworth (16.0%), and Waupaca (8.8%) counties exceeded the statewide average percentage of seasonal housing (USCB 2012a).

Housing Growth. Over the last half century, housing growth in the Southeast Glacial Plains counties has consistently exceeded statewide averages, especially in Waukesha, Ozaukee, Washington, Dane, and Sheboygan counties. Southeast Glacial Plains counties' housing growth from 1950 to 1960 (42.3%) was only slightly ahead of the statewide average (40.4%), then moved further ahead of statewide housing growth through the 1960s (33.8% in Southeast Glacial Plains counties versus 27.2% statewide). Housing growth in Southeast Glacial Plains counties has since continued to surpass statewide averages. Southeast Glacial Plains counties of more rural character have actually lagged behind statewide averages over the same period. From 1990 to 2000, Sheboygan (37.2%), Waukesha (37.2%), Calumet (34.1%), and Waukesha (33.4%) counties had the greatest housing growth among Southeast Glacial Plains counties, compared to 20.2% statewide (USCB 2009).

Housing Values. Southeast Glacial Plains counties had the state's top four median housing values in 2010 and six of the top seven counties in the state. Ozaukee ($249,400), Waukesha ($256,400), Washington ($224,200), Dane ($226,900), Walworth ($192,900), and Jefferson ($177,800) counties are

Residential development is occurring rapidly in some rural areas, altering land and water use, with many socioeconomic implications. Photo by Ryan O'Connor, Wisconsin DNR.

all well above the statewide median housing value ($166,100). Waupaca ($133,900) and Green Lake ($133,700) counties have the lowest housing values among Southeast Glacial Plains counties (USCB 2012b).

The Economy

Southeast Glacial Plains counties make up a large portion of Wisconsin's economic output across a wide range of industry sectors. Unemployment rates are lower than statewide figures and per capita income and average wages per job are high in the Southeast Glacial Plains counties, indicating more high paying jobs. Unemployment is low in most Southeast Glacial Plains counties, and poverty rates are comparatively low in Southeast Glacial Plains counties. Property values are highly variable among Southeast Glacial Plains counties, among the state's highest in suburban counties, and relatively low in more rural counties.

Income

■ **Per Capita Income.** Total personal income for Southeast Glacial Plains counties in 2006 was $80.3 billion (41.9% of the state total), with Dane County ($19.3 billion) and Waukesha County ($18.5 billion) contributing nearly half the income in Southeast Glacial Plains counties. Per capita income in Southeast Glacial Plains counties in 2006 ($38,934) was higher than the statewide average of $34,405 (Table 18.8) (USDC BEA 2006). Ozaukee County ($56,816) and Waukesha County ($49,219), counties neighboring Milwaukee, had the highest per capita incomes in the state. Dane ($41,179) and Washington ($39,797) counties were ranked third and fourth, respectively, in per capita income among Wisconsin counties. Even the Southeast Glacial Plains county with the lowest per capita income (Dodge County with per capita income of $28,694) fared better than half of Wisconsin's counties.

■ **Household Income.** Household income in Southeast Glacial Plains counties is relatively high. Median household income in Southeast Glacial Plains counties ranged in 2005 from only slightly less than the statewide median household income ($47,141) in Green Lake ($42,599) to the state's highest level in Ozaukee County ($73,447), according to U.S. Census Bureau estimates (USCB 2009).

■ **Earnings Per Job.** Southeast Glacial Plains counties had average earnings per job in ($37,551) higher than the statewide average ($36,142) and higher than all other ecological landscapes, with the exception of the Southern Lake Michigan Coastal Ecological Landscape (Table 18.8). Waukesha County ($42,841) had the highest earnings per job in the state, followed by Milwaukee County and then three other Southeast Glacial Plains counties: Ozaukee ($39,326), Dane ($39,228), and Winnebago ($38,714). The lowest earnings per job in Southeast Glacial Plains counties occurred in Calumet ($27,962), Green ($28,223), and Green Lake ($28,913) (USDC BEA 2006).

Unemployment

The Southeast Glacial Plains counties had a combined 2006 unemployment rate of 4.1%, comparatively lower than the state average of 4.7% (Table 18.8). The Southeast Glacial Plains counties contained six of the top ten Wisconsin counties in terms of the 2006 unemployment rate, including the state's three lowest unemployment rates in Dane County (3.3%), Ozaukee County (3.6%), and Waukesha County (3.8%). Only Green Lake County (5.5%) exceeded the statewide 2006 unemployment rate by more than a half of a percentage point. Unemployment rates became much higher throughout the state after 2008 but have become lower again.

Poverty

■ **Poverty Rates.** Southeast Glacial Plains counties fare very well in terms of poverty within their populations. The U.S. Census Bureau estimated the Southeast Glacial Plains counties' combined 2005 poverty rate for all people at 7.1%, compared to 10.2% for the state as a whole (Table 18.8). Ozaukee County (3.4%) and Waukesha County (3.8%) had the state's lowest poverty rates. Among the Southeast Glacial Plains counties, only Dane County (11.1%) had a higher poverty rate than the state as a whole (USCB 2009).

■ **Child Poverty Rates.** Compared to the statewide average (14%), 2005 estimates of poverty rates for people under age 18 in Southeast Glacial Plains counties followed similar trends as with overall poverty rates. Ozaukee County (3.5%) and Waukesha County (4.1%) had the lowest 2005 child poverty rates in the state, while Waukesha (5.6%) and Calumet County (5.8%) were ranked third and fourth statewide, respectively. Child poverty rates were highest in Green Lake County (11.9%) and Rock County (12.5%) but still ranked in the better half of the state's counties (USCB 2009).

Residential Property Values

Average residential property value in 2006 in the combined Southeast Glacial Plains counties ($164,504 per housing unit) was much higher than the statewide average ($134,021). However, residential property values were highly variable between Southeast Glacial Plains counties. Ozaukee County ($246,255) and Waukesha County ($244,435) had the highest values per residential property among Southeast Glacial Plains counties, followed by Walworth County ($219,484). Meanwhile, Rock County ($100,922) had the lowest average residential property value among eight Southeast Glacial Plains counties below the statewide average (Table 18.9). The Southeast Glacial Plains counties' disparate residential property values primarily reflect the correlation between close proximity to large urban centers and higher property values.

Important Economic Sectors

Southeast Glacial Plains counties together provided nearly 1.4 million jobs in 2007, or about 39.2% of the total employment in Wisconsin (Table 18.10; MIG 2009). The Manufacturing

Table 18.8. *Economic indicators for the Southeast Glacial Plains 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%**
Calumet	$36,107	$27,962	4.1%	4.8%
Columbia	$34,796	$30,339	4.7%	6.2%
Dane	$41,179	$39,228	3.3%	11.1%
Dodge	$28,694	$33,515	5.0%	6.7%
Fond du Lac	$32,923	$33,081	4.7%	7.6%
Green	$31,761	$28,223	4.4%	7.0%
Green Lake	$31,761	$28,913	5.5%	7.4%
Jefferson	$32,07	$30,781	4.6%	7.0%
Ozaukee	$56,816	$39,326	3.6%	3.4%
Rock	$30,356	$36,200	5.1%	8.8%
Sheboygan	$35,419	$35,618	4.0%	6.2%
Walworth	$30,688	$30,270	4.3%	8.8%
Washington	$39,797	$34,139	4.1%	5.0%
Waukesha	$49,219	$42,841	3.8%	3.8%
Waupaca	$31,662	$29,833	5.0%	7.9%
Winnebago	$33,874	$38,714	4.5%	9.3%
Southeast Glacial Plains counties	**$38,934**	**$37,551**	**4.1%**	**7.1%**

[a]U.S. Bureau of Economic Analysis, 2006 figures.
[b]U.S. 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.

Table 18.9. *Property values for the Southeast Glacial Plains 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**
Calumet	$2,484,051,200	18,872	$131,626
Columbia	$3,447,644,900	25,062	$137,565
Dane	$33,449,959,100	207,964	$160,845
Dodge	$4,091,356,300	36,381	$112,459
Fond du Lac	$4,533,863,100	42,430	$106,855
Green	$1,701,565,400	15,499	$109,785
Green Lake	$1,769,719,800	10,319	$171,501
Jefferson	$4,533,782,600	33,648	$134,742
Ozaukee	$8,716,442,700	35,396	$246,255
Rock	$6,810,643,400	67,484	$100,922
Sheboygan	$6,205,058,400	49,640	$125,001
Walworth	$10,924,604,900	49,774	$219,484
Washington	$10,317,711,100	52,462	$196,670
Waukesha	$37,785,791,600	154,584	$244,435
Waupaca	$2,651,381,700	24,224	$109,453
Winnebago	$7,711,186,700	70,675	$109,108
Southeast Glacial Plains counties	**$147,134,762,900**	**894,414**	**$164,504**

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.

(non-wood) sector is the principal employer in Southeast Glacial Plains counties (13.9% of their total employment), historically providing steady, well-paying jobs. With the presence of the state capital in Madison, accompanying government sector jobs were the second most prevalent in Southeast Glacial Plains counties (12.6% of employment). Tourism-related (10.6%), Retail Trade (9.2%), and Health Care and Social Services (8.8%) were other sectors with considerable employment. For definitions of economic sectors, see the U.S. Census Bureau's North American Industry Classification System web page (USCB 2014).

Importance of economic sectors within the Southeast Glacial Plains 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 Southeast Glacial Plains counties had 11 sectors of employment with location quotients higher than 1.0 (Figure 18.22, Appendix 18.I). However, because Southeast Glacial Plains counties make up such a large portion of all employment, only five sectors have location quotients exceeding 1.0 by more than 10%. The Mining sector has the highest location quotient among sectors in the Southeast Glacial Plains counties; though it is a minor employer in terms of real jobs, more than half of the state's jobs in the Mining sector are in Southeast Glacial Plains counties. Other sectors with relatively high location quotients, in order of their relative portion, are Information, Manufacturing (non-wood), Real Estate, Rental and Leasing, and Wholesale Trade. Other sectors providing a percentage of jobs in Southeast Glacial Plains counties only slightly higher than the state average are Construction, Other Services, Professional, Science and Technical Services, Government, Finance and Insurance, and Retail trade. Notably, Agriculture and Forest Products and Processing are the sectors with the lowest location quotients in Southeast Glacial Plains counties, indicating the high degree of urban influence in the region.

The Other Services sector consists primarily of equipment and machinery repairing, promoting or administering religious activities, grant making, advocacy, and providing

Table 18.10. *Total and percentage of jobs in 2007 in each economic sector within the Southeast Glacial Plains (SEGP) counties. The economic sectors providing the highest percentage of jobs in the Southeast Glacial Plains counties are highlighted in blue.*

Industry sector	WI employment	% of WI total	SEGP counties employment	% of SEGP counties total
Agriculture, Fishing & Hunting	110,408	3.1%	32,866	2.4%
Forest Products & Processing	88,089	2.5%	22,562	1.6%
Mining	3,780	0.1%	2,173	0.2%
Utilities	11,182	0.3%	2,928	0.2%
Construction	200,794	5.6%	85,129	6.1%
Manufacturing (non-wood)	417,139	11.7%	193,763	13.9%
Wholesale Trade	131,751	3.7%	60,007	4.3%
Retail Trade	320,954	9.0%	128,184	9.2%
Tourism-related	399,054	11.2%	147,260	10.6%
Transportation & Warehousing	108,919	3.1%	35,041	2.5%
Information	57,081	1.6%	27,249	2.0%
Finance & Insurance	168,412	4.7%	68,444	4.9%
Real Estate, Rental & Leasing	106,215	3.0%	48,718	3.5%
Professional, Science & Tech Services	166,353	4.7%	67,944	4.9%
Management	43,009	1.2%	15,799	1.1%
Administrative and Support Services	166,405	4.7%	60,019	4.3%
Private Education	57,373	1.6%	17,948	1.3%
Health Care & Social Services	379,538	10.7%	123,116	8.8%
Other Services	187,939	5.3%	77,886	5.6%
Government	430,767	12.1%	175,662	12.6%
Totals	**3,555,161**		**1,392,698**	**39.2%**

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

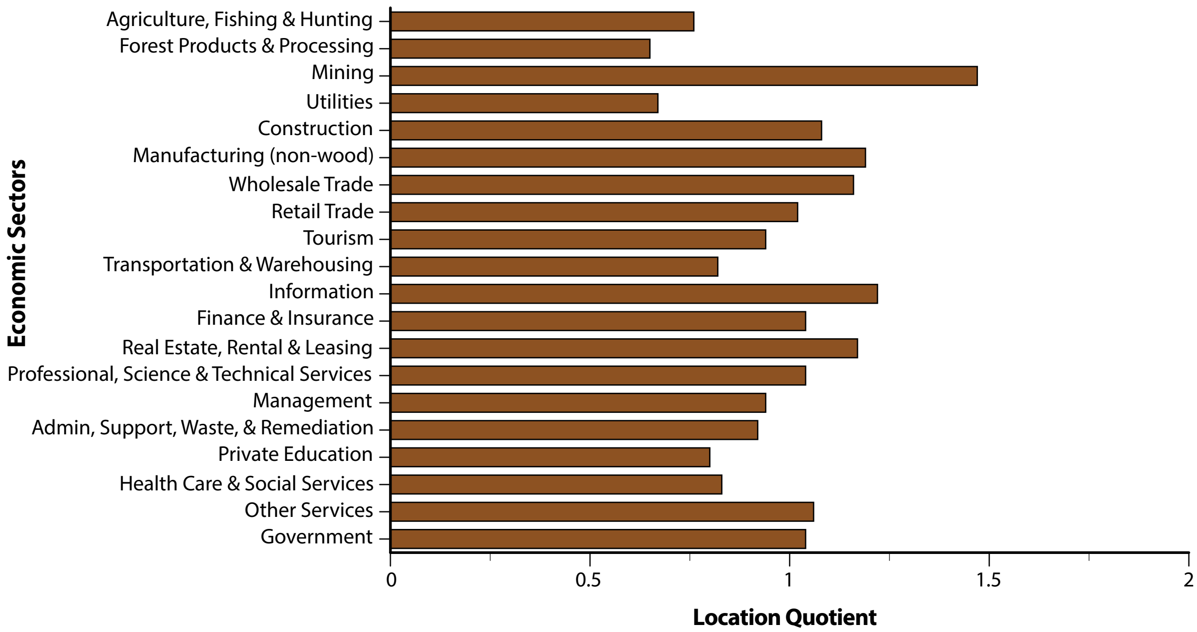


Figure 18.22. *Importance of economic sectors within the Southeast Glacial Plains counties when compared to the rest of the state. If the location quotient is greater than 1.0, the Southeast Glacial Plains counties are contributing more jobs to that economic sector than the state average. If the location quotient is less than 1.0, the Southeast Glacial Plains counties are contributing fewer jobs to that economic sector than the state average.*

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 USDA'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 population size, urbanization, and access to larger adjacent economies are crucial elements in evaluating potential of local economies. Ozaukee, Washington, and Waukesha counties are categorized as class 1 counties, included in the large metropolitan area of neighboring Milwaukee. Calumet, Columbia, Dane, Fond du Lac, Rock, Sheboygan, and Winnebago counties are classified as smaller metropolitan areas (class 2). Dodge, Jefferson, and Walworth counties are classified as micropolitan areas adjacent to large metropolitan areas (class 3). The remaining Southeast Glacial Plains counties are composed of nonmetropolitan (rural) counties with moderate degrees of "influence" from adjacent urban areas. Green is a class 5 county, while Green Lake and Waupaca are class 6 counties.

Economic Types

Based on the assumption that knowledge and understanding of different types of rural economies and their distinctive economic and sociodemographic profiles can aid rural policy making, the USDA ERS classifies counties in one of six mutually exclusive categories: farming-dependent counties, mining-dependent counties, manufacturing-dependent counties, government-dependent counties, services-dependent counties, and nonspecialized counties (USDA ERS 2012a). Thirteen Southeast Glacial Plains counties are classified as manufacturing-dependent. Dane County, with the state capital of Madison, is classified as federal/state government-dependent, while Green and Green Lake counties are classified as nonspecialized counties.

Policy Types

The USDA ERS also classifies counties according to "policy types" deemed especially relevant to rural development policy (USDA ERS 2012a). In 2004 Green Lake County and Walworth County were classified as "nonmetro recreation" (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. Waupaca County, classified as a "retirement destination" county (those in which the number of residents 60 and older grew by 15% or more between 1990 and 2000 due to ***in-migration***), is shaped by an influx of an aging population and has 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," in Part 1 of the book. 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 18.A. *Watershed water quality summary for the Southeast Glacial Plains Ecological Landscape.*

Watershed no.	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Very Poor/Poor/Fair/Good/Very Good/Excellent)
FX02	Lower Fox River/Illinois	72,983	Fair to Good; 48% agr; Indus. PS; Agr & urban NPS pollutants; ditching; dams
FX03	White River & Nippersink Creek	107,742	Fair; 47% agr/10% wetland; Agr cropland/residential devel > Sed/nutrients; ditching > Hab; lakes boats > Sed
FX04	Middle Fox River/Illinois	158,543	Fair to Good; 41% agr; Agr & urban NPS pollutants; ditching; some heavily developed, eutrophic lakes
FX05	Sugar & Honey creeks	106,381	Poor for Good; Agr NPS/ditching/cropland runoff > low D.O./ Hab/erosion/Sed; Flux;
FX06	Mukwonago River	55,177	Fair to V Good; 37% Agr; Agr/urban NPS; ditching > Hab; Flux; lakes: urban & rural NPS
FX07	Upper Fox River/Illinois	96,697	Poor to Fair; 20% urban & 21% agr; NPS; impoundments; flashy flows
LF03	Plum & Kankapot creeks	53,786	Poor; Agr crops/streambank pasturing/barnyard runoff > NPS nutrients/erosion > Low D.O./Sed
LF04	Fox River/Appleton	25,200	Poor to Fair; Agr/comm devel > NPS/Sed; PS; organic pollution
LF06	Little Lake Butte des Morts	28,010	Poor to Fair; NPS stormwater > blue-green algae > duck die-offs; Agr ditching > Hab; PS PCBs in Sed; low D.O.
LR01	Turtle Creek	184,621	Fair to Good; streambank grazing> erosion; ditching > Temp/ Hab; Agr/urban NPS > low D.O.; lakes eutrophic/weedy
LR02	Blackhawk Creek	69,192	Fair; 75% Agr; channel mod > Hab; Agr/urban NPS > siltation/ low D.O./Flux
LR03	Bass Creek	72,385	Fair to V Good; streambank grazing/barnyard NPS > erosion/ Sed/Hab; dam; ditching; inadequate cropland buffer
LR04	Rock River/Milton	31,205	Fair; urban NPS > Flux/Temp/Sed; eutrophic lake
LR05	Marsh Creek	27,985	Fair; ditching > Hab/Silt; cropland erosion; NPS > low D.O.
LR06	Yahara River & Lake Kegonsa	80,854	Very Poor to Good; 81% Agr; NPS > nutrients/solids/ organics/ metals/oil & grease/PCBs; ditching > Hab; street salt > chloride; dams; lakes: algae/weeds/Sed > eutrophic
LR07	Badfish Creek	53,894	Poor to Fair; urban PS/NPS; ditching > Hab/wetland degradation/Flux; crop erosion; streambank grazing > erosion
LR08	Yahara River & Lake Monona	59,985	Very Poor to Good; 70% urban; NPS > nutrients/solids/organics/ metals/oil & grease/PCBs; ditching > Hab; dams; street salt > chloride; lakes: algae/weeds/Sed > V eutrophic; GW drawdown
LR09	Yahara River & Lake Mendota	72,036	Very Poor to Good; 57% Agr/20% urban; NPS > nutrients/solids/ organics/metals/oil & grease/PCBs; ditching > Hab; dams; street salt > chloride; lakes: algae/weeds/Sed > eutrophic > low D.O.; GW drawdown
LR10	Six Mile & Pheasant Branch creeks	76,449	Poor to Fair; NPS; erosion; devel > stormwater overload/Hab/fish barriers; wetland loss > Flux; lakes: pesticide toxicity/eutrophic
LR11	Lower Koshkonong Creek	169,990	Fair to V Good; 55% Agr; streambank grazing/ditching > soil erosion/Hab/wetland loss; barnyard/field runoff > Agr NPS; some good wetlands; lakes meso- to eutrophic
LR12	Upper Koshkonong Creek	66,723	V Poor to Fair; streambank grazing/ditching/urban NPS > soil erosion/Hab/wetland loss; Flux; barnyard/field runoff > Agr NPS; lakes (deepwater marshes): no water quality data
LR13	Bark River	118,936	Poor to Excellent; 44% Agr; ditching > Hab; Agr/urban NPS > excess nutrients; some wetlands remain; GW vulnerable to septic flooding; lakes development > fair to excellent water quality

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Appendix 18.A, *continued.*

Watershed no.	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Very Poor/Poor/Fair/Good/Very Good/Excellent)
LR14	Whitewater Creek	48,195	Fair to V Good; Agr soil erosion > Sed; lake devel/septic failure/Agr NPS > lakes: some eutrophic/poor (L. Ten) to excellent (L. Tripp)
LR15	Scuppernong River	55,957	Fair to Good; ditching/Temp/wetland loss; Agr/urban NPS > Flux/Hab/Temp; lakes: meso- to eutrophic
LW17	Black Earth Creek[b]	67,325	Very Good; drained wetlands; urbanization; agr erosion
LW18	Roxbury Creek[b]	45,513	Fair to Good; NPS, ditching; stream grazing; loosestrife
LW19	Lake Wisconsin	137,576	Fair to Excellent; NPS; stream channelization; atrazine; excess nutrients; PCBs
LW20	Duck Creek & Rocky Run	x90,173	Poor to V. Good; manure; diversion; ditching > Hab, small dams > Temp
MA02	Lower Manitowoc River	107,732	Poor to Good; forest & wetland loss/bank erosion > NPS nutrients/Sed > weeds; dam; lakes: excess P/algae
MA05	South Branch Manitowoc River	95,789	Poor to V Good; forest & wetland loss/bank & crop erosion > NPS nutrients/Flux/Sed > weeds; dam; lakes: PCBs in Sed
MI02	Milwaukee River South[b]	107,456	Poor to Fair; 33% urban; 25% agr; stream bottom concrete & enclosure; Sed contamination; urban NPS
MI03	Menomonee River	87,115	Poor to Fair; 42% urban; stream bottom concrete & enclosure; Sed creosote contamination; urban NPS
MI04	Cedar Creek	82,724	Fair to Good; 49% agr; PCBs
MI05	North Branch Milwaukee River	95,790	Poor to V Good; 57% Agr; Agr NPS/ditching > Sed; erosion; lakes: failing septics/NPS > primarily eutrophic
MI06	E. & W. Branch Milwaukee River	170,241	Fair to Good; 47% Agr; dams/ditching/wetland loss > Hab/Flux; Agr/urban NPS> Sed/nutrients; lakes: Agr/urban NPS > meso- to eutrophic; shoreline mod > Hab
SH01	Sauk & Sucker creeks[b]	37,397	Poor to Fair; Agr/urban NPS/ditching > Sed/Hab; lakes: Unknown
SH03	Sheboygan River	166,477	Fair to Good; dams > Sed/Temp/D.O./Flux/fish barriers; PCBs in Sed; Agr/urban NPS; intact wetlands
SH04	Onion River	62,717	Poor to Excellent; Agr NPS; Sed metals/PAH; spring diversion; dams; no lakes
SH05	Mullet River	56,442	Fair to Good; agr/urban NPS; ditching; dams; lakes: NPS/low D.O.
SH06	Pigeon River	50,474	Poor d.s. to Good headwaters; Agr/urban NPS/ditching/erosion > turbidity/coliform/low D.O.; lakes: eutrophic
SP01	Honey & Richland creeks	51,255	Fair to Good; Agr/urban NPS > erosion/Sed/Hab
SP02	Jordan & Skinner creeks	60,196	Fair to Good. Agr major land use; no recent data
SP11	Lower Sugar River	139,423	Fair to V Good; Agr NPS/ditching > Hab; illegal dairy PS; some high quality wetlands; need updated water quality data
SP12	Lower Middle Sugar River	38,096	Good to V Good; wetland loss; ditching; dam; grazed wetlands
SP13	Allen Cr. & Middle Sugar River	98,566	Poor to V Good; Agr NPS; need updated water quality data
SP14	Little Sugar River	85,133	Fair to Good; ditching/streambank grazing/NPS > Sed; wetland loss/remnants
SP15	Upper Sugar River	67,816	Fair to Good; urban/Agr NPS > Sed/coliform; wetland loss > Hab; dam; UW golf herbicide threatens rare lotus; GW drawdown
SP16	West Br. Sugar River/Mt. Vernon Cr.	42,714	Poor to V Good; urban/rural NPS; crop erosion > Sed; failing septics > excess nutrients
UF01	Lake Winnebago/North & West	14,550	Fair; urban & industrial PS/NPS/stormwater > Sed/nutrients/metals; Agr NPS-P
UF02	Lake Winnebago/East	63,619	Spring flows impacted by animal waste/Agr soil erosion > Sed/nutrients/Hab; Agr/urban NPS
UF03	Fond du Lac River	156,632	Poor to Good; stream/wetland ditching; barnyard runoff; streambank grazing; cropland Sed; urban NPS; construction runoff; dam; CPR buffer protects wild rice marsh

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Appendix 18.A, *continued.*

Watershed no.	Watershed name	Area (acres)	Overall water quality and major stressors[a] (Range = Very Poor/Poor/Fair/Good/Very Good/Excellent)
UF04	Lake Butte Des Mortes	50,974	Poor to Fair; stormwater impacts; wetland loss > shoreline erosion > Hab/Sed; urban NPS
UF05	Fox River	76,644	Fair; Agr NPS; carp; P goes to Lake Winnebago
UF06	Fox River/Berlin	133,596	Fair to Good; P goes to Lake Winnebago
UF07	Big Green Lake	68,677	Fair to V. Good; some agr NPS sources remain; stream bank erosion; gulleying continues; Ripon PS; carp
UF08	White River	95,880	Good; some agr sedimentation & excess nutrients
UF11	Lower Grand River	70,012	God to Fair; Agr NPS; sedimentation; carp
UF12	Upper Grand River	39,652	Good to Poor; soil loss; canning waste nutrient potential
UF15	Swan Lake	51,593	Animal waste; streambank trampling; excessive P goes to Fox River; lake algal blooms
UR01	Middle Rock River	60,876	Fair (data needed) 60% Agr; NPS stormwater; dam > Flux/fish blockage; Sed load; construction erosion
UR02	Lower Crawfish River	113,699	Poor; Construction runoff Sed; bank erosion > Hab; Agr NPS > runoff > loss of mussels & wild rice; wetland loss; lakes: meso- to eutrophic
UR03	Beaver Dam River	186,760	Poor to Fair; pesticides; Agr sediments & nutrients; low D.O.
UR04	Calamus Creek	19,315	Fair; 67% agr; NPS > bacteria/turbidity/Hab; needs water quality data
UR05	Maunesha River	80,650	Fair; 70% agr; wetland loss; ditching; Agr NPS > sediment/ nutrients/low D.O.; dams > weeds/silt/turbidity
UR06	Upper Crawfish River	103,154	Fair to Poor; excess NPS agr nutrients; low flows; sediment
UR07	Johnson Creek	28,939	Fair; 62% Agr; heavy soil erosion; commercial/urban stormwater NPS > nutrients/Temp/Flux; water quality data needed
UR08	Sinissippi Lake	150,354	Poor to Fair; 62% Agr; wetland loss; Agr NPS/boating > Sed suspension/bank erosion/Hab; impoundment hypereutrophic/ turbidity/low D.O.
UR09	Oconomowoc River	83,750	Fair to V Good; 41% Agr; Agr ditching/tiling > NPS nutrients/ bacteria/Hab; lakes: urbanization > NPS > eutrophy
UR10	Ashippun River	43,969	Fair to V Good; 57% Agr; NPS/animal waste nutrients > Sed/ Hab; dams; lakes: oligo- to mesotrophic; water quality data needed
UR11	Rubicon River	50,657	Fair to Good; 59% Agr; high soil erosion; NPS > Sed/Hab/ nutrients; Pike Lake: meso- to eutrophic (P)
UR12	Upper Rock River	164,870	Poor to Fair; 59% Agr; good wetland remnants; ditching; wetland loss; Agr/urban NPS runoff; muni wastewater; streambank pasturing; bank erosion; carp
UR13	East Branch Rock River	127,356	Poor to Good; 66% Agr; good wetland remnants; ditching; wetland loss; Agr/urban NPS runoff; soil erosion; dams > fish barriers/Temp; muni wastewater; dredging; ponds degrade trout habitat
WR01	Arrowhead River & Daggets Creek	91,463	Fair to Good; low D.O.; NPS from barnyard runoff
WR02	Pine & Willow rivers	193,329	Good to Fair; animal waste; erosion; mill ponds
WR03	Walla Walla & Alder creeks	71,739	Good to Fair; animal waste; soil erosion; ditching
WR04	Lower Wolf River	76,768	Good; Hg in fish samples
WR05	Waupaca River	186,096	Very Good; animal waste on sandy soil; hi-cap wells
WR06	Lower Little Wolf River[b]	98,307	Fair to Good; animal waste & soil erosion problems
WR08	South Branch Little Wolf River	102,586	Good: sediments & habitat deterioration from streambank pasturing

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 this ecological landscape, so overall impacts of land uses within the landscape are unlikely to impact water quality within the watershed to any appreciable degree.

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Appendix 18.A, *continued.*

Abbreviations:
Agr = Agricultural.
D.O. = Dissolved oxygen.
d.s. = Downstream of this ecological landscape.
ERW = Exceptional Resource Water (very good to excellent water quality, with point source discharges).
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.
GW = Groundwater (without modifiers, indicates high nitrates, radon, manganese, or other negative use condition).
Hab = Stream habitat damage.
Hg = Mercury contamination of fish, mainly deposited by coal combustion, or sometimes by industry.
Mod = Modification of stream channel, habitat structure, or other aquatic feature.
Muni = Municipal.
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 = Phosphorous in excessive amounts, reducing oxygen concentration in a water body.
PAH = Polycyclic aromatic hydrocarbon contamination, often with other toxic substances.
PCBs = Polychlorinated biphenyl industrial pollutants in sediment and aquatic life.
PS = Point source pollutants, such as treated municipal and industrial wastewater.
Sed = Excess sedimentation.
Temp = Elevated temperatures in some stream reaches.
TSI = Trophic state index (indication of impacts of excess nutrients).
Tribs = Streams that are tributary to the stream(s) after which the watershed is named.
u.s. = Upstream of this ecological landscape.
303(d) = A water listed as impaired under Section 303(d) of the federal Clean Water Act.
> = Yields, creates, or results in (the listed impacts).

Appendix 18.B. *Forest habitat types in the Southeast Glacial Plains 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 Southeast Glacial Plains Ecological Landscape**
AFAs	*Acer saccharum-Fagus/Arisaema* Sugar maple-American Beech/Jack-in-the-pulpit
AFAs-O	*Acer saccharum-Fagus/Arisaema-Osmorhiza* Sugar maple-American beech/Jack-in-the-pulpit sweet cicely variant
AFrDe	*Acer saccharum-Fraxinus americana/Desmodium glutinosum* Sugar maple-white ash/tick-trefoil
AFrDeO	*Acer saccharum-Fraxinus americana/Desmodium-Osmorhiza* Sugar maple-white ash/tick-trefoil-Sweet cicely
AFrDe(Vb)	*Acer saccharum-Fraxinus americana/Desmodium (Viburnum* phase) Sugar maple-white ash/tick-trefoil (maple-leaf viburnum phase)
ATiFrCa	*Acer saccharum-Tilia-Fraxinus/Caulophyllum* Sugar maple-basswood-white ash/blue cohosh
ATiFrCa(O)	*Acer saccharum-Tilia-Fraxinus/Caulophyllum Osmorhiza* phase Sugar maple-basswood-white ash/blue cohosh sweet cicely phase
ATiFrVb	*Acer saccharum-Tilia-Fraxinus/Viburnum* spp. Sugar maple-basswood-white ash/viburnum
ATiFrVb(Cr)	*Acer saccharum-Tilia-Fraxinus/Viburnum* spp. *Cornus racemosa* phase Sugar maple-basswood-white ash/viburnum gray dogwood phase
Forest lowland	Undefined

Source: Kotar and Burger (1996).

Appendix 18.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 Southeast Glacial Plains (SEGP) Ecological Landscape in November 2009. See the Wisconsin Natural Heritage Working List online for current status (http://dnr.wi.gov, keyword "NHI").*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
MAMMALS[b]								
Myotis septentrionalis (northern long-eared bat)	2007	1	9	11%	S3	G4	SC/N	
Reithrodontomys megalotis (Western harvest mouse)	1997	2	11	18%	S3	G5	SC/N	
Sorex arcticus (Arctic shrew)	1999	3	31	10%	S3S4	G5	SC/N	
Sorex hoyi (pygmy shrew)	1995	3	39	8%	S3S4	G5	SC/N	
Spermophilus franklinii (Franklin's ground squirrel)	2005	3	12	25%	S2	G5	SC/N	
BIRDS[c]								
Aechmophorus occidentalis (Western Grebe)	1990	1	1	100%	S1B	G5	SC/M	
Ammodramus henslowii (Henslow's Sparrow)	2008	8	82	10%	S3B	G4	THR	
Ardea alba (Great Egret)	2003	5	14	36%	S2B	G5	THR	
Bartramia longicauda (Upland Sandpiper)	1987?	2	54	4%	S2B	G5	SC/M	
Botaurus lentiginosus (American Bittern)	2009	3	41	7%	S3B	G4	SC/M	
Bubulcus ibis (Cattle Egret)	1999	1	3	33%	S1B	G5	SC/M	
Buteo lineatus (Red-shouldered Hawk)	2009	34	301	11%	S3S4B,S1N	G5	THR	
Chlidonias niger (Black Tern)	2009	21	60	35%	S2B	G4	SC/M	
Chondestes grammacus (Lark Sparrow)	2002	1	6	17%	S2B	G5	SC/M	
Coccyzus americanus (Yellow-billed Cuckoo)	2009	12	39	31%	S3B	G5	SC/M	
Cygnus buccinator (Trumpeter Swan)	2000	1	22	5%	S4B	G4	SC/M	
Dendroica cerulea (Cerulean Warbler)[d]	2009	21	92	23%	S2S3B	G4	THR	
Dendroica dominica (Yellow-throated Warbler)[d]	1989	1	2	50%	S1B	G5	END	
Empidonax virescens (Acadian Flycatcher)	2009	16	47	34%	S3B	G5	THR	
Gallinula chloropus (Common Moorhen)	2003	5	10	50%	S2B	G5	SC/M	
Haliaeetus leucocephalus (Bald Eagle)	2008	27	1286	2%	S4B,S2N	G5	SC/P	
Helmitheros vermivorus (Worm-eating Warbler)[d]	1999	2	11	18%	S1B	G5	END	
Icteria virens (Yellow-breasted Chat)	1997	1	2	50%	S2B	G5	SC/M	
Ixobrychus exilis (Least Bittern)	2003	3	23	13%	S3B	G5	SC/M	
Lanius ludovicianus (Loggerhead Shrike)	1987	5	31	16%	S1B	G4	END	
Nyctanassa violacea (Yellow-crowned Night-heron)	1995	3	7	43%	S1B	G5	THR	
Nycticorax nycticorax (Black-crowned Night-heron)	2001	13	36	36%	S2B	G5	SC/M	
Oporornis formosus (Kentucky Warbler)[d]	2009	6	31	19%	S1S2B	G5	THR	
Pandion haliaetus (Osprey)	2008	40	733	5%	S4B	G5	SC/M	
Pelecanus erythrorhynchos (American White Pelican)	2005	1	2	50%	S1B,S1N	G3	SC/M	
Podiceps grisegena (Red-necked Grebe)	1997	3	13	23%	S1B	G5	END	
Protonotaria citrea (Prothonotary Warbler)	2005	16	40	40%	S3B	G5	SC/M	
Seiurus motacilla (Louisiana Waterthrush)	1992	2	34	6%	S3B	G5	SC/M	
Spiza americana (Dickcissel)	2007	2	44	5%	S3B	G5	SC/M	
Sterna caspia (Caspian Tern)[d]	1990	1	7	14%	S1B,S2N	G5	END	
Sterna forsteri (Forster's Tern)	2000	11	31	35%	S1B	G5	END	
Sterna hirundo (Common Tern)	2000	2	14	14%	S1B,S2N	G5	END	
Tympanuchus cupido (Greater Prairie-chicken)	1981	2	60	3%	S1B,S2N	G4	THR	
Tyto alba (Barn Owl)	1994	11	29	38%	S1B,S1N	G5	END	
Vireo bellii (Bell's Vireo)	2006	2	43	5%	S2B	G5	THR	
Wilsonia canadensis (Canada Warbler)[d]	1992	1	20	5%	S3B	G5	SC/M	
Wilsonia citrina (Hooded Warbler)[d]	2009	9	32	28%	S2S3B	G5	THR	

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Appendix 18.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
HERPTILES								
Acris crepitans (northern cricket frog)	2006	11	102	11%	S1	G5	END	
Coluber constrictor (North American racer)	1972	1	14	7%	S2	G5	SC/P	
Diadophis punctatus edwardsii (northern ring-necked snake)	1993	2	23	9%	S3?	G5T5	SC/H	
Emydoidea blandingii (Blanding's turtle)	2009	77	316	24%	S3	G4	THR	
Glyptemys insculpta (wood turtle)	2005	4	262	2%	S2	G4	THR	
Hemidactylium scutatum (four-toed salamander)	2009	3	63	5%	S3	G5	SC/H	
Heterodon platirhinos (eastern hog-nosed snake)	2009	1	6	17%	S3?	G5	SC/H	
Lithobates catesbeianus (American bullfrog)	2007	13	70	19%	S3	G5	SC/H	
Lithobates palustris (pickerel frog)	2009	1	2	50%	S3S4	G5	SC/H	
Ophisaurus attenuatus (slender glass lizard)	1985	1	67	1%	S1	G5	END	
Regina septemvittata (queensnake)	2008	7	8	88%	S1	G5	END	
Sistrurus catenatus catenatus (eastern massasauga)	1999	3	13	23%	S1	G3G4T3T4Q	END	C
Terrapene ornata (ornate box turtle)	1996	3	29	10%	S1	G5	END	
Thamnophis butleri (Butler's gartersnake)	2009	65	114	57%	S3	G4	THR	
Thamnophis proximus (western ribbonsnake)	1973	1	2	50%	S1	G5	END	
Thamnophis sauritus (eastern ribbonsnake)	2009	2	3	67%	S1	G5	END	
FISHES								
Acipenser fulvescens (lake sturgeon)	1991	16	99	16%	S3	G3G4	SC/H	
Anguilla rostrata (American eel)	1979	4	24	17%	S2	G4	SC/N	
Clinostomus elongatus (redside dace)	2002	7	96	7%	S3	G3G4	SC/N	
Erimystax x-punctatus (gravel chub)	2003	3	4	75%	S1	G4	END	
Erimyzon sucetta (lake chubsucker)	2008	57	85	67%	S3	G5	SC/N	
Etheostoma clarum (western sand darter)	1981	3	11	27%	S3	G3	SC/N	
Etheostoma microperca (least darter)	2008	43	83	52%	S3	G5	SC/N	
Fundulus diaphanus (banded killifish)	2008	56	105	53%	S3	G5	SC/N	
Fundulus dispar (starhead topminnow)	2008	7	33	21%	S2	G4	END	
Lepomis megalotis (longear sunfish)	2008	9	25	36%	S2	G5	THR	
Luxilus chrysocephalus (striped shiner)	1979	6	10	60%	S1	G5	END	
Lythrurus umbratilis (redfin shiner)	2006	26	37	70%	S2	G5	THR	
Macrhybopsis storeriana (silver chub)	1974	1	13	8%	S3	G5	SC/N	
Moxostoma carinatum (river redhorse)	1995	4	43	9%	S2	G4	THR	
Moxostoma valenciennesi (greater redhorse)	2008	14	56	25%	S3	G4	THR	
Notropis anogenus (pugnose shiner)	2004	25	49	51%	S2	G3	THR	
Notropis nubilus (ozark minnow)	2006	5	24	21%	S2	G5	THR	
Notropis texanus (weed shiner)	1979	8	45	18%	S3	G5	SC/N	
Noturus exilis (slender madtom)	1995	8	18	44%	S1	G5	END	
Opsopoeodus emiliae (pugnose minnow)	1995	11	31	35%	S3	G5	SC/N	
MUSSELS/CLAMS								
Alasmidonta marginata (elktoe)	2001	9	44	20%	S4	G4	SC/P	
Alasmidonta viridis (slippershell mussel)	2001	8	16	50%	S2	G4G5	THR	
Cyclonaias tuberculata (purple wartyback)	1990	1	16	6%	S1S2	G5	END	
Epioblasma triquetra (snuffbox)[e]	2001	3	5	60%	S1	G3	END	
Pleurobema sintoxia (round pigtoe)	2001	11	50	22%	S3	G4G5	SC/P	
Quadrula metanevra (monkeyface)	1990	1	11	9%	S2	G4	THR	
Tritogonia verrucosa (buckhorn)	2005	2	12	17%	S2	G4G5	THR	
Venustaconcha ellipsiformis (ellipse)	2001	21	28	75%	S2	G4	THR	
Villosa iris (rainbow shell)	2001	6	6	100%	S1	G5Q	END	

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Appendix 18.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
MISCELLANEOUS INVERTEBRATES								
Catinella exile (Pleistocene catinella)	1996	1	4	25%	S2	G2	SC/N	
Catinella gelida (a land snail)	1998	11	15	73%	S1S2	G1	SC/N	
Paravitrea multidentata (dentate supercoil)	1996	1	39	3%	S2S3	G5	SC/N	
Procambarus gracilis (prairie crayfish)	2002	4	17	24%	S2?	G5	SC/N	
Striatura ferrea (black striate)	1998	1	14	7%	S2	G5	SC/N	
Strobilops affinis (eightfold pinecone)	1996	1	7	14%	S3	G4G5	SC/N	
Stygobromus putealis (Wisconsin well amphipod)	1994	1	1	100%	S1	G2G3	SC/N	
Vallonia perspectiva (thin-lip vallonia)	1998	10	10	100%	S3	G4G5	SC/N	
Vertigo elatior (tapered vertigo)	2001	2	12	17%	S3	G5	SC/N	
Vertigo hubrichti (Midwest Pleistocene vertigo)	1997	4	47	9%	S1	G3	END	
Vertigo sp. 2 (Iowa Pleistocene vertigo)	1997	2	21	10%	S1S2	G3Q	SC/N	
Vertigo tridentata (honey vertigo)	1997	4	7	57%	S3	G5	SC/N	
Vitrina angelicae (transparent vitrine snail)	1998	1	4	25%	S1	G5	SC/N	
BUTTERFLIES/MOTHS								
Calephelis muticum (swamp metalmark)	2008	7	12	58%	S1	G3	END	
Callophrys henrici (Henry's elfin)	2006	1	19	5%	S1S2	G5	SC/N	
Catocala abbreviatella (abbreviated underwing moth)	1994	1	8	13%	S3	G4	SC/N	
Catocala whitneyi (Whitney's underwing moth)	1994	1	10	10%	S3	G3G4	SC/N	
Chlosyne gorgone (gorgone checker spot)	1994	4	40	10%	S3	G5	SC/N	
Erynnis lucilius (columbine dusky wing)	1982	2	11	18%	S2	G4	SC/N	
Euphyes bimacula (two-spotted skipper)	1996	3	17	18%	S3	G4	SC/N	
Exyra fax (pitcher plant moth)	1990	1	1	100%	S2S3	G4	SC/N	
Hemileuca nevadensis ssp. 3 (midwestern fen buckmoth)	2002	3	10	30%	S3	G5T3T4	SC/N	
Hesperia leonardus (Leonard's skipper)	1979	1	29	3%	S3	G4	SC/N	
Hesperia ottoe (ottoe skipper)	1997	1	16	6%	S2	G3G4	SC/N	
Lycaeides melissa samuelis (Karner blue)	2003	4	316	1%	S3	G5T2	SC/FL	LE
Lycaena dione (gray copper)	1992	1	14	7%	S2	G5	SC/N	
Macrochilo bivittata (an owlet moth)	2001	4	8	50%	S3	G3G4	SC/N	
Oarisma powesheik (powesheik skipperling)	2005	3	3	100%	S1	G2G3	END	
Papaipema beeriana (liatris borer moth)	2002	8	11	73%	S2	G2G3	SC/N	
Papaipema silphii (silphium borer moth)	2005	10	15	67%	S2	G3G4	END	
Poanes massasoit (mulberry wing)	2005	31	56	55%	S3	G4	SC/N	
Poanes viator (broad-winged skipper)	2001	20	36	56%	S3	G5	SC/N	
Pompeius verna (little glassy wing)	1993	3	7	43%	S1?	G5	SC/N	
Satyrium caryaevorum (hickory hairstreak)	1993	2	3	67%	S2	G4	SC/N	
Satyrodes eurydice fumosa (smokey eyed brown)	2001	2	8	25%	S2	G5T3T4	SC/N	
Speyeria idalia (regal fritillary)	2008	3	24	13%	S1	G3	END	
DRAGONFLIES/DAMSELFLIES								
Argia plana (highland dancer)	1989	1	4	25%	S2	G5	SC/N	
Arigomphus submedianus (jade clubtail)	2003	3	4	75%	S2	G5	SC/N	
Arigomphus villosipes (unicorn clubtail)	1989	1	1	100%	S1S2	G5	SC/N	
Chromagrion conditum (aurora damselfly)	1982	1	17	6%	S3	G5	SC/N	
Enallagma anna (river bluet)	1990	3	4	75%	S2	G5	SC/N	
Enallagma basidens (double-striped bluet)	2002	4	5	80%	S2	G5	SC/N	
Enallagma traviatum (slender bluet)	1990	1	2	50%	S1S2	G5	SC/N	
Gomphurus externus (plains clubtail)	1999	2	6	33%	S2	G5	SC/N	
Hetaerina titia (dark rubyspot)	1999	3	4	75%	S1S2	G5	SC/N	

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Appendix 18.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
Ischnura kellicotti (lilypad forktail)	1990	1	1	100%	S1	G5	SC/N	
Ischnura posita (fragile forktail)	2002	3	6	50%	S2S3	G5	SC/N	
Libellula incesta (slaty skimmer)	2003	2	4	50%	S1	G5	SC/N	
Nannothemis bella (elfin skimmer)	1992	1	12	8%	S2S3	G4	SC/N	
Ophiogomphus howei (pygmy snaketail)	1999	1	33	3%	S4	G3	THR	
Somatochlora hineana (Hine's emerald)	2003	1	15	7%	S1	G2G3	END	LE
Somatochlora incurvata (warpaint emerald)	1993	1	18	6%	S2	G4	END	
Stylurus plagiatus (russet-tipped clubtail)	1992	1	8	13%	S2	G5	SC/N	
BEETLES								
Cicindela lepida (little white tiger beetle)	2005	2	13	15%	S2	G3G4	SC/N	
Cicindela patruela huberi (a tiger beetle)	1999	1	84	1%	S3	G3T3	SC/N	
Hydroporus vittatus (a predaceous diving beetle)	2000	2	17	12%	S3	GNR	SC/N	
Laccobius reflexipennis (a predaceous diving beetle)	1999	1	3	33%	S1S2	GNR	SC/N	
Liodessus cantralli (Cantrall's bog beetle)	1985	1	4	25%	S1S2	GNR	SC/N	
Lioporeus triangularis (a predaceous diving beetle)	1999	1	4	25%	S1S2	GNR	SC/N	
Stenelmis fuscata (a riffle beetle)	1999	2	5	40%	S3	GNR	SC/N	
MISCELLANEOUS INSECTS/SPIDERS								
Aflexia rubranura (red-tailed prairie leafhopper)	2003	8	25	32%	S2	G2	END	
Amplicephalus kansiensis (a leafhopper)	1996	2	3	67%	S1?	GNR	SC/N	
Dichromorpha viridis (short-winged grasshopper)	1996	1	4	25%	S3?	G5	SC/N	
Flexamia prairiana (a leafhopper)	1996	2	2	100%	S1	GNR	SC/N	
Homoeoneuria ammophila (a brush-legged mayfly)	1992	2	3	67%	S1S2	G4	SC/N	
Pentagenia vittigera (a common burrower mayfly)	1992	2	3	67%	S1S2	G5	SC/N	
Prairiana cinerea (a leafhopper)	1996	2	6	33%	S2S3	GNR	SC/N	
Pseudiron centralis (a flat-headed mayfly)	1992	1	10	10%	S3	G5	SC/N	
PLANTS								
Adoxa moschatellina (musk-root)	1970	1	13	8%	S2	G5	THR	
Agalinis gattingeri (roundstem foxglove)	1973	1	23	4%	S3	G4	THR	
Agastache nepetoides (yellow giant hyssop)	1999	16	30	53%	S3	G5	THR	
Agrimonia parviflora (swamp agrimony)	2009	8	8	100%	S1S2	G5	SC	
Aplectrum hyemale (putty root)	1978	1	17	6%	S2S3	G5	SC	
Arabis shortii (Short's rock-cress)	1994	8	11	73%	S2	G5	SC	
Arethusa bulbosa (swamp-pink)	1996	2	96	2%	S3	G4	SC	
Asclepias lanuginosa (woolly milkweed)	1992	3	16	19%	S1	G4?	THR	
Asclepias ovalifolia (dwarf milkweed)	2000	1	60	2%	S3	G5?	THR	
Asclepias purpurascens (purple milkweed)	2009	7	39	18%	S3	G5?	END	
Asclepias sullivantii (prairie milkweed)	2009	17	23	74%	S2S3	G5	THR	
Aster furcatus (forked aster)	2005	19	44	43%	S3	G3	THR	
Bartonia virginica (yellow screwstem)	2005	1	81	1%	S3	G5	SC	
Besseya bullii (kitten tails)	2008	72	98	73%	S3	G3	THR	
Cacalia suaveolens (sweet-scented Indian-plantain)	2001	4	28	14%	S3	G4	SC	
Cacalia tuberosa (prairie Indian plantain)	2009	18	62	29%	S3	G4G5	THR	
Calamagrostis stricta (slim-stem small-reedgrass)	1998	5	34	15%	S3	G5	SC	
Calylophus serrulatus (yellow evening primrose)	2002	3	9	33%	S2	G5	SC	
Camassia scilloides (wild hyacinth)	2003	2	8	25%	S2	G4G5	END	
Cardamine pratensis (cuckooflower)	2005	21	42	50%	S3	G5	SC	
Carex crawei (Crawe's sedge)	2009	2	24	8%	S3	G5	SC	

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Appendix 18.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
Carex formosa (handsome sedge)	2001	2	16	13%	S2	G4	THR	
Carex gynocrates (northern bog sedge)	2000	2	31	6%	S3	G5	SC	
Carex livida var. *radicaulis* (livid sedge)	1996	1	21	5%	S2	G5T5	SC	
Carex richardsonii (Richardson sedge)	2001	2	24	8%	S2	G4	SC	
Carex swanii (swan sedge)	2002	1	1	100%	S1	G5	SC	
Carex sychnocephala (many-headed sedge)	1995	4	15	27%	S2	G4	SC	
Carex tenuiflora (sparse-flowered sedge)	1999	2	84	2%	S3	G5	SC	
Carex torreyi (Torrey sedge)	1997	1	1	100%	S1	G4	SC	
Chaerophyllum procumbens (spreading chervil)	1994	2	4	50%	S1	G5	SC	
Cirsium hillii (Hill's thistle)	2002	11	58	19%	S3	G3	THR	
Corallorhiza odontorhiza (Autumn coral-root)	2001	8	36	22%	S3	G5	SC	
Coreopsis tripteris (tall coreopsis)	2004	1	1	100%	S1	G5	SC	
Cypripedium arietinum (ram's-head lady's-slipper)	1986	2	21	10%	S2	G3	THR	
Cypripedium candidum (small white lady's-slipper)	2009	39	47	83%	S3	G4	THR	
Cypripedium parviflorum var. *makasin* (northern yellow lady's-slipper)	2004	31	78	40%	S3	G5T4Q	SC	
Cypripedium reginae (showy lady's-slipper)	2005	12	99	12%	S3	G4	SC	
Cystopteris laurentiana (Laurentian bladder fern)	1978	2	11	18%	S2	G3	SC	
Deschampsia cespitosa (tufted hairgrass)	1977	1	17	6%	S2	G5	SC	
Draba arabisans (rock whitlow-grass)	2000	2	9	22%	S2	G4	SC	
Drosera linearis (slenderleaf sundew)	1990	2	5	40%	S1	G4	THR	
Echinacea pallida (pale-purple coneflower)	2002	25	54	46%	S3	G4	THR	
Eleocharis compressa (flat-stemmed spike-rush)	2009	5	9	56%	S2	G4	SC	
Eleocharis engelmannii (Engelmann spike-rush)	1996	2	4	50%	S1	G4G5Q	SC	
Eleocharis quinqueflora (few-flower spikerush)	2007	3	18	17%	S2	G5	SC	
Eleocharis rostellata (beaked spikerush)	2005	13	14	93%	S2	G5	THR	
Epilobium strictum (downy willow-herb)	2006	5	22	23%	S2S3	G5?	SC	
Equisetum palustre (marsh horsetail)	1989	1	21	5%	S2	G5	SC	
Eupatorium sessilifolium var. *brittonianum* (upland boneset)	1975	2	40	5%	S3	G5T3T5	SC	
Fraxinus quadrangulata (blue ash)	2000	1	2	50%	S1	G5	THR	
Galium brevipes (swamp bedstraw)	1986	1	1	100%	S1S2	G4?	SC	
Gentiana alba (yellow gentian)	2000	8	80	10%	S3	G4	THR	
Gentianopsis procera (lesser fringed gentian)	2005	39	66	59%	S3	G5	SC	
Geum macrophyllum var. *macrophyllum* (large-leaved avens)	2004	1	1	100%	S1	G5T5	SC	
Glycyrrhiza lepidota (wild licorice)	1977	1	6	17%	S1S2	G5	SC	
Gymnocladus dioicus (Kentucky coffee-tree)	2000	3	9	33%	S2	G5	SC	
Houstonia caerulea (innocence)	1993	6	8	75%	S2	G5	SC	
Hypericum sphaerocarpum (roundfruit St. John's-wort)	1998	4	6	67%	S1S2	G5	THR	
Lespedeza leptostachya (prairie bush-clover)	2009	8	22	36%	S2	G3	END	LT
Liatris spicata (marsh blazing star)	2000	12	26	46%	S3	G5	SC	
Lithospermum latifolium (American gromwell)	2005	16	62	26%	S3	G4	SC	
Malaxis monophyllos var. *brachypoda* (white adder's-mouth)	1991	1	48	2%	S3	G4Q	SC	
Medeola virginiana (Indian cucumber-root)	1992	1	42	2%	S3	G5	SC	
Microseris cuspidata (prairie false-dandelion)	2003	2	15	13%	S2	G5	SC	
Minuartia dawsonensis (rock stitchwort)	1973	1	4	25%	S1	G5	SC	
Muhlenbergia richardsonis (soft-leaf muhly)	1994	2	2	100%	S1	G5	END	
Myosotis laxa (small forget-me-not)	1988	1	9	11%	S2	G5	SC	

Continued on next page

Appendix 18.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
Myriophyllum farwellii (Farwell's water-milfoil)	1980	1	60	2%	S3	G5	SC	
Napaea dioica (glade mallow)	2009	26	79	33%	S3	G4	SC	
Nuphar advena (Yellow water lily)	1975	1	2	50%	S1	G5T5	SC	
Onosmodium molle (marbleseed)	1974	1	42	2%	S3	G4G5	SC	
Opuntia fragilis (brittle prickly-pear)	2000	1	36	3%	S3	G4G5	THR	
Panicum wilcoxianum (wilcox panic grass)	1970	1	1	100%	SH	G5	SC	
Parthenium integrifolium (American fever-few)	1997	2	83	2%	S3	G5	THR	
Pediomelum esculentum (prairie turnip)	1991	1	47	2%	S3	G5	SC	
Penstemon hirsutus (hairy beardtongue)	1997	2	2	100%	S1	G4	SC	
Platanthera dilatata (leafy white orchis)	2001	2	31	6%	S3	G5	SC	
Platanthera flava var. *herbiola* (pale green orchid)	2009	1	20	5%	S2	G4T4Q	THR	
Platanthera leucophaea (prairie white-fringed orchid)	2008	16	22	73%	S2	G2G3	END	LT
Platanthera orbiculata (large roundleaf orchid)	1993	3	78	4%	S3	G5	SC	
Platanus occidentalis (sycamore)	1993	4	7	57%	S2	G5	SC	
Poa paludigena (bog bluegrass)	1986	1	41	2%	S3	G3	THR	
Poa sylvestris (woodland bluegrass)	1975	1	3	33%	S1	G5	SC	
Polygala incarnata (pink milkwort)	1992	2	4	50%	S1	G5	END	
Polystichum acrostichoides (Christmas fern)	1995	2	13	15%	S2	G5	SC	
Polytaenia nuttallii (prairie parsley)	2004	11	26	42%	S3	G5	THR	
Prenanthes aspera (rough rattlesnake-root)	2004	5	10	50%	S2	G4?	END	
Ptelea trifoliata (wafer-ash)	2008	6	14	43%	S2	G5	SC	
Rhus aromatica (fragrant sumac)	1995	2	5	40%	S1	G5	SC	
Ruellia humilis (hairy wild-petunia)	2005	8	13	62%	S2	G5	END	
Scirpus cespitosus (tufted bulrush)	2006	11	20	55%	S2	G5	THR	
Scirpus hallii (Hall's bulrush)	1996	1	1	100%	S1	G2G3	END	
Scleria triglomerata (whip nutrush)	2004	2	17	12%	S2S3	G5	SC	
Scleria verticillata (low nutrush)	2000	7	10	70%	S2	G5	SC	
Scutellaria parvula var. *parvula* (small skullcap)	1991	2	3	67%	S1	G4T4	END	
Solidago ohioensis (Ohio goldenrod)	2005	48	74	65%	S3	G4	SC	
Talinum rugospermum (prairie fame-flower)	2000	2	54	4%	S3	G3G4	SC	
Thalictrum revolutum (waxleaf meadowrue)	2000	6	13	46%	S2	G5	SC	
Thaspium trifoliatum var. *flavum* (purple meadow-parsnip)	1986	3	6	50%	S2	G5T5	SC	
Tofieldia glutinosa (sticky false-asphodel)	2006	11	23	48%	S2S3	G4G5	THR	
Tomanthera auriculata (earleaf foxglove)	2009	2	2	100%	S1	G3	SC	
Triglochin maritima (common bog arrow-grass)	2005	19	59	32%	S3	G5	SC	
Triglochin palustris (slender bog arrow-grass)	2001	18	36	50%	S3	G5	SC	
Trillium nivale (snow trillium)	1995	3	34	9%	S3	G4	THR	
Trillium recurvatum (reflexed trillium)	2002	16	58	28%	S3	G5	SC	
Valeriana sitchensis ssp. *uliginosa* (marsh valerian)	2000	2	16	13%	S2	G4Q	THR	
Verbena simplex (narrow-leaved vervain)	2005	2	3	67%	S1	G5	SC	
Viburnum nudum var. *cassinoides* (northern wild-raisin)	1973	1	6	17%	S2	G5T5	SC	
Viburnum prunifolium (smooth black-haw)	1981	1	23	4%	S2	G5	SC	
COMMUNITIES								
Alder Thicket	1989	2	106	2%	S4	G4	NA	
Bedrock Glade	2000	1	20	5%	S3	G2	NA	
Black Spruce Swamp	2000	2	41	5%	S3?	G5	NA	
Bog Relict	2003	7	8	88%	S3	G3	NA	
Calcareous Fen	2006	51	84	61%	S3	G3	NA	

Continued on next page

Appendix 18.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
Cedar Glade	1993	1	16	6%	S4	GNR	NA	
Dry Cliff	2003	3	88	3%	S4	G4G5	NA	
Dry Prairie	2005	20	146	14%	S3	G3	NA	
Dry-mesic Prairie	2001	18	37	49%	S2	G3	NA	
Emergent Marsh	2006	88	272	32%	S4	G4	NA	
Emergent Marsh – Wild Rice	1999	2	15	13%	S3	G3G4	NA	
Ephemeral Pond	1985	1	11	9%	SU	GNRQ	NA	
Floodplain Forest	2001	27	182	15%	S3	G3?	NA	
Forested Seep	2006	1	15	7%	S2	GNR	NA	
Hardwood Swamp	2006	12	53	23%	S3	G4	NA	
Lake—Deep, Hard, Drainage	1995	6	30	20%	S3	GNR	NA	
Lake—Deep, Hard, Seepage	1977	2	22	9%	S2	GNR	NA	
Lake—Hard Bog	1991	9	18	50%	S2	GNR	NA	
Lake—Oxbow	1983	3	14	21%	SU	GNR	NA	
Lake—Shallow, Hard, Drainage	1985	10	35	29%	SU	GNR	NA	
Lake—Shallow, Hard, Seepage	1998	20	52	38%	SU	GNR	NA	
Lake—Shallow, Soft, Seepage	1978	1	87	1%	S4	GNR	NA	
Lake—Soft Bog	1976	2	52	4%	S4	GNR	NA	
Mesic Prairie	2004	22	44	50%	S1	G2	NA	
Moist Cliff	2001	9	176	5%	S4	GNR	NA	
Northern Dry Forest	1978	1	63	2%	S3	G3?	NA	
Northern Dry-mesic Forest	1979	3	284	1%	S3	G4	NA	
Northern Mesic Forest	2004	4	383	1%	S4	G4	NA	
Northern Sedge Meadow	2000	5	231	2%	S3	G4	NA	
Northern Wet Forest	2002	42	322	13%	S4	G4	NA	
Northern Wet-mesic Forest	2006	10	243	4%	S3S4	G3?	NA	
Oak Opening	1998	13	25	52%	S1	G1	NA	
Oak Woodland	2002	2	10	20%	S1?	GNR	NA	
Open Bog	2001	15	173	9%	S4	G5	NA	
Patterned Peatland	2005	1	4	25%	S1	GNR	NA	
Poor Fen	1991	2	46	4%	S3	G3G4	NA	
Sand Prairie	1992	2	28	7%	S2	GNR	NA	
Shrub-carr	2006	61	143	43%	S4	G5	NA	
Southern Dry Forest	2001	20	97	21%	S3	G4	NA	
Southern Dry-mesic Forest	2007	69	293	24%	S3	G4	NA	
Southern Hardwood Swamp	2004	18	30	60%	S2	G4?	NA	
Southern Mesic Forest	2006	66	221	30%	S3	G3?	NA	
Southern Sedge Meadow	2005	84	182	46%	S3	G4?	NA	
Southern Tamarack Swamp (Rich)	2005	22	32	69%	S3	G3	NA	
Spring Pond	1998	3	69	4%	S3	GNR	NA	
Springs and Spring Runs, Hard	2006	23	71	32%	S4	GNR	NA	
Springs and Spring Runs, Soft	1978	1	12	8%	SU	GNR	NA	
Stream—Fast, Hard, Cold	1985	4	98	4%	S4	GNR	NA	
Stream—Fast, Hard, Warm	1973	2	10	20%	SU	GNR	NA	
Stream—Fast, Soft, Cold	1978	1	15	7%	SU	GNR	NA	
Stream—Slow, Hard, Warm	1985	3	20	15%	SU	GNR	NA	
Talus Forest	1999	1	6	17%	S1	G4G5	NA	
Wet Prairie	2001	13	22	59%	SU	G3	NA	
Wet-mesic Prairie	2005	47	81	58%	S2	G2	NA	

Continued on next page

Appendix 18.C, *continued.*

Scientific name (common name)	Lastobs date	EOs[a] in in SEGP	EOs in WI	Percent in SEGP	State rank	Global rank	State status	Federal status
OTHER ELEMENTS								
Bat hibernaculum	2002	2	43	5%	S3	GNR	SC	
Bird rookery	2009	15	54	28%	SU	G5	SC	
Herptile hibernaculum	1991	3	14	21%	SU	GNR	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]On 6/1/2011, four bats were added to the Wisconsin Threatened species list: big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), and eastern pipistrelle (*Perimyotis subflavus*). Northern long-eared bat was listed as U.S. Threatened on 5/04/2015.

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

[d]The American Ornithologist's Union lists these birds as Canada Warbler (*Cardellina canadensis*), Cerulean Warbler (*Setophaga cerulea*), Hooded Warbler (*Setophaga citrina*), Kentucky Warbler (*Geothlypis formosa*), Worm-eating Warbler (*Helmitheros vermivorum*), Yellow-throated Warbler (*Setophaga dominica*), and Caspian Tern (*Hydroprogne caspia*).

[e]The snuffbox mussel (*Epioblasma triquetra*) was listed as U.S. Endangered in 2012.

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.
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.)

Status and ranking definitions continued on next page

Appendix 18.C, *continued.*

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 18.D. *Number of species with special designations documented within the Southeast Glacial Plains Ecological Landscape, 2009.*

Listing status[a]	Taxa					Total fauna	Total flora	Total listed
	Mammals	Birds	Herptiles	Fishes	Invertebrates			
U.S. Endangered	0	0	0	0	2	2	0	2
U.S. Threatened	0	0	0	0	0	0	2	2
U.S. Candidate	0	0	1	0	0	1	0	1
Wisconsin Endangered	0	7	1	1	3	12	5	17
Wisconsin Threatened	0	7	3	4	7	21	12	33
Wisconsin Special Concern	2	20	3	7	66	98	28	126
Natural Heritage Inventory total	**2**	**34**	**7**	**12**	**76**	**131**	**45**	**176**

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.

[a]The snuffbox mussel (*Epioblasma triquetra*) was listed as U.S. Endangered in 2012. Big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), and eastern pipistrelle (*Perimyotis subflavus*) were listed as Wisconsin Threatened in 2011. Northern long-eared bat was listed as U.S. Threatened in 2015. These species are not not included in the numbers above.

Appendix 18.E. *Species of Greatest Conservation Need (SGCN) found in the Southeast Glacial Plains Ecological Landscape.*

These SGCNs have a high or moderate probability of being found in the Southeast Glacial Plains Ecological Landscape and use habitats that have the best chance for management here. Data are from the Wisconsin Wildlife Action Plan (WDNR 2005b) 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 SGCNs highly or moderately (H = high association, M = moderate association) associated with specific community types or other habitat types and which have a high or moderate probability of occurring in the ecological landscape are included here (SGCNs 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.


Eastern Meadowlark. Photo by Herbert Lange.

	MAJOR																					IMPORTANT												
	Bog Relict	Calcareous Fen	Dry Cliff	Dry Prairie	Dry-mesic Prairie	Emergent Marsh	Floodplain Forest	Impoundments/Reservoirs	Inland lakes	Mesic Prairie	Oak Opening	Oak Woodland	Shrub-carr	Southern Dry Forest	Southern Dry-mesic Forest	Southern Sedge Meadow	Southern Tamarack Swamp (rich)	Surrogate Grasslands	Warmwater rivers	Warmwater streams	Wet-mesic Prairie	Cedar Glade	Coolwater streams	Emergent Marsh – Wild Rice	Ephemeral Pond	Moist Cliff	Northern Hardwood Swamp	Northern Sedge Meadow	Northern Wet Forest	Northern Wet-mesic Forest	Southern Hardwood Swamp	Southern Mesic Forest	Submergent Marsh	Wet Prairie
Species That Are Significantly Associated with the Southeast Glacial Plains Ecological Landscape																																		
MAMMALS																																		
Franklin's ground squirrel					H					M	H	M						M			M													
BIRDS[a]																																		
Acadian Flycatcher							M								H																	H		
American Bittern						H										M												H						
American Golden Plover					M	M		M		M								M			M													M
American Woodcock	M	M											H				M										M							
Black Tern						H		M	M															M				M					M	
Black-billed Cuckoo							M						H				M																	
Blue-winged Teal					M	H	M	M	M	M						M		M			M			M				M					M	M
Blue-winged Warbler	M						M				M	M	M	M	M		M															M		
Bobolink					H					H						M		H			H							H						H
Brown Thrasher				M	M						H							M																
Buff-breasted Sandpiper					M	M												M			M													M
Canvasback								M	M										H					M									H	
Cerulean Warbler							H					M			H																	M		
Common Tern						M																												
Dickcissel					H					H								H																
Dunlin						M		M											M															
Eastern Meadowlark				M	H					H	M					M		H			M													
Field Sparrow				H	M					M	H							M			M	H												
Forster's Tern						H		M																									M	
Grasshopper Sparrow				H	H													H																
Henslow's Sparrow					H					H	M							H			M													M

Continued on next page

Appendix 18.E, *continued.*

Ornate box turtle. Photo by Herbert Lange.

	MAJOR																					IMPORTANT												
	Bog Relict	Calcareous Fen	Dry Cliff	Dry Prairie	Dry-mesic Prairie	Emergent Marsh	Floodplain Forest	Impoundments/Reservoirs	Inland lakes	Mesic Prairie	Oak Opening	Oak Woodland	Shru-carr	Southern Dry Forest	Southern Dry-mesic Forest	Southern Sedge Meadow	Southern Tamarack Swamp (rich)	Surrogate Grasslands	Warmwater rivers	Warmwater streams	Wet-mesic Prairie	Cedar Glade	Coolwater streams	Emergent Marsh – Wild Rice	Ephemeral Pond	Moist Cliff	Northern Hardwood Swamp	Northern Sedge Meadow	Northern Wet Forest	Northern Wet-mesic Forest	Southern Hardwood Swamp	Southern Mesic Forest	Submergent Marsh	Wet Prairie
Hooded Warbler															H																	H		
Hudsonian Godwit						H																												
King Rail						H										M																		
Least Flycatcher							M																				M							
Lesser Scaup								M	M										M					M									H	
Louisiana Waterthrush															H								H									H		
Northern Harrier				M	M					H						M		H			H							H						M
Prothonotary Warbler							H																											
Redhead						H																		M									H	
Red-headed Woodpecker							M				H	H		M	M																			
Red-necked Grebe						H																											M	
Rusty Blackbird	M	M				M	H						M				M								M						H			
Short-billed Dowitcher						H		M																										
Short-eared Owl				M	M					H			M			M		H			H							M						M
Vesper Sparrow				H	M						M																							
Western Meadowlark				M	H													H																
Whooping Crane						H										M												M					H	
Willow Flycatcher	M	M			M					M			H			M		M			M													M
Wood Thrush							M					M		M	H																	H		
Yellow-billed Cuckoo							H						M		M																M	M		
HERPTILES																																		
Blanding's turtle				H	M	H	M	H	H	M	H	M	M		M	M	M		M	M	M	M	M	H	H			M			M	M	H	H
Butler's garter snake		H			H	H	M			H			H			H					H							H						H
Eastern massasauga		H		H	H	H	H			H			H			H					H				H						M			H
Four-toed salamander	H					H	H						H			M	M						M		H		M	M	M	H	H	H		
Eastern ribbon snake	H								H				M																					
Ornate box turtle				H	M						H	H		H	H							H										M		
Pickerel frog		M				H	M	H	M	M			M			H			H	H	H		H		H			H	M	M	M	M	H	H
Queen snake						H		M	M				H			H			H	H			M										H	H
FISH																																		
Gravel chub																			H															
Greater redhorse								M	M										M	H														
Lake chubsucker									M																									
Lake sturgeon								H	H										H															
Least darter									M										M	M														
Longear sunfish									M										M	M														
Ozark minnow																				H														

Continued on next page

Appendix 18.E, *continued.*


Bobwhite male. Photo by Herbert Lange.

	MAJOR																					IMPORTANT												
	Bog Relict	Calcareous Fen	Dry Cliff	Dry Prairie	Dry-mesic Prairie	Emergent Marsh	Floodplain Forest	Impoundments/Reservoirs	Inland lakes	Mesic Prairie	Oak Opening	Oak Woodland	Shrub-carr	Southern Dry Forest	Southern Dry-mesic Forest	Southern Sedge Meadow	Southern Tamarack Swamp (rich)	Surrogate Grasslands	Warmwater rivers	Warmwater streams	Wet-mesic Prairie	Cedar Glade	Coolwater streams	Emergent Marsh – Wild Rice	Ephemeral Pond	Moist Cliff	Northern Hardwood Swamp	Northern Sedge Meadow	Northern Wet Forest	Northern Wet-mesic Forest	Southern Hardwood Swamp	Southern Mesic Forest	Submergent Marsh	Wet Prairie
Redfin shiner								M											H	M														
Redside dace																				M														
River redhorse																			M															
Slender madtom																				H														
Starhead topminnow									H										H	H														
Species That Are Moderately Associated with the Southeast Glacial Plains Ecological Landscape																																		
MAMMALS																																		
Eastern red bat	M	M				M	M		M		M	M	M	M	M	M			M	M			H		H		M	M	M	M	M	M	M	
Hoary bat	M	M				M	M		M				M			M			M	M			H		H		M	M	M	M			M	
Northern long-eared bat	M	M				M	M		M			M	M	M	M	M			M	M			H		H		M	M			M	M	M	
Prairie vole				H	H					M	M							M																
Silver-haired bat	M	M				M	M		M				M			M			M	M			H		H		M	M	M	M			M	
Woodland vole											H	H		H	H																			
BIRDS																																		
Bell's Vireo				M	M								M					M			M													M
Golden-winged Warbler													3														M		M					
Lark Sparrow				M																		H												
Loggerhead Shrike				M	M													H																
Marbled Godwit					M	H				M								M			M													M
Northern Bobwhite				M	M					M	M							H			M													
Red-shouldered Hawk							H								M										H							M		
Snowy Egret						H																											M	
Solitary Sandpiper						H	H													M			M		H									
Upland Sandpiper				H	H					M								H			M													M
Veery							M						H		M												H		M			M		
Whimbrel						M																												
Whip-poor-will	M											H		H	H																			
Wilson's Phalarope						H																						H					M	
Yellow-crowned Night-heron						M	H						M						M						H						M		M	
Yellow-throated Warbler							H								M																			
HERPTILES																																		
Mudpuppy								H	H										H															
Yellow-bellied racer			M	H	M									M	M							H												

Continued on next page

Appendix 18.E, *contined.*

Lake sturgeon.
Photo by Wisconsin DNR staff.

	MAJOR																					IMPORTANT												
	Bog Relict	Calcareous Fen	Dry Cliff	Dry Prairie	Dry-mesic Prairie	Emergent Marsh	Floodplain Forest	Impoundments/Reservoirs	Inland lakes	Mesic Prairie	Oak Opening	Oak Woodland	Shrub-carr	Southern Dry Forest	Southern Dry-mesic Forest	Southern Sedge Meadow	Southern Tamarack Swamp (rich)	Surrogate Grasslands	Warmwater rivers	Warmwater streams	Wet-mesic Prairie	Cedar Glade	Coolwater streams	Emergent Marsh – Wild Rice	Ephemeral Pond	Moist Cliff	Northern Hardwood Swamp	Northern Sedge Meadow	Northern Wet Forest	Northern Wet-mesic Forest	Southern Hardwood Swamp	Southern Mesic Forest	Submergent Marsh	Wet Prairie
FISH																																		
Banded killifish									M																									
Black buffalo								M											M															
Pugnose shiner									M											M														
Western sand darter																			M															

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

Appendix 18.F. *Natural communities[a] for which there are management opportunities in the Southeast Glacial Plains Ecological Landscape.*

Major opportunity[b]	Important opportunity[c]	Present[d]
Southern Dry Forest	Northern Wet-mesic Forest	Northern Dry-mesic Forest
Southern Dry-mesic Forest	Northern Wet Forest	
Floodplain Forest	Northern Hardwood Swamp	Alder Thicket
Southern Tamarack Swamp		
	Southern Mesic Forest	Sand Prairie
Oak Opening	Southern Hardwood Swamp	
Oak Woodland		Coldwater Stream
	Cedar Glade	
Bog Relict		
Shrub-carr	Wet Prairie	
	Northern Sedge Meadow	
Dry Prairie		
Dry-mesic Prairie	Emergent Marsh – Wild Rice	
Mesic Prairie	Submergent Marsh	
Wet-mesic Prairie	Ephemeral Pond	
Southern Sedge Meadow		
Surrogate Grasslands	Moist Cliff (Curtis' Shaded Cliff)	
Calcareous Fen (Southern)	Coolwater Stream	
Emergent Marsh		
Dry Cliff (Curtis's Exposed Cliff)		
Impoundment/Reservoir		
Inland Lake		
Warmwater River		
Warmwater Stream		

[a]See Chapter 7, "Natural Communities, Aquatic Features, and Selected Habitats, of Wisconsin" in Part 1 for definitions of natural community types. Also see Appendix E, "Opportunities for Sustaining Natural Communities in Each Ecological Landscape," in Part 3 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 18.G. *Public conservation lands in the Southeast Glacial Plain Ecological Landscape, 2005.*

Property name	Size (acres)[a]
STATE	
Albany State Wildlife Area	1,390
Allenton State Wildlife Area	1,160
Avon Bottoms State Wildlife Area	2,140
Aztalan State Park	190
Bad Fish Creek State Wildlife Area	1,150
Beulah Station State Wildlife Area	250
Big Foot Beach State Park	260
Bloomfield State Wildlife Area	1,100
Bong (Richard) State Recreation Area[b]	185
Brooklyn State Wildlife Area	2,490
Cedarburg Bog State Natural Area	1,680
Cherokee Marsh State Fishery Area	910
Clover Valley State Wildlife Area	530
Deansville State Wildlife Area	1,680
Deppe State Wildlife Area	200
Eldorado State Wildlife Area	6,420
Evansville State Wildlife Area	710
Fox Lake State Fishery Area	460
Glacial Habitat Restoration Area[b]	12,220
Goose Lake State Wildlife Area	2,280
Governor Nelson State Park	430
High Cliff State Park	1,130
Honey Creek State Wildlife Area	1,110
Hook Lake/Grass Lake State Wildlife and Natural Area	940
Horicon State Wildlife Area	11,090
Jackson Marsh State Wildlife Area	2,280
Karcher Marsh State Wildlife Area	290
Kettle Moraine State Forest-Northern Unit	29,550
Kettle Moraine State Forest-Southern Unit	20,460
Kiel Marsh State Wildlife Area	810
Koshkonong State Wildlife Area	840
La Budde Creek State Fishery Area	390
Lake Buttes Des Morts State Wildlife Area	275
Lake Kegonsa State Park	350
Lake Mills State Wildlife Area	3,300
Lapham Peak Unit-Kettle Moraine State Forest	1,020
Liberty Creek State Wildlife Area	565
Lima Marsh State Wildlife Area	2,030
Loew Lake Unit-Kettle Moraine State Forest	1,090
Lower Mud Lake State Fishery Area	300
Lulu Lake State Natural Area	870
Mud Lake State Wildlife Area-Columbia County	300
Mud Lake State Wildlife Area-Dodge County	4,800
Mukwa State Wildlife Area	1,320
Mullet Creek State Wildlife Area	2,210
New Munster State Wildlife Area	1,060
Nichols Creek State Wildlife Area	660
Paradise Marsh State Wildlife Area	1,570
Pike Lake Unit-Kettle Moraine State Forest	700
Poygan Marsh State Wildlife Area	3,510
Princes Point State Wildlife Area	1,610
Puchyan Prairie State Natural Area	260
Rat River State Wildlife Area[b]	4,350
Red Cedar Lake State Natural Area	500

Continued on next page

Appendix 18.G, *continued.*

Property name	Size (acres)[a]
Rome Pond State Wildlife Area	2,280
Shaw Marsh State Wildlife Area	940
Sheboygan Marsh State Wildlife Area	660
South Waubesa Wetlands State Natural Area	530
Storrs Lake State Wildlife Area	750
Theresa State Wildlife Area	5,820
Tichigan State Wildlife Area	1,230
Troy State Wildlife Area	760
Turtle Creek State Wildlife Area	1,040
Upper Waubesa State Fishery Area	260
Vernon State Wildlife Area	4,170
Waterloo State Wildlife Area	4,090
Waunakee State Wildlife Area	480
White River Marsh State Wildlife Area[b]	11,250
Willow Creek State Fishery Area[b]	395
Wolf River State Fishery Area	205
Wolf River State Wildlife Area	1,720
Miscellaneous Lands[c]	17,380
FEDERAL	
Horicon Marsh National Wildlife Refuge	1,470
Waterfowl Production Areas	6,165
COUNTY[d]	
Sheboygan Marsh County Park	7,330
TOTAL	**226,230**

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 program 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 18.H. *Land Legacy places in the Southeast Glacial Plains Ecological Landscape and their ecological and recreational significance.*

The *Wisconsin Land Legacy Report* (WDNR 2006c) identified 35 places in the Southeast Glacial Plains Ecological Landscape that merit conservation action based upon a combination of ecological significance and recreational potential.

Code	Place name	Size	Protection initiated	Protection remaining	Conservation significance[a]	Recreation potential[b]
AP	Arlington Prairie	Small	Moderate	Moderate	xx	xx
BK	Bark and Scuppernong Rivers	Large	Limited	Substantial	xxx	xxxx
CD	Campbellsport Drumlins	Small	Limited	Substantial	x	xxx
CC	Cedar Creek	Small	Limited	Substantial	xxx	xx
CB	Cedarburg Bog	Small	Substantial	Moderate	xxxxx	xx
CW	Crawfish River – Waterloo Drumlins	Large	Moderate	Substantial	xxxx	xxxxx
DR	Dunn-Rutland Savanna and Potholes	Medium	Moderate	Moderate	xxx	xxxx
GH	Glacial Habitat Restoration Area	Large	Substantial	Moderate	xxxx	xx
HM	Horicon Marsh	Medium	Substantial	Limited	xxxxx	xxx
IF	Illinois Fox River	Large	Limited	Substantial	xxx	xxxxx
JM	Jefferson Marsh	Medium	Moderate	Moderate	xxx	x
KM	Kettle Moraine State Forest	Large	Substantial	Moderate	xxxxx	xxxxx
LK	Lake Koshkonong to Kettle Moraine Corridor	Medium	Moderate	Substantial	xx	xxxxx
LP	Lakes of the Winnebago Pool	Large	Substantial	Moderate	xxxx	xxxxx
LR	Lower Rock River	Large	Limited	Substantial	xx	xxxxx
LB	Lower Wolf River Bottomlands	Large	Substantial	Moderate	xxxxx	xxxxx
MK	Middle Kettle Moraine	Medium	Substantial	Substantial	xxx	xxxxx
MH	Millhome Woods	Small	Limited	Substantial	xx	xxx
MI	Milwaukee River	Large	Moderate	Substantial	xxxx	xxxxx
MM	Monroe - Muralt Prairie	Medium	Limited	Substantial	xxxxx	xxx
MJ	Mukwonago River and Jericho Creek	Medium	Substantial	Substantial	xxxxx	xxxx
NE	Niagara Escarpment	Large	Moderate	Substantial	xxxxx	xxxxx
PT	Patrick Marsh	Small	Substantial	Limited	x	xx
RC	Raccoon Creek	Small	Limited	Substantial	xxx	xx
RL	Rush Lake	Medium	Substantial	Limited	xxxx	xxx
SH	Sheboygan County Trout Streams	Medium	Moderate	Moderate	x	xxx
SY	Sheboygan River Marshes	Medium	Substantial	Limited	xxxx	xxx
SL	Shoveler Lakes-Black Earth Trench	Small	Moderate	Moderate	xx	xxxxx
SK	Southern Kettle Moraine: Whitewater Lake to Turtle Creek	Medium	Limited	Substantial	xx	xxxxx
SV	Sugar Creek Valley	Small	Moderate	Moderate	xxx	xxx
SG	Sugar River	Large	Moderate	Substantial	xxxx	xxxx
UR	Upper Rock River	Large	Limited	Substantial	xx	xxxxx
UL	Upper Yahara River and Lakes	Medium	Substantial	Limited	xxx	xxxxx
WB	White River and Bloomfield Area	Small	Limited	Moderate	xxx	xxx
WM	White River Marsh and Uplands	Medium	Substantial	Limited	xxxxx	xx

[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.

Continued on next page

Appendix 18.H, *continued.*

[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 18.I. *Importance of economic sectors (based on the number of jobs) within the Southeast Glacial Plains 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
Agriculture, Fishing & Hunting	0.87	2.14	2.41	2.15	2.15	1.90	0.50	2.71	0.43	1.29	0.76	0.10	4.46	0.87	2.36	2.30
Forest Products & Processing	1.64	0.98	1.83	2.40	3.43	2.20	1.33	1.74	0.41	1.07	0.65	0.32	0.45	1.44	0.96	0.69
Mining	1.08	1.64	0.79	0.79	2.69	3.55	0.91	2.16	0.16	0.34	1.47	0.19	0.62	0.08	0.77	1.21
Utilities	2.44	1.08	0.81	0.39	0.61	0.45	0.58	0.41	1.96	1.76	0.67	0.65	0.81	1.83	1.19	0.51
Construction	1.12	1.02	0.89	0.96	1.14	0.92	2.38	1.08	1.07	1.14	1.08	0.67	0.98	1.13	1.03	1.11
Manufacturing (non-wood)	1.23	1.02	0.74	0.98	0.90	1.37	0.21	1.15	0.49	0.59	1.19	0.87	0.78	0.46	0.77	0.99
Wholesale Trade	0.99	0.63	0.61	0.95	0.62	0.53	0.47	0.60	1.15	0.72	1.16	0.98	0.89	0.76	0.83	0.53
Retail Trade	1.01	1.00	0.99	1.11	1.11	1.00	1.66	1.03	1.30	1.19	1.02	0.80	1.69	1.11	1.11	1.13
Tourism-related	0.99	1.12	0.97	0.86	0.99	1.05	1.51	1.28	1.34	1.41	0.94	1.02	0.78	1.33	1.08	1.12
Transportation & Warehousing	0.95	1.32	2.13	1.40	1.19	1.15	0.80	0.89	3.25	2.15	0.82	0.83	0.74	2.12	1.39	0.99
Information	0.76	0.49	0.69	0.74	0.58	0.68	0.80	0.70	0.38	0.49	1.22	1.11	1.09	0.64	0.62	0.57
Finance & Insurance	1.22	1.31	0.89	0.96	0.56	0.46	0.43	0.48	0.47	0.46	1.04	1.18	0.65	0.45	0.70	0.55
Real Estate, Rental & Leasing	0.84	0.73	0.59	0.60	0.52	0.34	1.37	0.95	0.42	0.50	1.17	1.14	0.47	0.46	0.87	0.66
Pro, Science & Tech Services	0.85	0.53	0.46	0.55	0.41	0.36	0.43	0.45	0.51	0.47	1.04	1.51	0.49	0.47	0.63	0.81
Management	0.80	0.26	0.63	0.54	0.37	0.21	0.17	0.24	0.65	0.47	0.94	1.62	0.08	0.64	0.87	0.45
Admin, Support, Waste, & Remediation	0.99	0.42	0.43	0.46	0.34	0.23	0.61	0.34	0.61	0.43	0.92	1.64	0.58	0.51	0.70	0.63
Private Education	0.86	0.68	0.39	0.42	0.86	0.72	0.87	0.55	0.08	0.12	0.80	1.94	0.09	1.53	0.68	0.55
Health Care & Social Services	0.85	0.88	1.27	1.04	0.82	0.90	0.87	0.84	0.96	0.91	0.83	1.32	0.84	0.99	1.09	0.94
Other Services	1.08	1.32	1.10	1.05	1.10	1.13	1.25	1.19	1.36	1.09	1.06	0.84	1.14	1.13	0.91	1.29
Government	0.78	1.09	1.11	1.03	1.26	1.36	1.08	1.03	1.36	1.54	1.04	0.89	1.15	1.50	1.14	1.21

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 2014).

Appendix 18.J. *Scientific names of species mentioned in text.*

Common name	Scientific name
Acadian Flycatcher[a]	*Empidonax virescens*
American basswood	*Tilia americana*
American beaver	*Castor canandensis*
American beech	*Fagus grandifolia*
American bison	*Bos bison*
American Bittern	*Botaurus lentiginosus*
American black bear	*Ursus americanus*
American Coot	*Fulica americana*
American elm	*Ulmus americana*
American gromwell	*Lithospermum latifolium*
American sycamore	*Platanus occidentalis*
American White Pelican	*Pelecanus erythrorhynchos*
American Woodcock	*Scolopax minor*
Arrowheads	*Sagittaria* spp.
Ashes	*Fraxinus* spp.
Asian longhorned beetle	*Anoplophora glabripennis*
Aspens	*Populus* spp.
Autumn olive	*Elaeagnus umbellata*
Bald Eagle	*Haliaeetus leucocephalus*
Banded killifish	*Fundulus diaphanus*
Barn Owl	*Tyto alba*
Bell's Vireo	*Vireo bellii*
Big brown bat	*Eptesicus fuscus*
Bird's-foot trefoil	*Lotus corniculata*
Bitternut hickory	*Carya cordiformis*
Black ash	*Fraxinus nigra*
Black cherry	*Prunus serotina*
Black locust	*Robinia pseudoacacia*
Black oak	*Quercus velutina*
Black spruce	*Picea mariana*
Black Tern	*Chlidonias niger*
Black walnut	*Juglans nigra*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Blanding's turtle	*Emydoidea blandingii*
Blue ash	*Fraxinus quadrangulata*
Blue-winged Teal	*Anas discors*
Bobolink	*Dolichonyx oryzivorus*
Broad-leaved cat-tail	*Typha latifolia*
Brown trout	*Salmo trutta*
Buckhorn	*Tritogonia verrucosa*
Buckthorns (nonnative)	*Rhanmnus* spp.
Bulrushes	*Schoenoplectus* and *Scirpus* spp., *Bolboschoenus fluviatilis*
Bur oak	*Quercus macrocarpa*
Bur-reeds	*Sparganium* spp.
Butler's gartersnake	*Thamnophis butleri*
Canada bluegrass	*Poa compressa*
Canada Goose	*Branta canadensis*
Canada Warbler	*Cardellina canadensis,* listed as *Wilsonia canadensis* on the Wisconsin Natural Heritage Working List
Canada yew	*Taxus canadensis*
Canadian waterweed	*Elodea canadensis*
Canvasback	*Aythya valisineria*
Caspian Tern	*Hydroprogne caspia,* listed as *Sterna caspia* on the Wisconsin Natural Heritage Working List

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Appendix 18.J, *continued.*

Common name	Scientific name
Cat-tails	*Typha* spp.
Cerulean Warbler	*Setophaga cerulea,* listed as *Dendroica cerulea* on the Wisconsin Natural Heritage Working List
Cisco	*Coregonus artedi*
Common buckthorn	*Rhamnus cathartica*
Common carp	*Cyprinus carpio*
Common Gallinule	*Gallinula galeata*
Common mudpuppy	*Necturus maculosus maculosus*
Common prickly-ash	*Zanthoxylum americanum*
Common reed	*Phragmites australis*
Common Tern	*Sterna hirundo*
Common Yellowthroat	*Geothlypis trichas*
Coon's-tail	*Ceratophyllum demersum*
Crappie	*Pomoxis* spp.
Crown vetch	*Coronilla varia*
Curly pondweed	*Potamogeton crispus*
Cut-leaved teasel	*Dipsacus laciniatus*
Dame's rocket	*Hesperis matronalis*
Dogwoods	*Cornus* spp.
Double-crested Cormorant	*Phalacrocorax auritus*
Dutch elm disease fungus	*Ophiostoma ulmi*
Earleaf foxglove	*Tomanthera auriculata,* listed as *Agalinus auriculata* on the Wisconsin Natural Heritage Working List
Eastern Bluebird	*Sialia sialis*
Eastern massasauga	*Sistrurus catenatus catenatus*
Eastern Meadowlark	*Sturnella magna*
Eastern pipistrelle	*Perimyotis subflavus*
Eastern red bat	*Lasiurus borealis*
Eastern red-cedar	*Juniperus virginiana*
Eastern red-backed salamander	*Plethodon cinereus*
Eastern ribbonsnake	*Thamnophis sauritus*
Eastern Whip-poor-will	*Antrostomus vociferus*
Eastern white pine	*Pinus strobus*
Elk	*Cervus canadensis*
Elktoe	*Alasmidonta marginata*
Ellegant spreadwing	*Lestes inaequalis*
Ellipse	*Venustaconcha ellipsiformis*
Elms	*Ulmus* spp.
Elusive clubtail	*Stylurus notatus*
Emerald ash borer	*Agrilus planipennis*
Eurasian honeysuckles	*Lonicera morrowii, Lonicera tatarica, Lonicera* x *bella*
Eurasian water-milfoil	*Myriophyllum spicatum*
Flowering rush	*Butomus umbellatus*
Forked aster	*Aster furcatus*
Forster's Tern	*Sterna forsteri*
Four-toed salamander	*Hemidactylium scutatum*
Fragile forktail	*Ischnura posita*
Garlic mustard	*Alliaria petiolata*
Glossy buckthorn	*Rhamnus frangula*
Gophersnake	*Pituophis catenifer*
Grasshopper Sparrow	*Ammodramus savannarum*
Gravel chub	*Erimystax x-punctatus*
Gray wolf	*Canis lupus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*

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Appendix 18.J, *continued.*

Common name	Scientific name
Greater Prairie-Chicken	*Tympanuchus cupido*
Greater redhorse	*Moxostoma valenciennesi*
Greater Scaup	*Aythya marila*
Green ash	*Fraxinus pennsylvanica*
Green Heron	*Butorides virescens*
Gypsy moth	*Lymantria dispar*
Hall's bulrush	*Schoenoplectus halii,* listed as *Scirpus hallii* on the Wisconsin Natural Heritage Working List
Hard-stem bulrush	*Schoenoplectus acutus*
Henslow's Sparrow	*Ammodramus henslowii*
Hermit Thrush	*Catharus guttatus*
Highland dancer	*Argia plana*
Hine's emerald	*Somatochlora hineana*
Hooded Warbler	*Setophaga citrina*
Japanese barberry	*Berberis thunbergii*
Karner blue butterfly	*Lycaeides melissa samuelis*
Kentucky bluegrass	*Poa pratensis*
Kentucky coffee-tree	*Gymnocladus dioicus*
Kentucky Warbler	*Geothlypis formosa,* listed as *Oporornis formosus* on the Wisconsin Natural Heritage Working List
King Rail	*Rallus elegans*
Kitten's-tails	*Besseya bullii*
Lake chubsucker	*Erimyzon sucetta*
Lake sturgeon	*Acipenser fulvescens*
Lake trout	*Salvelinus namaycush*
Largemouth bass	*Micropterus salmoides*
Laurentian bladder fern	*Cystopteris laurentiana*
Least Bittern	*Ixobrychus exilis*
Least darter	*Etheostoma microperca*
Least Flycatcher	*Empidonax minimus*
Lesser Scaup	*Aythya affinis*
Little brown bat	*Myotis lucifugus*
Loggerhead Shrike	*Lanius ludovicianus*
Longear sunfish	*Lepomis megalotis*
Mallard	*Anas platyrhynchos*
Marsh Wren	*Cistothorus palustris*
Midwest pleistocene vertigo	*Vertigo hubrichti*
Mississippi grass shrimp	*Palaemonetes kadiakensis*
Monkeyface	*Quadrula metanevra*
Mucket	*Actinonaias ligamentina*
Multiflora rose	*Rosa multiflora*
Mute Swan	*Cygnus olor*
Narrow-leaved cat-tail	*Typha angustifolia*
Nashville Warbler	*Oreothlypis ruficapilla*
North American river otter	*Lontra canadensis*
Northern Bobwhite	*Colinus virginianus*
Northern cricket frog	*Acris crepitans*
Northern Harrier	*Circus cyaneus*
Northern long-eared bat	*Myotis septentrionalis*
Northern pike	*Esox lucius*
Northern pin oak	*Quercus ellipsoidalis*
Northern red oak	*Quercus rubra*
Northern Saw-whet Owl	*Aegolius acadicus*
Northern Waterthrush	*Parkesia noveboracensis*
Northern white-cedar	*Thuja occidentalis*

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Appendix 18.J, *continued.*

Common name	Scientific name
Oak bark beetle	*Pseudopityophthorus* spp.
Oak wilt fungus	*Ceratocystis fagacearum*
Orchard Oriole	*Icterus spurius*
Ornate box turtle	*Terrapene ornata*
Osprey	*Pandion haliaetus*
Ozark minnow	*Notropis nubilus*
Passenger Pigeon	*Ectopistes migratorius*
Pickerel frog	*Rana palustris*
Pied-billed Grebe	*Podilymbus podiceps*
Pondweed	*Potamogeton spp.*
Powesheik skipperling	*Oarisma powesheik*
Prairie bush-clover	*Lespedeza leptostachya*
Prairie milkweed	*Asclepias sullivantii*
Prairie white-fringed orchid	*Platanthera leucophaea*
Predacious diving beetle	*Agabus bicolor*
Predacious diving beetle	*Agabus inscriptus*
Predacious diving beetle	*Copelatus glyphicus*
Predacious diving beetle	*Ilybius discedens*
Predacious diving beetle	*Ilybius incarinatus*
Predacious diving beetle	*Lioporeus triangularis*
Predacious diving beetle	*Rhantus sinuatus*
Prothonotary Warbler	*Protonotaria citrea*
Pugnose shiner	*Notropis anogenus*
Purple loosestrife	*Lythrum salicaria*
Purple wartyback	*Cyclonaias tuberculata*
Pygmy snaketail	*Ophiogomphus howei*
Queensnake	*Regina septemvittata*
Rainbow shell	*Villosa iris*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Red-backed vole	*Clethrionomys gapperi*
Red-breasted Nuthatch	*Sitta canadensis*
Redfin shiner	*Lythrurus umbratilis*
Redhead	*Aythya americana*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-necked Grebe	*Podiceps grisegena*
Red-shouldered Hawk	*Buteo lineatus*
Redside dace	*Clinostomus elongatus*
Red-tailed prairie leafhopper	*Aflexia rubranura*
Reed canary grass	*Phalaris arundinacea*
Reflexed trillium	*Trillium recurvatum*
Regal fritillary	*Speyeria idalia*
Ring-necked Pheasant	*Phasianus colchicus*
River birch	*Betula nigra*
River redhorse	*Moxostoma carinatum*
Rock stitchwort	*Arenaria stricta*
Rock whitlow-grass	*Draba arabisans*
Round pigtoe	*Pleurobema sintoxia*
Ruddy Duck	*Oxyura jamaicensis*
Rusty crayfish	*Orconectes rusticus*
Sago pondweed	*Stuckenia pectinatus*
Salamander mussel	*Simpsonaias ambigua*
Sandhill Crane	*Grus canadensis*
Sap feeding beetle	Family Nitidulidae
Savannah Sparrow	*Passerculus sandwichensis*

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Appendix 18.J, *continued.*

Common name	Scientific name
Scots pine	*Pinus sylvestris*
Sedge Wren	*Cistothorus platensis*
Shagbark hickory	*Carya ovata*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Siberian elm	*Ulmus pumila*
Silphium borer moth	*Papaipema silphii*
Silver maple	*Acer saccharinum*
Slender glass lizard	*Ophisaurus attenuatus*
Slender madtom	*Noturus exilis*
Slippershell	*Alasmidonta viridis*
Smallmouth bass	*Micropteris dolomieu*
Smooth brome	*Bromus inermis*
Snowshoe hare	*Lepus americanus*
Snuffbox	*Epioblasma triquetra*
Soft-stem bulrush	*Schoenoplectus tabernaemontani*
Sora	*Porzana carolina*
Speckled alder	*Alnus incana*
Sphagnum moss	*Sphagnum* spp.
Spotted knapweed	*Centaurea biebersteinii*
Starhead topminnow	*Fundulus dispar*
Stiff arrowhead	*Sagittaria rigida*
Striped shiner	*Luxilus chrysocephalus*
Stygian shadowdragon	*Neurocordulia yamaskanensis*
Sugar maple	*Acer saccharum*
Swamp darner	*Epiaeschna heros*
Swamp metalmark	*Calephelis muticum*
Swamp thistle	*Cirsium muticum*
Swamp white oak	*Quercus bicolor*
Swan's sedge	*Carex swanii*
Tamarack	*Larix laricina*
Torrey's sedge	*Carex torreyi*
Trumpeter Swan	*Cygnus buccinator*
Tundra Swan	*Cygnus columbianus*
Unicorn clubtail	*Arigomphus villosipes*
Veery	*Catharus fuscescens*
Virginia Rail	*Rallus limicola*
Walleye	*Sander vitreus*
Warpaint emerald	*Somatochlora incurvata*
Water star-grass	*Heteranthera dubia*
Water-celery	*Vallisneria americana*
Western foxsnake	*Elaphe vulpina*
Western ribbonsnake	*Thamnophis proximus*
Western sand darter	*Etheostoma clarum*
White ash	*Fraxinus americana*
White birch	*Betula papyrifera*
White oak	*Quercus alba*
White river crayfish	*Procambarus acutus*
White sweet clover	*Melilotus alba*
White-nose fungus	*Geomyces destructans*
White-tailed deer	*Odocoileus virginianus*
White-throated Sparrow	*Zonotrichia albicollis*
Wilcox's panic grass	*Dicanthelium wilcoxianum*
Wild parsnip	*Pastinaca sativa*
Wild rice	*Zizania* spp.
Wild Turkey	*Meleagris gallopavo*

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Appendix 18.J, *continued.*

Common name	Scientific name
Willow	*Salix* spp.
Willow Flycatcher	*Empidonax traillii*
Wood Duck	*Aix sponsa*
Wood frog	*Lithobates sylvaticus*
Wood turtle	*Glyptemys insculpta*
Worm-eating Warbler	*Helmitheros vermivorum*
Yellow perch	*Perca flavescens*
Yellow sweet clover	*Melilotus officinalis*
Yellow Warbler	*Setophaga petechia*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-crowned Night-Heron	*Nyctanassa violacea*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Yellow-throated Warbler	*Setophaga dominica,* listed as *Dendroica dominica* on the Wisconsin Natural Heritage Working List
Zebra mussel	*Dreissena polymorpha*

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

Appendix 18.K. *Maps of important physical, ecological, and aquatic features within the Southeast Glacial Plains Ecological Landscape.*

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

Note: *Go to http://dnr.wi.gov/topic/landscapes/index.asp?mode=detail&Landscape=2 and click the "maps" tab.*

Literature Cited

Annin, P. 2006. *The Great Lakes water wars*. Island Press, Washington, D.C.

Austin, H.R. 1948. *The Wisconsin story: the building of a vanguard state.* The Milwaukee Journal, Milwaukee.

Bernthal, T.W., B.M. Fevold, J. Kline, D.M. Reed, and K.A. Sherfinski. 2009. *Feasibility of mapping ephemeral pond wetlands in southeastern Wisconsin: the Wisconsin ephemeral ponds project (WEPP).* Wisconsin Department of Natural Resources, Office of Energy and Environmental Analysis, Southeast Region, Final Report to USEPA, Region V Wetland Grant No. CD 96576601, Milwaukee.

Bielefeldt, J., M.J. Mossman, E. Epstein, and B. Bubb. 2003. New distributional records for summer birds in southern Wisconsin conifer swamps. *Passenger Pigeon* 65:212-232.

Bleuer, N.K. 1970. Glacial stratigraphy of South-Central Wisconsin. Pages J1-J35 *in* R.F. Black, N.K. Bleuer, F.D. Hole, N.P. Lasca, and L.J. Maher, editors. *Pleistocene geology of southern Wisconsin. A field trip guide with special papers.* Wisconsin Geological and Natural History Survey, Information Circular No. 15, Madison.

Blumer, B. 2006. *Geomorphic history of the Allen Creek drainage basin, Jefferson County, Wisconsin.* University of Wisconsin-Whitewater, Department of Geography and Geology, Student Intern Paper, Whitewater.

Borman, R.G., and L.C. Trotta. 1975. *Ground-water resources and geology of Jefferson County, Wisconsin.* Wisconsin Geological and Natural History Survey, Information Circular 33, Madison.

Bray, J. Roger. 1960. The composition of savanna vegetation in Wisconsin. *Ecology* 41:721–732.

Brockman, K.M., and R.A. Dow, editors. 1982. *Wildlife in early Wisconsin: a collection of works by A.W. Schorger*. Student Chapter of The Wildlife Society, Stevens Point, Wisconsin.

Canham, C.D., and O.L. Loucks. 1984. Catastrophic windthrow in the presettlement forests of Wisconsin. *Ecology* 65(3):803–809.

Clayton, L. 2001. *Pleistocene geology of Waukesha County, Wisconsin.* Wisconsin Geological and Natural History Survey, Bulletin 99, Madison.

Clayton, L., and J.W. Attig. 1997. *Pleistocene geology of Dane County.* Wisconsin Geological and Natural History Survey, Bulletin 95, Madison.

Clayton, L., J.W. Attig, D.M. Mickelson, M.D. Johnson, and K.M. Syverson. 2006. *Glaciation of Wisconsin.* Third edition. Wisconsin Geological and Natural History Survey, Educational Series 36, Madison.

Cleland, D.T., P.E. Avers, W.H. McNab, M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. National hierarchical framework of ecological units. Pages 181–200 *in* M.S. Boyce and A. Haney, editors. *Ecosystem management: applications for sustainable forest and wildlife resources*. Yale University Press, New Haven, Connecticut.

Craven, S.R. 1988. The impact of wildlife damage on wildlife management programs in Wisconsin. Paper 5 *in* Proceedings of the thirteenth Vertebrate Pest Conference, 1–3 March 1988, Monterey, California.

Curtis, J.T. 1959. *Vegetation of Wisconsin: an ordination of plant communities*. University of Wisconsin Press, Madison. 640 pp.

Cutright, N.J., B.R. Harriman, and R.W. Howe. 2006. *Atlas of the breeding birds of Wisconsin*. Wisconsin Society for Ornithology, Waukesha. 602 pp.

Dane County Regional Planning Commission. 2004. *Dane County regional hydrologic study.* U.S. Geological Survey, Wisconsin Geological and Natural History Survey, and Dane County Regional Planning Commission, Madison. Available online at http://danedocs.countyofdane.com/webdocs/PDF/capd/2004_hydrostudy.pdf. Accessed January 2013.

Davis, M.G., editor. 1947. *A history of Wisconsin highway development, 1835–1945.* State Highway Commission of Wisconsin and the U.S. Public Roads Administration, Federal Works Agency, Madison.

de Szalay, F., D. Helmers, D. Humburg, S.J. Lewis, B. Pardo, and M. Shieldcastle. 2000. *Upper Mississippi River Valley/Great Lakes Regional Shorebird Conservation Plan.* U.S. Fish and Wildlife Service, Fort Snelling, Minnesota.

Dorney, John R. 1981. The impact of native Americans on presettlement vegetation in southeastern Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 69:26–36.

Dott, R.H., and J.W. Attig. 2004. *Roadside geology of Wisconsin*. Mountain Press Publishing Company, Missoula, Montana. 345 pp.

Epstein, E., W. Smith, C. Anderson, E. Spencer, J. Lyons, and D. Feldkirchner. 2002. *Wolf River Basin biotic inventory and analysis: a baseline inventory and analysis of natural communities, rare plants and animals, and other selected features.* Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUBL ER-802-2002, Madison. 37 pp + app.

Eslick, J.C. 2001. Bogs: a Web presentation. For Earth Science Department, course ES 767, Quaternary Geology, Kansas State University, Emporia Kansas. Available online at http://academic.emporia.edu/aberjame/student/eslick2/bog_report.html. Accessed April 2009.

Evans, T.J. 2003. *Geology of La Crosse County, Wisconsin*. Map at 1:100,000 scale. Wisconsin Geological and Natural History Survey, Bulletin 101, Madison.

Evans, T.J., K.M. Massie-Ferch, and R.M. Peters. 2004. *Preliminary bedrock geologic map of Walworth, Racine, Kenosha, Milwaukee, Waukesha, Ozaukee, and Washington counties*. Map at 1:100,000 scale. Wisconsin Geological and Natural History Survey Open-File Report 2004-18, Madison.

Finley. R. W. 1976. *Original vegetation cover of Wisconsin*. Map compiled from U.S. General Land Office notes. University of Wisconsin-Extension, Madison.

Forest Preserve District of Cook County (FPDCC). 1966. *Tamarack bogs.* Forest Preserve District of Cook County, Nature Bulletin No. 249-A, Argonne, Illinois. Available online at http://www.newton.dep.anl.gov/natbltn/200-299/nb249.htm. Accessed April 2009.

Goldstein, L. and J. Freeman 1997. Aztalan – a Middle Mississippian village. *The Wisconsin Archaeologist* 78(1–2):223–248.

Harr, C.A., L.C. Trotta, and R.G. Borman. 1978. *Ground-water resources and geology of Columbia County, Wisconsin.* Wisconsin Geological and Natural History Survey, Information Circular No. 37, Madison.

Heine, M. 2007. Delavan Lake could deteriorate without intervention, expert says. *GazetteXtra*, November 2, 2007, Janesville, Wisconsin. Available online at http://gazettextra.com/news/2007/nov/02/delavan-lake-could-deteriorate-without-interventio/. Accessed November 2012.

Helmers, D.L. 1992. *Shorebird management manual*. Western Hemisphere Shorebird Reserve Network, Manomet, Massachusetts. 58 pp.

Hole, F.D. 1976. *Soils of Wisconsin*. University of Wisconsin Press, Madison. 223 pp + maps.

Hooyer, T.S. 2007. *Late-glacial history of east-central Wisconsin.* Wisconsin Geological and Natural History Survey, Open-File Report 2007-01, Madison.

Hunt, R.J., K.R, Bradbury, and J.T. Krohelski. 2001. *The effects of large-scale pumping and diversion on the water resources of Dane County, Wisconsin.* U.S. Geological Survey, Fact Sheet FS-127-01, Middleton, Wisconsin.

Hyde, T., C. Isenring, R. O'Connor, A. Staffen, R. Staffen. 2010. *Biotic inventory and analysis of the Kettle Moraine State Forest: a baseline inventory and analysis of natural communities, rare plants, and animals.* Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUBL ER-821 2010, Madison.

Inter-university Consortium for Political and Social Research (ICPSR). 2007. United States historical census data browser. Available online at http://mapserver.lib.virginia.edu or http://www.icpsr.umich.edu/.

Jennings, M.J., M.A. Bozek, G.R. Hatzenbeler, E.E. Emmons, and M.D. Staggs. 1999. Cumulative effects of incremental shoreline habitat modification on fish assemblages in north temperate lakes. *North American Journal of Fisheries Management* 19:18–27.

Johnson, K.M., and C.L. Beale. 2002. Nonmetro recreation routines: their identification and rapid growth. *Rural America* 17(4):12–19.

Kahl, R.B. 1993. *Aquatic macrophyte ecology in the upper Winnebago pool lakes, Wisconsin.* Wisconsin Department of Natural Resources, Technical Bulletin 182, Madison. 60 pp.

Kanehl, P.D., J. Lyons, and J.E. Nelson. 1997. Changes in the habitat and fish community of the Milwaukee River, Wisconsin, following removal of the Woolen Mills Dam. *North American Journal of Fisheries Management* 17:387–400.

Kotar, J., and T. Burger. 1996. *A guide to forest communities and habitat types of central and southern Wisconsin*. Department of Forestry, University of Wisconsin-Madison, Madison.

Kumlien, L., and N. Hollister. 1903. The birds of Wisconsin. *Bulletin of the Wisconsin Natural History Society* 2:1–143.

Kunkel, K.E., M.A. Palecki, K.G. Hubbard, D.A. Robinson, K.T. Redmond, and D.R. Easterling. 2007. Trend identification in twentieth-century U.S. snowfall: the challenges. *Journal of Atmospheric and Oceanic Technology* 24:64–73.

LaBerge, G.L. 1994. *Geology of the Lake Superior region*. Penokean Press, Oshkosh, Wisconsin. 313 pp.

Lake Sinissippi Improvement District (LSID). 2012. Sedimentation and dredging. *Lake Sinissippi Improvement District newsletter*, Summer 2012. Available online at http://www.lakesinissippi.org/lsid_newsletters.asp. Accessed November 2012.

Lapham, I.A. 2001. *The antiquities of Wisconsin, as surveyed and described*. A facsimile of the 1855 edition published by the Smithsonian Institution. University of Wisconsin Press, Madison.

Lasca, N.P. 1970. Pleistocene geology from Milwaukee to the Kettle Interlobate Moraine. Pages C1–C14 *in* R.F. Black, N.K. Bleuer, F.D. Hole, N.P. Lasca, and L.J. Maher, editors. *Pleistocene geology of southern Wisconsin: a field trip guide with special papers.* Wisconsin Geological and Natural History Survey, Information Circular No. 15, Madison.

Lathrop, R.C., D.S. Liebl, and K. Welke. 2013. Carp removal to increase water clarity in shallow eutrophic Lake Wingra. *Lakeline* 33(3):23–30.

Leitner, L.A., C.P. Dunn, G.R. Guntenspergen, F. Stearns, and D.M. Sharpe. 1991. Effects of landscape features and fire regime on vegetation patterns in presettlement southern Wisconsin. *Landscape Ecology* 5(4):203–217.

Lyons, J. 1992. *Using the index of biotic integrity (IBI) to measure environmental quality in warmwater streams of Wisconsin.* U.S. Forest Service, North Central Forest Experimental Station. General Technical Report NC-149, St. Paul, Minnesota. 51 pp.

Macholl, J.A. 2007. *Inventory of Wisconsin's springs.* Wisconsin Geological and Natural History Survey, Open-File Report 2007-03, Madison. 28 pp.

Manies, K.L., and D.J. Mladenoff. 2000. Testing methods to produce landscape-scale presettlement vegetation maps from the U.S. public land survey records. *Landscape Ecology* 15:741–754.

Marcouiller, D., and X. Xia. 2008. Distribution of income from tourism-sensitive employment. *Tourism Economics* 14(3):545–565.

Marshall, D.W., and J. Lyons. 2008. Documenting and halting declines of nongame fishes in southern Wisconsin. Pages 171-181 *in* D.W. Waller and T.P. Rooney, editors. *The vanishing present: Wisconsin's changing lands, waters, and wildlife.* University of Chicago Press, Chicago. 536 pp.

Mason, C.I. 1988. *Introduction to Wisconsin Indians: prehistory to statehood.* Sheffield Publishing, Salem, Wisconsin. 327 pp.

Mason, R.J. 1997. The Paleo-Indian Tradition. *The Wisconsin Archaeologist* 78(1–2):78–110.

Mickelson, D.M. 2007. *Landscapes of Dane County, Wisconsin.* Wisconsin Geological and Natural History Survey, Educational Series 43, Madison.

Minnesota IMPLAN Group, Inc. (MIG). 2009. MIG software. Web page. Available online at https://implan.com. Accessed August 2009.

National Association of Counties. 2010. Website. Available online at http://www.naco.org. Accessed October 2010.

Natural Resources Conservation Service (NRCS). 2001. *Shallow water management for shorebirds.* U.S. Department of Agriculture, Natural Resoures Conservation Service – Minnesota, Fish and Wildlife Habitat Management Guidesheet, Washington, D.C. Available online at http://www.stearnscountyswcd.net/Wildlife/. Accessed April 2009.

North Temperate Lakes Long Term Ecological Research (NTLLTER). 2010. Water clarity responses to carp reduction in shallow eutrophic Lake Wingra. Web page. Available online at http://lter.limnology.wisc.edu/research/research_highlight/water-clarity-responses-carp-reduction-shallow-eutrophic-lake-wingra.

Odom, I.E. 1978. Lithostratigraphy and sedimentology of the Lone Rock and Mazomanie formations. Pages 91-96 *in* I.E. Odom, M.E. Ostrom, C.W. Byers, R.C. Morris, and R.A. Adams, editors. *Lithostratigraphy, petrology, and sedimentology of Late Cambrian-Early Ordovician rocks near Madison, Wisconsin*. Wisconsin Geological and Natural History Survey, Madison.

Ostergren, R., and T. Vale, editors. 1997. *Wisconsin land and life*. University of Wisconsin Press, Madison. 626 pp.

Paull, R.A., and R.K. Paull. 1977. *Geology of Wisconsin and Upper Michigan: including parts of adjacent states*. Kendall/Hunt Publishing Company, Dubuque, Iowa. 232 pp.

Quintero, J. 2007. *Regional economic development: an economic base study and shift-share analysis of Hays County, Texas.* Texas State University, Applied Research Projects, Paper 259, San Marcos, Texas. Available online at https://digital.library.txstate.edu/handle/10877/3656.

Ramsar Convention on Wetlands. 1990. *Conference report of the 4th Meeting of the Conference of the Contracting Parties.* Montreux, Switzerland, June 27–July 4, 1990. Available online at http://www.ramsar.org/cda/en/ramsar-documents-cops-cop4/main/ramsar/1-31-58-131_4000_0. Accessed January 2012.

RENEW Wisconsin. 2009. Proposed windpower projects in Wisconsin. Madison. Available online at http://www.renewwisconsin.org/midwest/projects.htm. Accessed December 2010.

Renewable Fuels Association. 2013. Biorefinery locations. Web page. Last update May 10, 2013. Available online at http://www.ethanolrfa.org/bio-refinery-locations/.

Rhemtulla, J.M., D.J. Mladenoff, and M.K. Clayton. 2009. Legacies of historical land use on regional forest composition and structure in Wisconsin, USA (mid-1800s to 1930s to 2000s). *Ecological Applications* 19:1061–1078.

Ritzenthaler, R. 1970. *Prehistoric Indians of Wisconsin*. Milwaukee Public Museum, Milwaukee.

Rogers, D.A., T.P. Rooney, D. Olson and D.M. Waller. 2008. Shifts in southern Wisconsin forest canopy and understory richness, composition, and heterogeneity. *Ecology* 89(9):2482–2492.

Sample, D.W., and M J. Mossman. 1997. *Managing habitat for grassland birds: a guide for Wisconsin*. Wisconsin Department of Natural Resources, PUBL-SS-925-97, Madison.

Schneider, A.F. 1983. Wisconsinan stratigraphy and glacial sequence in southeastern Wisconsin. *Geoscience Wisconsin* 7:59–85.

Schorger, A.W. 1937. The range of the bison in Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 30:117–130. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1937.

Schorger, A.W. 1942a. Extinct and endangered mammals and birds of the upper Great Lakes region. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 34:23–44. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1942.

Schorger, A.W. 1942b. The wild turkey in early Wisconsin. *The Wilson Bulletin* 54(3):173–182. Available online at http://sora.unm.edu/sites/default/files/journals/wilson/v054n03/p0173-p0182.pdf.

Schorger, A.W. 1943. The prairie chicken and sharp-tailed grouse in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 35:1–59. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1943.

Schorger, A.W. 1944. The quail in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 36:77–103. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1944.

Schorger, A.W. 1946. The passenger pigeon in Wisconsin and problems with its history. Delivered at annual meeting of Wisconsin Society for Ornithology, Appleton, Wisconsin, April 6, 1946. Reprinted in K.M. Brockman and R.A. Dow, Jr., editors. 1982. *Wildlife in early Wisconsin: a collection of works by A.W. Schorger*. Student Chapter of The Wildlife Society, Stevens Point, Wisconsin.

Schorger, A.W. 1947. The introduction of pheasants into Wisconsin. *The Passenger Pigeon* 9(3):101–102. Available online at http://digital.library.wisc.edu/1711.dl/EcoNatRes.pp09n03.

Schorger, A.W. 1949. The black bear in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 39:151–194. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1947.

Schorger, A.W. 1953. The white-tailed deer in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 42:197–247. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1953.

Schorger, A.W. 1954. The elk in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 43:5–23. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1954.

Schorger, A.W. 1965. The beaver in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 54:147–179. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1965.

Schorger, A.W. 1970. The otter in early Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* 58:129–146. Available online at http://digital.library.wisc.edu/1711.dl/WI.WT1970.

Schulte, L.A., and D.J. Mladenoff. 2001. The original U.S. public land survey records: their use and limitations in reconstructing presettlement vegetation. *Journal of Forestry* 99:5–10.

Schultz, G. 2004. *Wisconsin's foundations: a review of the state's geology and its influence on geography and human activity*. The University of Wisconsin Press, Madison. 222 pp.

Skagen, S.K., PB. Sharpe, R.G. Waltermire and M.B. Dillon. 1999. *Biogeographical profiles of shorebird migration in midcontinental North America.* U.S. Geological Survey, Biological Science Report 2000-0003, Fort Collins, Colorado. 167 pp.

Smith, E.I. 1978. Introduction to Precambrian rocks of south-central Wisconsin. *Geoscience Wisconsin* 2:1–17.

Southeastern Wisconsin Regional Planning Commission (SEWRPC). 1997. *A regional natural areas and critical species habitat protection and management plan for southeastern Wisconsin.* Southeastern Wisconsin Regional Planning Commission, Planning Report No. 42. Waukesha. 531 pp.

Steele, Y., editor. 2007. *Important bird areas of Wisconsin: critical sites for the conservation and management of Wisconsin's birds*. Wisconsin Department of Natural Resources, PUB-WM-475 2007, Madison. 240 pp.

Stevenson, K.P., R.F. Boszhardt, C.R. Moffat, P.H. Salkin, T.C. Pleger, J.L. Theler, and C.M. Arzigian. 1997. The Woodland Tradition. *The Wisconsin Archaeologist* 78(1–2):140–201.

Stoltman, J.B. 1997. The Archaic Tradition. *The Wisconsin Archaeologist* 78(1–2):112–139.

Summers, W.K. 1965. *Geology and ground-water resources of Waushara County, Wisconsin.* U.S. Department of the Interior, U.S. Geological Survey, prepared in cooperation with the University of Wisconsin Geological and Natural History Survey, United States Geological Survey Water-Supply Paper 1809-B, Washington, D.C.

The Wisconsin Cartographers' Guild. 1998. *Wisconsin's past and present: a historical atlas*. The University of Wisconsin Press, Madison. 144 pp + maps.

Thwaites, F.T., W.H. Twenhofel, and L. Martin. 1922. *Geography, geology and mineral resources of the Sparta and Tomah quadrangles, Wisconsin.* U.S. Department of the Interior, U.S. Geological Survey, prepared in cooperation with the Wisconsin Geological and Natural History Survey, Open-File Report 1922-3-DI, Washington D.C. 162 pp.

U.S. Census Bureau (USCB). 2009. U.S. Census Bureau website. Available online at http://www.census.gov. Accessed April 2009.

U.S. Census Bureau (USCB). 2012a. 2010 census data. State and county quickfacts. Web page. Available online at http://quickfacts.census.gov/qfd/states/55000.html. Accessed February 2012.

U.S. Census Bureau (USCB). 2012b. *Wisconsin 2010: population and housing unit counts.* U.S. Department of Commerce, U.S. Census Bureau, Washington, D.C. 217 pp. Available online at http://www.census.gov/prod/www/decennial.html.

U.S. Census Bureau (USCB). 2012c. *Wisconsin 2010: summary population and housing characteristics.* U.S. Department of Commerce, U.S. Census Bureau, Washington, D.C. Available online at http://www.census.gov/prod/www/decennial.html.

U.S. Census Bureau (USCB). 2014. North American Industry Classification System. Web page. Available online at http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2012a. 2004 county typology codes. Available online at http://www.ers.usda.gov, keywords "county typology codes." Last updated July 5, 2012.

U.S. Department of Agriculture Economic Research Service (USDA ERS). 2012b. 2003 and 1993 Urban influence codes for U.S. counties. Available online at http://www.ers.usda.gov, keywords "urban influence codes." Last updated July 5, 2012.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2004. *2002 Census of Agriculture: Wisconsin state and county data.* Volume 1, Chapter 2: County level data. Table 1, county summary highlights: 2002. Available online at http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_2_County_Level/Wisconsin/.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS). 2009. *2007 Census of Agriculture: Wisconsin state and county data.* Volume 1, Chapter 2: County level data. Table 1: County summary highlights: 2007. Available online at http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Wisconsin/. Accessed December 2010.

U.S. Department of Commerce, Bureau of Economic Analysis (USDC BEA). 2006. Regional accounts data: local area personal income. Available online at http://www.bea.gov/regional/index.htm. Accessed September 2009.

U.S. Department of Energy (USDE). 2013. *Wisconsin 50-meter wind power*. Map. Web page. Available online at http://www.windpoweringamerica.gov/maps_template.asp?stateab=wi.

U.S. Environmental Protection Agency (USEPA). 2012. Model Post-Construction Stormwater Runoff Control Ordinance. Available online at http://water.epa.gov/polwaste/nps/mol6.cfm. Accessed October 2013.

U.S. Forest Service (USFS). 2004. Forest Inventory and Analysis, Mapmaker, Version 1.0. Accessed October 2007. (*Note: USFS has discontinued the Forest Inventory and Analysis Mapmaker program. See the U.S. Forest Service's "Data and tools" web page, http://www.nrs.fs.fed.us/fia/data-tools/mapping-tools/ and the Forest Inventory Data Online (FIDO) database, http://apps.fs.fed.us/fia/fido/index.html.*)

U.S. Forest Service (USFS). 2007. Forest inventory and analysis, timber product output mapmaker, Version 1.0. Available online at http://srsfia2.fs.fed.us/php/tpo_2009/tpo_rpa_int1.php. (*Note: USFS has discontinued the Timber Product Output Mapmaker program. See the U.S. Forest Service's "Data and tools" web page, http://www.nrs.fs.fed.us/fia/data-tools/mapping-tools/ and the Forest Inventory Data Online database, and the Forest Inventory Data Online (FIDO) database, http://apps.fs.fed.us/fia/fido/index.html.*) Accessed October 2007.

U.S. Forest Service (USFS). 2009. Forest Inventory and Analysis, Mapmaker, Version 4.0. Previously available online http://www.ncrs2.fs.fed.us/4801/fiadb/fim40/wcfim40.asp. Accessed July 2009. (*Note: USFS has discontinued the Timber Product Output Mapmaker program. See the U.S. Forest Service's "Data and tools" web page, http://www.nrs.fs.fed.us/fia/data-tools/mapping-tools/ and the Forest Inventory Data Online (FIDO) database, http://apps.fs.fed.us/fia/fido/index.html.*)

U.S. Forest Service (USFS). 2014. Forest health and economics. Web page. Available online at http://na.fs.fed.us/fhp/index.shtm. Accessed Dec. 2014.

U.S. Geological Survey (USGS). 2008. Protecting groundwater through comprehensive planning. Web page. Available online at http://wi.water.usgs.gov/gwcomp/integrate/index.html. Accessed April 2009.

U.S. Geological Survey (USGS). 2009. Peak streamflow for Wisconsin. Web page. Available online at http://nwis.waterdata.usgs.gov/nwis/peak?state_cd=wi&format=station_list&sort_key=site_no&group_key=NONE&set_logscale_y=1&date_format=YYYY-MM-DD&rdb_compression=file&hn2_compression=file&list_of_search_criteria=state_cd. Accessed July 2009.

U.S. Geological Survey (USGS). 2010. Estimated use of water in the United States in 2005: data by county. Web page. Available online at http://water.usgs.gov/watuse/data/2005/index.html. Accessed December 2010.

Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. *Fisheries* 22(6):6–12.

Wisconsin Cartographers' Guild. 1998. *Wisconsin's past and present: a historical atlas.* University of Wisconsin Press, Madison. 144 pp.

Wisconsin Commercial Ports Association (WCPA). 2010. Wisconsin ports.

Website. Available online at http://www.wcpaports.org/ports. Accessed December 2010.
Wisconsin Department of Administration (WDOA). 2000. Wisconsin roads 2000 TIGER line files (dataset). Wisconsin Department of Administration, Office of Land Information Services, Madison.
Wisconsin Department of Administration (WDOA). 2006. *Wisconsin energy statistics, 2006.* Wisconsin Department of Administration, Division of Energy, Madison. Available online at http://www.doa.state.wi.us/, keywords "Wisconsin energy statistics."
Wisconsin Department of Agriculture, Trade, and Consumer Protection (WDATCP). 2015. *Confirmed EAB finds in Wisconsin by county and municipality*. Wisconsin Department of Agriculture, Trade, and Consumer Protection, Madison. Available online at http://datcpservices.wisconsin.gov/eab/articleassets/ConfirmedEABFindsInWisconsin.pdf or http://datcpservices.wisconsin.gov, "emerald ash borer" link.
Wisconsin Department of Natural Resources (WDNR). 1993. Land cover data (WISCLAND). Available online at http://dnr.wi.gov/, keyword "WISCLAND." Accessed December 2012.
Wisconsin Department of Natural Resources (WDNR). 2000. *Wisconsin's lake sturgeon management plan.* Wisconsin Department of Natural Resources, Bureau of Fisheries Management and Habitat Protection, Sturgeon Management Assessment Team, Madison.
Wisconsin Department of Natural Resources (WDNR). 2001. *The state of the upper Fox River basin.* Wisconsin Department of Natural Resources in cooperation with the Upper Fox River Basin Partnership Team and stakeholders, PUBL WT 665-2001, Madison.
Wisconsin Department of Natural Resources (WDNR). 2002a. *The Niagara Escarpment: Inventory findings 1999–2001 and considerations for management.* Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Natural Heritage Inventory Program, PUBL ER-801 2002, Madison. 77 pp.
Wisconsin Department of Natural Resources (WDNR). 2002b. *Upper Rock River Watershed Management Plan: Upper Rock River Watershed appendix.* Wisconsin Department of Natural Resources, Publ-WT-668b-2002, Madison.
Wisconsin Department of Natural Resources (WDNR). 2004. *Lake Koshkonong environmental assessment.* Wisconsin Department of Natural Resources, Madison.
Wisconsin Department of Natural Resources (WDNR). 2005a. Wisconsin DNR-managed lands – "dissolved" version. Wisconsin Department of Natural Resources, Madison. See Wisconsin DNR managed lands web mapping application for current database, available at http://dnr.wi.gov/topic/Lands/DMLmap/.
Wisconsin Department of Natural Resources (WDNR). 2005b. *Wisconsin strategy for wildlife species of greatest conservation need.* Wisconsin Department of Natural Resources, Wisconsin Wildlife Action Plan, PUB-ER-641-2005, Madison. Available online at http://dnr.wi.gov, keywords "wildlife action plan."
Wisconsin Department of Natural Resources (WDNR). 2006a. *Old-growth and old forests handbook*. Chapter 18 – Bottomland hardwood. Wisconsin Department of Natural Resources, Handbook 2480.5, Madison.
Wisconsin Department of Natural Resources (WDNR). 2006b. *The 2005-2010 Wisconsin Statewide Comprehensive Outdoor Recreation Plan (SCORP).* Wisconsin Department of Natural Resources, PUB-PR-026-2006, Madison. Available online at http://dnr.wi.gov, keyword "SCORP."
Wisconsin Department of Natural Resources (WDNR). 2006c. *Wisconsin land legacy report: an inventory of places to meet conservation and recreation needs*. Wisconsin Department of Natural Resources, PUB-LF-040-2006, Madison. Available online at http://dnr.wi.gov, keyword "land legacy."
Wisconsin Department of Natural Resources (WDNR). 2008. Managed Forest Law stumpage rates. These data are available by request from the forest tax program, Wisconsin DNR, Madison.
Wisconsin Department of Natural Resources (WDNR). 2009. *Wisconsin Natural Heritage Working List.* April 2009. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Madison. Accessed March 11, 2010. Current Working List available online at http://dnr.wi.gov/, keyword "NHI." (*Note: The Wisconsin Natural Heritage Working List is dynamic and updated periodically as new information is available. The April 2009 Working List was used for this book. Those with questions regarding species or natural communities on the Working List should contact Julie Bleser, Natural Heritage Inventory Data Manager, Bureau of Natural Heritage Conservation, Wisconsin DNR at (608) 266-7308 or julie.bleser@wisconsin.gov.*)
Wisconsin Department of Natural Resources (WDNR). 2010a. Wisconsin's impaired waters list. Available online at http://dnr.wi.gov/, keywords "impaired waters." Accessed September 2010.
Wisconsin Department of Natural Resources (WDNR). 2010b. Wisconsin wetland inventory. Web page. Available online at http://dnr.wi.gov/, keywords "wetland inventory." Accessed September 2010.
Wisconsin Department of Natural Resources (WDNR). 2011. *Rapid ecological assessment for the Ice Age National Scenic Trail for the Kettle Moraine region: an addendum to the 2010 Kettle Moraine State Forest Biotoc Inventory Report summarizing recent findings.* Wisconsin Department of Natural Resources, Bureau of Endangered Resources, PUB-ER-825 2011, Madison.
Wisconsin Department of Natural Resources (WDNR). 2013. Outstanding and Exceptional Resource Waters. Web page. Last revised April 25, 2012. Available online at http://dnr.wi.gov, keywords "ORW/ERW." Accessed January 2013.
Wisconsin Department of Natural Resources (WDNR). 2014a. Forest health. Web page. Available online at http://dnr.wi.gov, keywords "forest health."
Wisconsin Department of Natural Resources (WDNR). 2014b. Game fishes of Wisconsin: lake sturgeon. Web page. Available online at http://dnr.wi.gov/topic/fishing/species/index.html.
Wisconsin Department of Natural Resources (WDNR). 2014c. Hydrography Geodatabase. Web page. Available online at http://dnr.wi.gov/, keywords "hydrography geodatabase."
Wisconsin Department of Natural Resources (WDNR). 2014d. Invasive species. Web page. Available online at http://dnr.wi.gov/, keywords "invasive species."
Wisconsin Department of Natural Resources (WDNR). 2014e. Rush Lake restoration. Web page. Available online at http://dnr.wi.gov/, keywords "Rush Lake restoration."
Wisconsin Department of Natural Resources (WDNR). 2014f. State Natural Areas Program. Web page. Available online at http://dnr.wi.gov/, keywords "state natural areas."
Wisconsin Department of Natural Resources (WDNR). 2014g. Surface water integrated monitoring systems (SWIMS). Web page. Last updated September 3, 2014. Available online at http://dnr.wi.gov/, keyword "SWIMS."
Wisconsin Department of Natural Resources (WDNR). 2014h. Trumpeter Swan. Web page. Available online at http://dnr.wi.gov/, keywords "Trumpeter Swan," species guidance tab. Accessed October 2014.
Wisconsin Department of Transportation (WDOT). 1998. 1:100,000-scale Rails Chain Database. Wisconsin Department of Transportation, Bureau of Planning, Madison.
Wisconsin Department of Transportation (WDOT). 2012. 2011–2012 airport directory – by city name. Available online at http://wisconsindot.gov/Pages/home.aspx, keywords "airport directory." Accessed December 2012.
Wisconsin Department of Workforce Development (WDWD). 2009. Bureau of Workforce Training – labor market information. Available online at http://dwd.wisconsin.gov/det/workforcetraining/. Accessed January 2009.
Wisconsin Geological and Natural History Survey (WGNHS). 2006. *Bedrock stratigraphic units in Wisconsin.* Wisconsin Geological and Natural History Survey, Open-File Report 2006-06, Madison.
Wisconsin Groundwater Advisory Committee (WGAC). 2006. *Report to the Legislature on Groundwater Management Areas.* Wisconsin Groundwater Coordinating Council. Wisconsin DNR Bureau of Drinking and Groundwater, Madison.
Wisconsin Groundwater Coordinating Council (WGCC). 2008. *Groundwater: Wisconsin's buried treasure – 2008.* Report to the Legislature. Wisconsin Groundwater Coordinating Council, Madison. Available from the Wisconsin DNR Bureau of Drinking Water and Groundwater.
Wisconsin Historical Society (WHS). 2009. Dictionary of Wisconsin history.

Database. Available online at http://www.wisconsinhistory.org/dictionary/. Accessed February 2009.

Wisconsin Landtype Association (WLTA) Project Team. 2002. *Landtype Associations of Wisconsin*. Wisconsin Department of Natural Resources. Madison. Map at 1:500,000 scale.

Wisconsin State Climatology Office (WSCO). 2011. Climate summaries by location. Retrieved April 29, 2009, from http://www.aos.wisc.edu/~sco/, "past Wisconsin climate" tab to "daily data from National Weather Service reporting stations."

Wisconsin Wetland Association (WWA). 2009. Wisconsin's wetland gems. Web page. Available online at http://www.wisconsinwetlands.org/gems.htm. Accessed January 2012.

Wisconsin Wind Information Center (WWIC). 2013. Existing Wisconsin wind farms: commercial wind energy installations in Wisconsin 1998-2013. Web page. Available online at http://www.wiwindinfo.net/projects/overview.html.

Wittry, W.L. 1957. A preliminary study of the Old Copper Complex. *The Wisconsin Archaeologist* 38(4):204–221.

Zaporozec, A. 1982. *Ground-water quality of Rock County, Wisconsin*. Wisconsin Geological and Natural History Survey, Information Circular No. 41, Madison.

Additional References

Anderson, C., E. Epstein, W. Smith, and N. Merryfield. 2002. *The Niagara Escarpment: inventory findings 1999–2001 and considerations for management.* Wisconsin Department of Natural Resources, Natural Heritage Inventory Program, PUBL ER-801-02, Madison.

Burzynski, M., and M. Thiede. 2002. The state of the Southeast Fox River basin. Wisconsin Department of Natural Resources, PUBL WT-701-2002, Madison.

Mathiak, H.A. 1979. *A river survey of the unionid mussels of Wisconsin 1973–1977*. Sand Shell Press, Horicon, Wisconsin.

Paull, R.A. 1977. The Upper Ordovician Neda Formation of eastern Wisconsin. Pages C1- C18 *in* K.G. Nelson, editor. *Geology of southeastern Wisconsin: a guidebook for the 41st Annual Tri-State Field Conference*. Wisconsin Geological and Natural History Survey. Madison. 151 pp.

Scheffer, M. 2001. *Ecology of shallow lakes*. Kluwer Academic Publishers, Boston.

Schorger, A.W. 1939. The great Wisconsin passenger pigeon nesting of 1871. *The Passenger Pigeon* 1(1):3–11. Available online at http://digital.library.wisc.edu/1711.dl/EcoNatRes.pp01n01.

U.S. Department of Labor, Bureau of Labor Statistics. 2015. Local area unemployment statistics data. Available online at http://www.bls.gov/lau/.

Wisconsin Department of Natural Resources. 2001. *The Upper Green Bay Basin Integrated Management Plan: a report by the Wisconsin Department of Natural Resources in cooperation with the Upper Green Bay Basin Partnership Team and stakeholders.* Wisconsin Department of Natural Resources, PUBL WT 663 2001, Madison.

Wisconsin Department of Natural Resources. 2002. *Remedial decision-making for the lower Fox River/Green Bay remedial investigation, feasibility study, proposed remedial action plan, and Record of Decision: Response to comments on the remedial investigation for the lower Fox River and Green Bay, Wisconsin, feasibility study for the lower Fox River and Green Bay, Wisconsin, proposed remedial action plan for the lower Fox River and Green Bay, and Record of Decision for the lower Fox River and Green Bay*. Wisconsin Department of Natural Resources, Bureau of Remediation and Development, White paper No. 9, Madison.

Wisconsin Department of Natural Resources. 2003. *Remedial decision-making for the lower Fox River/Green Bay remedial investigation, feasibility study, proposed remedial action plan, and Record of Decision for operable units 3 through 5 response to comments on the remedial investigation for the lower Fox River and Green Bay, Wisconsin, feasibility study for the lower Fox River and Green Bay, Wisconsin, proposed remedial action plan for the lower Fox River and Green Bay, and Record of Decision for operable unit 1 and operable unit 2.* Wisconsin Department of Natural Resources, White paper No. 22, Madison.

Wisconsin Department of Natural Resources. 2012. Lakes. Web page. Available online at http://dnr.wi.gov/topic/lakes/.

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Authors

This chapter was authored by the Wisconsin Department of Natural Resources Ecosystem Management Planning Team members Jerry Bartelt, Owen Boyle, Eric Epstein, Vern Everson, Drew Feldkirchner, Eunice Padley, Jeff Schimpff, and Andy Stoltman. See "About the Authors" in Part 3, "Supporting Materials," for a description of team member expertise and experience.

Contributors

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