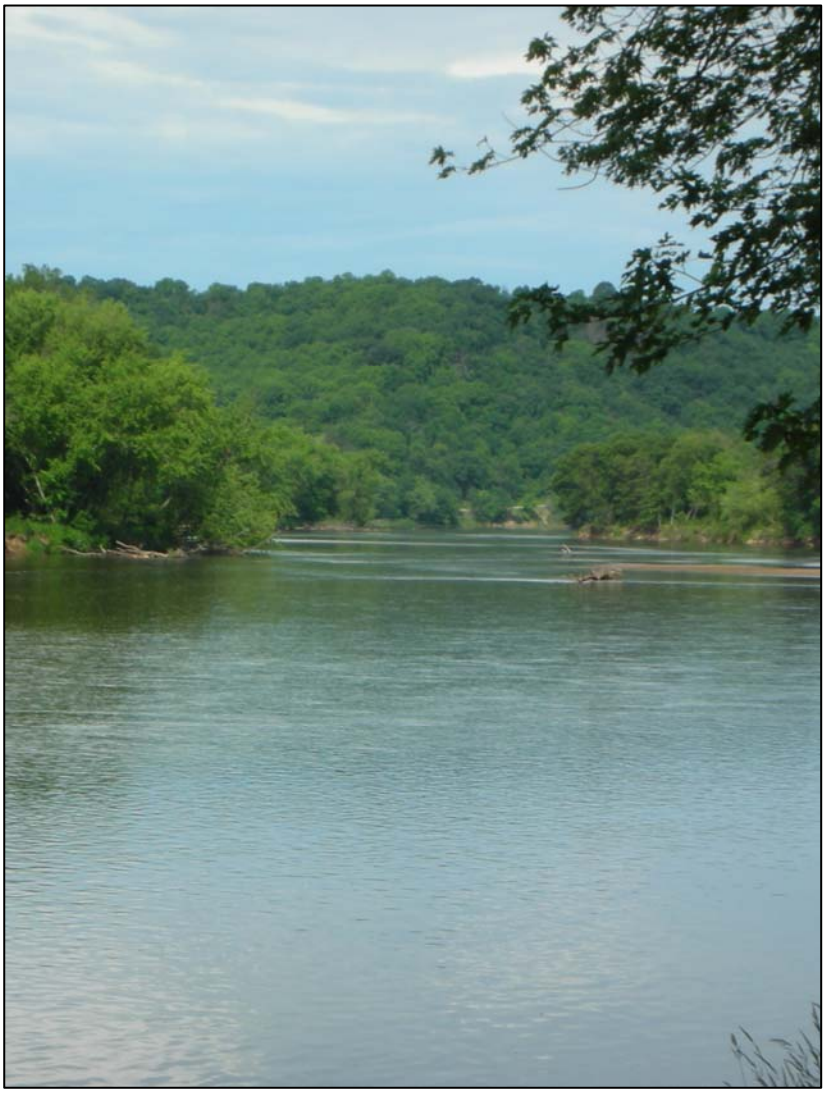

Biotic Inventory and Analysis of the Lower Wisconsin State Riverway

A Baseline Inventory and Analysis of Natural Communities, Rare Plants, and Animals

June 2011

Natural Heritage Inventory Program
Bureau of Endangered Resources
Department of Natural Resources
P.O. Box 7921

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Cover Photos (clockwise, from left): Long Island, photo by Brad Hutnik; Hine's emerald dragonfly (*Somatochlora hineana)* from the study areas, photo by Todd Sima; snow trillium (*Trillium nivale)* from the study area, photo by Ryan O'Connor; Blanding's turtle *(Emydoidea blandingii)* from the study area, photo by Richard Staffen.

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Biotic Inventory and Analysis of the Lower Wisconsin State Riverway

A Baseline Inventory and Analysis of Natural Communities, Rare Plants, and Animals

Primary Authors: Terrell Hyde, Christina Isenring, Ryan O'Connor, Amy Staffen, Richard Staffen

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P.O. Box 7921

Madison, WI 53707-7921

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Executive Summary

Project Purpose and Objectives

The Lower Wisconsin State Riverway Biotic Inventory is the result of a multi-year project to inventory and analyze selected biotic resources of the Lower Wisconsin State Riverway (LWSR), Tower Hill State Park (THSP), State Natural Areas (SNA) within the LWSR, and the surrounding landscape. This project was undertaken by the Natural Heritage Inventory (NHI) program of the Wisconsin Department of Natural Resources' (WDNR) Bureau of Endangered Resources, in cooperation with the Division of Forestry, Water Division, Enforcement and Science Division, and the Bureau of Lands and Facilities. The overall goals were to provide baseline information on rare species, high-quality natural communities, and the overall ecology of the Lower Wisconsin State Riverway (LWSR). Highlighting the study area's best opportunities to conserve biological diversity was the major focus of this project.

A biotic inventory and analysis is one of a number of assessments identified as critical for developing a new state property master plan. The information provided in this report consolidates background information useful for the property master planning team and is intended to be used in conjunction with other sources of information, including the "Regional and Property Assessment," to develop overall recommendations for the property. It is our hope that this information will also be useful to a wider audience that includes managers, administrators, conservation groups, private landowners, and others who have an interest in conserving the biological diversity of this landscape.

The primary objectives of this project were:

- identification and evaluation of natural communities,
- identification and evaluation of rare or otherwise significant plant and animal populations,
- identification and evaluation of selected aquatic features and their associated biota,
- identification of sites appropriate for the restoration of lost or declining communities or important habitats,
- identification of especially important protection, management, and restoration opportunities, focusing on both unique and representative natural features of the LWSR, as well as the surrounding landscape,
- the interpretation and synthesis of the information gathered for use by the property master planning team, as well as managers, administrators, and others involved in the implementation of land use decisions on the LWSR, as well as the surrounding landscape.

Description of the Study Area

The study area is located in Columbia, Crawford, Dane, Grant, Iowa, Richland, and Sauk counties and comprises about 49,995 acres. The study area includes only fee-title WDNR lands and not easements or private conservation lands. The LWSR is within the Lower Wisconsin River Basin, an area that drains approximately 5,050 square miles of southwestern and south central Wisconsin. This area is significant at a national and international scale because the Lower Wisconsin River and all waters of the basin drain into the Mississippi River which then transports the water from the Lower Wisconsin River to the Gulf of Mexico.

The LWSR crosses the width of the Driftless Area. The Driftless Area, also found in southeast Minnesota, northeast Iowa, and northwest Illinois, is an area in which, other than outwash sediments in the river valleys, no glacial features are found. The Lower Wisconsin State Riverway begins at the dam in Prairie

du Sac, near the furthest extent of the Green Bay Lobe of the Laurentide Ice Sheet. From the last dam on the Wisconsin River to the confluence with the Mississippi River, the Lower Wisconsin River is 92.3 miles. The Lower Wisconsin River is one of the longest free-flowing stretches of river in the Midwest. The river valley is four miles wide in the sandstone near Sauk City, but only a half-mile wide in the more resistant dolomite at Bridgeport near the Mississippi River.

Alongside the main stem of the Lower Wisconsin River is an extensive network of floodplain sloughs, lakes and ponds, tributaries, and wetlands. Five wetland impoundments are maintained in the LWSR. Small wetland scrapes have also been created to increase open water in lowlands and floodplain forests.

Although wetlands are sparse in the Western Coulees and Ridges, comprising less than 5% of the land cover, wetlands within the LWSR are numerous and comprise 60% of the land cover. Over half of the LWSR wetlands are forested and almost all of those are deciduous types within a floodplain complex on wet soils. The remaining wetland areas are complexes of emergent marsh, wet meadow, and shrubs.

Historical vegetation for the LWSR was diverse and included both upland and wetland types. Oak Openings and lowland hardwoods were the most common type at 30 and 29%, respectively. Forested and open wetlands, upland woodlands and forests, barrens, and prairies can all be found in high-quality examples within the study area.

Exceptional Characteristics of the Study Area

The LWSR study area contains numerous ecologically important attributes, including several examples of High Conservation Value Forests (see “Priority Opportunities to Conserve Biodiversity”). The characteristics described below are of major importance for master planning and understanding the area’s biodiversity values. They are not listed in order of importance.

- **Ecological Connections:** The LWSR offers a significant opportunity to manage a landscape mosaic of diverse habitats. The connection of upland forests with bedrock outcrops of Dry Prairie with the steep slopes typical of Driftless Area topography to the expansive lowland forests and wetlands of the river valley bottom are an exceptional opportunity for landscape level management. This mosaic of diverse habitats meets the needs of many animal species that require a variety of habitat types for shelter, foraging, rearing their young, and hibernating. By providing this waterbody-to-wetland-to-upland continuum, the habitat needs for wildlife are maximized, and their safe movement from one habitat type to the next is ensured.

- **Migration Corridor:** The Wisconsin River, flowing 430 miles from its point of origin on the Wisconsin-Michigan border at Lac Vieux Desert to its confluence with the Mississippi, provides a critical link from the forests of the north to the Mississippi River and the Gulf of Mexico. In particular, the LWSR is important to the migration of many terrestrial and aquatic species because of its shared boundaries with the nationally significant Mississippi River, the Driftless Area, and the Upper Mississippi migratory bird flyway. Within the Upper Mississippi River Basin, loss of migratory bird habitat was noted as one of three key issues impacting the area (UMFP unk. date).

- **Older Forests / Old-Growth Management Opportunities**: The LWSR offers exceptional opportunities to manage for older forests and old-growth forests on a landscape level and the prospect for old-growth stand development is very good on the LWSR within the next 20 years (WDNR 2010b). Although only 4% of Wisconsin’s forests are over 100 years old and most are between 60 and 80 years old (WDNR 2010c), WDNR Forest Reconnaissance data for the LWSR indicate that 16% of the oak forests and 32% of the bottomland hardwood forests are over 100 years old (WISFIRS 2010). Older forests of the LWSR provide habitat for many rare and declining species in the state, including red-shouldered hawk (*Buteo lineatus)*, cerulean warbler (*Dendroica cerulea*), prothonotary warbler (*Protonotaria citrea)*, Kentucky warbler (*Oporornis*

formosus), Acadian flycatcher (*Empidonax virescens*), and all of Wisconsin's summer resident forest bats including the recently state listed big brown (*Eptesicus fuscus*), little brown (*Myotis lucifugus*), eastern pipistrelle (*Perimyotis subflavus*), and northern long-eared bats (*Myotis septentrionalis*).

- **Natural Community Management and Restoration Opportunities**: The LWSR study area provides important opportunities to protect and enhance many high-quality natural communities including open wetlands, Floodplain Forests, aquatic features, prairies, Oak Openings, Oak Woodlands, and barrens.
- **Management Opportunities for Rare Plants**: Significant management opportunities are present on the LWSR study area related to rare plant species associated with Floodplain Forests, Southern Mesic Forests, Oak Barrens, and Oak Woodlands/Oak Openings.
- **Significant Populations of Rare Animals**: Many animal species groups that are facing declining populations or severe threats have significant management opportunities on the LWSR study area. These groups include: grassland birds, forest interior birds, herptiles, fish, aquatic and terrestrial invertebrates, marsh birds, and bats.

Summary of Biotic Inventory Results

Natural Communities

Within the LWSR, 114 high-quality natural communities representing 26 different types have been documented and are mapped in the NHI database (Table 4). These areas can be considered opportunities to develop or protect High Conservation Value Forests (HCVF; Forest Stewardship Council 2009; HCVFs are not limited to forest types and can include wetlands and prairies).

Rare Vascular Plants

The LWSR supports 92 known element occurrences of 44 NHI Working List plant species, including 4 State Endangered, 5 State Threatened, and 35 State Special Concern species (Table 5). Element occurrences of rare plants are listed by Management Unit in Appendix E. Particularly significant are rare plants associated with four groups of natural communities: 1) Floodplain Forest, 2) Southern Mesic Forest, 3) Oak Barrens, and 4) Oak Woodland/Oak Openings.

Rare Animals

One hundred and three NHI Working List animal species have been documented in the study area, including 15 State Endangered, 22 State Threatened species, and 66 State Special Concern species. Of these species, two Federally Endangered species and one candidate for federal listing is also known from the study area (Table 6). This large number of rare animals from numerous taxonomic groups reflects the overall diversity of good-quality habitats that are present throughout the property. Over 37% of the animals on the State Threatened and Endangered Species lists are found in the LWSR

Threats to Natural Communities, Aquatic Systems, and Rare Species

Potential threats to the biodiversity of the LWSR are all interrelated and include ecological simplification, habitat fragmentation, altered ecological processes, invasive species, deer abundance, climate change, and stormwater runoff and non-point source pollution. Avoiding, limiting, eliminating, or reversing these threats wherever possible will play a key role in conserving and enhancing the biological diversity of the landscape.

Primary Sites: Significance and Summaries

Twenty-eight ecologically important sites were identified on the LWSR study area. These "Primary Sites" were identified because they contain relatively undisturbed, high-quality, natural communities, provide

important habitat for rare species, offer opportunities for restoration, could provide important ecological connections, or some combination of the above factors. Descriptions for each of the Primary Sites can be found in Appendix G. Information provided includes location information, a site map, a brief summary of the natural features present, the site's ecological significance, and management considerations.

Future Inventory, Monitoring and Research Needs

Major inventory, monitoring, and research needs related to the LWSR study area involve taxa specific needs such as fishes, small mammals, bats, invertebrates, and herptiles. Other research needs identified include the impact of management actions on rare and declining species, long-term trends in water quality, and additional biotic inventory at areas such as islands, sandbars, and floodplain lakes.

Introduction

Project Purpose and Objectives

This report is the result of a multi-year project to inventory and analyze selected biotic resources of the Lower Wisconsin State Riverway (LWSR), Tower Hill State Park (THSP), State Natural Areas (SNA) within the LWSR, and the surrounding landscape. This project was undertaken by the Natural Heritage Inventory (NHI) program of the Wisconsin Department of Natural Resources' (WDNR) Bureau of Endangered Resources, in cooperation with the Division of Forestry, Water Division, Enforcement and Science Division, and the Bureau of Lands and Facilities. Project goals were to provide baseline information on the rare species, high-quality natural communities, significant aquatic features, and ecology of the study area relevant to the development of a new master plan for the LWSR and the conservation of biological diversity. Much of the funding and resulting field inventory data collected focused on the terrestrial habitat resources of the property. Additional data pertaining to the aquatic resources of the property, particularly the main channel fishes, is available through Fisheries Management and Science Services. The study area (referred to as LWSR) for this project is shown in Figure 1.

A biotic inventory and analysis is one of a number of assessments identified as critical for developing a new state property master plan. The information provided in this report consolidates background information useful for the property master planning team and is intended to be used in conjunction with other sources of information, including the "Regional and Property Assessment," to develop overall recommendations for the property, including specific management actions. It is our hope that this information will also be useful to a wider audience that includes managers, administrators, conservation groups, private landowners, and others who have an interest in conserving the biological diversity of this landscape.

The primary objectives of this project were:

- identification and evaluation of natural communities,
- identification and evaluation of rare or otherwise significant plant and animal populations,
- identification and evaluation of selected aquatic features and their associated biota,
- identification of sites appropriate for the restoration of lost or declining communities or important habitats,
- identification of especially important protection, management, and restoration opportunities, focusing on both unique and representative natural features of the LWSR, as well as the surrounding landscape, and
- interpretation and synthesis of the information gathered for use by the property master planning team, as well as managers, administrators, and others involved in the implementation of land use decisions on the LWSR, as well as the surrounding landscape.

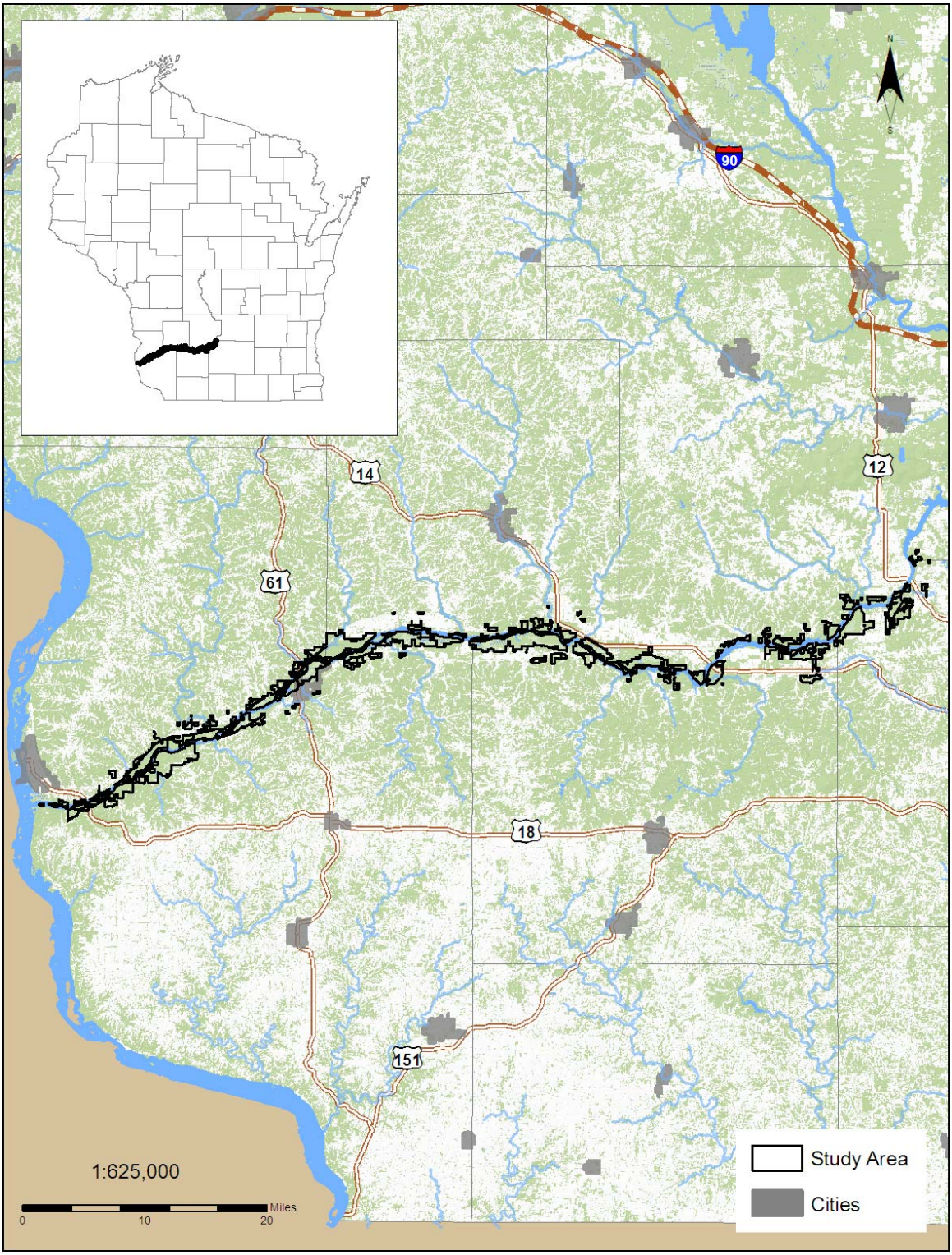

Figure 1. The study area and surrounding landscape.

Overview of Methods

The Wisconsin Natural Heritage Inventory (NHI) program is part of the Wisconsin DNR's Bureau of Endangered Resources and a member of an international network of natural heritage programs representing all 50 states, as well as portions of Canada, Latin America, and the Caribbean. These programs share certain standardized methods for collecting, processing, and managing data for rare species and natural communities. NatureServe, an international non-profit organization, coordinates the network (see *www.NatureServe.org* for more information).

Natural heritage programs track certain elements of biological diversity: rare plants, rare animals, high-quality examples of natural communities, and other selected natural features. The NHI Working List lists plants and animals, as well as the natural community types recognized by NHI. The NHI Working List is periodically updated to reflect new information about the rarity and distribution of the state's plants, animals, and natural communities. The most recent Working List is available from the Wisconsin DNR Web site ("Wisconsin Natural Heritage Working List").

The Wisconsin NHI program uses standard methods for biotic inventory to support master planning (Appendix A). Our general approach involves collecting relevant background information, planning and conducting surveys, compiling and analyzing data, mapping rare species and high quality natural community locations into the NHI database, identifying ecologically important areas, and providing interpretation of the findings through reports and other means.

Biotic inventory for the LWSR was slightly different than most other properties. The NHI Program expressed the need to conduct biotic inventory for the LWSR in 2007 due to the lack of recent data, the known biological importance of the area, and the apparent heightened interest in conducting active timber management at that time. "Coarse-filter" sites (see Appendix A) were delineated in 2007 using information available at that time. As there was no funding to conduct surveys, it was decided that these sites might temporarily serve as surrogate "Primary Sites" for discussing timber management options. In 2008, funding became available through the Division of Forestry and the Bureau of Facilities and Lands to conduct a limited level of rare plant and natural community surveys, and in 2009 funding became available to conduct the full-scale biotic inventory efforts that culminated in this report. Throughout the project, the original "coarse-filter" sites were a major tool for guiding inventory efforts; however, the final Primary Sites are very different, as they are based on much more detailed level of survey data and subsequent analyses.

Field surveys for the LWSR biotic inventory were conducted in 2008 and 2009. Many sources were consulted to aid in the identification and prioritization of survey sites within the LWSR. Existing NHI data and discussions with LWSR staff, and the expertise of several biologists familiar with the properties or with

Inventory and Primary Site selection for the Lower Wisconsin State Riverway

- The ecological significance of the LWSR is well-known and inventory of the biotic resources of the property and surrounding area have been ongoing for decades and been done by many people and organizations.
- In 2007, prior to any funding available for a full-scale biotic inventory, the Natural Heritage Inventory Program used best available data to develop "coarse-filter" sites.
- These "coarse-filter" sites served as surrogate "Primary Sites" for discussing timber management options.
- Biotic inventory by the NHI program and partners occurred in 2008 and 2009. This followed standard methods NHI uses to conduct all biotic inventories
- The original "coarse-filter" sites were a major tool for guiding NHI's inventory efforts.
- Official Primary Sites were designated after the biotic inventory effort and were developed using standards similar to other state lands.

similar habitats in the region are often the starting point for conducting a biotic inventory to support master planning. Additional references included interpretations of local and regional land cover from recent aerial photographs and topographical maps and information from the original land surveys for the area. The collective results from these surveys and subsequent analyses were used to identify survey sites on the LWSR.

Key inventory considerations for the LWSR were gaps in existing inventory data and habitats with management opportunities. Focal areas included large blocks of Floodplain Forest, patches of less fragmented older forest with diverse structure (or the potential for developing structural attributes associated with older forests), oak forests with rich and diverse ground layer composition, intact wetland and aquatic backwater communities, and remnant prairies. These areas have been found to harbor rare or otherwise sensitive habitat specialists. Private lands surrounding the LWSR were not surveyed.

Standard methods were used for surveying each taxa group. Table 1 summarizes the surveys conducted during the project along with the principal investigator(s) and the scope of each survey.

Table 1. Field surveys coordinated by the Natural Heritage Inventory during 2008-2009

Survey	Biologist(s)	Scope of Taxa Surveyed
Aquatic Invertebrates	Matthew Berg, Todd Sima, Nick Sievert, Robert Dubois, Gregor Schuurman, William A. Smith	All species sampled were documented.
Bats	Dave Redell, Jennifer, Schehr, Paul White	Data were collected for all species encountered.
Birds	Matthew Berg, Barb Duerksen, Richard Staffen	Bird counts documenting all species encountered and targeted surveys for select species on the Working List.
Herptiles	Gary S. Casper	Targeted surveys for Working List species. All species encountered during these surveys were documented.
Natural Communities	Craig Anderson, Andy Clark, Christina Isenring, Janeen Laatsch, Ryan O'Connor	All plant species encountered during these surveys were documented as part of the natural community description.
Rare Forest Raptors	Richard Staffen	Targeted surveys for Working List species.
Rare Plants	Craig Anderson, Andy Clark, Christina Isenring, Janeen Laatsch, Ryan O'Connor	Targeted surveys for Working List species. All species encountered during these surveys were documented.
Terrestrial Invertebrates	Kathryn Kirk, Scott Sauer, Cathy Bleser	Targeted surveys for Working List species. All species encountered during these surveys were documented.

Table 2. Additional recent or ongoing field survey efforts accessed for the Biotic Inventory Report

Survey	Biologist(s)	Scope of Taxa Surveyed
Aquatic Invertebrates	Steven Burian, Marian Havlik, Dave Heath, Karl Legler, Richard Lillie, Glenn Miller, Kurt Schmude, Ken Tennessen	Data were collected for all species encountered. Records were entered into the Invertebrate Atlas database as well as NHI.
Birds	Cathy Bleser, Mike Mossman, Aaron Holsbach, eBird, WBCI Bird Monitoring	Data were collected for all species encountered. Targeted taxa include marsh birds, nocturnal birds, forest birds.
Fishes	John Lyons, Dave Marshall, Jean Unmuth	Data were collected for all species encountered. Targeted aquatic habitats include main channel and floodplain sloughs, lakes and ponds
Herptiles	Cathy Bleser, Mike Mossman	Wisconsin Frog and Toad Surveys
Invasive Species	Brad Hutnik, Mike Mossman, SCR SNA Crew	
Natural Communities	Brad Hutnik	
Small Mammals	Mike Mossman, Ryan Stephens	All species encountered during surveys were documented.
Terrestrial Invertebrates	Ann and Scott Swengel, Rich Henderson	Targeted surveys for Working List species. All species encountered during these surveys were documented

Background on Previous Efforts

Various large-scale research and planning efforts have identified a number of locations within the LWSR as being ecologically significant. The following are examples of such efforts and the sites that were identified and described by those efforts.

Land Legacy Report

The Land Legacy Report (WDNR 2006a) was designed to identify Wisconsin's most important conservation and recreation needs for the next 50 years. The report assigned a score of five points on their five-point scale of conservation significance to the LWSR, meaning it possesses "outstanding ecological qualities, is of adequate size to meet the needs of the critical components, and/or harbors natural communities or species of global or continental significance."

Lower Wisconsin State of the Basin Report

The Lower Wisconsin State of the Basin Report (2002) was prepared in consultation with local units of government, other agencies, private citizens and other conservation organizations in the Lower Wisconsin River Basin. The report is designed to give an overall assessment of the health and status of land and water resources throughout the basin. Issues and threats that affect the basin are discussed as are their impact on statewide resources.

Wisconsin Wildlife Action Plan: Conservation Opportunity Areas

The area encompassing the LWSR was recognized in the Wisconsin Wildlife Action Plan (WWAP; WDNR 2006b) as having three Conservation Opportunity Areas (COA) (Appendix B). All of these COAs include land that is outside of the study area, including private land and other public land. Conservation Opportunity Areas are places in Wisconsin containing ecological features, natural communities, or Species of Greatest Conservation Need (SGCN) habitat for which Wisconsin has a unique responsibility for protecting when viewed from the global, continental, upper Midwest, or state perspective (WDNR 2006b).

The Lower Wisconsin Bluffs and Floodplain COA and the Lower Wisconsin River COA were recognized because of the large river system that includes riparian natural and upland natural communities that support numerous Species of Greatest Conservation Need.

The Snow Bottom COA and Dodgeville Wyoming Oak Woodlands/Savanna COA were recognized because of the Driftless Area natural communities including a continuum of Dry Prairie, Dry-Mesic Prairie, Oak Opening, Oak Woodland, Southern Dry Forest, Southern Dry-mesic Forest, Southern Mesic Forest, Shrub-carr, Dry Cliffs, and Moist Cliffs that support SGCN.

The Nature Conservancy's Prairie Forest Border Ecoregion: A Conservation Plan

The Nature Conservancy's (TNC) Prairie-Forest Border Ecoregion Conservation Plan (TNC 2001) recognized the Lower Wisconsin River as a "Functional Landscape." A functional landscape is a portfolio site selected for both coarse-scale aquatic and terrestrial targets and is intended to represent many other ecological systems, communities, and species (i.e., "all" biodiversity). The Lower Wisconsin River was recognized because it represents an aquatic system of the highest ecological significance, as it supports numerous rare species of fish, mussels, and insects. The diversity of natural communities adjoining the river is exceptional, including prairies of many types, Oak Barrens, Pine Barrens, Emergent and Submergent Marshes, Floodplain Forest, and upland hardwood forests. Several of these communities are represented by occurrences that are among the largest and most viable of their respective types. Plant and animal life is correspondingly rich, and this landscape must be regarded as critical habitat for many rare or otherwise sensitive species.

The Nature Conservancy's Rivers of Life: Critical Watersheds for Protecting Freshwater Biodiversity Report

The Lower Wisconsin River was one of 327 small watersheds, identified by The Nature Conservancy as a critical watershed to protect and restore to conserve all at-risk freshwater fish and mussel species in the United States (Master 1998). This 1998 report identified the following threats to these communities: pollution (point and non-point), non-native species, dams and associated operations, land-use changes/alterations, and water extraction.

Important Bird Area

Important Bird Areas (IBA; WDNR 2007) are critical sites for the conservation and management of Wisconsin's birds. The Lower Wisconsin River IBA includes all but the final 6 miles of the 92 mile stretch of the Lower Wisconsin River. The Lower Wisconsin River IBA is especially significant for: 1) birds of floodplain and upland forest, especially species that require large tracts; 2) barrens (ranging from sand prairie to oak-pine woodland); and 3) open wetlands (ranging from wet prairie to shallow and deep marsh and shrub carr) (M. Mossman personal communication). Especially important within the IBA are the gradual and fairly natural ecotones between various community types.

Wisconsin Wetlands Association Wetland Gems

The LWSR, along with Wyalusing State Park, was recognized by the Wisconsin Wetlands Association (WWA) as being a "wetland gem." "Wetland gems" support habitats that are critically important to Wisconsin's biodiversity, provide nearby communities with valuable functions and services, and serve as recreational and educational opportunities (WWA 2009). The LWSR was recognized because the floodplain wetlands are critical to maintaining the health of the Wisconsin River and support a variety of rare and sensitive species.

Grassland Bird Habitat Management

The Lower Wisconsin River Prairies and Barrens was recognized as a Priority Landscape for Grassland Bird Management (Sample and Mossman 1997) because of the complex of sites that contains high quality bird habitat of dry or sand prairie and oak or river barrens sites, which are especially important for lark sparrows (*Chondestes grammacus*) and associated species. This Priority Landscape has the potential for connecting sites along the river corridor and expanding grassland acreage through restoration and buffering.

Special Management Designations

State Natural Areas are places on the landscape that protect high quality examples of natural communities, rare species populations, significant geological formations, and archeological sites.

Twenty SNAs, totaling approximately 6,740 acres or 13% of the fee-title property within the LWSR, have been established within the LWSR. These sites harbor a broad spectrum of native terrestrial and aquatic plant communities that are an excellent reflection of the diversity of this biologically rich landscape (WDNR 2010b).

Eighteen State Natural Areas within the LWSR are owned by the WDNR and covered in this report:

- Adiantum Woods
- Arena Pines and Sand Barrens
- Avoca Prairie and Savanna
- Bakken's Pond
- Blue River Bluffs
- Blue River Sand Barrens
- Ferry Bluff
- Gotham Jack Pine Barrens
- Mazomanie Bottoms
- Mazomanie Oak Barrens
- Orion Mussel Bed
- Richwood Bottoms
- Smith Slough and Sand Prairie
- Tower Hill Bottoms
- Wauzeka Bottoms
- Woodman Lake Sand Prairie and Dead Lake
- Wyalusing Hardwood Forest
- Wyalusing Walnut Forest

The remaining two SNA's not owned by the WDNR and not covered in this report are:

- Lodde's Mill Bluff (owned by the University of Wisconsin)
- Spring Green Preserve (owned by The Nature Conservancy with some WDNR-owned easements)

Dedicated State Natural Areas are permanently protected through an Article of Dedication on the property. Within the LWSR, portions or all of Blue River Bluffs SNA, Ferry Bluff SNA, and Wyalusing Hardwood Forest SNA are dedicated. Dedicated SNAs differ from designated SNAs because the Article of Dedication can be removed from the property only with the approval of the governor and the legislature. SNAs designated through a designation agreement can be cancelled after a short notice period.

Habitat Preservation Areas are defined as lands and waters containing excellent natural habitat and characteristics that are conducive to perpetuation and production of fish and wildlife. The 1988 master plan for the LWSR proposed two Habitat Preservation Areas, totaling 642 acres, to protect rare invertebrates (WDNR 1988). The Orion Mussel Bed State Natural Area was established as one Habitat Preservation Area. The other, Woodman Habitat Preservation Area, has not yet been established.

A **National Natural Landmark** has been officially recognized within the LWSR at the Avoca River-Bottom Prairie because it contains the largest intact prairie in Wisconsin. The National Natural Landmarks Program is administered by the National Park Service and recognizes outstanding examples of biological and geological features throughout the country.

Exceptional Resource and Outstanding Resource Waters are officially designated (NR 102.11) waters that provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. The Lower Wisconsin River is listed as an Exceptional Resource Waterway (ERW) affording increased water quality protection. Other ERW within the LWSR are Dunlap Creek, Hoover Hollow Creek, Crooked Creek, and all lacustrine bodies of water in the floodplain of the Wisconsin River. Other waterways designated Outstanding Resource Waters within the LWSR are the Big and Little Green Rivers. Outstanding Resource Waters (ORW) typically do not have any point sources discharging pollutants directly to the water (for instance, no industrial sources or municipal sewage treatment plants) and no increases of pollutant levels are allowed. Less than 8% of the rivers and streams in Wisconsin have been designated Outstanding Resource Waters. In addition, there are 38 ERW tributary streams and 7 ORW tributary streams that eventually flow into the river within the LWSR.

Forest Certification

All DNR-managed lands, including state parks, wildlife areas, and natural areas, are recognized by the Forest Stewardship Council and the Sustainable Forestry Initiative as being responsibly managed (WDNR 2009). This certification emphasizes the state's commitment to responsibly managing and conserving forestlands, supporting economic activities, protecting wildlife habitat, and providing recreational opportunities.

Lower Wisconsin River slough (Photo by William A. Smith)

Regional Ecological Context

Western Coulee and Ridges Ecological Landscape

This section is largely reproduced from the Ecological Landscapes of Wisconsin Handbook (WDNR In Prep. a). This Handbook was developed by the WDNR Ecosystem Management Planning Team (EMPT) 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.

The WDNR has mapped the state into areas of similar ecological potential and geography called Ecological Landscapes. The Ecological Landscapes are based on aggregations of smaller ecoregional units (Subsections) from a national system of delineated ecoregions known as the National Hierarchical Framework of Ecological Units (NHFEU) (Cleland et al. 1997). These ecoregional classification systems delineate landscapes of similar ecological pattern and potential for use by resource administrators, planners, and managers. The majority of the LWSR is located within the Mississippi-Wisconsin River Ravines Subsection of the NHFEU.

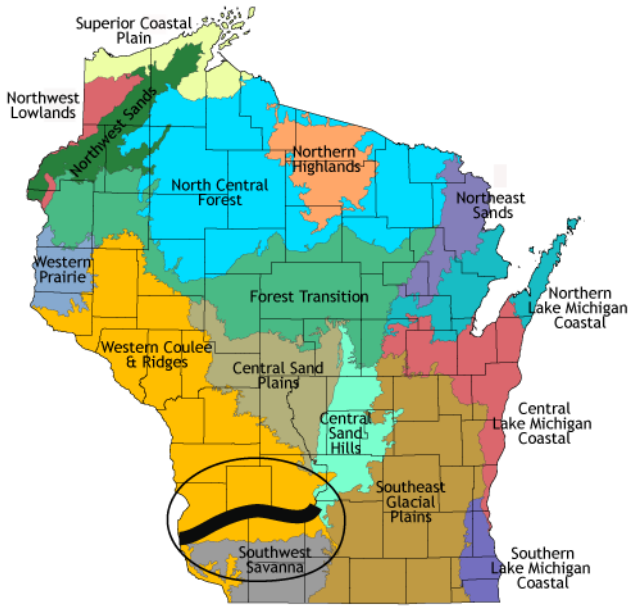

Figure 2. Location of the study area and the Ecological Landscapes of Wisconsin

The LWSR study area is located in the Western Coulee and Ridges Ecological Landscape (WDNR In prep. a) (Figure 2). The Western Coulee and Ridges Ecological Landscape extends over 9,642 square miles, representing 17.2% of the land area of the State of Wisconsin. It is the largest Ecological Landscape in the State.

The Western Coulee and Ridges Ecological Landscape in southwestern and west central Wisconsin is characterized by its lack of glaciation. It is part of the region called the “Driftless Area” because it lacks glacial deposits (although glacial outwash materials do occur in river valleys). The topography here is unique in Wisconsin due to the long period of erosion, with dissected ridges, steep-sided valleys, and extensive networks of streams. The Western Coulee and Ridges is still relatively heavily forested as compared with the rest of southern Wisconsin. The Baraboo Range, formed primarily of the Precambrian Baraboo Quartzite, is located in the eastern part of the Ecological Landscape. Several large rivers

including the Wisconsin, Mississippi, Chippewa, Kickapoo and Black flow through or border the Ecological Landscape.

Historical vegetation for the Western Coulee and Ridges Ecological Landscape consisted of southern hardwood forests, oak savanna, scattered prairies, and Floodplain Forests and marshes along the major rivers. As a result of widespread Euro-American settlement, most of the relatively flat land on ridgetops and valley bottoms were cleared of oak savanna, prairie, and forest for agriculture. The steep slopes between valley bottom and ridgetop, unsuitable for raising crops, grew into oak-dominated forests after the pre-settlement wildfires were suppressed.

Regional Biodiversity Needs and Opportunities

Opportunities for sustaining natural communities in the Western Coulee and Ridges Ecological Landscape were developed by the Ecosystem Management Planning Team (EMPT 2007) and later presented in the Wisconsin Wildlife Action Plan (WDNR 2006b). The goal of sustaining natural communities is to manage for natural community types that historically occurred in a given landscape and have a high potential to maintain its characteristic composition, structure, and ecological function over a long period of time (e.g., 100 years). This list can help guide land and water management activities so that they are compatible with the local ecology of the Ecological Landscape while maintaining important components of ecological diversity and function. These are the most appropriate community types that could be considered for management activities within the Western Coulee and Ridges Ecological Landscape.

There are management opportunities for 45 natural communities in the Western Coulee and Ridges Ecological Landscape. Of these, 24 are considered “major” opportunities (Table 2). A “major” opportunity indicates that the natural communities can be sustained in the Ecological Landscape, either because many significant occurrences of the natural community have been recorded in the landscape or major restoration activities are likely to be successful in maintaining the community’s composition, structure, and ecological function over a longer period of time. An additional 13 natural communities are considered “important” in this landscape. An “important” opportunity indicates that although the natural community does not occur extensively or commonly in the Ecological Landscape, one to several occurrences do occur and are important in sustaining the community in the state. In some cases, important opportunities may exist because the natural community may be restricted to just one or a few Ecological Landscapes within the state and there may be a lack of opportunities elsewhere.

Table 2. Major Natural Community Management Opportunities in the Western Coulee and Ridges Ecological Landscape (EMPT 2007 and WDNR 2006b)

Algific Talus Slope	Dry Prairie	Oak Barrens	Southern Dry Forest
Bedrock Glade	Dry-mesic Prairie	Oak Opening	Southern Dry-mesic Forest
Cedar Glade	Emergent Marsh	Oak Woodland	Southern Mesic Forest
Coldwater streams	Floodplain Forest	Pine Relict	Submergent Marsh
Coolwater streams	Hemlock Relict	Sand Prairie	Surrogate Grasslands
Dry Cliff	Moist Cliff	Shrub Carr	Warmwater rivers

Rare Species of the Western Coulee and Ridges Ecological Landscape

Numerous rare species are known from the Western Coulee and Ridges Ecological Landscape. "Rare" species include all of those species on the WDNR's NHI Working List (*Wisconsin Natural Heritage Working List*) that are classified as "Endangered," "Threatened," or "Special Concern." Table 3 lists species known to occur in the Southeast Glacial Plains Ecological Landscape based on information stored in the NHI database as of November 2009 (WDNR In Prep. a).

Table 3. Listing Status for rare species in the Western Coulee and Ridges Ecological Landscape as of 2009.

Listing Status	Birds	Fishes	Herptiles	Invertebrates	Mammals	Plants	Total Fauna	Total Flora	Total Listed
WI Endangered	6	7	5	16	0	18	34	18	52
WI Threatened	9	9	2	10	0	28	30	28	58
WI Special Concern	15	11	11	70	7	84	114	84	198
U.S. Endangered	0	0	0	2	1	0	3	0	3
U.S. Threatened	0	0	0	0	0	2	0	2	2
U.S. Candidate	0	0	1	2	0	0	3	0	3

The Wisconsin Wildlife Action Plan denoted Species of Greatest Conservation Need. Species of Greatest Conservation Need are animals that have low and/or declining populations that are in need of conservation action. They include various birds, fish, mammals, reptiles, amphibians, and invertebrates (e.g. dragonflies, butterflies, and freshwater mussels) that are:

- Already listed as threatened or endangered;
- At risk because of threats to their life history needs or their habitats;
- Stable in number in Wisconsin, but declining in adjacent states or nationally.
- Of unknown status in Wisconsin and suspected to be vulnerable.

There are 72 vertebrate SGCN significantly associated with the Western Coulee and Ridges Ecological Landscape (See Appendix C). This means that these species are (and/or historically were) significantly associated with the Ecological Landscape, and that restoration of natural communities with which they are associated would significantly improve conditions for their survival. SGCN status is independent of State Listing Status and the NHI Working List. Most but not all SGCNs are on the NHI Working List (published April 2009); in addition, the NHI Working List also includes rare species that are not designated as SGCN.

Covering less than 1% of the Western Coulee and Ridges Ecological Landscape, the study area supports 47% of the rare species and 71% of the natural communities (that are major management opportunities) that are known from this landscape.

Description of the Study Area

Location and Size

The study area is located in Columbia, Crawford, Dane, Grant, Iowa, Richland, and Sauk counties and comprises about 49,995 acres. The study area includes only fee-title WDNR lands and not easements or private conservation lands. The LWSR is within the Lower Wisconsin River Basin, an area that drains approximately 5,050 square miles of southwestern and south central Wisconsin. This area is significant at a national and international scale because the Lower Wisconsin River and all waters of the basin drain into the Mississippi River which then transports the water from the Lower Wisconsin River to the Gulf of Mexico. The surrounding landscape of the LWSR consists of fragmented upland forests on the steep slopes and agricultural lands in the river valleys and on the flat ridge tops (Figure 3).

The Study Area

- The study area (referred to as the LWSR) includes only fee-title WDNR lands and not easements or private conservation lands.
- The study area is located in Columbia, Crawford, Dane, Grant, Iowa, Richland, and Sauk counties and comprises about 49,995 acres.
- The study area spans the width of the Driftless Area and includes a level outwash area that forms the current river valley and sandstone cliffs 160 to 300 ft high at the valley walls.
- Soils on hilltops and sideslopes range from well-drained to moderately well-drained and floodplain soils are poorly drained.
- The Lower Wisconsin River flows about 92.3 miles through the study area.
- Important hydrological features include tributary streams; floodplain sloughs, lakes, ponds, and wetlands; and impounded wetlands.

Figure 3. Landcover for the study area and surrounding landscape from the WDNR Wiscland GIS coverage (WDNR 1993).

Ecoregion

Landtype Associations

Nested hierarchically within each Ecological Landscape are Subsections derived from the NHFEU and each Subsection is further divided into Landtype Associations (LTAs) (Cleland et al. 1997). Landtype Associations (LTAs) are the finer scaled polygons, areas of 10,000 – 300,000 acres, that make up each subsection characterized by repeating patterns of characteristic landforms, soil groups, regional climate, and potential vegetation and are most relevant to this study. Figure 4 shows the distribution of the following LTAs on the LWSR:

- **Mississippi River Valley Train-South (222Lc17).** The characteristic landform pattern is valley train terrace and floodplain with river islands and flood plains. Soils are excessively drained and poorly drained sandy soils with a loamy fine sand or sand surface over non-calcareous sand alluvium or outwash. This LTA comprises 73% of the LWSR.
- **Hills and Valleys - Wisconsin River Drainage (222Lc18).** Soils are well drained and moderately well drained silty and loamy with a silt loam or sandy loam surface over non-calcareous clayey or loamy residuum or over silty loess; most areas over limestone, sandstone, or shale bedrock. This LTA comprises 16% of the LWSR.
- **LeFarge Hills and Valleys (222Ld02).** Soils are well drained loam and silt with a silt loam surface over non-calcareous loamy, sandy, or clayey residuum or over silty loess; most areas over glauconitic sandstone bedrock. This LTA comprises 5% of the LWSR.
- Comprising less than 1% of the LWSR are the following LTAs: **Roxbury Hills (222Kd09); Rountree Ridges, Tunnel City Hills, and Valleys-South (222Lc16);Viroqua Ridge (222Lc15);** and **Richland Ridge (222Ld01).**

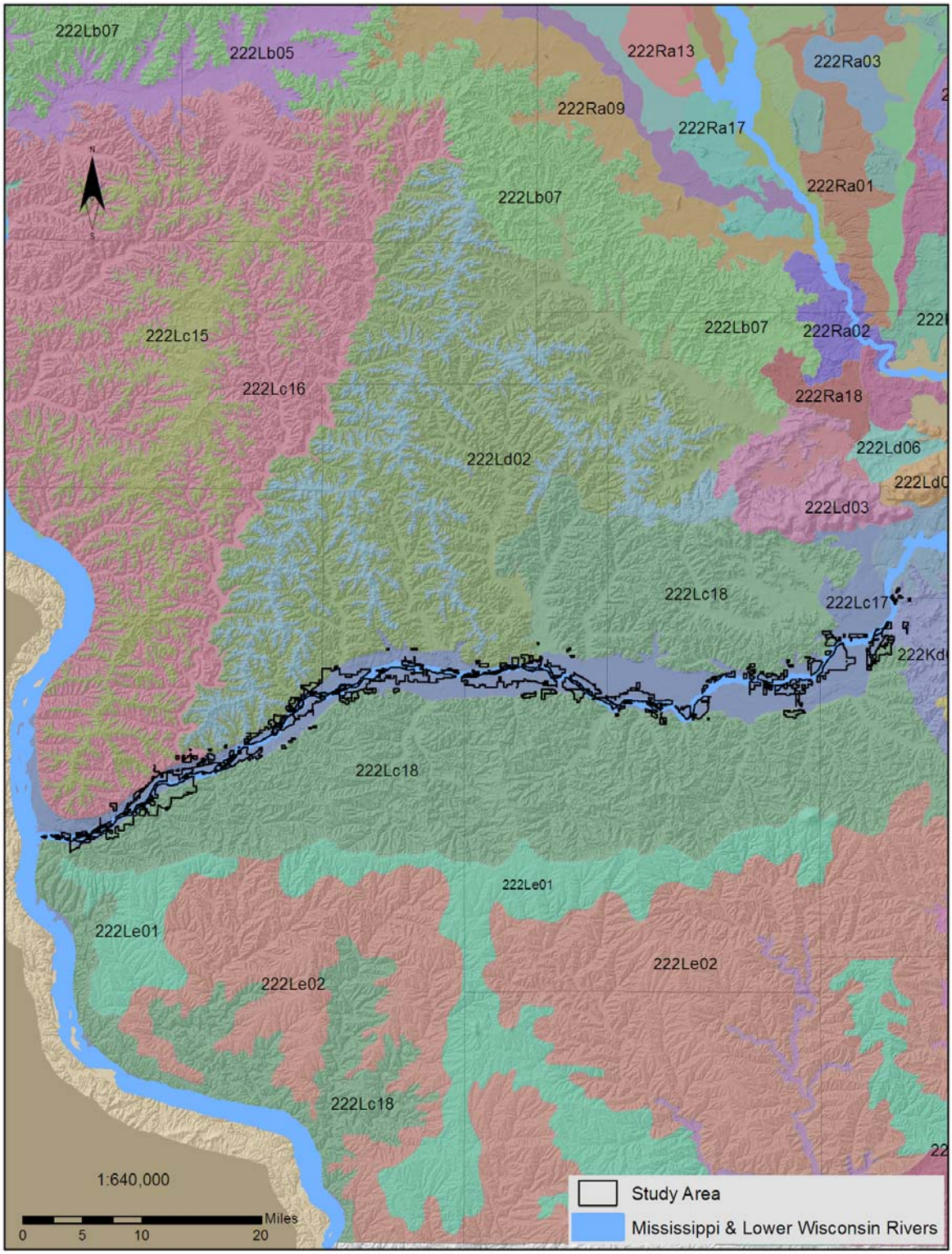

Figure 4. Landtype Associations of the study area and surrounding landscape.

Physical Environment

Geology and Geography

The LWSR crosses the width of the Driftless Area. The Driftless Area, also found in southeast Minnesota, northeast Iowa, and northwest Illinois, is an area in which, other than outwash sediments in the river valleys, no glacial features are found (WDNR In Prep. a). Glaciers have not been active in this area for at least 2.4 million years, and if any glacial till were deposited prior to that time, it has been removed by erosion. The stream-dissected topography of this eroded landscape is characterized by deeply incised, steep-walled valleys, and bedrock controlled ridgetops.

The Lower Wisconsin State Riverway begins at the dam in Prairie du Sac, near the furthest extent of the Green Bay Lobe of the Laurentide Ice Sheet. The terminal moraine that formed along the edge, called the Johnson Moraine, is visible in the broad outwash plain north of Sauk City in Sauk County.

The ancient Lower Wisconsin River eroded through St. Peter Sandstone and Prairie du Chien Dolomite into the Cambrian sandstone, carving a valley as much as 500 feet deep. Braided outwash rivers that drained the western edge of the Green Bay Lobe later partly filled the valley with 100 to 200 feet of sands and gravels flushed from the melting glacier. As the ancient braided outwash rivers cut through the Prairie du Chien Dolomite and St. Peter Sandstone, sandstone cliffs 160 to 300 feet high formed at valley walls that were capped with resistant Prairie du Chien Dolomite (Schultz 1986; Dott and Attig 2004).

The level outwash areas, called valley trains, that form the current river valley, create an area of glacial drift in an otherwise drift-free region. The level outwash areas are eroded and create terraces or benches that are somewhat higher and better drained than the floodplain.

The river continues to move glacial outwash and eroded sandstone downriver forming islands and constantly changing sandbars.

Soils

After the glaciers from the Laurentide Ice Sheet retreated from Wisconsin, the exposed outwash in the floodplains of the Mississippi and its tributaries, including the Lower Wisconsin River, became the source of windblown material that settled as loess over the region. The westerly prevailing winds resulted in a thick layer of loess on the hills of the Driftless Area. Close to the Mississippi, the loess can be up to 60 feet deep (Dott and Attig 2004). Loess forms a fertile soil with excellent moisture-holding characteristics, and floodplain soils with incorporated loess are highly productive (WDNR In Prep. a).

Soils on hilltops and sideslopes are formed in loess, loamy to clayey residuum, and loamy colluvium over sandstone or dolomite (WDNR In Prep. a; Soil Survey Staff). They range from well-drained to moderately well-drained and typically have silt loam to sandy loam surface textures, moderate permeability, and moderate available water capacity. Sideslopes, particularly on south- and west-facing slopes, tend to be dry and erodible, and have shallow depths to bedrock.

The floodplain soils of the LWSR are poorly drained, frequently flooded sandy, silty, or loamy alluvium. Some of the floodplain soils are stratified with different textural classes deposited by streamflows of different intensity (WDNR In Prep. a).

Hydrology

The stretch of the Lower Wisconsin River included in the study area is from the last dam on the Wisconsin River to the confluence with the Mississippi River, about 92.3 miles. This stretch of the Lower Wisconsin River is one of the longest free-flowing stretches of any river in the Midwest. The river valley is four miles wide in the sandstone near Sauk City, but only a half-mile wide in the more resistant dolomite at Bridgeport near the Mississippi River. The channel averages an eighth to a quarter of a mile wide (Dott and Attig 2004) and carries sediment dominated by medium to coarse sand and small pebbles.

The largest tributary to the Lower Wisconsin River below the Prairie du Sac dam is the Kickapoo River, a warm water river that enters at Wauzeka. Other tributaries include Honey Creek, Pine River, Mill Creek, Blue Mounds Creek, and Blue River.

Alongside the main stem of the section of the Lower Wisconsin River below the Prairie du Sac dam is an extensive network of floodplain sloughs, lakes and ponds, small tributaries, and wetlands. Some of the larger floodplain lakes are named, including Avoca Lake (48 acres), Woodman Lake, and Bakken's Pond, both around 20 acres and connected to the river during high water (WDNR In Prep. a). Other lakes and sloughs are small, numerous, and generally unnamed. Many of these unique waterbodies are ecologically diverse, supporting an unusual blend of both lake and riverine fishes, aquatic plants, mussels and other aquatic animals not commonly found in the main channel of the river. Studies suggest that upland groundwater plays an important role in sustaining off-channel fish habitats. Pfieffer et al. (2006) describe the groundwater surrounding the Lower Wisconsin River as a dynamic river aquifer consisting of deep, intermediate and shallow groundwater flow systems. Elsewhere, upland or hillslope groundwater has been recognized as an important factor in the survival of many fish species (Amoros and Bornette 2002). The highest quality floodplain lakes, sloughs and oxbows surveyed were biologically productive, but were relatively clear due to a combination of upland groundwater inputs and rooted aquatic plant suppression of planktonic algae (Marshall 2008, 2009, 2010). These backwater areas include large numbers of Special Concern, Threatened and Endangered fish species.

Five wetland impoundments are maintained in the LWSR. Flowage water levels are managed by periodic drawdowns to enhance waterfowl food production, to maintain a 1:1 ratio of open water and emergent vegetation, to allow for dam inspections and to control plant community succession. Small wetland scrapes have also been created to increase open water in lowlands and floodplain forests (WDNR 2010b).

Although wetlands are sparse in the Western Coulee and Ridges, comprising less than 5% of the land cover, wetlands within the LWSR are numerous and comprise 60% of the land cover. Over half of the LWSR wetlands are forested and almost all of those are deciduous types within a floodplain complex on wet soils. The remaining wetland areas are complexes of emergent marsh, wet meadow, and shrubs.

Vegetation

Historical Vegetation

The LWSR is located south of the tension zone, a zone that separates two floristic provinces, the prairie-forest province and the northern hardwoods province (Curtis 1959).

The Public Land Survey System were surveys conducted by the US General Land Office to establish the current township-range-section system of property description. For the area comprising the LWSR, these surveys were conducted between 1832 and 1850. Data from these surveys are often used to infer forest composition and tree species dominance for large areas in Wisconsin prior to widespread Euro-American settlement (Schulte and Mladenoff 2001). 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 which 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 (WDNR In Prep. a).

The narrow, linear shape of the study area does not lend itself well to a thorough evaluation of the Public Land Survey System tree data due to the low number of witness trees located within the boundary, but general tree abundance can be examined. Using Wisconsin Wetlands Inventory (WWI) maps, the Public Land Survey System tree data was differentiated between upland and wetland areas.

Historically, Oak Openings were the most common type at 30% of the study area (Finley 1976; Figure 5). Other common upland types included oak and mesic forest. Prairie was less common and wasn't distinguished between dry or wet types. Based on witness trees recorded for the areas within the study area that were not represented as wetlands in the WWI, the top four most often reported trees (representing 83% of the trees in the uplands) were, in descending order, white oak (*Quercus alba)*, black oak (*Quercus velutina)*, northern pin oak (*Quercus ellipsoidalis)*, and bur oak (*Quercus macrocarpa)* (Figure 6). Twenty-two other trees were mentioned, but each was represented by 10 or fewer trees.

Lowlands hardwoods were the second most common type at 29% of the study area (Finley 1976; Figure 5). Other common wetland types included marsh, sedge meadow, wet prairie, and lowland shrubs. Based on the witness trees recorded for the areas within the study area represented by wetlands in the WWI, the top eight most often reported trees (representing almost 80% of the trees within the wetlands) were, in descending order, white oak (most likely swamp white oak), bur oak, elm (*Ulmus* sp.), white maple (silver maple [*Acer saccharinum*]), black oak, white ash (*Fraxinus americana*), pin oak, and hickory (*Carya* sp.) (Figure 7). Fifteen other trees were mentioned, but each was represented by 10 or fewer trees.

Historical Vegetation of the Study Area

- The uplands of the study area historically supported Oak Openings as the most common type (Finley 1976). The top four most often reported trees by the early surveyors for the PLSS were: white oak, black oak, northern pin oak, and bur oak.
- The wetlands of the study area historically supported lowland hardwoods as the most common type (Finley 1976). The eight most often reported trees by the early surveyors for the PLSS (representing almost 80% of the trees within the wetlands) were: white oak, bur oak, elm, white maple (silver maple), black oak, white ash, pin oak, and hickory.

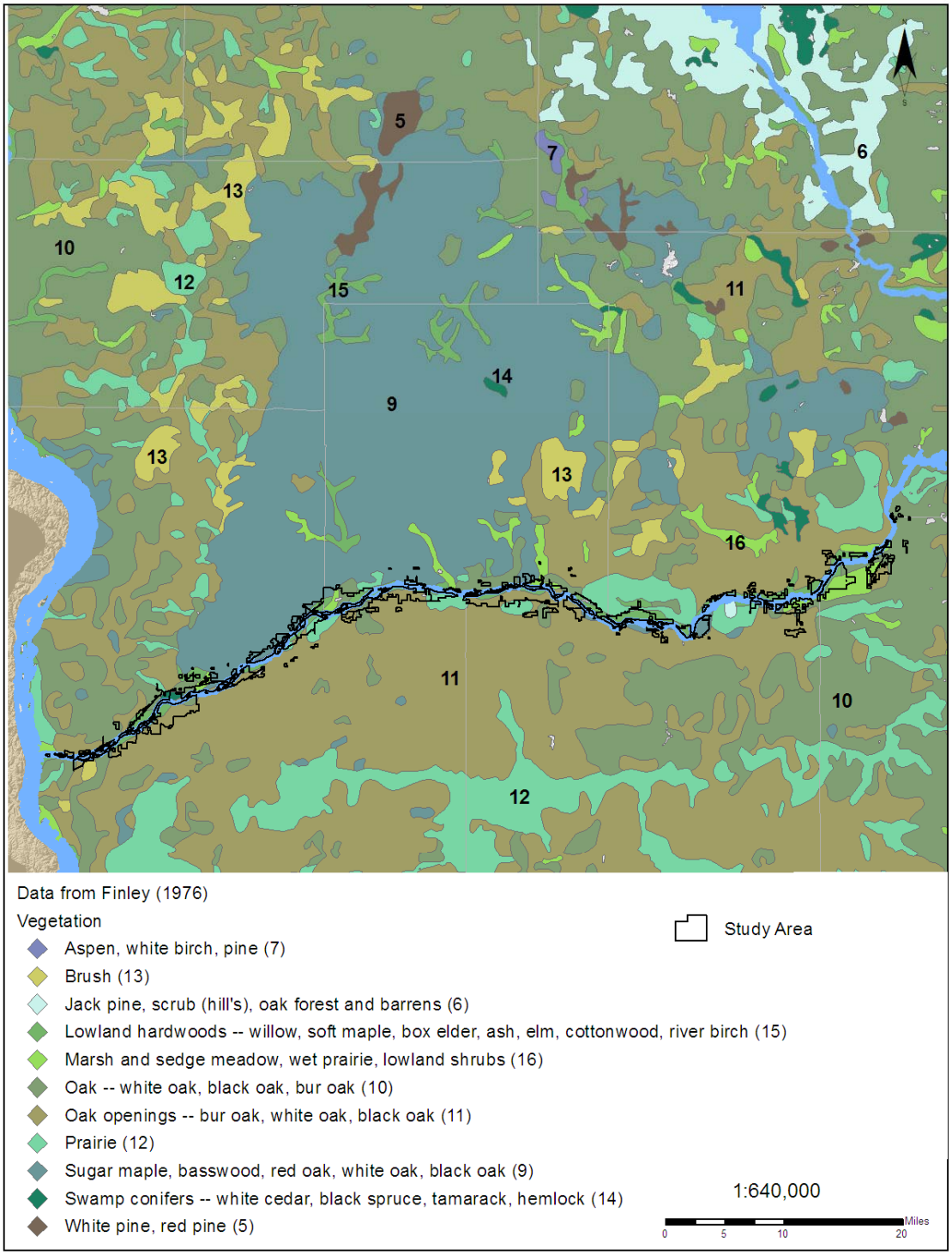

Figure 5. Pre-European Settlement vegetation for the study area and surrounding landscape.

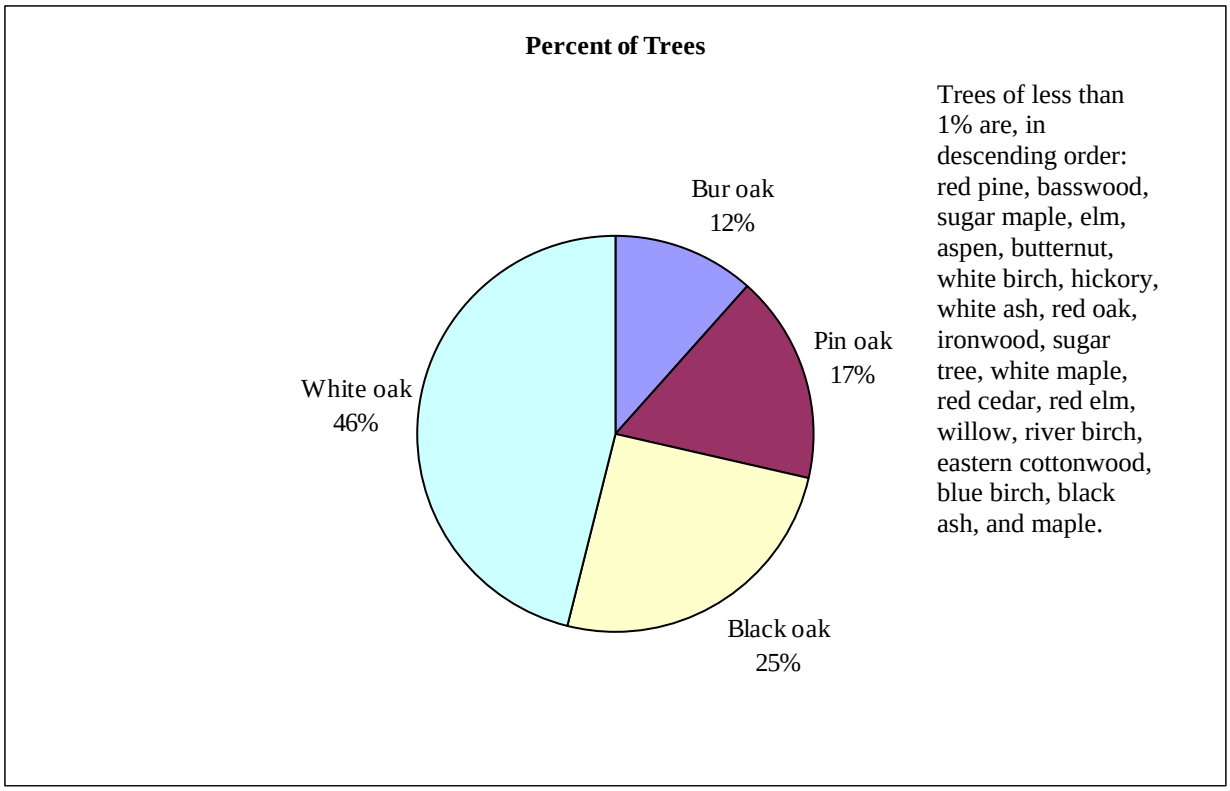

Figure 6. Public Land Survey System tree data for uplands within the study area.

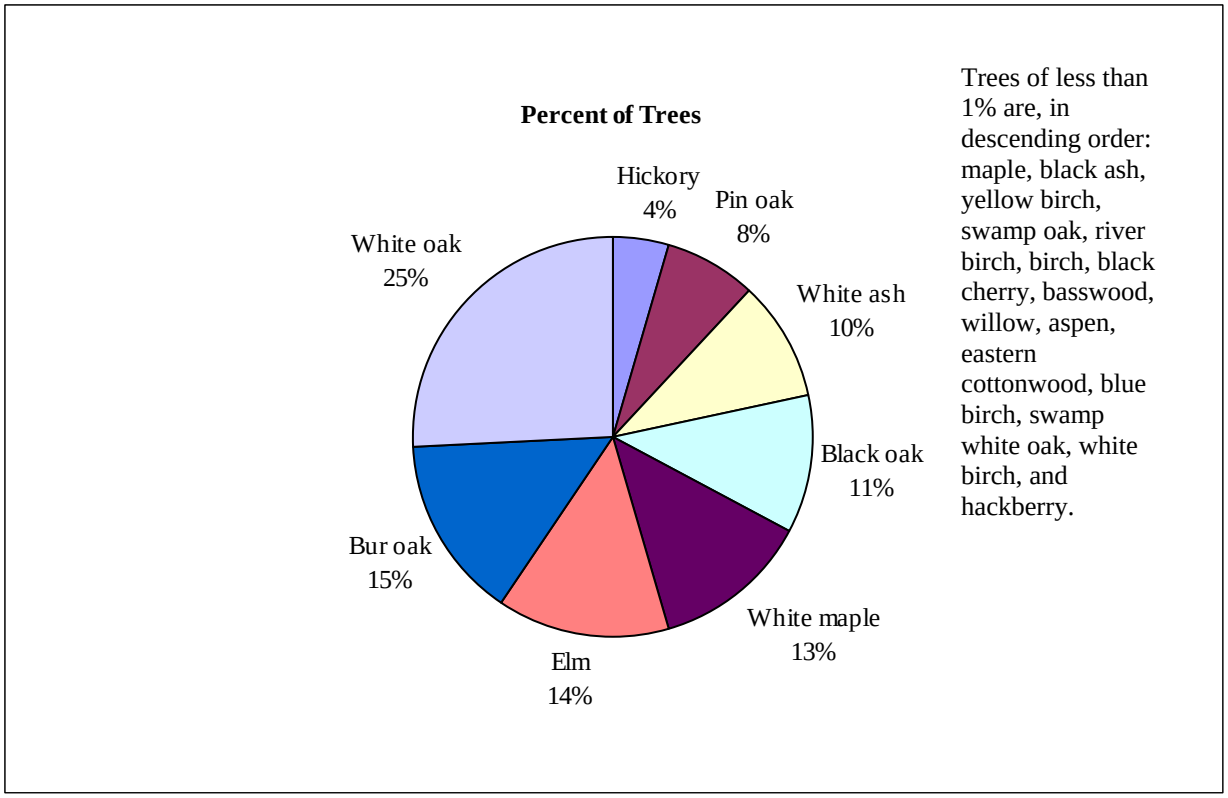

Figure 7. Public Land Survey System tree data for wetlands within the study area.

Current Vegetation

Current vegetation of the LWSR is greatly influenced by historical disturbance patterns and recent changes to those patterns. Current and historical land use has impacted the historical disturbance patterns differently throughout the LWSR. Land use such as over-grazing, development, unregulated logging during the "cutover" period, agricultural cropland runoff, and fire suppression have greatly impacted the current vegetation and habitat quality and availability. Turner et al. (2004) also found that within the Wisconsin River floodplain, landform and flood regime were particularly important in predicting occurrence, community composition, and abundance of trees. Forest Reconnaissance data for the LWSR (Figure 8) show the dominance of the bottomland hardwood and oak cover types. A discussion on how these types have changed since pre-widespread European settlement can be found in the Community Level Priorities and Restoration Opportunities section (page 67).

Floodplain Forests of the LWSR are represented by many large, high-quality examples. The dominant trees of these forests can vary depending on local elevation differences, hydrology, soil characteristics, and disturbance history. Canopy trees include silver maple, river birch, green ash (*Fraxinus pennsylvanica*), hackberry (*Celtis occidentalis*), swamp white oak (*Quercus bicolor*), quaking aspen (*Populus tremuloides)*, basswood (*Tilia americana)*, bitter-nut hickory (*Carya cordiformis*), white pine (*Pinus strobus)*, eastern cottonwood, honey locust (*Gleditsia triacanthos*), and black walnut (*Juglans nigra*). Around small streams, spring ponds, and oxbow lakes, shrubs such as buttonbush (*Cephalanthus occidentalis*) may be abundant. Ground layer species include wood nettle (*Laportea canadensis*), stinging nettle (*Urtica dioica*), sedges (e.g., Gray's sedge [*Carex grayi]*,common hop sedge *[C. lupulina]*,bottlebrush sedge *[C. hystericina]*, bent-seeded hop sedge *[C. tuckermanii*]), native grasses (e.g., common wood-reed [*Cinna arundinacea]*,silky wild-rye *[Elymus villosus]*, white grass *[Leersia virginica*]), ostrich fern (*Matteuccia struthiopteris*), and green-headed coneflower (*Rudbeckia laciniata*).

Lianas such as Virginia creeper (*Parthenocissus quinquefolia*), grapes (*Vitis* sp.), Canada moonseed (*Menispermum canadense*), and poison-ivy (*Toxicodendron radicans*) reach their highest density in Floodplain Forests.

Dry Upland Forests of the LWSR have changed dramatically in size and quality since widespread Euro-American settlement. The Oak Openings that were once the most common upland type (Finley 1976), along with Oak Woodland, and Southern Dry Forests have largely converted to closed-canopy oak-dominated forests due to suppression of fire or have been cleared and converted to agriculture. Forest Reconnaissance data show that these forest stands are dominated by older age classes with stand maximum ages clustered between 60 – 100 years (WISFIRS 2010). The majority of the oak forests (48% of the total oak forest acreage) have oak as a secondary type and almost 40% of the acreage has either central hardwoods or northern hardwoods as a secondary type. Forests that are typed as oak have 50% or more of the basal area in oak. Secondary types are the next most common forest type, by basal area.

Over many years these forests, as well as the closed-canopy Southern Dry-mesic Forests, have suffered from continued fire suppression, grazing, timber harvesting, and invasive species. Most of these areas, including the previously open forests, have now developed into closed-canopy forests that may have a mix of forest, savanna, and prairie species. High-quality examples of **Southern Dry-mesic Forests** are rare, though extant examples have recovered well from previous disturbances and sometimes only have small populations of invasive plant species. Red oak is the most abundant canopy species with sugar and red maple (Acer rubrum), white oak, and basswood as important associates. These forests generally have a diverse ground layer that varies from rich mesic herbs on lower slopes to drier, savanna species on upper slopes. Associated **Dry Cliffs** are known from the north side of the river on south-facing slopes. These steep sandstone cliffs have smooth cliff brake (*Pellaea glabella*), wild columbine (*Aquilegia canadensis*), sand cress (*Arabis lyrata*), bittersweet nightshade (*Solanum dulcamara*), bristly greenbrier (*Smilax tamnoides*), Virginia creeper, bladder fern (*Cystopteris fragilis*), mosses, and lichens and are embedded within Southern Dry-mesic Forests. Based on current knowledge of the study area, high-quality **Southern Dry Forests** are currently very rare on the LWSR and are only represented by one low-quality example on a south-facing slope. About 20-40% of the canopy trees are black oak, with hackberry and basswood also common. Prickly-ash (*Zanthoxylum americanum*), raspberry (*Rubus idaeus*), blackberry (*Rubus allegheniensis*), and sand cherry (*Prunus pumila*) are present in the sapling/shrub layers. Common ground layer species include wild geranium (*Geranium maculatum*), false Solomon's-seal (*Smilacina racemosa*) and hog-peanut (*Amphicarpaea bracteata*).

Floodplain Forest within the Lower Wisconsin State Riverway.
Photo by Christina Isenring.

Oak Openings and Oak Woodlands were once very common on the LWSR. Fire suppression, agriculture, and other previous disturbances have largely reduced these types. Based on current knowledge of the study area high-quality examples persist in only three areas of the LWSR and only under an intensive regime of prescribed fire and brush removal. The only known remnant **Oak Opening** is within the large Avoca Prairie and Savanna SNA and consists of only a few scattered open grown black oak over a mix of prairie and wetland species. Based on current knowledge of the study area remnant **Oak Woodlands** are found at two sites, Ferry Bluff SNA and Millville Woodland & Adiantum Woods Primary Sites, and are characterized by semi open-grown white and bur oaks over a ground layer for which species composition varies. These small examples of Oak Openings and Oak Woodlands are embedded within high-quality natural matrices in which complementary restoration management is critical to their survival.

Southern Mesic Forests of the LWSR are typically located in ravines and on steep north-facing slopes. Based on current knowledge of the study area high-quality examples of this type are uncommon in the LWSR and have a dense canopy of large sugar maple and red oak with basswood, black walnut, hackberry, and white ash as canopy associates. The sapling and shrub layer varies and includes sugar maple and basswood saplings and bladdernut (*Staphylea trifolia*). The ground layer is dense, rich, and diverse with wood nettle, hairy sweet cicely (*Osmorhiza claytonii*), spring beauty (*Claytonia virginica*), maidenhair fern (*Adiantum pedatum*), wild geranium, bishop's-cap (*Mitella diphylla*), and Virginia waterleaf (*Hydrophyllum virginianum*). Associated **Moist Cliffs** and seepages may occur with sugar maple, red oak, clubmosses (*Lycopodium* sp.), lichens, liverworts, wood nettle, giant wood fern (*Dryopteris goldiana*), wild leek (*Allium tricoccum*), and mayapple (*Podophyllum peltatum*).

Barrens natural communities of the LWSR are present on the broad sandy river terraces of the Lower Wisconsin River and include Pine Barrens, Oak Barrens, and Sand Barrens. **Pine Barrens and Oak Barrens** of the LWSR are very similar, except that the Pine Barrens are dominated by jack pine (*Pinus banksiana*) in the overstory and Oak Barrens are dominated by black oak with bur oak and occasionally white oak. Based on current knowledge of the study area **Pine Barrens** are only known from one high-quality example, Gotham Jack Pine Barrens SNA, and **Oak Barrens** are known from four primary sites, Mazomanie Oak Barrens, Blue River – Muscoda Sand Barrens, Millville Woodland and Adiantum Woods, and Smith Slough. Many of the highest quality barrens sites are being managed for these types through prescribed burning and brush and tree removal. Generally these barrens sites have scattered trees over a ground layer typical of Sand Prairies with lichens common. **Sand Barrens** are potentially anthropogenic in origin and may have developed from attempts to farm the unstabilized or semi-stabilized sands along the Lower Wisconsin River. Unvegetated "blow-outs" are characteristic features. Barrens, Dry Prairie and Sand Prairie plants such as false-heather (*Hudsonia tomentosa*), bearberry (*Arctostaphylos uva-ursi*), sedges (*Cyperus filiculmis* and *C. schweinitzii*), sand cress, three-awn grasses (*Aristida* spp.), rock spikemoss (*Selaginella rupestris*), and the earthstar fungi (*Geaster* spp.) are present in this community.

Prairies of the LWSR, although never historically abundant, play an important role in the floodplain wetlands, sandy river terrace barrens, and the upland woodland/forest complex. Prairie types currently represented by high-quality examples in the LWSR include Dry Prairie, Dry-mesic Prairie, Wet-mesic Prairie, and Sand Prairie. Many **Dry Prairie** remnants are small and occur on steep south or west-facing slopes or at the summits of river bluffs with sandstone or dolomite bedrock near the surface. Remnant **Dry-mesic Prairies** are very rare on the LWSR because of agricultural conversion and woody encroachment. The only remaining known high-quality examples are on upper slopes of south-facing ridges and have a diverse ground layer with characteristic tall grasses (big blue-stem [*Andropogon gerardii*] and Indian grass [*Sorghastrum nutans*]). Very few high-quality examples of **Wet-mesic Prairie** are known from the LWSR. The highest-quality site, Avoca Prairie and Savanna SNA, is located on an extensive outwash sand terrace along the Wisconsin River and contains one of the largest natural tallgrass prairies east of the Mississippi River, with more than 200 species of vascular plants. Frequent flooding

has created braided stream topography characterized by low, sandy ridges with barrens vegetation interspersed with small linear wetlands giving a local relief of four feet. Tall grasses (big blue-stem, prairie cord grass [*Spartina pectinata*], and Indian grass) and sedges characterize the low Wet-mesic Prairie. Historically, **Sand Prairies** may have been common on the broad sandy terraces of the Lower Wisconsin River. Many of these areas were farmed, planted to pine plantations, developed for residential use, or through succession, developed into forests. Today, Sand Prairie remnants are generally represented by small openings within a barrens-dominated area or by long, narrow prairies along railroad corridors maintained by periodic accidental fires.

Open wetlands of the LWSR are found within the floodplain of the Lower Wisconsin River, often in very large complexes that include **Southern Sedge Meadow, Emergent Marsh, Submergent Marsh**, and **Shrub-carr**. These wetlands show typical zonation of dominant plants likely based on age and depth of peat, with the younger, less consolidated peat supporting Emergent Marsh and the firmer peat supporting Southern Sedge Meadow and Shrub-carr. Characteristic Southern Sedge Meadow species include tussock sedge (*Carex stricta*), blue-joint grass (*Calamagrostis canadensis*), northern bugleweed (*Lycopus uniflorus*), spotted Joe Pye-weed (*Eupatorium maculatum*), broad-leaved cat-tail (*Typha latifolia*), and swamp milkweed (*Asclepias incarnata*). Characteristic Emergent Marsh species include cat-tails (*Typha* spp.), bulrushes (*Scirpus* sp*p.*), common bur-reed (*Sparganium eurycarpum*), pickerel-weed (*Pontederia cordata*), arrowheads (*Sagittaria* spp.), common spike rush (*Eleocharis palustris*), and wild rice (*Zizania aquatica*). Characteristic Submergent marsh species include pondweeds (*Potamogeton* spp.), waterweed (*Elodea canadensis),* slender naiad (*Najas flexilis),* and milfoil (*Myriophyllum* spp.). Characteristic Shrub-carr species include red-osier dogwood (*Cornus stolonifera*) and slender willow (*Salix petiolaris*) over typical Southern Sedge Meadow species.

Pine Relicts are pine-dominated conifer forests that occur as discrete, isolated stands in the Driftless Area. Within the LWSR, Pine Relicts are extremely rare and based on current knowledge of the study area only one high-quality example is known. Above a 30-foot sandstone ridge is a forest with a white pine (12-20 inches dbh) dominated canopy with white oak (to 30 inches plus dbh), red oak, white oak, red maple, and big-tooth aspen (*Populus grandidentata*) as canopy associates. The subcanopy cover is dense, dominated by white pine and red maple, with red and white oaks as associates. The sapling layer has a moderate cover of red maple with red oak, hackberry, bitter-nut hickory (*Carya cordiformis*), and shagbark hickory (*Carya ovata*). The shrub layer has a moderate cover of prickly ash, Alleghany blackberry, Virginia creeper, and red raspberry. Ground layer species generally considered as indicators of Pine Relicts are rare at this site. The current ground layer is sparse and includes wood nettle, wood anemone (*Anemone quinquefolia*), wild sarsaparilla (*Aralia nudicaulis*), partridgeberry (*Mitchella repens*), and hairy sweet cicely.

False-heather at Woodman Lake Sand Prairie and Dead Lake SNA. Photo by Kathryn Kirk.

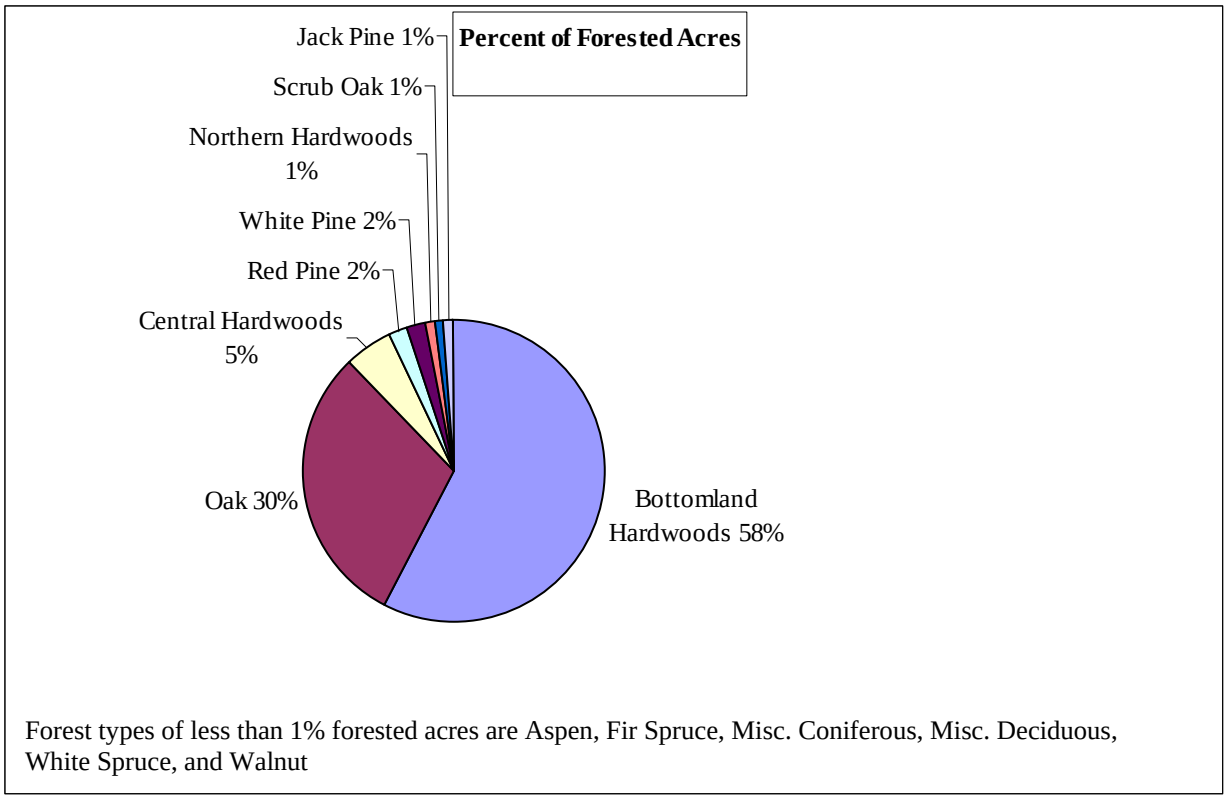

Figure 8. Forested cover types for the LWSR. Data are from the Division of Forestry WISFIRS (accessed November 4, 2010).

Natural Communities of the Study Area

Within the LWSR, 114 high-quality natural communities representing 26 different types have been documented and are mapped in the NHI database (Table 4). These areas can be considered opportunities to develop or protect High Conservation Value Forests (HCVF; Forest Stewardship Council 2009; HCVFs are not limited to forest types and can include wetlands and prairies). Descriptions of natural community types are provided previously and in Appendix D. Other community types are present, but these are represented by stands that are too small, too highly disturbed, or too altered to warrant inclusion in the NHI database. High-quality natural communities are listed by Management Unit in Appendix E.

Table 4. NHI natural community types, with last observed dates, documented within the study area. For an explanation of state and global ranks, as well as state status, see Appendix F.

Common Name	Last Observed Date	State Rank	Global Rank
Natural Communities			
Alder Thicket	1969	S4	G4
Cedar Glade	1983	S4	GNR
Dry Cliff	2008	S4	G4G5
Dry Prairie	2009	S3	G3
Dry-mesic Prairie	2008	S2	G3
Emergent Marsh	2009	S4	G4
Ephemeral Pond	1978	SU	GNRQ
Floodplain Forest	2009	S3	G3?
Lake--Oxbow	2009	SU	GNR
Lake--Spring	2009	S3	GNR
Moist Cliff	2008	S4	GNR
Oak Barrens	2009	S2	G2?
Oak Opening	2009	S1	G1
Oak Woodland	2009	S1?	GNR
Pine Barrens	2008	S2	G2
Pine Relict	2008	S2	G4
Sand Barrens	2009	SU	GNR
Sand Prairie	2009	S2	GNR
Shrub-carr	1976	S4	G5
Southern Dry Forest	2009	S3	G4
Southern Dry-mesic Forest	2009	S3	G4
Southern Mesic Forest	2008	S3	G3?
Southern Sedge Meadow	2009	S3	G4?
Springs and Spring Runs, Hard	2009	S4	GNR
Stream--Slow, Hard, Warm	2009	SU	GNR
Wet-mesic Prairie	2010	S2	G2
Other			
Bat Hibernaculum	1990	S3	GNR
Bird Rookery	2009	SU	G5
Herp Hibernaculum	2007	SU	GNR
Mussel Bed	2007	S3?	G3

Rare Vascular Plants of the Study Area

The LWSR supports 92 known element occurrences of 44 NHI Working List plant species, including 4 State Endangered, 5 State Threatened, and 35 State Special Concern species (Table 5). Element occurrences of rare plants are listed by Management Unit in Appendix E. Particularly significant are rare plants associated with four groups of natural communities: 1) Floodplain Forest, 2) Southern Mesic Forest, 3) Oak Barrens, and 4) Oak Woodland/Oak Openings.

The LWSR contains one of the most extensive Floodplain Forests in the state. Correspondingly, it supports a significant portion of rare plants associated with this habitat, including purple rocket (*Iodanthus pinnatifidus*). Although this native species was previously reported from Waukesha Co. (1942), its nativity was questioned. The discovery of purple rocket on the LWSR during recent field inventories represents the first definitive native population in the state. Futhermore, the entire known statewide population is contained within the LWSR. The species was found on wet-mesic ridges dominated by swamp white oak in dense, mature Floodplain Forest. Purple rocket is listed as endangered in Minnesota, is known from two counties in Iowa, and is more common in states to the south such as Missouri (NatureServe 2010). It was found in four sites along the lower portions of the LWSR, and with only these four sites known in the state, it will be added to the NHI working list as a new species of Special Concern upon the June 2011 list revision.

Floodplain Forests also support significant populations of several other rare species. The LWSR contains approximately 20% of the known populations in the state of: Kentucky coffee-tree (*Gymnocladus dioica*), sycamore (*Platanus occidentalis*), spreading chervil (*Chaerophyllum procumbens*), small forget-me-not (*Myosotis laxa*), and sweet-scented Indian-plantain (*Cacalia suaveolens*). This habitat occurs along the entire LWSR, but is particularly important in the Richwood, Millville, and Woodman units.

Southern Mesic Forests, which often occur on north-facing slopes and ravines along the LWSR, support significant populations (over 25% of the known populations in the state) of putty root (*Aplectrum hyemale*) and great water-leaf (*Hydrophyllum appendiculatum*). Other rare species present in these forests include the southwestern-most populations of snow trillium (*Trillium nivale*) and broad beech fern (*Phegopteris hexagonoptera*). These habitats are especially significant in the Richwood, Millville, and Wyalusing units. Two additional plants, jeweled shooting star (*Dodecatheon amethystinum*) and Short's rock-cress (*Arabis shortii*) occur in more specific habitat within Southern Mesic Forests. These species are found where Moist Cliffs and outcrops occur on shaded, north-facing slopes.

Oak Barrens, found on sandy terraces above the river, also support significant populations of rare plants, including nearly 50% of the state's known populations of prairie ragwort (*Senecio plattensis*). Other rare plants with a large percentage of their sites along the LWSR include prairie fame-flower (*Phemeranthus*

Rare Vascular Plants of the Study Area

- 44 NHI Working List plant species have been documented in the study area, including:
  - 4 State Endangered species
  - 5 State Threatened species
  - 35 State Special Concern species
- The discovery of purple rocket on the LWSR during recent field inventories represents the first definitive native populations in the state.
- The LWSR supports 20% of the known populations in the state of many Floodplain Forest species.
- Southern Mesic Forests of the LWSR support many rare plant species, including over 25% of the known populations of putty root and great water-leaf.
- Over 50% of the state's known populations of prairie ragwort occur in Oak Barrens in the LWSR.
- Many rare plants are associated with Oak Barrens, Oak Woodlands, and Oak Openings in the LWSR.

rugospermus), clustered poppy-mallow (*Callirhoe triangulata*), narrow-leaved day-flower (*Commelina erecta* var. *deamiana*), and violet bush-clover (*Lespedeza violacea*). Significant areas for rare plants associated with Oak Barrens include the Avoca, Blue River, Buena Vista, Mazomanie, Lone Rock, and Millville units.

Finally, several rare plants associated with Oak Woodlands/Oak Openings occur along the LWSR. These habitats typically occur on south-facing or west-facing slopes, and are often interspersed with small prairie openings. Rare plants in this habitat with a significant number of their known populations along the LWSR include chinquapin oak (*Quercus muhlenbergii*), lance-leaved buckthorn (*Rhamnus lanceolata*), and upland boneset (*Eupatorium sessilifolium*). Important sites for Oak Woodland/Oak Opening species include the Wauzeka, Marietta, Richwood, Riverview Bluff, Buena Vista, and Cassel Prairie units.

Table 5. NHI Working List plants documented within the study area. For an explanation of state and global ranks, as well as state status, see Appendix F. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	Last Observed Date	State Rank	Global Rank	State Status	Federal Status
American fever-few	*Parthenium integrifolium*	2008	S3	G5	THR	
arrow-headed rattle-box	*Crotalaria sagittalis*	1992	S1	G5	SC	
broad beech fern	*Phegopteris hexagonoptera*	2008	S2	G5	SC	
buttonweed	*Diodia teres var. teres*	2009	S1	G5T5	SC	
chinquapin oak	*Quercus muehlenbergii*	2009	S1S2	G5	SC	
cleft phlox	*Phlox bifida*	1993	S1	G5?	SC	
cluster fescue	*Festuca paradoxa*	1941	SH	G5	SC	
clustered poppy-mallow	*Callirhoe triangulata*	2009	S3	G3	SC	
glade mallow	*Napaea dioica*	1997	S3	G4	SC	
great water-leaf	*Hydrophyllum appendiculatum*	2008	S2S3	G5	SC	
hairy wild-petunia	*Ruellia humilis*	2008	S2	G5	END	
heart-leaved skullcap	*Scutellaria ovata*	2008	S3	G5	SC	
hooker orchid	*Platanthera hookeri*	1985	S2S3	G4	SC	
jeweled shooting star	*Dodecatheon amethystinum*	2008	S2	G4	SC	
Kentucky coffee-tree	*Gymnocladus dioicus*	2008	S2	G5	SC	
lanced-leaved buckthorn	*Rhamnus lanceolata var. glabrata*	2008	S1	G5T4T5	SC	
narrow-leaved dayflower	*Commelina erecta var. deamiana*	2009	S1	G5T5	SC	
nodding pogonia	*Triphora trianthophora*	1957	S2	G3G4	SC	
one-flowered broomrape	*Orobanche uniflora*	2008	S3	G5	SC	
pale false foxglove	*Agalinis skinneriana*	2001	S2	G3G4	END	
pale green orchid	*Platanthera flava var. herbiola*	2009	S2	G4T4Q	THR	
pink milkwort	*Polygala incarnata*	2007	S1	G5	END	
prairie false-dandelion	*Microseris cuspidata*	1998	S2	G5	SC	
prairie fame-flower	*Phemeranthus rugospermus*	2009	S3	G3G4	SC	
prairie Indian plantain	*Cacalia tuberosa*	2008	S3	G4G5	THR	
prairie ragwort	*Senecio plattensis*	2008	S3	G5	SC	
prairie turnip	*Pediomelum esculentum*	1974	S3	G5	SC	
purple milkweed	*Asclepias purpurascens*	2007	S3	G5?	END	
purple-stem cliff-brake	*Pellaea atropurpurea*	2008	S2	G5	SC	
putty root	*Aplectrum hyemale*	2009	S2S3	G5	SC	
Richardson sedge	*Carex richardsonii*	2008	S2	G4	SC	
shadowy goldenrod	*Solidago sciaphila*	2008	S3	G3G4	SC	
Short's rock-cress	*Arabis shortii*	2009	S2	G5	SC	
small forget-me-not	*Myosotis laxa*	2009	S2	G5	SC	
snow trillium	*Trillium nivale*	2009	S3	G4	THR	
spreading chervil	*Chaerophyllum procumbens*	2009	S1	G5	SC	
sweet-scented Indian-plantain	*Cacalia suaveolens*	2009	S3	G4	SC	
sycamore	*Platanus occidentalis*	1985	S2	G5	SC	
upland boneset	*Eupatorium sessilifolium var. brittonianum*	2009	S3	G5T3T5	SC	
violet bush-clover	*Lespedeza violacea*	2009	S2	G5	SC	
whip nutrush	*Scleria triglomerata*	2001	S2S3	G5	SC	
white camas	*Zigadenus elegans var. glaucus*	1977	S2S3	G5T4T5	SC	
Wilcox panic grass	*Panicum wilcoxianum*	1940	SH	G5	SC	

Common Name	Scientific Name	Last Observed Date	State Rank	Global Rank	State Status	Federal Status
yellow gentian	*Gentiana alba*	2002	S3	G4	THR	

Rare Animals of the Study Area

One hundred and three NHI Working List animal species have been documented in the study area, including 15 State Endangered, 22 State Threatened species, and 66 State Special Concern species. Of these species, two Federally Endangered species and one candidate for federal listing is also known from the study area (Table 6). This large number of rare animals from numerous taxonomic groups reflects the overall diversity of good-quality habitats that are present throughout the property. Over 37% of the animals on the State Threatened and Endangered Species lists are found in the LWSR. Element occurrences of rare animals are listed by Management Unit in Appendix E.

Perhaps the most dramatic species-related finding was the discovery of the Federally Endangered Hine's emerald dragonfly *(Somatochlora hineana)* in spring fed wetlands near Muscoda. This species was previously known only from Door and Ozaukee counties in Wisconsin and was believed to require wetlands over dolomite bedrock or till. First seen by a local photographer in 2007 and documented by WDNR in 2008, adults were documented in 2009 at five wetlands in Iowa, Grant, and Richland counties with dozens of similar wetlands along the Riverway offering similar habitat and in need of further surveys.

Other highlights include:

- More than 25 new red-shouldered hawk (*Buteo lineatus*) nesting territories were located with the most significant areas at Richwood Bottoms, Clear Creek Lowlands, and from Spring Green downriver to Bakken's Pond and Long Island. This species requires large tracts of older growth, closed canopy forest in close proximity to wetlands and water, predominately found throughout the extensive Floodplain Forests of the LWSR. The LWSR may support the largest population in the state for this State Threatened species with estimates of 40-80 breeding pairs present. Prothonotary warbler (*Protonotaria citrea*) (Special Concern) was also found in very high numbers in these lowland forests. This species requires cavities in trees near open water for nesting.

Rare Animals of the Study Area

- 103 NHI Working List animal species have been documented in the study area, including:
  - 15 State Endangered species
  - 22 State Threatened species
  - 66 State Special Concern species

  Of these species:
  - 2 are Federally Endangered species
  - 1 is a candidate species for federal listing
- The Federally Endangered Hine's emerald dragonfly, previously only known from Door and Ozaukee counties, was located during recent surveys.
- The LWSR may support the largest population in the state for the State Threatened red-shouldered hawk.
- The LWSR has been critical to the recovery of the bald eagle.
- The expansive Floodplain Forests support a number of significant forest-interior bird populations.
- Significant populations of barrens, savanna, and grassland birds breed in the LWSR.
- Open marshes and sedge meadows support uncommon marsh-dwelling birds.
- The LWSR supports habitat for uncommon reptiles, including some of the best remaining populations of the State Endangered ornate box turtles.
- All bat species known to occur in Wisconsin within the past fifty years are represented within the LWSR.
- The floodplain lake and sloughs are important habitat for many rare fish and invertebrate species.
- The main channel of the Lower Wisconsin River supports globally rare fishes and mussels.
- Rare butterflies, moths, leafhoppers, grasshoppers, beetles, bees, and wasps are known from the LWSR.

- Bald eagles (*Haliaeetus leucocephalus*) are found nesting in abundance (24 active territories) throughout the LWSR along the main channel, floodplain lakes, and large open impoundments. The LWSR is also an important wintering area for bald eagles with several roost areas present. Wintering bald eagles seek out areas with appropriate roost locations with features that include large, mature canopy trees in close proximity to open water foraging areas. The eagles have a reduced activity level in winter as compared to the breeding season, so the proximity of the roosts to good open water foraging areas is a critical component of winter habitat selection (Hall 2005). Eagles tend to utilize large portions of the LWSR for these foraging and roosting areas when the river is open, but begin to congregate more near the Prairie du Sac dam as more and more of the river becomes iced-over. This makes the Prairie du Sac dam the single most highly utilized area by wintering eagles in the state (Martell et al 1991).
- A number of significant forest-interior bird populations occur at several units along the Riverway, especially at Millville, and also at Riverview Bluff, Woodman, Wauzeka, and Long Island / Bakken's Pond. The LWSR is one of the few remaining major forested landscapes of southern Wisconsin and supports good populations of conservative, area-sensitive birds. Much of this is attributed to the large, expansive Floodplain Forest habitats, but connections to upland mesic and dry-mesic forests add to the importance of these areas.
- Significant populations of barrens, savanna, and grassland birds breed along the river terraces and open bluffs, including lark sparrow, brown thrasher (*Toxostoma rufum*), blue-winged warbler (*Vermivora pinus*), field sparrow (*Spizella pusilla*), red-headed woodpecker (*Melanerpes erythrocephalus*), a suite of rare grassland birds, and what may be the largest population of whip-poor-will (*Caprimulgus vociferus*) in southern Wisconsin (Mossman and Steele in Prep.)
- Marsh bird surveys from the larger open marshes and sedge meadows detected some of our more uncommon marsh-dwelling birds including the American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), common moorhen (*Gallinula chloropus*), and a possible king rail (*Rallus elegans*) (all Special Concern).
- A number of new herptile records were noted, especially for uncommon prairie snakes and lizards inhabiting barrens and dry prairies such as the six-lined racerunner (*Aspidoscelis sexlineata*), gophersnake (*Pituophis catenifer*), and North American racer (*Coluber constrictor*). Warmwater marshes with nearby sandy fields throughout the LWSR, but especially from Avoca to Blue River are critical habitat for Blanding's turtles (*Emydoidea blandingii*; State Threatened); it is estimated that hundreds of females nest in this area. Sandy terraces in Dane, Sauk, and Iowa counties provide critical habitat for some of the best remaining populations of the State Endangered ornate box turtle (*Terrapene ornata*).
- The LWSR provides excellent habitat for rare small mammals and bat populations. Several records of the prairie vole (*Microtus ochrogaster*) are located within the LWSR at sand prairie and barrens habitats. More survey work is needed to detail the rarity of this species statewide, but the LWSR appears to be an important landscape for maintaining this uncommon small mammal. All bat species known to occur in Wisconsin within the past fifty years are represented within the LWSR. Excellent habitat is present throughout the LWSR to maintain strong bat populations through a critical period for bat management nationwide as White Nose Syndrome spreads across the country and threatens large populations of over-wintering cave bats.
- The floodplain lakes and sloughs have been found to support a healthy distribution of the State Endangered starhead topminnow (*Fundulus dispar*) (documented from 55 waterbodies to date), good numbers of Special Concern fish species including lake chubsucker (*Erimyzon sucetta*), pirate perch (*Aphredoderus sayanus*), mud darter (*Etheostoma asprigene*), least darter (*Etheostoma microperca*), weed shiner (*Notropis texanus*), pugnose minnow (*Opsopoeodus*

emiliae), as well as rare invertebrates like the flat floater mussel (*Anodonta suborbiculata)*, and the rare freshwater shrimp, the Mississippi grass shrimp (*Palaemonetes kadiakensis*).

- The main channel of the Lower Wisconsin River supports globally rare fishes and mussels. Ten state listed fish species are present within the LWSR, including globally rare species like crystal darter (*Crystallaria asprella*), blue sucker (*Cycleptus elongatus*), and western sand darter (*Ammocrypta clara*). Several important mussel beds are scattered throughout the LWSR supporting significant populations of the Federally Endangered Higgins' eye pearly mussel (*Lampsilis higginsii*) and sheepnose (*Plethobasus cyphyus*) a candidate for Federal listing, along with eight additional state listed mussel species. Several rare "big river" turtle species (map turtles (*Graptemys pseudogeographica*), and smooth soft shell turtle (*Apalone mutica*) utilize the main channel of the Lower Wisconsin River and are found at few other locations in the state.
- Numerous terrestrial invertebrate taxa are represented in the LWSR but very poor data exists on current populations especially compared to aquatic invertebrates. The bluff prairies and mesic prairies found in the floodplain of the river support populations of rare leafhoppers and Lepidoptera. The State Threatened prairie leafhopper (*Polyamia dilata*) is known from five sites within LWSR. Rare butterflies and moths found in open prairies and wetlands on the floodplain terraces include the Leonard's skipper (*Hesperia leonardus)*, gorgone checker spot (*Chlosyne gorgone)*, several species of dusky wing butterflies (wild indigo dusky wing [*Erynnis baptisiae*], Columbine dusky wing [*E. lucilius*], and mottled dusky wing [*E. martialis*]), and three Special Concern moth species. The sandy terrace openings and barrens, islands and sand blows support populations of rare grasshoppers (five species of Special Concern were located in 2009 at separate locations throughout). Tiger beetles and bees and wasps are also found in these habitats. Several species of tiger beetle (*Cicindela patruela huberi, C. macra,* and *C. lepida*) are found in the Lone Rock and Buena Vista Units. Additional terrestrial invertebrate survey efforts in the LWSR are an important future inventory need because of a general lack of baseline inventory data (poor weather conditions during this study's scheduled survey period prevented a complete inventory) and the vital importance of considering terrestrial invertebrate conservation during the management planning process.
- The wide variety of habitats in the river and the associated backwaters and spring ponds have created a diverse and species rich aquatic invertebrate community, one of the richest in Wisconsin. The vast majority of the main channel is sand bottomed harboring a number of sand dwelling specialists including many that are rare like the Pecatonica River mayfly (*Acanthametropus pecatonica)*, the flat-headed mayfly (*Pseudiron centralis*), and the yellow sandshell mussel (*Lampsilis teres*). Snags, which are common along the shoreline and down-stream sandbar edges, create areas of turbulence that often harbor unique fauna, including several rare riffle beetles like Knobel's riffle beetle (*Stenelmis knobeli*) and mayflies like Wallace's deepwater mayfly (*Spinadis simplex)*. Backwaters and spring ponds also have a great diversity of species, hosting rare species such as the state imperiled white-spangled skimmer (*Libellula cyanea*), swamp darner (*Epiaeschna heros*), flat floater mussel, and Mississippi grass shrimp. One of the hottest spots of aquatic invertebrate species diversity occur where the main channel flows adjacent to an upland bluff and the substrate shifts from the loose sand to firm gravel, rubble or even bedrock bottom. These areas are especially important for mussels which require firm substrate in which to establish themselves.
- The LWSR was chosen by the US Fish and Wildlife Service and the WDNR for long-term monitoring and conservation of the Higgins' eye pearly mussel population, because it was one of the few tributaries of the Mississippi River that had an existing population of Higgins' eye, and was not immediately threatened by zebra mussels (*Dreissena polymorpha*).

Table 6. Rare animals documented within the study area. For an explanation of state and global ranks, state status, and NHI tracking, see Appendix F. Listing status is based on the NHI Working List published April 2009. An explanation of Species of Greatest Conservation Need is on page 15. Species with a "W" in the "Tracked by NHI" column are on the Watch List (see Appendix F) and are not mapped in the NHI database. Various sources were used to determine the Watch List species and SGCN present and this may not be a complete list.

Common Name	Scientific Name	Last Observed Date	State Rank	Global Rank	State Status	Federal Status	SGCN	Tracked by NHI
Amphibians								
American bullfrog	*Lithobates catesbeianus*	2009	S3	G5	SC/H		N	Y
pickerel frog	*Lithobates palustris*	1995	S3S4	G5	SC/H		Y	Y
Beetles								
a tiger beetle	*Cicindela macra*	2001	S1S2	G5	SC/N		Y	Y
Cicindela patruela huberi	*Cicindela patruela huberi*	1978	S3	G3T3	SC/N		Y	Y
Bird								
Acadian flycatcher	*Empidonax virescens*	2010	S3B	G5	THR		Y	Y
American bittern	*Botaurus lentiginosus*	2008	S3B	G4	SC/M		Y	Y
American woodcock	*Scolopax minor*	2009	S4B	G5	SC/M		Y	W
bald eagle	*Haliaeetus leucocephalus*	2010	S4B,S2N	G5	SC/P		Y	Y
Bell's vireo	*Vireo bellii*	2008	S2B	G5	THR		Y	Y
black-billed cuckoo	*Coccyzus erythropthalmus*	2008	S4B	G5	SC/M		Y	W
blue-winged teal	*Anas discors*	2008	S4B	G5	SC/M		Y	W
blue-winged warbler	*Vermivora pinus*	2010	S4B	G5	SC/M		Y	W
bobolink	*Dolichonyx oryzivorus*	2010	S4B	G5	SC/M		Y	W
brown thrasher	*Toxostoma rufum*	2010	S4B	G5	SC/M		Y	W
Canada warbler	*Wilsonia canadensis*	2008	S3B	G5	SC/M		Y	Y
cerulean warbler	*Dendroica cerulea*	2010	S2S3B	G4	THR		Y	Y
common moorhen	*Gallinula chloropus*	2009	S2B	G5	SC/M		N	Y
dickcissel	*Spiza americana*	1993	S3B	G5	SC/M		Y	Y
eastern meadowlark	*Sturnella magna*	2010	S4B	G5	SC/M		Y	W
field sparrow	*Spizella pusilla*	2010	S4B	G5	SC/M		Y	W
golden-winged warbler	*Vermivora chrysoptera*	2009	S4B	G4	SC/M		Y	W
grasshopper sparrow	*Ammodramus savannarum*	2010	S4B	G5	SC/M		Y	W
Henslow's sparrow	*Ammodramus henslowii*	2009	S3B	G4	THR		Y	Y
hooded warbler	*Wilsonia citrina*	2010	S2S3B	G5	THR		Y	Y
Kentucky warbler	*Oporornis formosus*	2008	S1S2B	G5	THR		Y	Y

Common Name	Scientific Name	Last Observed Date	State Rank	Global Rank	State Status	Federal Status	SGCN	Tracked by NHI
lark sparrow	*Chondestes grammacus*	2009	S2B	G5	SC/M		Y	Y
least bittern	*Ixobrychus exilis*	2009	S3B	G5	SC/M		N	Y
least flycatcher	*Empidonax minimus*	2010	S4B	G5	SC/M		Y	W
prothonotary warbler	*Protonotaria citrea*	2010	S3B	G5	SC/M		Y	Y
red-headed woodpecker	*Melanerpes erythrocephalus*	2009	S3B	G5	SC/M		Y	W
red-shouldered hawk	*Buteo lineatus*	2009	S3S4B,S1N	G5	THR		Y	Y
sedge wren	*Cistothorus platensis*	2010	S4B	G5	SC/M		N	W
trumpeter swan	*Cygnus buccinator*	2010*	S4B	G4	SC/M		Y	Y
veery	*Catharus fuscescens*	2008	S4B	G5	SC/M		Y	N
vesper sparrow	*Pooecetes gramineus*	2010	S4B	G5	SC/M		Y	W
whip-poor-will	*Caprimulgus vociferus*	2008	S3B	G5	SC/M		Y	N
willow flycatcher	*Empidonax traillii*	2010	S4B	G5	SC/M		Y	W
wood thrush	*Hylocichla mustelina*	2010	S4B	G5	SC/M		Y	W
worm-eating warbler	*Helmitheros vermivorus*	2004	S1B	G5	END		Y	Y
yellow-billed cuckoo	*Coccyzus americanus*	2009*	S3B	G5	SC/M		Y	Y
yellow-breasted chat	*Icteria virens*	1995	S2B	G5	SC/M		N	Y
yellow-crowned night heron	*Nyctanassa violacea*	2009*	S1B	G5	THR		Y	Y
yellow-throated warbler	*Dendroica dominica*	1993*	S1B	G5	END		Y	Y
Butterflies and Moths								
a looper moth	*Euchlaena milnei*	1981	S1S2	G2G4	SC/N		Y	Y
Columbine dusky wing	*Erynnis lucilius*	2010	S2	G4	SC/N		Y	Y
dusted skipper	*Atrytonopsis hianna*	1991	S3	G4G5	SC/N		N	Y
gorgone checker spot	*Chlosyne gorgone*	1991	S3	G5	SC/N		N	Y
Leonard's skipper	*Hesperia leonardus*	2010	S3	G4	SC/N		N	Y
mottled dusky wing	*Erynnis martialis*	1938	S2	G3	SC/N		Y	Y
phyllira tiger moth	*Grammia phyllira*	2001	S2	G4	SC/N		Y	Y
Whitney's underwing moth	*Catocala whitneyi*	1996	S3	G3G4	SC/N		Y	Y
wild indigo dusky wing	*Erynnis baptisiae*	1989	S2S3	G5	SC/N		Y	Y
Crustaceans								
Mississippi grass shrimp	*Palaemonetes kadiakensis*	2009	S1	G5	SC/N		Y	Y
Dragonflies and Damselflies								
Cyrano darner	*Nasiaeschna pentacantha*	1992	S3	G5	SC/N		N	Y

Common Name	Scientific Name	Last Observed Date	State Rank	Global Rank	State Status	Federal Status	SGCN	Tracked by NHI
fragile forktail	*Ischnura posita*	1989	S2S3	G5	SC/N		Y	Y
Hine's emerald	*Somatochlora hineana*	2009	S1	G2G3	END	LE	Y	Y
plains clubtail	*Gomphurus externus*	1991	S2	G5	SC/N		N	Y
russet-tipped clubtail	*Stylurus plagiatus*	1988	S2	G5	SC/N		N	Y
smoky shadowfly	*Neurocordulia molesta*	1993	S2S3	G4	SC/N		N	Y
swamp darner	*Epiaeschna heros*	1991	S1?	G5	SC/N		Y	Y
white-spangled skimmer	*Libellula cyanea*	1988	S1	G5	SC/N		Y	Y
Fishes								
American eel	*Anguilla rostrata*	2004	S2	G4	SC/N		Y	Y
black buffalo	*Ictiobus niger*	2010	S2	G5	THR		Y	Y
blue sucker	*Cycleptus elongatus*	2010	S2	G3G4	THR		Y	Y
crystal darter	*Crystallaria asprella*	2009	S1	G3	END		Y	Y
goldeye	*Hiodon alosoides*	2010	S2	G5	END		Y	Y
greater redhorse	*Moxostoma valenciennesi*	1957	S3	G4	THR		Y	Y
lake chubsucker	*Erimyzon sucetta*	2009	S3	G5	SC/N		Y	Y
lake sturgeon	*Acipenser fulvescens*	2010	S3	G3G4	SC/H		Y	Y
least darter	*Etheostoma microperca*	2004	S3	G5	SC/N		Y	Y
mud darter	*Etheostoma asprigene*	2009	S3	G4G5	SC/N		N	Y
paddlefish	*Polyodon spathula*	2010	S2	G4	THR		Y	Y
pallid shiner	*Hybopsis amnis*[1]	1962	S2	G4	END		Y	Y
pirate perch	*Aphredoderus sayanus*	2009	S3	G5	SC/N		N	Y
pugnose minnow	*Opsopoeodus emiliae*	2004	S3	G5	SC/N		N	Y
river redhorse	*Moxostoma carinatum*	2010	S2	G4	THR		Y	Y
shoal chub	*Macrhybopsis hyostoma*[2]	2009	S2	G5	THR		Y	Y
silver chub	*Macrhybopsis storeriana*	2010	S3	G5	SC/N		N	Y
starhead topminnow	*Fundulus dispar*	2009	S2	G4	END		Y	Y
weed shiner	*Notropis texanus*	2009	S3	G5	SC/N		N	Y
western sand darter	*Ammocrypta clara*	2010	S3	G3	SC/N		Y	Y

[1] *Notropis amnis* on Wisconsin's List of Threatened and Endangered Species

[2] *Macrhybopsis aestivalis* on Wisconsin's List of Threatened and Endangered Species.

Common Name	Scientific Name	Last Observed Date	State Rank	Global Rank	State Status	Federal Status	SGCN	Tracked by NHI
Grasshoppers								
large-headed grasshopper	*Phoetaliotes nebrascensis*	2006	S3?	G5	SC/N		Y	Y
northern marbled locust	*Spharagemon marmorata*	2009	S3	G5	SC/N		Y	W
sand locust	*Psinidia fenestralis*	2009	S3?	G5	SC/N		Y	Y
short-winged grasshopper	*Dichromorpha viridis*	1998	S3?	G5	SC/N		Y	Y
spotted-winged grasshopper	*Orphulella pelidna*	2009	S2S3	G5	SC/N		Y	Y
yellow-winged grasshopper	*Arphia xanthoptera*	2008	S3?	G5	SC/N		Y	Y
Leafhoppers and True Bugs								
prairie leafhopper	*Polyamia dilata*	1998	S2	GNR	THR		Y	Y
Mammals								
prairie vole	*Microtus ochrogaster*	2009	S1S2	G5	SC/N		Y	Y
western harvest mouse	*Reithrodontomys megalotis*	2005	S3	G5	SC/N		N	Y
Mayflies								
a flat-headed mayfly	*Macdunnoa persimplex*	1995	S1?	G4	SC/N		Y	Y
a flat-headed mayfly	*Pseudiron centralis*	1992	S3	G5	SC/N		Y	Y
a small minnow mayfly	*Paracloeodes minutus*	1995	S1?	G5	SC/N		Y	Y
Pecatonica River mayfly	*Acanthametropus pecatonica*	1998	S1	G2G4	END		Y	Y
Wallace's deepwater mayfly	*Spinadis simplex*	1990	S1	G2G4	END		Y	Y
Mussels								
buckhorn	*Tritogonia verrucosa*	2005	S2	G4G5	THR		Y	Y
sheepnose	*Plethobasus cyphyus*	2002	S1	G3	END	C	Y	Y
butterfly	*Ellipsaria lineolata*	2003	S2	G4	END		Y	Y
ebony shell	*Fusconaia ebena*	1988	S1	G4G5	END		Y	Y
elktoe	*Alasmidonta marginata*	2002	S4	G4	SC/P		N	Y
fawnsfoot	*Truncilla donaciformis*	2004	S1S2	G5	SC/P		Y	Y
flat floater	*Anodonta suborbiculata*	1988	S1S2	G5	SC/P		Y	Y
Higgins' eye	*Lampsilis higginsii*	2009	S1	G1	END	LE	Y	Y
mapleleaf	*Quadrula quadrula*	2002	S2S3	G5	SC/P		Y	Y
monkeyface	*Quadrula metanevra*	2004	S2	G4	THR		Y	Y
rock pocketbook	*Arcidens confragosus*	2002	S1S2	G4	THR		Y	Y
round pigtoe	*Pleurobema sintoxia*	2002	S3	G4G5	SC/P		N	Y
salamander mussel	*Simpsonaias ambigua*	1997	S2S3	G3	THR		Y	Y

Common Name	Scientific Name	Last Observed Date	State Rank	Global Rank	State Status	Federal Status	SGCN	Tracked by NHI
wartyback	*Quadrula nodulata*	1988	S1S2	G4	THR		Y	Y
yellow and slough sandshells	*Lampsilis teres*	2005	S1	G5	END		Y	Y
Reptiles								
Blanding's turtle	*Emydoidea blandingii*	2010	S3	G4	THR		Y	Y
eastern hog-nosed snake*	*Heterodon platirhinos*	1998	S3?	G5	SC/H		N	Y
false map turtle	*Graptemys pseudogeographica*	1992	S4	G5	SC/H		N	Y
gophersnake	*Pituophis catenifer*	2010	S2S3	G5	SC/P		Y	Y
gray ratsnake	*Pantherophis spiloides*	2010	S2S3	G5T5	SC/P		Y	Y
North American racer	*Coluber constrictor*	2009	S2	G5	SC/P		Y	Y
ornate box turtle	*Terrapene ornata*	2010	S1	G5	END		Y	Y
prairie ring-necked snake	*Diadophis punctatus arnyi*	2009	S3	G5T5	SC/H		Y	Y
six-lined racerunner	*Aspidoscelis sexlineata*	2009	S3	G5	SC/H		Y	Y
smooth softshell	*Apalone mutica*	1988	S3	G5	SC/H		Y	Y
timber rattlesnake	*Crotalus horridus*	2009	S2S3	G4	SC/P		Y	Y
wood turtle	*Glyptemys insculpta*	1998	S2	G4	THR		Y	Y

*This record is not yet mapped in the NHI database or the last observation date is more recent than what is in the NHI database.

Rare species that are located within one mile of the LWSR and not found on the LWSR or are mapped at a low precision in the NHI Database are important to consider during planning efforts. These species may be located on easement lands, adjacent private lands, or nearby State Natural Areas. Additional inventory can be done to determine whether or not these species are found within the study area and management may be considered that supports habitat for these species.

Table 7. Rare species that are either 1) found within one mile of the LWSR and not found on the LWSR, 2) mapped at a low precision, or 3) ranked as historical. No natural communities fit this criteria.

Animals	
Common Name	**Scientific Name**
a predaceous diving beetle	*Laccobius reflexipennis*
a predaceous diving beetle	*Lioporeus triangularis*
barn owl	*Tyto alba*
eastern massasauga	*Sistrurus catenatus catenatus*
juniper hairstreak	*Callophrys gryneus*
Knobel's riffle beetle	*Stenelmis knobeli*
little white tiger beetle	*Cicendela lepida*
loggerhead shrike	*Lanius ludovicianus*
Louisiana waterthrush	*Seiurus motacilla*
northern cricket frog	*Acris crepitans*
Royal river cruiser	*Macromia taeniolata*
western harvest mouse	*Reithrodontomys megalotis*
western ribbonsnake	*Thamnophis proximus*
Plants	
autumn coral-root	*Corallorhiza odontorhiza*
christmas fern	*Polystichum acrostichoides*
clustered broomrape	*Orobanche fasciculata*
crossleaf milkwort	*Polygala cruciata*
engelmann spike-rush	*Eleocharis engelmannii*
flat-stemmed spike-rush	*Eleocharis compressa*
glade fern	*Diplazium pycnocarpon*
grassleaf rush	*Juncus marginatus*
great Indian-plantain	*Cacalia muehlenbergii*
marbleseed	*Onosmodium molle*
Maryland senna	*Senna marilandica*
prairie parsley	*Polytaenia nuttallii*
roundstem foxglove	*Agalinis gattingeri*
showy lady's-slipper	*Cypripedium reginae*
silky willow	*Salix sericea*
small white lady's-slipper	*Cypripedium candidum*
small-flowered woolly bean	*Strophostyles leiosperma*
twinleaf	*Jeffersonia diphylla*
Virginia meadow-beauty	*Rhexia virginica*
woolly milkweed	*Asclepias lanuginosa*
yellow giant hyssop	*Agastache nepetoides*
yellow screwstem	*Bartonia virginica*
yerba de tajo	*Eclipta prostrata*

Threats to the Biodiversity of the LWSR

Potential threats to the biodiversity of the LWSR are all interrelated and include ecological simplification, habitat fragmentation, altered ecological processes, invasive species, deer abundance, climate change, and stormwater runoff and non-point source pollution.

Ecological Simplification

Ecological simplification refers to the progressive degradation of native communities to systems that are dominated by a very small number of aggressive and/or generalist species. This is initially often expressed in terms of plant life, but as plant species disappear, the animal species that rely on them disappear as well. This phenomenon can also describe the loss of diverse habitat structures and ecological processes. Factors contributing to ecological simplification include invasive species, disrupted predator-prey relationships, habitat patch edge and size, loss of genetic variability due to isolation, altered ecological processes, and some land use and management practices. Virtually every ecosystem in Wisconsin has been impacted by simplification to some extent. While we don't have specific data on how ecological simplification has changed the biological diversity of the LWSR, we do know that many of the factors shown to contribute to ecological simplification in other areas of the state are present in the LWSR.

Open and forested habitats in the LWSR are being impacted by factors that may be contributing to ecological simplification. Within both wetland and upland open habitats, invasive species, past grazing, native tree/brush invasion, isolation, small patch size, abundant habitat edge, and fire suppression may be impacting the biological diversity of these communities. Specifically, within wetlands and aquatic habitats, altered hydrology and sediment/nutrient-laden runoff from croplands (Marshall et al. 2011) may be causing changes that could lead to ecological simplification.

At a statewide level, ecological simplification is causing significant changes to Wisconsin's forests. A major conclusion of Wisconsin's Statewide Forest Assessment 2010 was that Wisconsin forest composition and structure is changing and becoming more simplified (WDNR 2010c). There is a continued decline of the oldest age classes of trees (WDNR 2010c), a decline in native herbaceous species diversity (Rogers et al. 2009; Rooney et al. 2004) and a general lack of large trees, cavity trees, snags, and coarse woody debris in most Wisconsin forests, resulting in habitat simplification and commensurate reductions in the animal species that rely on them.

Opportunities to mitigate the impacts from factors that may cause ecological simplification should be evaluated during the master planning process. In particular, recent evaluations of site level data for riparian forests in southern Wisconsin indicate that ground layer species diversity has increased between the 1950s and today (Johnson and Waller 2011). Johnson and Waller (2011) found that the increases in native diversity in riparian forest may reflect 'mesification' occurring due to dam-altered flow regimes, or an increased landscape connectivity via forest regrowth, or the frequent disturbance and micro-site heterogeneity of floodplain systems that may be promoting the co-existence of native and non-native species. The complexity of the issue of ecological simplification is great and the dynamic nature of the habitats of the LWSR will continue to make the need for research and monitoring of these areas beneficial.

Habitat Fragmentation

Habitat fragmentation is one of the greatest threats to biological diversity (including species movement and genetic diversity), forest health, and water flow and quality in the Lower Wisconsin River Basin (WDNR 2002; UMFP unk. date; WDNR 2010b). The LWSR plays a critical role in providing high-quality habitat in the region and the state because of the large size of habitat patches available. Habitat fragmentation has varied across the study area. Historical aerial photographs were examined by Freeman

et al. (2003) to determine how land cover has changed along the Wisconsin River between 1930 and 1990. In the 1930s, the Wisconsin River floodplain was dominated by forests and agriculture. Since then, forest patch size in the floodplain has increased with forests replacing agricultural and grassland areas. Between 1937 and 1990, grassland in the Wisconsin River floodplain declined by two-thirds with large reductions in the number, density, and size of grassland patches. This change has resulted in increased fragmentation of grasslands within the Wisconsin River floodplain since the 1930s and a decrease in forest fragmentation.

Although Freeman et al. (2003) determined that forest cover has increased in the Wisconsin River floodplain, forest fragmentation continues to be a concern at the landscape level and in many of the upland forests. Forest fragmentation at the landscape level can impact species diversity (Robinson et al. 1995; Rogers et al. 2009). Rogers et al. (2009) found that large forest patches in mostly minimally fragmented landscapes lost few native species, were more likely to recruit new species, and experienced slower rates of ecological simplification over the past 55 years than did smaller and more isolated patches. Forest fragmentation results in an increase in forest edge and an increase in nest failure in ground and shrub-nesting forest birds, including neotropical migrants (Donovan et al. 1995; Knutson et al. 2004). The forest edge can be an "ecological trap" for ground and shrub-nesting forest bird species. Flaspohler et al. (1999) showed that the zone around a cleared area in a forest can extend almost up to 1000 feet into the intact forest. Within this zone, ground-nesting bird nest density increases, but the nest success decreases. The decrease in nest success could be due to the increase in edge-adapted predators such as raccoons, skunks, and crows; nest-parasitizing cowbirds; and competition from edge-adapted species.

Fragmentation of open landscapes such as grasslands can impact the species that rely on these habitats, especially area sensitive birds. Larger habitat patches increase the viability of bird populations by supporting larger, healthy populations and diminishing the amount of edge habitats that increase nest predators. Pine plantations in open fields, prairies, and barrens planted from the 1930s until the 1970s on the LWSR, in addition to tree and brush encroachment, agriculture, development activities, etc., have shaded out and fragmented these habitats, thus limiting the habitat availability and quality to species dependent on these areas.

Water control structures such as dams and impoundments fragment free-flowing waterways, altering the hydrology and impacting fish populations (WDNR 2002). Historically, there were extensive and regular movements of Mississippi River fishes upstream to at least Wisconsin Dells and perhaps as far as Nekoosa or Stevens Point. The construction of the Prairie du Sac Dam led to the demise of populations of a number of large river fishes (e.g., paddlefish and blue sucker) and mussels from the Wisconsin River in Columbia County (about 45 miles of river) and eliminated access to excellent spawning habitat in the Baraboo River at Baraboo (J. Lyons, personal communication).

Altered Ecological Processes

The vegetation that historically occurred within the LWSR developed within a complex environment comprised of both elements that are static over ecological time (e.g., soils, underlying landforms) and dynamic ecological processes (e.g., hydrological cycles, nutrient cycles, wildfires). Many of the dynamic ecological processes that shaped the landscape of the LWSR have been altered by humans.

The hydrology of the Wisconsin River has been manipulated by humans for the past 180 years (Durbin 1997). The river was used in to 1800s to move logs and lumber downstream, dams were later built to provide power, create reservoirs, and to create deeper channels on the river. Starting in 1907, the river was managed to reduce seasonal flood peaks and augment low flows (Pfeiffer 2001). The continued focus on manipulating the river's hydrology for water storage and power generation has resulted in a shift in the timing of floods and a decrease in the natural extremes of the river flow. The reservoirs are drawn down in winter to prepare for spring flood storage and mid-summer to augment river flow from water loss due to evapotranspiration (Pfeiffer 2001). Since the construction of large reservoirs on the Wisconsin River,

minimum flows on the Lower Wisconsin River have decreased by as much as 17% and maximum flows have decreased by 10 to 15% (Pfeiffer 2001).

How this change in hydrology has impacted the plant and animal communities of the LWSR is not entirely known. In general, dams affect aquatic species and habitats by fragmenting them into disjunct segments, preventing the movements of some species between different stretches of the river. Increased water levels associated with dams can displace small mammals due to prolonged flooding and can restrict dispersal corridors and foraging areas of upland small mammals (Bautz 2010). In addition, natural hydrological fluctuations associated with free-flowing rivers and streams are integral to wetlands formed under fluctuating water levels and the many species that depend upon them, including amphibians that rely on a specific hydrological regime to complete certain life-stages (PARC 2002). Canopy tree dominants that may have used the natural hydrological fluctuations to obtain a niche on certain geomorphic surfaces (point bars, levees, swales) may have declined in dominance, while opportunistic species importance may have increased (Tingle et al. 2001).

Possibly the most significant impact for the LWSR from the hydrological manipulations are related to the decrease in variability of water levels, especially at high water and low water extremes and the impacts this has on floodplain landform development (sand bars, islands, slough channels, levees, etc.) and inundation period of floodplain habitats. Pfeiffer (2001) showed that the decrease in the maximum flows has had a significant impact on the frequency of complete inundation of the Deacon Thomas Slough area (also known as Cambell Bottoms) of the LWSR. This has resulted in a decrease in the amount of time the ridges and higher areas of the floodplain are fully saturated, therefore oxygen depletion of the root zone occurs less frequently, and there may be greater tree survival possibly leading to a more closed-canopy forest. The impacts from the decrease in flood severity and length of periods of flooding may also be impacting the lower floodplain areas as less scouring is occurring and anoxic conditions may not be long enough to favor species that can tolerate these conditions. Landform development within the floodplain may be impacted by changes in hydrology and since diversity in landforms is correlated with plant species diversity (Crow et al. 2000), this has the potential to have long-term impacts on vegetation. Another likely impact is that the changes in timing of flooding and current higher base flows in the late summer/fall means that the floodplain areas are less exposed to fire than was the case in pre-settlement times when the majority of the fires occurred during this period.

Given the long history of hydrological manipulation of the Wisconsin River and the likely impacts it is going to continue to have on the plant and animal communities of the LWSR it is unlikely vegetation management is going to be able to mitigate for such large changes. The loss of sediment due to the blockage at the Prairie du Sac dam, the change in variability of flooding events, and human impacts to the ground water that feeds the wetlands of the LWSR, thus it is unlikely that plant and animal communities will ever exactly resemble those seen by the early settlers of the area. As Tingle et al. (2001) state: “In general, plant communities are dependent on riverine processes and features and unless we restore the processes we cannot expect the same communities to return.”

Another ecological process that has been altered is how fire interacts with the natural communities and rare species of the LWSR. For many of the natural communities, especially the barrens, woodlands, wetlands, and prairies, fire was a critical process in the development of the communities and the species that depend on them. Without regular fire, native woody species can invade and dominate these communities. By volatilizing elevated soil nitrogen, fire also indirectly influences nutrient cycling, shifting conditions to generally favor native plants and to disfavor non-natives. In woodlands, fire facilitates seedling establishment, controls tree species that are not adapted to fire, and prevents smothering of short-statured plants through the removal of leaf litter. In grasslands, fire effects include promoting growth, flowering and overall diversity of native plants by removing excess thatch. Re-introducing fire into an area should be done with consideration of all of the species currently using the habitat and how the fire may impact the amount and quality of habitat available. For example, fire is a useful tool in managing sedge meadows, however, it has been shown to not only provide no actual control

of narrow-leaved cattail, but may, in some circumstances, actually increase the cover (Beule and Hine 1979; Mallik and Ross 1986).

Invasive Species

Many invasive plants, animals and pathogens, both terrestrial and aquatic, are present in the LWSR and surrounding landscape. Non-native invasive species thrive in newly disturbed areas, but also may invade and compromise high-quality natural areas. They establish quickly, tolerate a wide range of conditions, are easily dispersed, and are free of the diseases, predators, and competitors that kept their populations in check in their native range.

In terrestrial settings, invasive plants out-compete and even kill native plants by monopolizing light, water, and nutrients, and by altering soil chemistry and, in the case of garlic mustard, mycorrhizal relationships. In situations where invasive plants become dominant, they may even alter ecological processes by limiting one's ability to use prescribed fire (a striking example being common buckthorn), by modifying hydrology (e.g., reed canary grass (*Phalaris arundinacea*) can alter surface flow and clog culverts), and by limiting tree regeneration and ultimately forest composition (WDNR In prep.b). In addition to the threats on native communities and native species diversity, terrestrial invasive species negatively impact forestry (by reducing tree regeneration, growth and longevity), recreation (by degrading wildlife habitat and limiting access), agriculture, and human health (plants that cause skin rashes or blisters). For example, in bottomland forests, dense patches of reed canary grass can prevent regeneration of trees and a minor infestation can become dense if the canopy is opened beyond 80% cover (WDNR In prep.b).

Similarly to terrestrial invasives, aquatic invasives are successful because they originate in other regions or continents, thus lacking natural checks and balances. Early and abundant growth of aquatic plants not only overwhelms native plants, it may disrupt aquatic predator-prey relationships by fencing out larger fish, and may limit important aquatic food plants for waterfowl. The die-off of plants such as curly-leaf pondweed in summer can cause oxygen depletion in waterbodies, and decaying plants can contribute to nutrient loading and algal blooms. Aquatic invasive animals similarly present overwhelming competition to their native counterparts (e.g., rusty crayfish versus native crayfish). One non-native invasive fish, the common carp, has a strong negative impact on Wisconsin River fishes. Lyons (2005) notes the feeding and spawning by common carp are blamed for resuspending sediments and nutrients and destroying macrophyte beds. Three species of Asian carp, the silver carp (*Hypophthalmichthys molitrix*), bighead carp (*H. nobilis*), and grass carp (*Ctenopharyngodon idella)* are spreading through the Mississippi River system and have access to the lower reach of the Wisconsin River and could fundamentally alter the fish assemblage (Lyons 2005). Another example is invasive mussels, which feed on plants, animals and debris that are suspended in the water, and can lead to increased water clarity and light penetration (fostering overgrowth of rooted aquatic plants), as well as a depleted food supply for native aquatic organisms. Zebra mussels not only monopolize resources and alter the aquatic environment, they literally smother native mussels by attaching to their shells in great masses. Apart from environmental impacts, aquatic invasives diminish aquatic recreational resources by inhibiting boat and swimming access, and by negatively affecting game fish populations.

The high recreational usage of the LWSR has contributed to the introduction and spread of invasive species throughout the property. Campgrounds, trails, navigable waters, and other high-use areas are typical entry points for invasive species that are introduced by visitors' footwear, clothing, vehicle tires, boats, and recreational equipment. Once established, these invasives may continue to spread along natural corridors (e.g., the Wisconsin River) and along recreational corridors (e.g, trails). They even have the potential to invade remote high-quality natural areas via vectors such as wind, water, and wildlife. Invasive species may also be spread inadvertently through management activities such as timber operations and roadside mowing, especially if Best Management Practices aren't followed.

Invasive species that are widespread in the LWSR and pose the greatest immediate threat to native species diversity, rare species habitats, or high-quality natural communities are listed in Table 8. When resources for complete control of widespread invasives are lacking, containment (i.e., limiting further spread) may be considered as an alternative action. Early detection and rapid control of new and/or small infestations, however, may be considered for higher prioritization in an invasive species management strategy (Boos et al. 2010). A number of invasive species are, in fact, new or are not yet widespread in the LWSR (Table 9), while others are known in the vicinity (Table 10); monitoring for these species and rapid response to small infestations represent high-impact actions.

Table 8. Widespread non-native invasive species currently known from the LWSR. Sources are the working knowledge of contributors to this report, including three WDNR property managers, two WDNR foresters, and two WDNR aquatic resource specialists, plus information from the WDNR and GLIFWC websites.

		Upland Habitats		Wetland Habitats		
Common Name	**Latin Name**	**Open**	**Wooded**	**Open**	**Wooded**	**Abundance Comments**
Plant						
autumn olive	*Eleagnus angustifolia*	X				Mostly moderate, though abundant in areas, esp along STH 60.
black locust	*Robinia pseudoacacia*	X	X			Abundant.
Eurasian bush honeysuckles	*Lonicera* spp.	X	X			Abundant.
garlic mustard	*Alliaria petiolata*		X		X	Abundant.
moneywort	*Lysimachia nummularia*				X	Common to abundant in Floodplain Forest.
narrow-leaved cattail	*Typha angustifolia*			X		Abundance information limited.
purple loosestrife	*Lythrum salicaria*			X		Moderate (*e.g.*, Wauzeka, Kickapoo Bottoms) to abundant (*e.g.*, Mazomanie Unit).
reed canary grass	*Phalaris arundinacea*			X	X	Abundant.
spotted knapweed	*Centaurea biebersteinii*	X				Moderate to abundant.
wild parsnip	*Pastinaca sativa*	X		X		Moderate to abundant.
yellow and white sweet clover	*Melilotus officinalis and M. alba*	X				Moderate to abundant.
Fungus						
oak wilt	*Ceratocystis fagacearum*		X		X	Common, especially on the sand terrace and sandstone dominated areas.
annosum root rot	*Heterobasidion annosum*		X			Common in pine plantations.

Table 9. New or not-widespread non-native invasive species currently known from the LWSR. Sources are the working knowledge of contributors to this report, including three WDNR property managers, two WDNR foresters, and two WDNR aquatic resource specialists, plus information from the WDNR and GLIFWC websites.

		Upland Habitats		Wetland Habitats			
Common Name	**Latin Name**	**Open**	**Wooded**	**Open**	**Wooded**	**Aquatic**	**Abundance Comments**
Plant							
common buckthorn	*Rhamnus cathartica*	X	X	X	X		Moderate to dense upstream, becoming rarer past Muscoda going downstream.
common teasel	*Dipsacus fullonum subsp. Sylvestris*	X					Rare. One popn on CTH K from Green River Rd all the way to Woodman Landing.
crown vetch	*Coronilla varia*	X					Moderate.
curly-leaf pondweed	*Potamogeton crispus*					X	Moderate. Found in 18 out of 100 sampled lakes/sloughs by Marshall. May be abundant in the main river channel south of the Prairie du Sac dam.
cut-leaved teasel	*Dipsacus laciniatus*	X					Rare. One popn on N roadside at STH 35 bridge at Bridgeport, by boat landing parking lot.
dame's rocket	*Hesperis matronalis*		X		X		Moderate.
grass carp	*Ctenopharyngodon idella*					X	Rare. Two specimens located below the Prairie du Sac dam. Grass carp have been seen in the Mississippi River (and a few other places around the state) on multiple occasions over the last 25 years, but all have been adults, and there is no evidence of successful spawning by the species in Wisconsin waters.
Japanese hedge parsley	*Torilis japonica*		X				Rare. Four known popns: 1) Along CTH C, just W of Helena Rd E of Tower Hill S.P.; 2) Watcher Road and STH 78, S of Sauk City; 3) Conservation Rd near Wisconsin R., N of Mazomanie; 4) Mazomanie Sand Barrens State Natural Area.
Japanese knotweed	*Polygonum cuspidatum*	X	X	X	X		Rare, though several problem sites in Crawford, Richland and Grant Co's. One popn at end of Algner Lane on the Wisconsin R., E of Orion. Another on Island in Wisconsin R. under STH 130 Bridge, S of Lone

							Rock. Also found at Mazomanie Barrens SNA.
Eurasian water milfoil	*Myriophyllum spicatum*					X	Moderate. Found in 22 out of 100 sampled lakes/sloughs by Marshall.
multiflora rose	*Rosa multiflora*	X	X				Moderate.
poison hemlock	*Conium maculatum*	X		X			Rare. Known at 3 locations.
Animal							
rusty crayfish						X	Moderate.
zebra mussel	*Dreissena polymorpha*					X	Rare. Found attached to native mussels in LWSR during 2009 surveys. Also present on the Prairie du Sac dam.

Table 10. Non-native invasive species known from the area surrounding the LWSR, but not currently known from within the LWSR. Sources are the working knowledge of contributors to this report, including three WDNR property managers, two WDNR foresters, and two WDNR aquatic resource specialists, plus information from the WDNR and GLIFWC websites.

		Upland Habitats		Wetland Habitats			
Common Name	**Latin Name**	**Open**	**Wooded**	**Open**	**Wooded**	**Aquatic**	**Location Comments**
Plant							
black swallow-wort	*Vincetoxicum nigrum*	X	X				Known popns in Prairie du Chien area, though not in LWSR..
Japanese hops	*Humulus japonicus*			X	X		Very problematic along the Platte River in Grant Co.; not yet known in LWSR.
oriental bittersweet	*Celastrus orbiculatus*	X	X				Known popns in Grant Co, though not in LWSR.
Animal							
Asian carp	*Hypophthalmichthys nobilis* and *H. molitrix*					X	Found in Mississippi R. near mouth of Wisconsin R.
common carp	*Cyprinus carpio*					X	
European earthworms	*Families of Acanthodrilidae, Lumbricidae, and Megascloedidae*						
emerald ash borer	*Agrilus planipennis*		X				
faucet snail	*Bithynia tentaculata*					X	Has been detected from

							Pool 4 to Pool 11 in the Mississippi River.
gypsy moth	*Lymantria dispar*		X				
quagga mussel	*Dreissena bugensis*					X	
western mosquitofish	*Gambusia affinis*					X	Found in Mississippi R. near mouth of Wisconsin R.
Fungus and Other Pathogens							
viral hemorrhagic septicemia						X	

For recommendations on controlling specific invasive species consult with DNR staff, refer to websites on invasive species, such as that maintained by the DNR (http://dnr.wi.gov/invasives) and by the Invasive Plants Association of Wisconsin (http://www.ipaw.org), and seek assistance from local invasive species groups:

- Greater Sauk County Invasive Plant Team [Contact: John Exo, UW-Extension Basin Educator, john.exo@ces.uwex.edu (608) 355-3554].
- Southwestern Wisconsin Weed Management Association [Contact: Mark Horn, mark.horn@monarda.biz, (608) 836-0054.]

Also refer to invasive species Best Management Practices (BMPs) for forestry, recreation, urban forestry, and rights-of-way, which were developed by the Wisconsin Council on Forestry (http://council.wisconsinforestry.org/).

Emerald Ash Borer

The emerald ash borer (*Agrilus planipennis*), an invasive, wood-boring beetle that attacks ash trees, was positively identified for the first time in Wisconsin in 2008, and is now found in six counties. The beetle attacks all species of ash (*Fraxinus* spp.) in Wisconsin, and the risk to forests is high: Models predict that a healthy forest could lose 98% of its ash trees in six years (http://www.emeraldashborer.wi.gov).

The lowland forests of the LWSR are particularly vulnerable to the effects of emerald ash borer, as white, green, and black ash are important tree species within this ecosystem and are the dominant canopy species regenerating. Large-scale loss of ash in this area, whether through EAB-caused mortality or harvesting, could cause a cascade of negative impacts. Degradation of diverse, high-quality forests and loss of forest cover could further lead to diminishment of important habitat for rare plants and animals, elevated water tables, and infestation of disturbance-loving invasives such as reed canary grass and glossy buckthorn (*Rhamnus frangula*) (WDNR 2010a). It is important to note that removal of all ash as a stopgap measure against EAB is not recommended (WDNR 2010a).

European Earthworms

The invasion of forests by European earthworms of the families *Acanthodrilidae*, *Lumbricidae*, and *Megascloedidae* is a concern throughout Wisconsin. While native earthworms were absent from much of Wisconsin after the last glaciation, non-native invasive earthworms have been introduced since widespread Euro-American settlement, primarily as discarded fishing bait (Hendrix and Bohlen 2002, Hale et al. 2005). The LWSR is unique in that it includes both unglaciated uplands and glacial outwash in the valleys. There are many uncertainties with regard to worm populations in this area and the presence of European earthworms is only speculative. Non-native earthworms can have dramatic impacts on forest floor properties by greatly reducing organic matter (Hale et al. 2005), microbial biomass (Groffman et al.

2004), nutrient availability (Bohlen et al. 2004, Suarez et al. 2004), and fine-root biomass (Groffman et al. 2004). These physical changes in the forest floor reduce densities of tree seedlings and rare herbs (Gundale 2002) and can favor invasive plants (Kourtev et al. 1999). In a study of 51 Northern Wisconsin forest stands, Wiegmann (2006) found that shifts in ground layer plant community composition due to non-native earthworms were more severe in stands with high white-tailed deer densities.

Oak Wilt

Oak wilt is caused by a fungus, *Ceratocystis fagacearum*, that effects water movement within oak trees, often killing the trees. The fungus was thought to be native, but the most recent science suggests that it is not (J. Cummings Carlson, pers. comm.). It has been in the state for at least 100 years and is widespread throughout the southern part of the state. Oak wilt is often not a major concern for woodland or barrens restoration areas where open canopy conditions are favored, and dead oak trees can make long-lasting wildlife cavity trees. It can, however, have significant impacts to forested stands with a heavy oak component.

Deer Abundance

The current level of the white-tailed deer (*Odocoileus virginianus*) herd in Wisconsin has become a significant barrier to the conservation of biodiversity and sustainable forest management (WDNR 2010c). The Deer Management Units that include the LWSR have much higher deer numbers per square mile of deer range than the goal of 20 (WDNR 2010b). Data resulting from the monitoring of changes in deer populations by the WDNR in the chronic wasting disease management zone allows for another analysis of deer abundance. Only a very small percentage of the study area was included in the 2011 surveys. Within this area, deer abundance ranged from 4 to 43 deer per square mile. Winter deer counts vary across the habitats of the LWSR with the uplands and adjacent agricultural lands possibly having higher counts than the bottomlands.

Herbivory by white-tailed deer has been identified as a major disturbance contributing to ecological simplification of Wisconsin's forests (Rooney et al 2004; Kovach et al 2006; Wisconson Council on Forestry 2007; WDNR 2010c). Deer herbivory impacts songbirds, small mammals (Flowerdew and Ellwood 2001), invertebrate populations (Allombert et al. 2005), and rare plant abundance and frequency by altering natural community composition and structure. Deer herbivory causes a decreased cover in the shrub and sapling layer which negatively impacts species richness and abundance of songbirds that nest in that layer (deCalesta 1994, McShea and Rappole 2000).

Although there are many factors affecting long-term changes in Wisconsin's forests, including invasive species and surrounding landscape condition, impacts from deer, in combination with other factors, remain a primary source of ecological change (Waller et al. 2009).

Climate Change

Climate change will have an impact on the natural resources of the LWSR, however, many of the changes are yet uncertain. Some changes that may result from climate change include increases in both summer and winter minimum temperatures, shifts in seasonal precipitation (more in the winter, less in the summer), and more frequent extreme weather events such as very heavy rainstorms or heat waves (WICCI 2011). Results of these changes may include the shifting of species ranges, including species at the southern end of their range in the LWSR (sugar maple, white pine, and jack pine) and species at the very northern end of their range (honey locust, Kentucky coffee tree, sycamore and chinquapin oak). The LWSR may play an especially critical role in this migration of species because of the river's connection to the Mississippi River Valley and eventually the Gulf of Mexico as well as the large amount of high-quality habitat available. Changing rainfall patterns may affect runoff and groundwater inflows to wetlands (Mitsch and Gosselink 2000). Lyons et al. (2010) notes Wisconsin models predict major declines in the occurrence of many fish species in response to a warmer climate, and is not limited to only

cold-water species, which was expected, but cool-water species would decline to the same or a greater extent.

Natural resources of the LWSR will also be impacted by proposed climate change mitigation efforts including using biomass for fuel (WICCI 2011) and engineered ditching and other drainage modifications intended to relieve flooding of populated areas (WDNR 2010b).

Water Quality

The primary water quality problems in the LWSR basin are caused by nonpoint sources of pollution, particularly from agricultural operations (including pesticides, fertilizers, and liquid manure) and urban areas (including construction sites and urban storm sewers); excessive populations of rough fish; and hydrologic modifications of the streams such as damming, straightening, and the ditching, draining or other alteration of wetlands. Other threats to water quality and aquatic life in the basin come from toxics, including the atmospheric deposition of mercury, PCBs, nonpoint source pollution (road salts and other chemicals), and point source discharges that exceed permit limits and development.

Water quality of the Lower Wisconsin River is greatly influenced by Lake Wisconsin (WDNR 2010b). The lake is a hyper-eutrophic impoundment plagued by recent excessive cyano-bacteria (blue-green algae) blooms, excessive phosphorus and frequent oxygen depletion. These water quality problems are transferred to the Lower Wisconsin River. Recent 2007 water quality sampling in the tailwater area below the Prairie du Sac (Alliant Energy) dam indicated frequent high levels of total phosphorus, and dissolved oxygen levels below the standard of 5 mg/l as outlined in ch. NR 102, Wis. Adm. Code (WDNR 2010b).

Stormwater runoff and nonpoint source pollution are the biggest threats to groundwater quality in the Lower Wisconsin River basin and the aquatic resources that depend on it (WDNR 2002; Marshall et al. 2011). Stormwater runoff and nonpoint source pollution occur when water from rainfall, snowmelt, or irrigation runs over the land, picks up pollutants, and deposits them into rivers, lakes, sewer systems, or groundwater (WDNR 2002). Marshall et al. (2011) note that groundwater plays an important role in sustaining off-channel fish habitats. Threats in the form of polluted runoff and contaminated groundwater are a concern as the entire LWSR floodplain is designated as highly susceptible to groundwater contamination (Marshall et al. 2011). The most susceptible areas to groundwater contamination are where shallow groundwater tables exist with coarse sandy soils present (Marshall et al. 2011). Oxbows and backwater sloughs that receive upland groundwater inflow are the most favorable to the unique assemblage of fish that inhabit these areas, yet these habitats are particularly susceptible to groundwater contamination.

Management Considerations and Opportunities for Biodiversity Conservation for the Lower Wisconsin State Riverway

The Primary Site(s) listed for each opportunity for biodiversity conservation mentioned below represents the best known site(s) to protect, manage, and/or restore that feature. Primary Sites contain relatively undisturbed, high-quality, natural communities; provide important habitat for rare species; offer opportunities for restoration; provide important ecological connections; or some combination of the above factors. See Appendix G for more information on Primary Sites of the LWSR.

Landscape Level Priorities

Ecological Connections

The LWSR offers a significant opportunity to manage a landscape mosaic of diverse habitats. The connection of upland forests with bedrock outcrops of Dry Prairie to the expansive lowland forests and wetlands of the river valley bottom are an exceptional opportunity for landscape level management.

This mosaic of diverse habitats meets the needs of many animal species that require a variety of habitat types for shelter, foraging, rearing their young, and hibernating. By providing this waterbody-to-wetland-to-upland continuum, the habitat needs for wildlife are maximized, and their safe movement from one habitat type to the next is ensured.

Some examples of multiple-habitat usage include:

- Turtles such as the Blanding's use a wide variety of habitat types. In addition to a variety of aquatic habitats, they are largely utilizing a variety of wetland types, but spend a good deal of time on land during the nesting season. They prefer to nest in sandy or loose soils within close proximity to wetlands, and are most vulnerable while traveling to (and from) their nesting site.
- Other reptiles including many snakes like the timber rattlesnake (*Crotalus horridus*) seek out rocky outcrops on south or west-facing slopes associated with open grassy areas in spring and fall but move into deciduous forest areas during the summer in search of prey. For cold-blooded species, these connections of diverse habitats are crucial for thermoregulation.
- Many salamander species spend most of the year in the forest under woody debris and leaf litter, but move to fishless wetlands or ephemeral ponds for breeding. Similarly, some frogs and toads breed in fishless ponds or wetlands, but forage far from open water in upland forest or wet prairie and meadow areas.
- The habitat for many dragonfly species' nymphs is shallow, slow-moving waters (such as oxbow lakes) or spring-fed wetlands, while upland meadows and fields near breeding habitat are typically used by foraging adults.
- Summer resident bats use cavities in snags or hollow trees, tree branches and loose bark, or foliage, for roosting but require safe passage to nearby open areas including rivers and streams, lakes or ponds, and open fields or forest openings for foraging.
- Wintering bald eagles congregate within the LWSR due to its suitable upland forests of large trees utilized for night-time roosting but within close proximity for commuting to daytime open water foraging areas.

- Off-channel areas (e.g. sloughs, wetlands, floodplain lakes) are important spawning/nursery habitats for fish that live in the main channel as adults (e.g. silver chub, northern pike) and should be maintained as a mosaic of diverse and connected habitats.

Migration Corridor

The Wisconsin River, flowing 430 miles from its point of origin on the Wisconsin-Michigan border at Lac Vieux Desert to its confluence with the Mississippi, provides a critical link from the forests of the north to the Mississippi River and the Gulf of Mexico. In particular, the LWSR is important to the migration of many terrestrial and aquatic species because of its shared boundaries with the nationally significant Mississippi River, the Driftless Area, and the Upper Mississippi migratory bird flyway. Within the Upper Mississippi River Basin, loss of migratory bird habitat was noted as one of three key issues impacting the area (UMFP unk. date).

The LWSR is used as a migration corridor by many species for both long-distance and short-distance migration. Frogs, salamanders, turtles, birds, and other animals migrate from uplands to the river and associated lowlands throughout their yearly life cycles (WDNR 2010b). Migratory bats generally require breeding sites, overwintering sites, and migrations corridors that link the two (Eby and Fleming 2003).

The LWSR is a well-known bird migration corridor, hosting hundreds of thousands of birds in spring and fall, from songbirds to shorebirds, waterbirds and raptors. In the winter, raptors such as rough-legged hawk (*Buteo lagopus*), American kestrel (*Falco sparverius*), sharp-shinned hawk (*Accipiter striatus*), northern goshawk (*Accipiter gentilis*), and sometimes short-eared owl (*Asio flammeus*) concentrate in the river valley. Large populations of bald eagles, diving ducks and gulls occur in winter, often congregating below the Prairie du Sac dam when the river freezes elsewhere. Numerous wooded bluffs, including Ferry Bluff, Lone Rock Bluffs and Sugarloaf are important roost sites for wintering bald eagles (Mossman and Steele In prep.). Since 2002, during the spring and fall migrations, whooping cranes (*Grus americana*) have used the wetlands of the LWSR for foraging and roosting.

The habitat requirements for migrating birds (Lincoln et al. 1998) and bats (Eby and Fleming 2003) are largely unknown. This makes the assessment of habitat needs and threats difficult. Known threats to migration corridors for these species include habitat fragmentation and aerial obstructions (e.g., communication towers and wind turbines).

The migration corridor that the main channel of the river provides is essential to the maintenance of many fish species and mussels, but the dam at Prairie du Sac has long blocked upstream migrations of Mississippi River fishes. Historically, there were extensive and regular movements of Mississippi River fishes upstream to at least Wisconsin Dells and perhaps as far as Nekoosa or Stevens Point. The construction of the dam led to the demise of populations of a number of large river fishes (e.g., paddlefish and blue sucker) and mussels from the Wisconsin River in Columbia County (about 45 miles of river) and eliminated access to excellent spawning habitat in the Baraboo River at Baraboo. The ongoing installation of an upstream fish passage at the Prairie du Sac Dam, scheduled to become operational in 2014, is one of the most important management actions concerning river fish migrations in the state, potentially re-connecting the Mississippi and Lower Wisconsin with a big chunk of the Middle Wisconsin and Baraboo Rivers after 100 years of isolation (J. Lyons, personal communication).

Older Forests / Old-Growth Forests

Older forests (greater than 100-120 years old) in Wisconsin are rare and declining, largely due to timber harvesting and conversion to other land uses (WDNR 2010c). The WDNR has identified a need to conserve, protect, and manage old-growth forests (WDNR 2004, WDNR 1995) and old-growth management is a component of Forest Certification.

Old-growth stands are sometimes characterized by a multi-layered, uneven age and size class structure; a high degree of compositional and structural patchiness and heterogeneity; and significant amounts of

coarse woody debris and tip-up mounds (WDNR In Prep. a). This is true in Floodplain Forests since flood pulse dynamics create patches of recruitment of new age classes into the canopy (WDNR In prep. b). The structural diversity provided by old-growth and older forests that support unique assemblages of plants, birds, and other animals. Old-growth forest management is one important facet of providing the diverse range of habitats needed for sustainable forest management (WDNR 2010c).

The LWSR offers exceptional opportunities to manage for older forests and old-growth forests on a landscape level and the prospect for old-growth stand development is very good on the LWSR within the next 20 years (WDNR 2010b). In Wisconsin, bottomland hardwood types older than 100 years represent less than 2.4% of this type's total acreage statewide (WDNR In Prep. b). On the LWSR, currently 32% of the bottomland hardwood forests are over 100 years old.

Although only 4% of Wisconsin's forests are over 100 years old and most are between 60 and 80 years old (WDNR 2010c), WDNR Forest Reconnaissance data for the LWSR indicate that 16% of the oak forests are over 100 years old (WISFIRS 2010). Another 11% of the forests are between 96 and 100 years old. Many of the oak species of the LWSR, including northern red, white, and bur, are all exceptionally long-lived trees with maximum lifespans of 300 to 600 years (Burns and Honkala 1990). Recently, northern red oak, an important canopy tree in the older forests of the LWSR has been declining in volume in some parts of the state due to high harvest levels relative to the standing volume (WDNR 2010c). Throughout the rest of the state, the Statewide Forest Assessment 2010 (WDNR 2010c) notes that northern red oak has been increasing in growing stock volume. This results in significant opportunities to promote forest stands that are at least 200 years old and for the development of structural characteristics required for species that use old-growth forests.

Older forests of the LWSR provide habitat for many rare and declining species in the state, including red-shouldered hawk, cerulean warbler, prothonotary warbler, Kentucky warbler, Acadian flycatcher, and all of Wisconsin's summer resident forest bats including the recently state listed big brown, little brown, eastern pipistrelle, and northern long-eared bats. For example, Richwood Bottoms SNA is considered a relict stand or landscape (WDNR In prep. b). Relict stands or landscapes appear never to have been manipulated, exploited, or severely disturbed by humans of European origin; in Wisconsin, a stand would thus show no evidence of significant human disturbance since about 1800 AD. Greater than 200 year old swamp white oaks are known from Richwood Bottoms SNA, which provides habitat for many of the species listed above.

High Conservation Value Forests

The Wisconsin DNR manages 1.5 million acres that are certified by the Forest Stewardship Council (FSC) and the Sustainable Forest Initiative (SFI). Forest certification requires forests to be managed using specified criteria for ecological, social, and economic sustainability. Principle 9 of the *Draft 7 FSC-US Forest Management Standard* concerns the maintenance of High Conservation Value Forests (HCVF). High Conservation Value Forests are defined as possessing one or more of the following High Conservation Values:

- Contain globally, regionally, or nationally significant concentrations of biodiversity values, including rare, threatened, or endangered species and their habitats
- Globally, regionally, or nationally significant large landscape level forests, contained within, or containing the management unit, where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance
- Are in or contain rare, threatened, or endangered ecosystems
- Provide basic services of nature in critical situations (e.g., watershed protection, erosion control)
- Are fundamental to meeting basic needs of local communities (e.g., subsistence, health)

- Are critical to local communities' traditional cultural identity (areas of cultural, ecological, economic, or religious significance identified in cooperation with such local communities)

Based on the current draft criteria for defining HCVFs (Forest Stewardship Council 2009) the best opportunities for HCVF on the LWSR are the Primary Sites, as well as high quality natural communities and rare species habitat areas that are outside of the Primary Sites.

Community Level Priorities and Restoration Opportunities

Open Wetlands

Open wetlands (wetlands not dominated by woody vegetation) of the LWSR include Southern Sedge Meadows, Emergent Marsh, and Wet-mesic Prairie. These wetlands are an important part of the habitat needs of numerous invertebrates, birds, fish, and amphibians and perform important ecological services such as water filtration and flood mitigation.

Southern Sedge Meadows at one time covered nearly one million acres in the state (Hoffman 2002), but wetland losses increased with technological advancements in converting wetlands to agriculture in the mid 1900's. Now only about 200,000 acres remain and many of these acres are now dominated by the invasive reed canary grass (Hoffman 2002). Protecting, managing, and restoring the remaining sedge meadows and low prairies within a matrix of open wetland types would benefit the many plant and animal species requiring these habitats.

Threats to open wetland communities include disruption of hydrology, runoff from roads and adjacent agricultural areas, and invasive species. Especially problematic are non-native shrubs such as glossy buckthorn which convert diverse, open, graminoid-dominated wetlands to shrub thickets. Reed canary grass and non-native cat-tail (narrow-leaved cat-tail [*Typha angustifolia*]) and hybrid cat-tail [*T.* X *glauca*]) pose a particular threat to sedge meadows. Management to reduce invasive species in these areas is critical. Monitoring of invasive species before and after management would be beneficial to ensure activities are helping to meet overall restoration objectives.

The LWSR offers several opportunities to manage and protect wetlands within a mosaic of native grasslands, older forests, and good-quality aquatic communities. Some of the best wetlands could be considered for special management and protection designation, particularly where rare and declining species have been documented. Primary sites with opportunities to protect and manage open wetlands and their associated flora and fauna are: Bakken's Pond Marsh and Woods, Smith Slough, Avoca Prairie and Savanna, Goodwiler Lake Lowlands, Fishtrap Flowage and Bottoms, and Wauzeka Bottoms.

Floodplain Forests

Floodplain Forests were uncommon historically, occupying only about 3% of the Western Coulee and Ridges Ecological Landscape and even smaller percentages of other Ecological Landscapes (Finley 1976). The acreage of Floodplain Forests in Wisconsin has been steadily increasing from 1% historically to about 9% of all forest land currently and silver maple, an important canopy tree, continues to show steady and significant increases in volume (WDNR 2010c).

Changes to the historical disturbance regimes in the lowland forests of the LWSR are described in the previous "Altered Ecological Processes" section above. These alterations have undoubtedly changed the lowland forests of the LWSR over the past 180 years. Understanding how these alterations have changed the composition, structure, and age class distribution of these forests is difficult and determining how to protect and enhance these forests in the future given the continued alterations to historical disturbance regimes is even more challenging. For example, eastern cottonwood is a species that has generally been thought to have declined due to changes in the historical disturbance regimes in the LWSR. Understanding the historical importance of eastern cottonwood to the study area, establishment and growth requirements, and what the limiting factors are to its current abundance is important. According to

the Public Land Survey System tree data collected between 1832 and 1850, eastern cottonwood was historically rare with only two trees counted in the study area that was classified as a wetland by the WWI. In Curtis' (1959) seminal work, eastern cottonwood was an important species in southern lowland forests and was typically found on pioneer sites along sand bars, mud flats, and other open places of recent soil disturbance near the water's edge. In the absence of further disturbance by the river, these stands tend to be replaced by silver maple and American elm. Alsum (2003) found that in five resampled plots along the Lower Wisconsin Riverway, eastern cottonwood decreased. In another study of Curtis' plots in this study area, Johnson (unpublished data) found that eastern cottonwood increased from 0 trees to 1 in the four plots sampled.

This ambiguity over the prevalence of a species such as eastern cottonwood prior to widespread Euro-American settlement is less important than understanding how current water regulation of the LWSR will impact the future of this species. Regulated flow of the river that creates frequent floods has shown to result in stable, yet smaller populations of eastern cottonwood due to high flood mortality (Lytle and Merritt 2004). This, in combination with other variables, may be favoring silver maple over other species in lowland forests of the Wisconsin River. In proportion to other trees in the lowland forests of the Wisconsin River, silver maple has increased since widespread Euro-American settlement (Turner et al. 2008). The extent of lowland forests along the Wisconsin River, and especially within the LWSR, have increased due to the replacement of crops and grassland by forest (Freeman et al. 2003). Therefore, it is difficult to know whether or not silver maple has increased enough in abundance over that period to reduce the proportional abundance of other species even as these species persisted at a similar numerical abundance.

Other factors that may be favoring silver maple over other species such as eastern cottonwood, black willow, and river birch may be that it's less dependent on mineral soil and more tolerant of long duration flooding than other species. The shade tolerance of silver maple compared to other species may also be favoring this species. The tolerance to shade of silver maple ranges from moderately tolerant to very intolerant (Burns and Honkala 1990; Barnes and Wagner 2004), depending on site quality and location. Silver maple is often classified as mid-tolerant (Barnes et al. 1998) to tolerant, although it has been rated very intolerant on bottomland sites in the southern United States (Burns and Honkala 1990).

Silver maple's potential intolerance to shade on certain sites and seasonal inundation (Tepley et al. 2004) may be a factor in the low amount of seedlings currently present. According to Curtis (1959), lowland forests characteristically have low densities of seedling reproduction and subsequent lowered values in the sapling class. Although it is impossible to determine from Curtis' data whether or not the understory density has increased in the LWSR (Hale et al. 2008), Hale et al. (2008) determined that understory (sapling) density is abnormally high in the LWSR. The inability to quantify the understory density during Curtis' surveys in the 1950s and pre-widespread European settlement, lead to many questions over the historical age class distribution of the Floodplain Forests of the LWSR.

The Floodplain Forests of the LWSR have changed since widespread Euro-American settlement. Data for the understory (seedling and sapling layers) of Floodplain Forests are incomplete for the LWSR and not available for analysis of the entire study area. When this inventory is complete and available in the NED system (see Glossary), it may be available to analyze stand level data. User opinion of the data suggests that canopy species, including silver maple and eastern cottonwood, are not being regenerated across large areas of the LWSR. After reviewing plots and walking through forest stands, it has been stated that based on the number and size of trees in the canopy now, early successional species such as eastern cottonwood were part of the development of the stands, but these species are not part of the dominant regeneration pools. As shown earlier, there is a very small amount of data available for analysis of pre-settlement conditions.

Floodplain Forests and other natural communities of the LWSR and throughout Wisconsin may be transitioning to novel ecosystems. With enough data we may be able to say whether or not the Floodplain

Forests of the LWSR are developing new combinations of species or are the result of biotic response to human-induced abiotic conditions (Hobbs et al. 2006). Ecological restoration that aims to restore plant communities to reflect undisturbed conditions may not be appropriate given the long history of hydrologic modification and other disturbances (Tingle et al. 2001). Given that many of the changes to these forests were made by factors that are likely to continue into the future, key management considerations are how to maximize the beneficial changes to these forests (habitat for rare and declining species as an example) and reduce the less beneficial aspects (ecological simplification for example). This may help focus efforts to return these areas to the plant and animal communities present when early settlers arrived in Wisconsin by maintaining the least impacted areas so they don't develop into a novel ecosystem and recognizing when there isn't enough time or resources available to convert areas to a pre-existing condition.

Critical sites for protecting and managing Floodplain Forest and their associated flora and fauna are the following Primary Sites: Richwood Bottoms Area, Wauzeka Bottoms, Mazomanie Bottoms, Weniger Island and Forest, Millville Woodland and Adiantum Woods, Cynthia Slough, Bakken's Pond Marsh and Woods, Cedar Island, and Smith Slough.

Aquatic Features

Unique aquatic resources present in the LWSR include springs, spring ponds, spring runs, oxbow lakes, and sloughs. In the Driftless Area where natural lakes are scarce, the extensive network of Wisconsin River sloughs, floodplain and oxbow lakes function as ecologically significant areas for rare fishes, bryozoans, aquatic insects, reptiles and amphibians (WDNR 2010b). All add significantly to the overall diversity of the LWSR and more research is needed to better understand the representative plants and animals of these aquatic types.

Floodplain lakes and spring ponds in the LWSR are especially important as habitat for a number of rare fish. Wetlands adjacent to these spring ponds support rare marsh birds. These groundwater influenced waterbodies typically have high water clarity, colder water temperatures, higher dissolved oxygen levels, low sedimentation, and are relatively stable with very little change in water temperature, water flow, or chemical composition. Historically, these floodplain lakes and ponds were likely more dynamic as flooding during high water periods changed water temperature, flow, sedimentation and chemical composition. These waterbodies typically have much greater plant and fish diversity than those fed mainly by alluvial riverine water similar to the main channel of the river. These features are highly susceptible to damage, and land use practices that lead to soil or hydrological disturbance should be avoided. Recharge areas need to be identified and managed carefully if the springs and seeps are to remain functional.

Floodplain lakes and the main channel of the Lower Wisconsin River support a unique blend of riverine and lake fish populations, and contain perhaps the most abundant populations of rare and endangered aquatic species in southern Wisconsin (WDNR 2010b). These important areas are susceptible to the effects of area land use development because potential stormwater runoff and groundwater impacts may degrade habitat and water quality (Marshall et al. 2011). During recent surveys conducted in floodplain lakes of the LWSR, rare fish generally were not found along developed shorelines where aquatic plants and coarse woody debris had been removed (WDNR 2010b).

Important Primary Sites for the protection of aquatic features are the Goodwiler Lake Lowlands, Smith Slough, Avoca Prairie and Savanna, Bakken's Pond Marsh and Woods, Orion Mussel Bed, and Fishtrap Flowage and Bottoms. In addition, Jones, Wood, and Norton sloughs on private lands near Spring Green have high importance for aquatic features and should be a priority for acquisition.

Slough within a Floodplain Forest. Photo by Janeen Laatsch.

Prairies, Oak Openings, Oak Woodlands, and Barrens

Prairies, Oak Openings, Oak Woodlands, and barrens were historically common in Wisconsin but are now rare throughout the state. Restoration of these globally rare natural communities is critical to the survival of many rare plants and animals that depend on them. The LWSR offers opportunities to restore prairies, Oak Openings, Oak Woodlands, and barrens on a landscape scale and within a matrix of other habitats.

Historically, Oak Openings were abundant in Wisconsin, covering approximately 5.5 million acres (Curtis 1959) south of the Tension Zone. Review of historical literature indicates that Oak Openings once supported an exceptionally diverse flora, about 25% of the entire native flora of Wisconsin (Leach and Givnish 1999). Of the about 75,000 acres (Hoffman 2009) of Oak Opening remaining in Wisconsin, many of these are highly degraded or have succeeded to closed-canopy oak forests. The few extant remnants are mostly on drier sites, with the mesic and wet-mesic Oak Openings almost totally destroyed by conversion to agricultural or residential uses and by the encroachment of other woody plants due to fire suppression.

Oak woodland once occupied approximately 1.4 million acres (Curtis 1959) in pre-widespread Euro-American settlement Wisconsin; today, it is extraordinarily rare – only about 140,000 acres remain in the state (Hoffman 2009). Most of these remnants are highly degraded and have converted to closed-canopy oak forest.

Prairie once occupied approximately 2.1 million acres in Wisconsin. Now, approximately 2,000 acres remain – less than 0.1% (Leach and Givnish 1999). Of these, only those prairies that occurred at the wet and dry ends of the soil spectrum survived. Virtually all deep-soil Mesic Prairies were converted to agricultural or residential uses. The surviving remnants are highly degraded due to fire suppression, over-grazing, invasion of woody species, invasive species and, in the case of Wet Prairies, ditching, and tiling. Wisconsin has more Dry Prairies than any other state because of the many steep-sided bluffs in the extensive Driftless Area, the rough terrain of the kettle interlobate moraine, and the north-south orientation of several major river valleys such as the Mississippi, the Chippewa, and the St. Croix (WDNR 2006b). These topographic attributes provide suitable sites for the development and persistence of this prairie type.

Oak Barrens are uncommon in Southern Wisconsin and Pine Barrens are very rare with a high-quality example of Pine Barrens in the LWSR being the southern-most example of this globally rare natural community type in the state. Many of the highest quality barrens sites in the LWSR are being managed through prescribed burning and brush and tree removal. These areas provide critical habitat to many barrens specialist plant and animal species.

Prairie, Oak Openings, and Oak Woodlands were historically more heterogeneous than today and offered early successional forest habitat through a shifting mosaic of trees, shrubs, and prairies. Animal species that may now benefit from early successional forest types such as aspen (*Populus* sp.) were not likely abundant historically in the LWSR and/or used other habitats such as prairies, Oak Openings, and Oak Woodlands. Although these species may be currently using aspen dominated areas, it is currently scarce on the LWSR, comprising less then 1% of the forested acres. Focusing management on improving habitat within prairies, Oak Openings, and Oak Woodlands, instead of small aspen patches within large forested blocks would benefit certain species while not fragmenting habitat important to State Threatened and Endangered Species.

Opportunities exist in the LWSR to restore prairies, Oak Openings, Oak Woodlands, and barrens, increase connectivity between remnant sites, and improve habitat for many grassland, savanna, woodland, and barrens plants and animal specialists. Remnant prairies and Oak Openings should be restored if resources are available to maintain the restored habitat. Many former Oak Woodlands are now closed-canopy forests that provide critical habitat for numerous species. Ecological restoration that converts closed-canopy forests to Oak Woodland may benefit some savanna specialist species at the expense of other

species. As with all ecological restoration opportunities, sufficient resources must be available to ensure success of the project before the difficult decision of limiting habitat for some species in favor of other species is made. Primary sites with opportunities to protect and manage prairie, Oak Opening, Oak Woodland, barrens and their associated flora and fauna are (Figure 9): Ferry Bluff, Avoca Prairie and Savanna, Richwood Bottoms Area, Mazomanie Oak Barrens, Gotham Jack Pine Barrens, and Millville Woodland and Adiantum Woods.

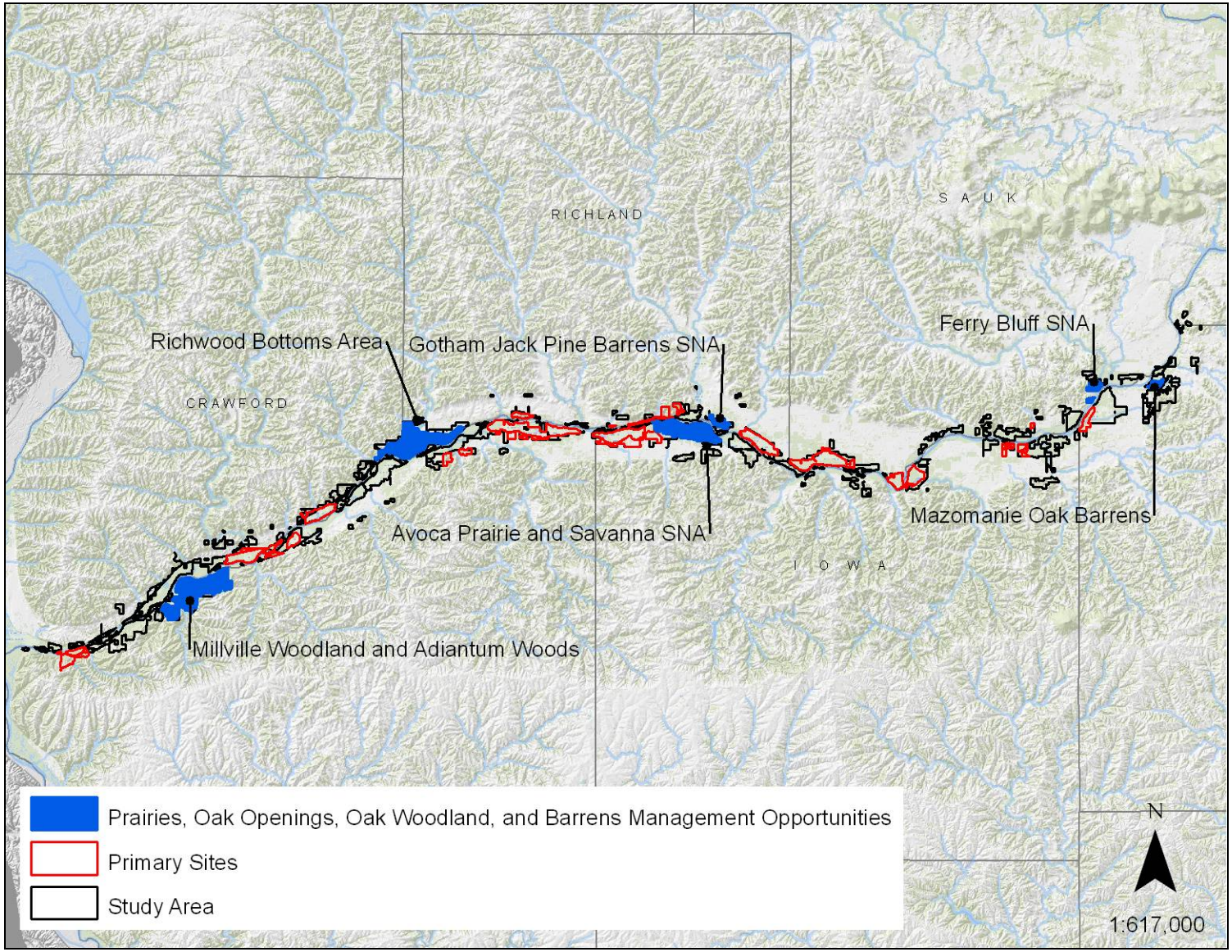

Figure 9. Primary sites identified as having significant opportunities to protect and manage prairies, Oak Openings, Oak Woodlands, and Barrens within the study area.

Ecological Priorities for SGCN

The Wisconsin Wildlife Action Plan identifies ecological priorities in each Ecological Landscape. Ecological priorities are the natural communities in each Ecological Landscape that are most important to the Species of Greatest Conservation Need. Appendix C highlights the Ecological Priorities for the vertebrate SGCN on the LWSR. Note that these Ecological Priorities include all of the natural communities that we have determined to provide the best opportunities for management on the LWSR from an ecological/biodiversity perspective.

Natural Community Management Opportunities

The Wisconsin Wildlife Action Plan (WAP) (WDNR 2006b) identifies 34 natural communities for which there are "Major" or "Important" opportunities for protection, or restoration, or management in the Western Coulee and Ridges Ecological Landscape. Twenty-two of these natural communities are present on the LWSR:

- Cedar Glade
- Dry Prairie
- Dry-mesic Prairie
- Emergent Marsh
- Ephemeral Pond
- Floodplain Forest
- Mesic Prairie
- Moist Cliff
- Oak Barrens
- Oak Opening
- Oak Woodland
- Pine Barrens
- Pine Relict
- Sand Prairie
- Shrub Carr
- Southern Dry Forest
- Southern Dry-mesic Forest
- Southern Mesic Forest
- Southern Sedge Meadow
- Surrogate Grasslands
- Warmwater River
- Warmwater Streams
- Wet-mesic Prairie

Priority Conservation Actions

The Wildlife Action Plan developed Priority Conservation Actions that make effective use of limited resources and address multiple species with each action. Implementing these actions and avoiding actions that may preclude successful implementation of these actions in the future would greatly benefit the SGCN on the LWSR.

Priority Conservation Actions identified in the Wisconsin Wildlife Action Plan (WDNR 2006b) that are applicable to the LWSR include:

- Focus management and restoration efforts in the loess-influenced forest Conservation Opportunity Areas to emphasize a matrix of older oak-central hardwood forest with smaller patches of oak woodland, oak opening, regenerating younger forest, native prairies and relict forests.
- Focus management and restoration efforts in the sandstone-influenced Conservation Opportunity Areas to emphasize dry oak savanna, oak woodland and sand prairie communities with smaller embedded patches containing oak forest, pine relicts, dry prairie, open shrubby barrens, closed canopy oak forest, and rock outcrops.
- Protect the ecological river corridor gradients from lowlands to uplands, along with protection of the floodplain corridor. This will enlarge the amount of habitat available, allow for the movement of species upslope and downslope as environmental conditions change over time, provide migratory bird stopover habitat, and provide suitable habitat for species that require large areas or are dependent upon a mosaic of interconnected habitats, including a full range of seral stages, for their long-term survival.

- Maintain and connect large blocks of older floodplain forest to provide habitat for the large number of SGCN that utilize this habitat while addressing the regeneration difficulties associated with dense stands of reed canary grass.
- Conduct large-scale planning efforts with state agencies and partners regarding the Upper Mississippi River and its adjacent blufflands.
- Restore oak openings and woodlands and expand and enhance dry prairie and shrub habitats on public lands in appropriate Conservation Opportunity Areas through fire, ground layer enhancement, and timber management.
- Identify additional sites containing high quality or restorable oak barrens, oak savannas and woodlands.
- Develop bluffland zoning that recognizes the critical importance of maintaining dry prairies, oak savanna restoration opportunities, connecting habitat corridors, migratory bird stopover sites, and forested habitat that is essential for long-term maintenance of viable SGCN populations.
- Manage appropriate native sand prairie and sand prairie restoration sites for nesting ornate box and Blanding's turtles.
- Conduct inventories to better delineate cerulean warbler populations on public and private lands.
- Continue head starting program for ornate box turtles.
- Conduct research on the interspecies competition between increasing "channel" shiners (*Notropis sp.*) and the greatly decreasing pallid shiner (*Notropis amnis*).
- Protect and restore appropriate habitat in the Mississippi and Lower Wisconsin Rivers for shoal chub (*Macrhybopsis aestivalis*).
- Focus restoration of stream habitat and morphology on areas where land use and other factors suggest the most successful outcomes.
- Protect and restore appropriate natural stream habitat with focus on accommodating the habitat needs of wood turtle.

Wisconsin's Statewide Forest Strategy

Wisconsin's Statewide Forest Assessment (WDNR 2010c) was based on Wisconsin's Forest Sustainability Framework ("Wisconsin Forest Sustainability Framework") and was designed to assess the current state of Wisconsin's public and private forests and analyze the sustainability of our forested ecosystems. Wisconsin's Statewide Forest Strategy (WDNR 2010d) contains a collection of strategies and actions designed to address the management and landscape priorities identified in the Statewide Forest Assessment. The strategies are broad guides intended to focus the actions of the forestry community.

All three of these documents include topics related to biological diversity in Wisconsin's forests, and provide information useful for department master planning and management activities. The following strategies, organized using their number in the Statewide Forest Strategy document, are particularly pertinent to the LWSR planning efforts in regard to opportunities to maintain or enhance biological diversity (WDNR 2010d). These strategies may not be applicable to all units of the LWSR.

Strategy Number	Strategy
1	Encourage planting to enhance, protect, and connect larger tracts of forested land in appropriate locations consistent with ecological landscapes.
5	Pursue the conservation and protection of large, unfragmented blocks of forest lands
6	Strengthen collaborative and large scale planning at the town, county, state and federal levels
7	Increase the functional size of forest blocks by encouraging coordination of management of clusters of forest ownerships
11	Encourage the management of under-represented forest communities
12	Improve all forested communities with a landscape management approach that considers the representation of all successional stages
13	Increase forest structure and diversity
14	Encourage the use of disturbance mechanisms to maintain diverse forest communities
15	Maintain the appropriate forest types for the ecological landscape while protecting forest health and function
22	Strive to prevent infestations of invasive species before they arrive
23	Work to detect new (invasive species) infestations early and respond rapidly to minimize impacts to forests
24	Control and management of existing (invasive species) infestations.
25	Rehabilitate, restore, or adapt native forest habitats and ecosystems
29	Attempt to improve the defenses of the forest and increase the resilience of natural systems to future climate change impacts

Management Opportunities for Rare Species

Significant Populations of Plants

The LWSR supports 92 known element occurrences of 43 rare plant species, including four State Endangered species, five State Threatened species, and 34 State Concern species. Particularly significant are rare plants associated with four groups of natural communities for which significant management opportunities exist on the LWSR: 1) Floodplain Forest, 2) Southern Mesic Forest, 3) Oak Barrens, and 4) Oak Woodland/Oak Openings.

The LWSR contains some of the most extensive Floodplain Forest in the state, and the Western Coulee and Ridges Ecological Landscape is a major conservation opportunity for this community type (WDNR In prep. a). Floodplain Forests along the LWSR support the state's entire population of purple rocket and significant populations of several other rare species (Table 11). Many of the rare plant species associated with Floodplain Forests require a mature forest canopy, and virtually all benefit from the relatively natural hydrologic regime and accompanying periodic flooding. Because of the unique circumstances on the LWSR, including a wide valley that supports the development of extensive forests, limited urban and industrial development, and 92 miles of free-flowing LWSR, conservation opportunities to support Floodplain Forests and the rare plants are perhaps greater here than anywhere else in the state.

Table 11. Rare plant species on the LWSR associated with Floodplain Forests. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status
Kentucky coffee-tree	*Gymnocladus dioicus*	SC
small forget-me-not	*Myosotis laxa*	SC
spreading chervil	*Chaerophyllum procumbens*	SC
sweet-scented Indian-plantain	*Cacalia suaveolens*	SC
sycamore	*Platanus occidentalis*	SC

Southern Mesic Forests, which occur on north-facing slopes and ravines along the LWSR, also present a significant conservation opportunity for rare plants (Table 12). Southern Mesic Forests have drastically declined since about 1800 due to unsustainable logging, clearing for agriculture, and grazing. Today, these forests are threatened by invasive species like garlic mustard (*Alliaria petiolata*) and non-native earthworms (Hale et al. 2005). Opportunities that seek to maintain older trees (>100 years of age), maintain an intact forest canopy, mitigate threats, and minimize disturbance will help conserve these forests and plants.

Table 12. Rare plant species on the LWSR associated with Southern Mesic Forest. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status
broad beech fern	*Phegopteris hexagonoptera*	SC
great water-leaf	*Hydrophyllum appendiculatum*	SC
jeweled shooting star	*Dodecatheon amethystinum*	SC
heart-leaved skullcap	*Scutellaria ovata*	SC
Hooker's orchid	*Platanthera hookeri*	SC
nodding pogonia	*Triphora trianthophora*	SC
putty root	*Aplectrum hyemale*	SC

Short's rock-cress	*Arabis shortii*	SC
snow trillium	*Trillium nivale*	THR

Oak Barrens and Dry Prairies are found on sandy terraces deposited by glacial meltwater and the LWSR provides one of the best conservation opportunities in southwest Wisconsin for rare plant species associated with this community type (Table 13). Historically maintained by periodic fire, Oak Barrens and associated species now require prescribed burning and may also benefit from tree and shrub clearing. During the Dust Bowl era, treeless barrens were often planted to conifers due to perceived threats of soil erosion. Today, removal of aging pine plantations may present an opportunity to restore Oak Barrens and enlarge habitat for rare and declining species. In particular, Oak Barrens present an opportunity to manage for plants like prairie fame-flower and clustered poppy-mallow. Globally rare, these species reach their greatest abundance nationwide in Wisconsin. Since these species require open sandy soil with sparse vegetation, careful management of Oak Barrens could help protect these species from further declines.

Table 13. Rare plant species on the LWSR associated with Oak Barrens and Dry Prairies. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status
American fever-few	*Parthenium integrifolium*	THR
arrow-headed rattle-box	*Crotalaria sagittalis*	SC
cleft phlox	*Phlox bifida*	SC
clustered poppy-mallow	*Callirhoe triangulata*	SC
hairy wild-petunia	*Ruellia humilis*	END
narrow-leaved dayflower	*Commelina erecta var. deamiana*	SC
one-flowered broomrape	*Orobanche uniflora*	SC
pale false foxglove	*Agalinis skinneriana*	END
prairie false-dandelion	*Microseris cuspidata*	SC
prairie fame-flower	*Phemeranthus rugospermus*	SC
prairie Indian plantain	*Cacalia tuberosa*	THR
prairie ragwort	*Senecio plattensis*	SC
prairie turnip	*Pediomelum esculentum*	SC
Richardson sedge	*Carex richardsonii*	SC
violet bush-clover	*Lespedeza violacea*	SC
yellow gentian	*Gentiana alba*	THR

Oak Woodland and Oak Openings have suffered drastic declines since the early 1800s, primarily due to fire suppression, grazing, and unsustainable logging. These natural communities typically occur on south-facing or west-facing slopes, and are often interspersed with small prairie openings and Dry Cliffs. Significant conservation opportunities for these communities and associated rare species exist in southwest Wisconsin, but land ownership patterns prevent large-scale management. The LWSR presents a unique opportunity to manage for Oak Woodland, Oak Openings, and Dry Cliffs in the Driftless Area through activities like prescribed burning, which benefit upland boneset, purple milkweed and several other rare species (Table 14). As a result of ongoing management, species like upland boneset have expanded and its status in the state has greatly improved. Similar benefits could be realized for other species and communities as a whole as additional management opportunities are acted upon on the LWSR.

Table 14. Rare plant species on the LWSR associated with Oak Woodland, Oak Openings, and Dry Cliffs. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status
chinquapin oak	*Quercus muehlenbergii*	SC
lanced-leaved buckthorn	*Rhamnus lanceolata var. glabrata*	SC
purple-stem cliff-brake	*Pellaea atropurpurea*	SC
purple milkweed	*Asclepias purpurascens*	END
shadowy goldenrod	*Solidago sciaphila*	SC
upland boneset	*Eupatorium sessilifolium var. brittonianum*	SC
white camas	*Zigadenus elegans var. glaucus*	SC
Wilcox's panic grass	*Panicum wilcoxianum*	SC

Significant Populations of Animals

The Lower Wisconsin State Riverway supports 480 known occurrences of 121 rare animal species (including 3 Federally listed or candidates for listing, 15 State Endangered species, 21 State Threatened species, and 84 state Special Concern species). The LWSR plays a critical role in conserving several taxa in particular.

Grassland Birds

Biologists and birders are concerned about population declines of many grassland bird species. Since the North American Breeding Bird Survey (BBS) began in 1966, grassland birds have declined more steeply than any other group of birds in North America and the Midwest (Sample and Mossman 1997; Askins et al. 2007). The Lower Wisconsin River Prairies and Barrens from Sauk City to Blue River Sand Barrens SNA is noted as one of the highest priority landscapes for grassland birds in the state with current grassland acreage totaling over 2,000 acres with potential for 5,000 grassland acres (Sample and Mossman 1997; WDNR 2006b). This grassland acreage supports numerous uncommon bird species (Table 15) and is made up of a highly diverse mix of remnant prairies (from Dry to Wet-mesic), Sand Prairie and Barrens, Surrogate Grassland, Southern Sedge Meadow, upland shrub, and Oak Opening.

Grassland bird habitat is most effectively maintained as large landscapes of continuous grassland, uninterrupted by hedgerows, with the cover of woody plants less than 5% (Sample and Mossman 1997). Hedgerows fragment grasslands and provide habitat/movement corridors for predators of grassland birds. Structural diversity within the grassland, including short and tall grass, a mix of grasses and forbs, and a management rotation of type, intensity, and frequency, is also important for grassland bird habitat. Many grassland bird species, however, require the structure present in other habitats within a grassland complex, including upland shrubs (Bielefeldt 2010). Managing from a landscape perspective can better accommodate complex habitat needs, including wetland, upland, and savanna components, needed for grassland birds and other grassland obligate species. Much of the need for grassland bird management in the LWSR is for connection of sites along the river corridor (Sample and Mossman 1997). With continuing grassland, wet prairie/meadow, and barrens restoration work in the LWSR, the potential for connection and additional expansion of these open habitats could provide substantial benefits to the full suite of grassland birds.

Remnants of original prairie and savanna and expansive grasslands should be retained/maintained and possibly expanded where appropriate to benefit grassland and savanna birds. Areas with marginal habitat for grassland-dependent species, such as ridgetops and old-fields embedded within a forested landscape should be evaluated for potential for reforestation. Although these marginal areas may currently provide some habitat for grassland-dependent species, there are expansive grassland landscapes such as Military Ridge where grasslands are a clear priority and where large tract sizes probably contribute to higher rates of nest success, and where the entire prairie plant-animal community is more intact; but there are very few forested landscapes that are suitable for such high densities of forest interior birds and their associated plant-animal community (M. Mossman, personal communication). The best opportunities for maintaining viable source populations of area-sensitive grassland bird species in a landscape context are at Avoca Prairie and Savanna SNA, Mazomanie Unit, Cassel Prairie Unit, Helena Unit, the barrens from Bakken's Pond to Sauk County Forest, Buena Vista Unit – Gotham Jack Pine Barrens SNA, and Boscobel Unit.

Table 15. Bird species of conservation concern found in grassland habitats of the LWSR. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status
Bell's vireo	*Vireo bellii*	THR
black-billed cuckoo	*Coccyzus erythropthalmus*	SGCN
blue-winged warbler	*Vermivora pinus*	SGCN
bobolink	*Dolichonyx oryzivorous*	SGCN
brown thrasher	*Toxostoma rufum*	SGCN
dickcissel	*Spiza americana*	SC/M
eastern meadowlark	*Sturnella magna*	SGCN
field sparrow	*Spizella pusilla*	SGCN
grasshopper sparrow	*Ammodramus savannarum*	SGCN
Henslow's sparrow	*Ammodramus henslowii*	THR
northern harrier	*Circus cyaneus*	SGCN
lark sparrow	*Chondestes grammacus*	SC/M
loggerhead shrike	*Lanius ludovicianus*	END
vesper sparrow	*Pooecetes gramineus*	SGCN
western meadowlark	*Sturnella neglecta*	SC/M
willow flycatcher	*Empidonax traillii*	SGCN
yellow-breasted chat	*Icteria virens*	SC/M

Forest Interior Birds

The LWSR is one of the few remaining major forested landscapes of southern Wisconsin and holds one of the highest opportunities in the state to manage for southern forest birds, particularly those associated with Floodplain Forest and area-sensitive species requiring large blocks of forested habitats (e.g. prothonotary and cerulean warbler; Mossman and Steele in Prep). An impressive assemblage of rare forest interior breeding birds (Table 16) is present throughout the LWSR. The area-sensitive species are utilizing the minimally fragmented, contiguous, and older forests present on the LWSR.

Protected large blocks of forest interior habitat are rare in Southcentral Wisconsin and slightly more common in Southwestern Wisconsin. The total land area for the Western Coulee and Ridges Ecological Landscape is approximately 6.2 million acres, of which 38% is classified as timberland and only a small percentage (3%) is in protected public land ownership (WDNR In Prep. a). Important opportunities exist in the LWSR to provide large blocks of forest spanning from the extensive mature bottomland forests in the valley bottom to Southern Dry-mesic Forests on the steep slopes and ridge tops. These areas that were unsuitable for raising crops grew into oak-dominated forests after the ubiquitous presettlement wildfires were suppressed (WDNR in Prep. a). The Oak Openings that were once the most common upland type (Finley 1976) have largely converted to closed-canopy oak-dominated forests. Forest Reconnaissance data show that these forest stands are dominated by older age classes with stand maximum ages clustered between 60 – 100 years old (WISFIRS 2010). For many species, the LWSR likely provides the most viable forest habitat in the southern portion of the state.

Many of the rare forest interior birds found on the LWSR have had significant population declines in Wisconsin and throughout their range, further reinforcing the importance of the LWSR for providing habitat. Breeding Bird Survey data show an annual decline of 4.4% for cerulean warblers in Wisconsin (Mossman 2006). Other forest interior birds that may be declining include Acadian flycatcher, least flycatcher (*Empidonax minimus*) and veery (*Catharus fuscescens*). Species that have had population increases continue to be threatened by the edge effects of forest fragmentation.

Primary determinants of interior forest habitat quality include stand composition, age, size, structure, canopy closure, proximity to water or roads, slope and aspect, stand size and shape, and proximity to other stands on the landscape (Wilson 2008). Limiting fragmentation associated with, but not limited to, clear-cutting, road building, or utility and pipeline development is important to the continued viability of these large blocks of forest and their associated bird species (WDNR 2006b).

Maintaining the vertical structural diversity currently found within less fragmented forest stands is also important for some forest interior species. Cerulean, Kentucky, and hooded warblers (*Wilsonia citrina*), as well as veery and wood thrush (*Hylocichla mustelina*) all require a complexity of forest layers for nesting. These species use both shrub and tree species. Some forest interior birds also rely on limb structure that promotes horizontal canopy nesting areas.

Oak savanna and Oak Woodlands, in the context of large contiguous forest patches, can provide a 'soft edge' between other habitat types and a closed-canopy forest. Oak Woodland restoration, within a large forested area, could promote understory growth and development of full-canopied oaks that produce horizontal limb structure for nesting that is favorable for cerulean warblers and other area-sensitive species such as Kentucky warbler, hooded warbler, veery, and wood thrush.

Maintaining and expanding large blocks of contiguous, older forests in southern Wisconsin is critical for the future of many forest interior birds. The LWSR offers opportunities, within a landscape context to provide habitat for these species. Primary sites that provide excellent habitat and likely support source populations of forest interior birds in the LWSR (Figure 10) are Mazomanie Bottoms, Tower Hill Bottoms and Cynthia Slough (combined, these sites represent the size and conditions needed for a breeding population), Bakken's Pond Marsh and Woods, Richwood Bottoms, Wauzeka Bottoms, and Millville Woodland. These areas should be considered for maintaining forest interior bird populations.

Red-shouldered Hawk. Photo by Brian M. Collins.

Table 16. Forest interior breeding birds of the LWSR. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status
Acadian flycatcher	*Empidonax virescens*	THR
cerulean warbler	*Dendroica cerulea*	THR
hooded warbler	*Wilsonia citrina*	THR
Kentucky warbler	*Oporornis formosus*	THR
least flycatcher	*Empidonax minimus*	SC/M
Louisiana waterthrush	*Seiurus motacilla*	SC/M
ovenbird	*Seiurus aurocapilla*	none
prothonotary warbler	*Protonotaria citrea*	SC/M
red-shouldered hawk	*Buteo lineatus*	THR
scarlet tanager	*Piranga olivacea*	none
veery	*Catharus fuscescens*	SC/M
whip-poor-will	*Caprimulgus vociferus*	SC/M
wood thrush	*Hylocichla mustelina*	SC/M
worm-eating warbler	*Helmitheros vermivorus*	END
yellow-billed cuckoo	*Coccyzus americanus*	SC/M
yellow-crowned night-heron	*Nyctanassa violacea*	THR
yellow-throated vireo	*Vireo flavifrons*	none
yellow-throated warbler	*Dendroica dominica*	END

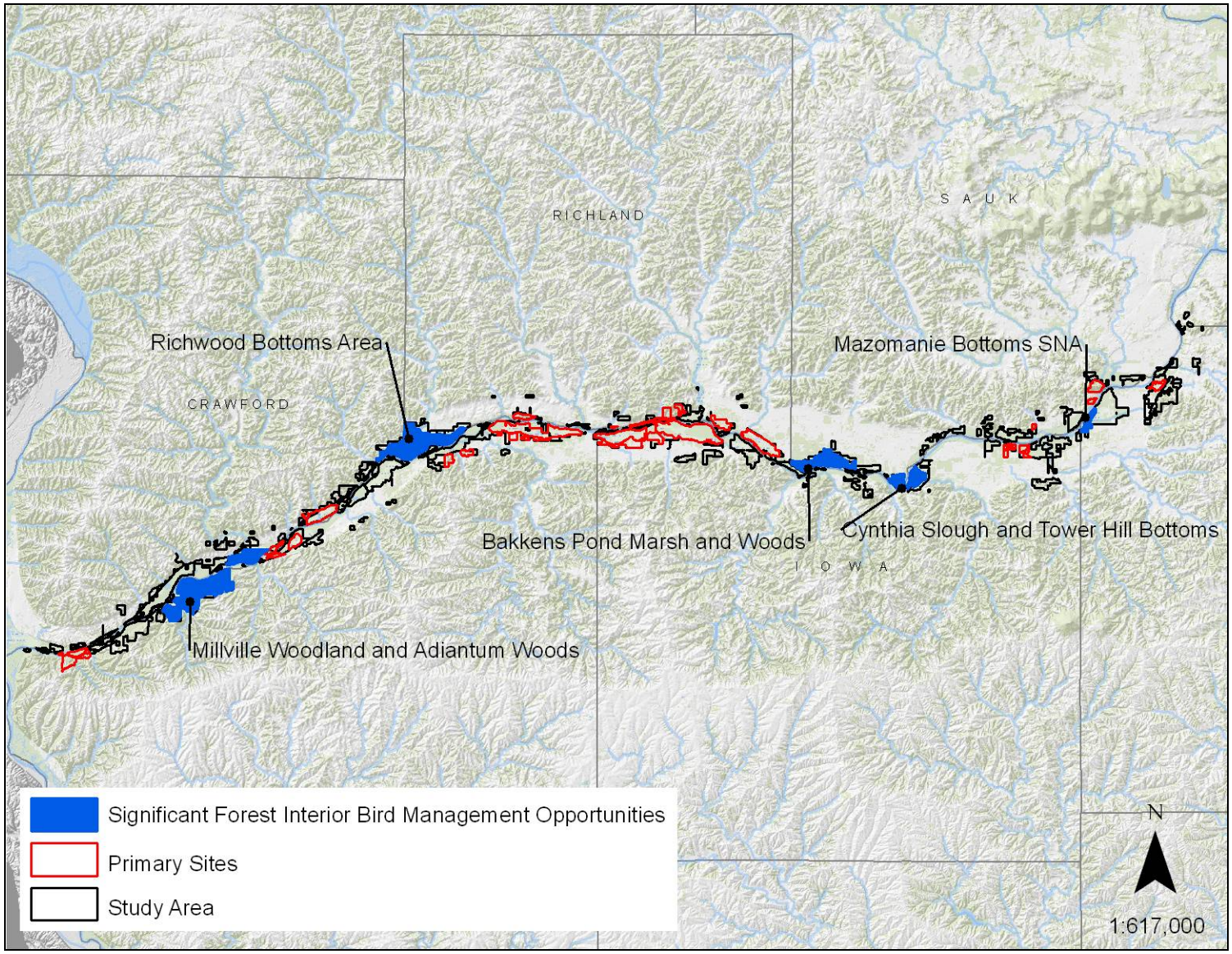

Figure 10. Primary sites identified as having significant management opportunities for forest interior birds.

Herptiles

The LWSR was identified as supporting or having potential for restoring habitat for rare herptiles. In particular, a suite of high conservation priority reptiles associated with sand prairies, sand barrens, and bluff prairies (Casper 2009). Dramatic declines of these community types have occurred since widespread Euro-American settlement with losses being attributed to fire suppression, agriculture and subsequent planting to pines, over-grazing, invasion of woody species, poaching, and invasive species. Natureserve (2010) identifies Oak Openings and barrens communities as globally imperiled (G1 or G2) and Leach and Givnish (1999) note that less than 0.1% of the approximately 2.1 million acres of original prairie remains in Wisconsin. Extensive prairie, Oak Opening, and barrens habitats still occur within the LWSR on sand terraces and extend to adjacent bluffs overlooking the river. Numerous records exist for uncommon lizards, snakes, and turtles utilizing these areas. The LWSR presents one of the best opportunities in the state to protect and enhance populations of ornate box turtles, Blanding's turtle, gophersnake, timber rattlesnake, North American racer (*Coluber constrictor*), gray ratsnake (*Pantherophis spiloides*), prairie ring-necked snake (*Diadophis punctatus arnyi*), and six-lined racerunner.

Management that mimics natural disturbance regimes is needed to restore and maintain these fire-dependant habitats, however, the poor dispersal abilities of many herptiles needs to be taken into account when planning habitat management and species recovery. Species conservation actions should focus on known sites of species occurrence, while management plans for specific sites should take into account the needs of the species present or targeted for recovery (Casper 2009). Initial conservation efforts should focus on securing extant viable populations, followed by recovering known dwindling populations (Casper 2009). Units present within the LWSR with management needs aimed at continued maintenance or restoring open prairie or savanna / barrens conditions to enhance target reptile populations include Mazomanie, Blackhawk, Cassel Prairie, Spring Green, Bakken's Pond, Buena Vista, Blue River, and Millville.

Uncommon amphibians are known from the study area as well, but the LWSR generally represents only a small portion of each of these species overall population abundance and distribution in the state. Examples include common mudpuppy (*Necturus maculosus*), American bullfrog (*Lithobates catesbeianus*), and pickerel frog (*Lithobates palustris*). Good or likely better opportunities exist for management of these species in other ecological landscapes. One possible exception is the northern cricket frog (*Acris crepitans*). This species has experienced a severe range contraction since the 1960's and is now restricted to extreme southwestern Wisconsin. Numerous historical records exist but only a few records post-1972 are available from the study area. However, current populations are known in close proximity to the LWSR and thus warrant ongoing survey effort to allow for discovering and protecting populations (Casper 2009).

Fishes

The Black, Chippewa and Wisconsin Rivers present very important opportunities to maintain and improve the ecological function of large rivers with extensive floodplain areas (WDNR in Prep. a). They all have high "Indices of Biotic Integrity" indicating high quality and healthy ecosystems with the Lower Wisconsin River supporting 98 species of the 147 native fishes in the state (Marshall and Lyons 2008). The unimpeded 92-mile stretch of the Lower Wisconsin River from Prairie du Sac to the Mississippi River supports probably the largest remaining populations in WI of the State Threatened paddlefish (*Polyodon spathula*), blue sucker, and black buffalo (*Ictiobus niger*) along with the exceedingly rare goldeye (*Hiodon alosoides*), crystal darter and river redhorse (*Moxostoma carinatum*). In all, there are 20 rare fishes known from the LWSR, 10 species of Special Concern, six State Threatened, and four State Endangered. Many of the populations represent some of the last remaining strongholds for large river fishes in the Upper Midwest.

The floodplain or oxbow lakes and sloughs, largely overlooked in the past during fish survey efforts, were assessed in 2007 and 2008 by Dave Marshall through a WDNR river planning grant. These diverse habitats are a reflection of a natural river floodplain, unlike impounded rivers where the off-channel habitats became permanently flooded and destroyed (Marshall 2008). The recent sampling found significant populations of water-quality sensitive species such as pirate perch (SC), lake chubsucker (SC), mud darter (SC), starhead topminnow (END), and weed shiner (SC) in the spring-fed floodplain lakes and sloughs. The diversity and distribution of these nongame fish, sensitive to environmental degradation, serve as good indicators for the health of streams and lakes (Table 17; Marshall and Lyons 2008).

Table 17. Sensitive fish species identified in the Lower Wisconsin River (Marshall and Lyons 2008). Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status
chestnut lamprey	*Ichthyomyzon castaneus*	none
silver lamprey	*Ichthyomyzon unicuspis*	none
Mississippi silvery minnow	*Hybognathus nuchalis*	none
pallid shiner (no records since 1962)	*Hybopsis amnis*	End
spottail shiner	*Notropis hudsonius*	none
weed shiner	*Notropis texanus*	SC/N
shoal chub	*Macrhybopsis hyostoma*	THR
highfin carpsucker	*Carpidoes velifer*	none
black buffalo	*Ictiobus niger*	THR
northern hog sucker	*Hypentilium nigricans*	none
spotted sucker	*Minytrema melanops*	none
greater redhorse (no recent records)	*Moxostoma valenciennesi*	THR
muskellunge (stocked)	*Esox masquinongy*	none
smallmouth bass	*Miropterus dolomieu*	none
rock bass	*Ambloplites rupestris*	none
western sand darter	*Ammocrypta clara*	SC/N
crystal darter	*Crystallaria asprella*	END
rainbow darter	*Etheostoma caeruleum*	none
Iowa darter	*Etheostoma exile*	none
least darter	*Etheostoma microperca*	SC/N
banded darter	*Etheostoma zonale*	none
slenderhead darter	*Percina phoxocephala*	none
mottled sculpin	*Cottus bairdii*	none

Aquatic Invertebrates

Aquatic habitats in the Lower Wisconsin River range from flowing to semi-flowing to springs to isolated waters, from shaded to open canopy, from herbaceous to non-vegetated, and from sand to gravel to muck substrates. This wide variety of habitats in the river and the associated backwaters and spring ponds have created a diverse and species rich aquatic invertebrate community. Federal and State Endangered and Threatened aquatic invertebrate species found within the Lower Wisconsin River are listed in Table 18.

The main channel hosts a large diversity of invertebrates. Rock and gravel bottom substrates harbor many of these species and are relatively rare, making up an estimated 13% of the total shoreline area. These hot spots of invertebrate species diversity occur where the main channel flows adjacent to an upland bluff and the substrate shifts from the loose sand to firm gravel, rubble or even bedrock bottom. These areas are especially important for mussels which require firm substrate in which to establish themselves (see Mussels section below for more details). The vast majority of the main channel is sand bottomed. This habitat is highly variable ranging from loose unconsolidated sand and ripple bottomed ‘sand dunes’ to firm depositional sand. A number of sand dwelling specialists occupy these habitats and include many that are rare like the Pecatonica River mayfly, the flat-headed mayfly, and the yellow sandshell mussel. Snags, which are common along the shoreline and down-stream sandbar edges create areas of turbulence that often harbor unique fauna (Lillie and Hilsenhoff 1992). Snags include woody debris and other irregularly shaped substrates like cobble. These habitats support several rare riffle beetles like Knobel’s riffle beetle and mayflies like Wallace’s deepwater mayfly.

Table 18. Federal and State Endangered and Threatened aquatic invertebrate species known from the Lower Wisconsin River. Listing status is based on the NHI Working List published April 2009.

Common Name	Scientific Name	State Status	Federal Status
Knobel's riffle beetle	*Stenelmis knobeli*	END	
Pecatonica River mayfly	*Acanthametropus pecatonica*	END	
Wallace's deepwater mayfly	*Spinadis simplex*	END	
rock pocketbook	*Arcidens confragosus*	THR	
butterfly	*Ellipsaria lineolata*	END	
ebony shell	*Fusconaia ebena*	END	
Higgins' eye	*Lampsilis higginsii*	END	LE
yellow and slough Sandshells	*Lampsilis teres*	END	
bullhead	*Plethobasus cyphyus*	END	C
monkeyface	*Quadrula metanevra*	THR	
wartyback	*Quadrula nodulata*	THR	
salamander mussel	*Simpsonaias ambigua*	THR	
buckhorn	*Tritogonia verrucosa*	THR	

Backwaters and spring ponds also have a great diversity of species, hosting rare species such as the state imperiled white-spangled skimmer, swamp darner, flat floater mussel, and Mississippi grass shrimp.

Tables 19 and 20 and figures 7 and 8, were created to illustrate the Lower Wisconsin River's importance to the state's aquatic invertebrate community. The tables and figures were created using the WDNR-ER's Invertebrate Atlas database, which contains over 150,000 observations of rare and common invertebrate species in the state. Tables 19 and 20 list the waterbodies in the state that have been documented to have over100 aquatic invertebrate species. Table 19 summarizes the number of species (i.e., species richness) by state and federal protection categories as well as global and state imperiled ranks. The Lower Wisconsin River is the third most species rich water in the state and has the highest count of globally and state imperiled species and SGCN species, and the second highest count for Wisconsin Endangered/Threatened species. Table 20 summarizes species richness by taxonomic group. The Lower Wisconsin River has a large diversity of species within a wide variety of taxonomic groups and has the second highest count for beetles and true bugs, third highest for mussels, and fourth highest for mayflies in the state.

Table 19. Aquatic invertebrate species richness by protection status and imperiled rank. Data are from WDNR-ER's Invertebrate Atlas database (data accessed Jan. 27, 2011).

Waterbody	Total	FWS E/T/C	WI E/T	Global Imperiled (G1-G3)	State Imperiled (S1-S2)	SGCN
Wolf River	319		6	6	17	50
Pine River	302		1	2	3	26
Lower Wisconsin River	243	2	15	10	28	50
Peshtigo River	225		2	2		17
Upper Wisconsin River	222	2	9	7	13	33
Saint Croix River	219	3	16	10	23	40
Black River	205		4	7	12	27
Flambeau River	198	1	5	5	7	23
Popple River	188		0	1	1	7
North Branch Pine River	177		0		2	10
Woods Creek	151		0	1	2	8
Chippewa River	151	2	11	10	16	29
South Fork Flambeau River	138		3	2	2	11
Little Wolf River	132		3	3	2	10
Embarrass River	130		3	4	4	15
Menominee River	111		1	2		6
Mississippi River	106	4	14	6	18	26

Table 20. Aquatic invertebrate species richness by taxonomic order. Data are from WDNR-ER's Invertebrate Atlas database (data accessed Jan. 27, 2011).

Waterbody	Coleoptera (Beetles)	Diptera (Flies)	Ephemeroptera (Mayflies)	Heteroptera (True Bugs)	Odonata (Dragonflies)	Plecoptera (Stoneflies)	Trichoptera (Caddisflies)	Unionoida (Mussels)
Wolf River	59	17	54	24	75	11	36	31
Pine River	43	11	32	38	37	29	108	
Lower Wisconsin River	44	8	48	33	48	4	11	38
Peshtigo River	39	7	27	31	50	4	30	10
Upper Wisconsin River	29	10	41	20	73	3	10	31
Saint Croix River	20	1	49		87	7	11	41
Black River	20		57	8	59	14	14	27
Flambeau River	28	8	36	18	41	6	25	22
Popple River	18	12	25	28	36	29	36	1
North Branch Pine River	15	4	15	20	18	7	95	
Woods Creek	8	8	12	17	10	21	73	
Chippewa River	6		38		58	4	9	33
South Fork Flambeau River	14	9	23	3	50	5	16	12
Little Wolf River	22	6	26	10	16	5	22	18
Embarrass River	18	3	30	6	17	6	19	23
Menominee River	11		37	1	28	8	10	15
Mississippi River			2		59		1	40

The number of state imperiled (S1, S2) aquatic invertebrates by township is illustrated in Figure 9. The Lower Wisconsin River is clearly defined and has the most number of townships intersecting the waterbody with greater than 10 state imperiled species. Figure 10 focuses in on the area around the Lower Wisconsin State Riverway and summarizes species richness by section and their proximity to properties Biotic Inventories Primary Sites.

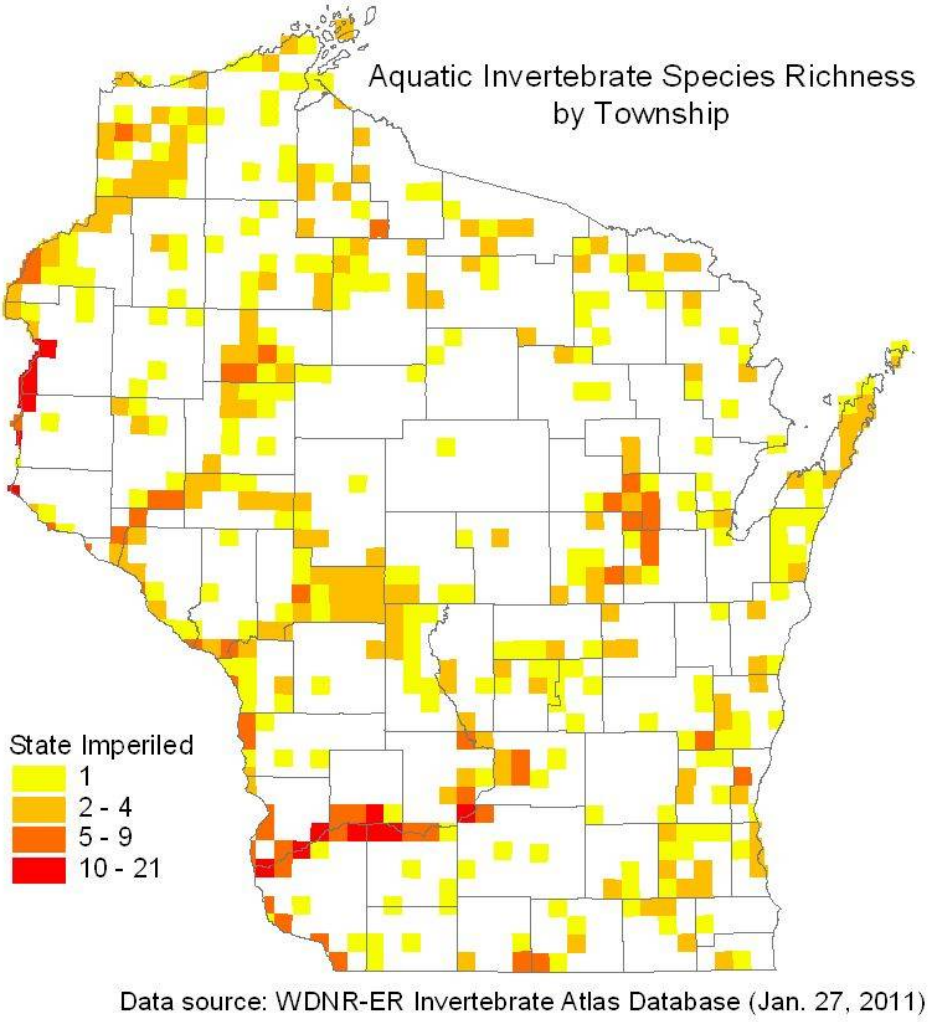

Figure 11. State Imperiled (S1/S2) aquatic invertebrate species richness by township. Data are from WDNR-ER's Invertebrate Atlas database (data accessed Jan. 27, 2011).

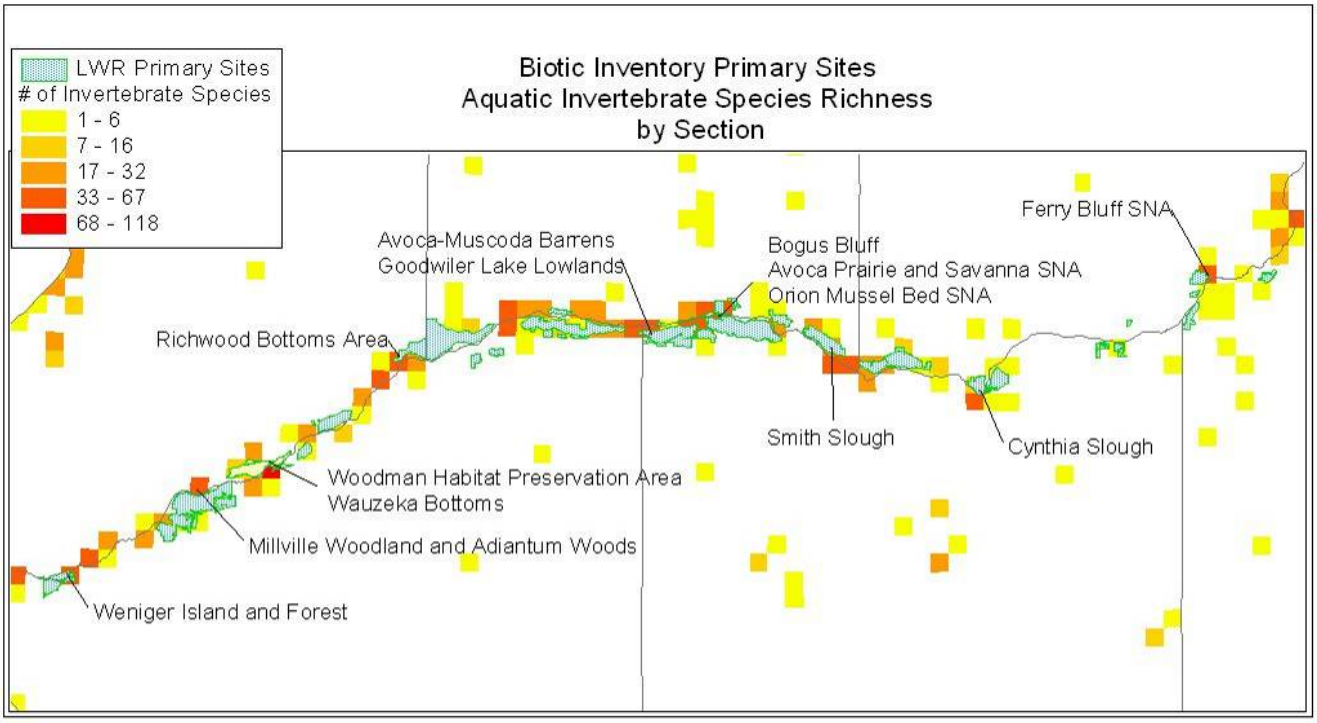

Figure 12. Aquatic invertebrate species richness by section with Primary Sites labeled. Data are from WDNR-ER's Invertebrate Atlas database (data accessed Jan. 27, 2011).

The only documented occurrence in Wisconsin of Knobel's riffle beetle, a Globally and State imperiled and State Endangered riffle beetle, is in the Lower Wisconsin River. Half of the Wallace's deepwater mayfly populations, also Globally and State imperiled and a State Endangered Species, are in the Lower Wisconsin River.

In 1986, the State Endangered Pecatonica River mayfly was only found at one site in the Lower Wisconsin River. It was the first documented observation in Wisconsin and was the first record for the Midwest since 1927 (Lillie and Hilsenhoff 1992). Since then, it has been found at four other sites in Wisconsin, including the Black and Chippewa Rivers. It was last observed in the Lower Wisconsin River in the summer of 2010 at the original site. Pecatonica River mayflies require sandy habitat. Like many species of mayfly, they are known to be highly susceptible to water pollution. Dredging, which slowed the rivers and created mud bottoms, undoubtedly hastened the demise of the Illinois populations of this species. Activities protecting the integrity of large, clean, sand-bottom rivers will be beneficial to this mayfly.

The most comprehensive survey of the aquatic insect community in the Lower Wisconsin River took place in 1985-1986 and was conducted by Lillie and Hillsenhoff (1992). The surveys resulted in more than 6,500 specimens, representing at least 232 different species, 9 taxonomic orders, and 63 families.

Lillie and Hilsenhoff (1992) identified the river segment near Woodman as being of special importance and worthy of protection because of the number of rare and unusual insects found. This was the only named site recognized in their comprehensive aquatic survey of the Lower Wisconsin River report. Subsequently, this site and the Orion Mussel Beds were designated as Habitat Preservation Areas in the existing LWSR Plan.

Worthy of special mention is the recent discovery of a population of the Federally Endangered Hine's emerald dragonfly in the LWSR. Nymphs of this species are generally thought to be restricted to open herbaceous wetlands with groundwater input, but that usually dry up on the surface in late summer. Since the aquatic nymphs have a 4-5 year life cycle, this species survives dehydration (and freezing) by occupying the burrows of the devil crayfish (*Cambarus diogenes)*. These crayfish are primary burrowers that survive extreme conditions by digging down to the water table. Another general requirement for Hine's emerald dragonflies is that the groundwater is relatively high in dissolved carbonates. Previous to 2007 this species was only known from Door and Ozaukee Counties in Wisconsin and is generally Midwestern with populations ranging from the Ozarks of Missouri to the Upper Peninsula of Michigan. In 2008, a photo taken by a naturalist in the LWSR the previous year was verified by experts as a Hine's emerald dragonfly and surveys were initiated in the area to confirm that a population was established and to pinpoint the breeding area. Adult occurrences were documented at three general areas near Muscoda between 2008 and 2010. Although the exact breeding sites have not been located, it appears that the required elements based on proximity of adults and other known sites are present. These LWSR potential breeding sites can be characterized as open herbaceous wetlands with a minor shrub component, near or adjacent to the upland sand terrace bordering the floodplain, with spring seeps or runs discharging into the wetland from the terrace (above and or below the surface), and with burrowing crayfish present. Searches for new populations and to document breeding are planned.

Wisconsin's mussel populations are part of the Upper Mississippi River fauna which is significant to the whole diversity of the mussel fauna of North America (WDNR in Prep. a). There are 26 currently known and mapped mussel beds scattered throughout the LWSR. These areas are largely responsible for supporting the 15 rare (state or federally listed and Special Concern) mussel species occurring in the LWSR. There is one Federally Endangered mussel, the Higgins' eye pearly mussel, and one candidate for federal listing, the bullhead, occurring in the LWSR. The LWSR was chosen by the US Fish and Wildlife Service and the WDNR for long-term monitoring and conservation of the Higgins' eye pearly mussel population. The Lower Wisconsin River was one of the few tributaries of the Mississippi River that had an existing population of Higgins' eye, and was not immediately threatened by zebra mussels (*Dreissena polymorpha*). Although zebra mussels have now been documented in the Lower Wisconsin, the threat remains low at this time.

Mussels are important ecologically because their presence in streams and rivers increases the diversity of other aquatic invertebrates (insects, crayfish, and snails) by both providing food (through pseudofeces) and habitat (bioturbation of the substrate) (WDNR in Prep. a). Mussels and other aquatic invertebrates serve as water-quality indicators and important food sources for numerous vertebrate species such as fish, birds, and mammals. In addition, mussels filter nutrients from waterways helping maintain the water quality of streams and rivers. Mussels have declined globally due to loss of water quality, and sometimes quantity, as well as habitat alteration. Declines can be direct impacts to the mussels themselves or indirect from the loss of a host fish, and subsequent loss of reproduction (WDNR in Prep. a).

Mussel sites in the river that are worthy of mentioning because of the number of individuals and species found there, are Orion and Woodman boat landings.

New management initiatives that may impact the aquatic invertebrate community include the downstream fish passage installation at the Prairie du Sac Dam. This dam separates the LWSR from the upper segments of the Wisconsin River. This is the first fish passage installation in the Midwest at a dam as large and complex as Prairie du Sac (Lyons 2007). While mandated as part of the Prairie Du Sac FERC license, concerns have been raised about the advisability of creating a connection that could also potentially be utilized by a number of invasive fish species.

Terrestrial Invertebrates

The LWSR supports numerous terrestrial invertebrate taxa. Population surveys of these species for this assessment were limited and upland habitats targeted were 1) old river terrace sand, 2) sand blows, 3) dry bluff prairie, 4) Sand Barrens, and 5) Pine and Oak Barrens. Most of these habitats within the LWSR have suffered many years of human encroachment including recreational vehicle trails, road-building, conversion of natural habitats to monotypic pine plantations and agriculture, fire suppression, and sand removal. Pennsylvania sedge (*Carex pennsylvanica*) has taken over the open sand areas and pushed out many of the native sand prairie plants and reducing the availability of open sand areas for insects to live or lay eggs (Kirk 2009). In many cases, management for prairie herptiles and small mammals, favoring short bunch-forming grasses and bare sand would benefit terrestrial insects as well (Kirk 2009).

A big river feature extremely well represented in the Lower Wisconsin River is open sandbars. The presence of sand bars is directly related to the abundant sand substrate and fluctuation of flow levels. Taxa found in the open sand islands of the river channels include two species of rare tiger beetles (*Cicindela hirticollis hirticollis* and *Cicindela macra*). These rare species rely on large patches of open sand habitat created by river dynamics. Larvae of *C. hirticollis* have been shown to be sensitive to trampling which may be an issue at some upper section sand bars.

Other habitats of the LWSR that support terrestrial invertebrates include barrens and sand blows, both often located on old river terraces or dunes. Terrestrial invertebrates of the barrens of the LWSR include a rare tiger beetle (*Cicindela patruela*) and the spotted-winged grasshopper (*Orphulella pelidna*). Sand blows, open, loose sand-dominated habitats, support *Cicindela lepida*, a State imperiled tiger beetle, as well as several species of wasps. In mixed woodland areas with open sand or dune habitats the Special Concern northern marbled locust (*Spharagemon marmorata*) was located. Dry-bluff prairies are also important sites for terrestrial invertebrates and sites within the LWSR support the state Threatened *Polyamia dilata*.

Numerous terrestrial invertebrate taxa are represented in the LWSR but very poor data exists on current population size and status especially compared to aquatic invertebrates. Additional terrestrial invertebrate survey efforts in the LWSR are an important future inventory need for a couple of reasons: a general lack of baseline inventory data (poor weather conditions during this study's scheduled survey period prevented a complete inventory), and the vital importance of considering terrestrial invertebrate conservation during the management planning process.Primary sites currently supporting the best populations of terrestrial invertebrates are Blue River Bluffs SNA, Blue River – Muscoda Sand Barrens, Millville, and Avoca-Muscoda Barrens. Gotham Jack Pine Barrens SNA has high potential for supporting rare terrestrial invertebrate populations but additional surveys and management aimed at restoring the open barrens and sand prairie habitat is needed.

Marsh Birds

Open wetland types including Emergent Marsh and Southern Sedge Meadow are not common in the Western Coulee and Ridges Ecological Landscape, but examples are present within major river bottoms including the Lower Wisconsin River. There are several large, high-quality marsh and meadow complexes in the LWSR supporting a unique assemblage of secretive marsh-dwelling birds. Uncommon marshbirds located in moderate numbers during nocturnal surveys in extensive open marsh habitats include least bittern, common moorhen, yellow-headed blackbird (*Xanthocephalus xanthocephalus*), and American bittern (in wetlands larger than 50 acres). The best examples of these habitats and associated marshbirds exist at the following primary sites: Bakken's Pond Marsh; Smith Slough; East Avoca; Fishtrap Flowage and Bottoms; and Wauzeka Bottoms. Additionally, large, open meadow complexes, especially those in close proximity to upland grasslands, are increasingly important to grassland-associated species like savannah sparrow (*Passerculus sandwichensis*), eastern meadowlark (*Sturnella magna*), bobolink (*Dolichonyx oryzivorus*), northern harrier (*Circus cyaneus*), and short-eared owl. Examples of these types occur at Fisher Lake, Cruson Slough, and Avoca Prairie. Of high importance for

birds throughout the LWSR are the shrubby meadows and marshes throughout the river bottoms. These areas support good populations of species of conservation need including willow flycatcher (*Empidonax traillii*), Bell's vireo (*Vireo bellii*), black-billed cuckoo (*Coccyzus erythropthalmus*), blue-winged warbler, and American woodcock (*Scolopax minor*).

Bat Conservation

The Driftless Area of Wisconsin is particularly rich in known and potential bat hibernacula sites within easy commuting distance to the LWSR for summer resident bat populations. The LWSR also functions as a critical migratory corridor for bats. The older forests of the LWSR provide favorable characteristics for bats by offering roosting, foraging, and commuting habitat. Extensive, mobile water-based acoustic bat surveys were conducted in the LWSR during the 2009 summer residency periods. The surveys indicated the presence of seven of the possible eight bat species known to historically occur in Wisconsin with the only species not detected being the Indiana bat (*Myotis sodalis*), which has not been detected in Wisconsin since 1954.

By feeding on destructive insects, bats are an important component of a healthy forest. Opportunities to promote bat habitat include providing resources for roosting, foraging, and drinking. Bats of the LWSR roost under loose, peeling bark and in crevices and cavities. Often these attributes are found in older forests with snags of varying decay level, size, and height. Foraging is done in and along small to medium forest openings or gaps, such as ponds, natural and artificial openings, roads, or water courses (Taylor 2006). Maintaining diverse forest flora and reducing non-native plant abundance is important for promoting invertebrate prey diversity and thus promoting foraging opportunities for bats (WDNR 2006b). Water resources are used for drinking, travel, and foraging. Maintaining high-water quality and access to water is important for protecting bat populations. Wide buffers (generally wider than those recommended in Best Management Practices for water quality) around water, including rivers, streams, and wet meadows, are important for bats and other wildlife species using these areas (Taylor 2006).

Hibernaculum disturbance, habitat degradation, and wind-turbine mortality are threats that affect all bat species found in Wisconsin. An emerging threat to Wisconsin's bats, White-Nose Syndrome, has been called the "most precipitous wildlife decline in the past century in North America" by Bat Conservation International and has devastated bat populations in the eastern United States since 2006 (*White-nose Syndrome)*. It is currently unknown how the fungus (*Geomyces destructans)* causing White-Nose Syndrome kills the bats. Due to the emerging threats that bat populations face in Wisconsin, more information in the form of surveys (acoustic and roost) are needed to more accurately describe the bats that use the LWSR.

Primary Sites: Significance and Summaries

Primary Sites were developed and finalized following two years of biotic inventory and followed standard methodology. Primary Sites are different from inventory sites and Deferral / Consultation Sites (see glossary) and are finalized only after biotic inventory is completed. Twenty-eight Primary Sites were identified on the LWSR. These "Primary Sites" were identified because they contain relatively undisturbed, high-quality, natural communities; provide important habitat for rare species; offer opportunities for restoration; provide important ecological connections; or some combination of the above factors. Figures 9 and 10 illustrates the locations of the Primary Sites. Not all of the study area was thoroughly surveyed because of budget and time constraints, therefore there may be other ecologically important areas not identified as Primary Sites.

Descriptions for each of the Primary Sites can be found in Appendix G. Information provided includes location information, a site map, a brief summary of the natural features present, the site's ecological significance, and management considerations.

Lower Wisconsin State Riverway Primary Sites

LWSR01	Mazomanie Oak Barrens
LWSR02	Ferry Bluff SNA
LWSR03	Mazomanie Bottoms SNA
LWSR04	Boneset Savanna
LWSR05	Cedar Island
LWSR06	Buttonweed Barrens
LWSR07	Arena Pines and Sand Barrens SNA
LWSR08	Tower Hill Bottoms
LWSR09	Cynthia Slough
LWSR10	Bakken's Pond Marsh and Woods
LWSR11	Smith Slough
LWSR12	Gotham Jack Pine Barrens SNA
LWSR13	Avoca Prairie and Savanna SNA
LWSR14	Bogus Bluff
LWSR15	Orion Mussel Bed SNA
LWSR16	Avoca-Muscoda Barrens
LWSR17	Goodwiler Lake Lowlands
LWSR18	Fishtrap Flowage and Bottoms
LWSR19	Blue River – Muscoda Sand Barrens
LWSR20	Pine Relict
LWSR21	Blue River Bluffs SNA
LWSR22	Richwood Bottoms Area
LWSR23	Clear Creek Lowlands
LWSR24	Woodman Lake Sand Prairie and Dead Lake SNA
LWSR25	Woodman Habitat Preservation Area
LWSR26	Wauzeka Bottoms
LWSR27	Millville Woodland and Adiantum Woods
LWSR28	Weniger Island and Forest

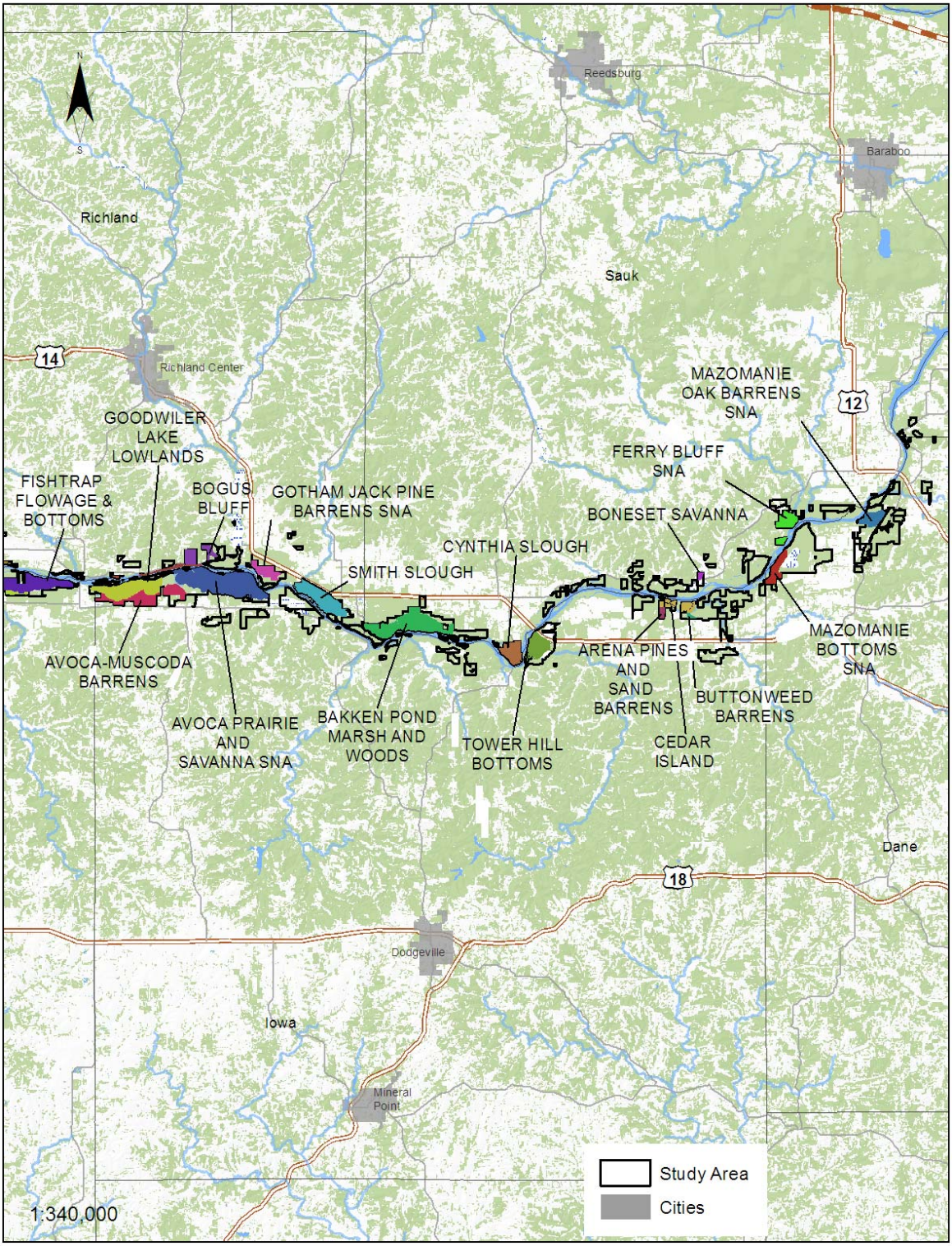

Figure 13. Location of Primary Sites on the eastern half of the Lower Wisconsin State Riverway. Site descriptions are provided in Appendix G.

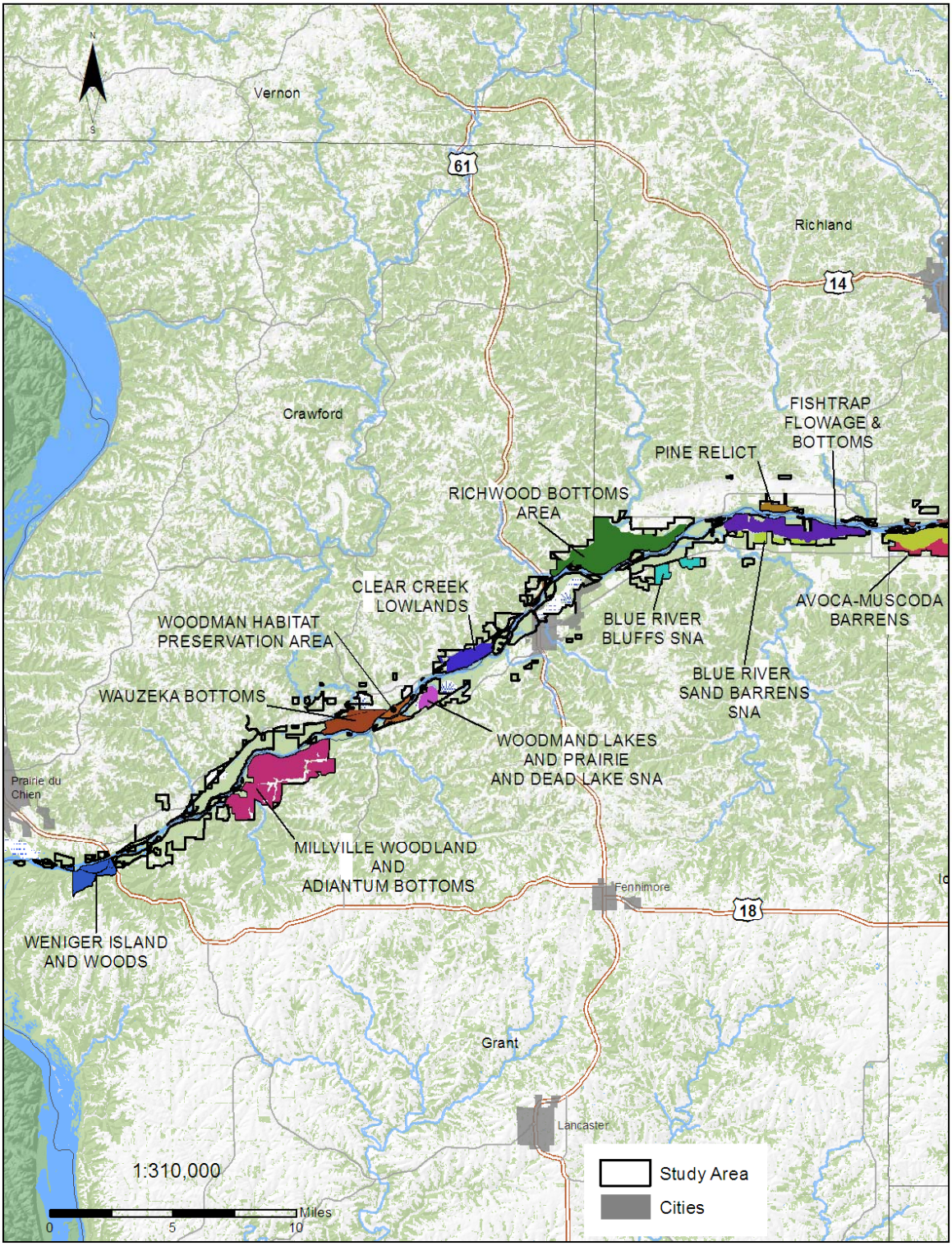

Figure 14. Location of Primary Sites on the western half of the Lower Wisconsin State Riverway. Site descriptions are provided in Appendix G.

Future Inventory, Monitoring, and Research Needs

Aquatic Plants – Detailed submerged, floating, and emergent aquatic plant inventories within the floodplain and specifically in the backwater sloughs and floodplain lakes is needed.

Aquatic Animals – Although much data exists for aquatic species in the LWSR, continued monitoring and research of rare fish and invertebrates is vital due to the importance of the river for extremely large numbers of globally rare mussels and fish species.

Bats – Due to the emerging threats that bat populations face in Wisconsin, more information in the form of surveys (acoustic and roost) are needed to more accurately describe the bats that use the LWSR.

Biofuel Harvesting – Using best management practices, determine where biofuel harvesting may be used as a technique to restore a natural community.

Fire-sensitive Species – Research and monitoring is needed to determine effects of prescribed burning on fire-sensitive species.

Floodplain Sloughs, Lakes, and Ponds – Additional surveys are necessary since very few of these areas have been monitored quantitatively for fish and aquatic plants. More comprehensive ground and surface water quality monitoring would provide data to support the link between ground water quality, floodplain lakes water quality, and integrity of biota.

Forest Interior Bird Research – More research is needed on the effects of forest management, including timing and intensity of thinnings and regeneration harvests, and savanna restoration on forest interior birds in southern Wisconsin. Continue a LWSR study to develop a monitoring protocol for forest interior birds with respect to forest management.

Herptiles – The LWSR represents one of the best opportunities in Wisconsin to protect and enhance reptile populations associated with prairies, barrens, and southern dry forests. Inventory efforts during the course of this project were largely restricted to habitat assessments and historical records review. Additional extensive inventory work for reptiles is needed to inform adaptive management throughout the LWSR.

Invasive Species – Continued monitoring and control of terrestrial and aquatic non-native invasive species will be critical on the LWSR.

Islands – Biotic inventory of the islands during this survey effort was limited. These islands provide important habitat to many species and a systematic survey of them is needed.

Prescribed burning – Identify the conditions and constraints of prescribed burning to assess where it can be applied at a large scale to maximize limited funding.

Road Mortality – Identify places where herptile mortality on roadways is a problem and consider use of road signs or ecopassages in these areas.

Sandbars – The extensive series of sandbars on the Lower Wisconsin River are a unique resource in the state because their large size provides habitat for a distinct community of terrestrial invertebrates and plants. Systematic surveys are needed to determine the rarity of the species present and how best to protect and manage these unique areas.

Small Mammals – Several records of the prairie vole are located within the LWSR at sand prairie and barrens habitats. More survey work is needed to detail the rarity of this species statewide, but the LWSR appears to be an important landscape for maintaining this uncommon small mammal.

Terrestrial Invertebrates – Because 2009 was among the worst years on record for sampling insects across the Midwest, and these groups impact management in the LWSR, further surveys of upland barrens, prairies, sand blows and savannas is needed.

Tributary Streams – Tributary streams are numerous in the LWSR, and should have baseline monitoring for water chemistry, fish, habitat and aquatic insects to assess how they are impacting the LWSR.

Glossary

bioturbation – the alteration and disturbance of a site by living organisms; the turning and mixing of sediments by organisms, as rodents.

colluvium – loose rock and soil at the base of a cliff or steep slope.

Deferral / Consultation sites – as stated in manual code 1750.15, these sites will be identified and maintained for deliberation during master planning that represent the best known: 1) opportunities for native community management, 2) special conservation areas (such as "High Conservation Value Forests" required for Forest Certification, and 3) rare species habitat.

Ecological Landscape – landscape units developed by the WDNR to provide an ecological framework to support natural resource management decisions. The boundaries of Wisconsin's sixteen Ecological Landscapes correspond to ecoregional boundaries from the National Hierarchical Framework of Ecological Units, but sometimes combine subsections to produce a more manageable number of units.

Ecological Reference Areas – Also known as 'ecological benchmarks.' Places on the landscape identified and managed primarily for their ecological values, particularly high-quality natural communities. Management considerations for production of forest products, wildlife habitat for game species, recreational activities, and other natural resource objectives are secondary, though some uses may be compatible. They provide a framework for improving our understanding of ecological systems and the impacts of humans on them. Ecological reference areas for some natural community types are in later successional stages still subjected to the natural processes with which they developed, thus requiring little or no active management. Other types require active management that reintroduces or mimics natural processes, such as fire, that are now absent from the landscape. These areas thus also serve as important reference sites for evaluating various management strategies.

Ecopassage – a series of guidewalls and/or under-highway tunnels that allow wildlife to safely cross roadways.

Element Occurrence - an Element Occurrence (EO) is an area of land and/or water in which a rare species or natural community is, or was, present. An EO should have practical conservation value for the Element as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location. For species, the EO often corresponds with the local population, but when appropriate may be a portion of a population (e.g., a single nest territory or long distance dispersers) or a group of nearby populations (e.g., metapopulation). For communities, the EO may represent a stand or patch of a natural community or a cluster of stands or patches of a natural community. Because they are defined on the basis of biological information, Eos may cross jurisdictional boundaries.

Forest Certification – a market-based, non-regulatory forest conservation tool designed to recognize and promote environmentally-responsible forestry and sustainability of forest resources. The certification process involves an evaluation of management planning and forestry practices by a third-party according to an agreed-upon set of standards (from http://www.pinchot.org/project/59). See http://dnr.wi.gov/forestry/certification/ regarding certification of WDNR managed lands.

Landtype Association (LTA) – a level in the National Hierarchical Framework of Ecological Units (see next entry) representing an area of 10,000 – 300,000 acres. Similarities of landform, soil, and vegetation are the key factors in delineating LTAs.

Last Observed Date (LastObs) - The last confirmed observation date of the element occurrence extant at this site (not necessarily the date the site was last visited).

loess – windblown, silt-size dust derived mostly from the glacial four carried by outwash rivers. It typically forms a cover over the landscape that thins with distance downwind from braided outwash rivers.

moraine - landforms composed of unsorted materials deposited by glaciers. They can cover broad geographic areas of millions of acres. Topography can vary from nearly level "till" plains to rough end moraine landscapes composed of steep dry ridges interspersed with deep kettle holes. These glacial "kettles" are frequent locations for lakes and wetlands.

natural community – an assemblage of plants and animals, in a particular place at a particular time, interacting with one another, the abiotic environment around them, and subject to primarily natural disturbance regimes. Those assemblages that are repeated across a landscape in an observable pattern constitute a community type. No two assemblages, however, are exactly alike.

NED system – a collection of software products being developed by the USDA Forest Service. The NED software is intended to aid resource managers to develop goals, assess current and future conditions, and produce sustainable management plans for forest properties.

novel ecosystem – ecosystems containing new combinations of species that arise through human action, environmental change, and the impacts of the deliberate and inadvertent introduction of species from other parts of the world.

nymph – the immature form of some invertebrates, particularly insects, which undergoes in gradual metamorphosis before reaching its adult stage.

Primary Type – the cover type and size class comprising the major component of a stand as determined by basal area. In the absence of adequate tree stocking, the prominent ground cover is the primary type.

pseudofeces – are a way that filter-feeding bivalve mollusks (and filter-feeding gastropod mollusks) get rid of suspended particles which have been rejected as unsuitable for food.

representative - native plant species that would be expected to occur in native plant communities influenced primarily by natural disturbance regimes in a given landscape – e.g., see Curtis (1959).

Secondary Type - The cover type and size class or ground cover comprising the largest minor component of a stand.

SGCN (or "Species of Greatest Conservation Need") – native wildlife species with low or declining populations that are most at risk of no longer being a viable part of Wisconsin's fauna (from the "Wisconsin Wildlife Action Plan," WDNR 2006b).

Wisconsin Wetland Inventory – Wisconsin Wetland Inventory (WWI) maps show graphic representations of the type, size and location of wetlands in Wisconsin. These maps have been prepared from the analysis of high altitude imagery in conjunction with soil surveys, topographic maps, previous wetland inventories and field work.

Species List

Common Name	Scientific Name
Animals	
Acadian flycatcher	*Empidonax virescens*
American bittern	*Botaurus lentiginosus*
American bullfrog	*Lithobates catesbeianus*
American kestrel	*Falco sparverius*
American woodcock	*Scolopax minor*
bald eagle	*Haliaeetus leucocephalus*
Bell's vireo	*Vireo bellii*
big brown bat	*Eptesicus fuscus*
black buffalo	*Ictiobus niger*
black-billed cuckoo	*Coccyzus erythropthalmus*
Blanding's turtle	*Emydoidea blandingii*
blue sucker	*Cycleptus elongatus*
blue-winged warbler	*Vermivora pinus*
bobolink	*Dolichonyx oryzivorus*
brown thrasher	*Toxostoma rufum*
bullhead/sheepnose	*Plethobasus cyphyus*
cerulean warbler	*Dendroica cerulea*
channel shiner	*Notropis sp.*
common moorhen	*Gallinula chloropus*
common mudpuppy	*Necturus maculosus*
crystal darter	*Crystallaria asprella*
devil crayfish	*Cambarus diogenes*
eastern massasauga rattlesnake	*Sistrurus catenatus*
eastern meadowlark	*Sturnella magna*
eastern pipistrelle bat	*Perimyotis subflavus*
emerald ash borer	*Agrilus planipennis*
European earthworms	*Acanthodrilidae, Lumbricidae, Megascloedidae*
field sparrow	*Spizella pusilla*
flat floater mussel	*Anodonta suborbiculata*
goldeye	*Hiodon alosoides*
gophersnake	*Pituophis catenifer*
gray ratsnake	*Pantherophis spiloides*
Higgins' eye pearly mussel	*Lampsilis higginsii*
Hine's Emerald Dragonfly	*Somatochlora hineana*
hooded warbler	*Wilsonia citrina*
Indiana bat	*Myotis sodalis*
Kentucky warbler	*Oporornis formosus*
king rail	*Rallus elegans*
Knobel's riffle beetle	*Stenelmis knobeli*
lake chubsucker	*Erimyzon sucetta*
lark sparrow	*Chondestes grammacus*
least bittern	*Ixobrychus exilis*
least flycatcher	*Empidonax minimus*

Common Name	Scientific Name
little brown bat	*Myotis lucifugus*
Animals	
map turtle	*Graptemys pseudogeographica*
Mississippi grass shrimp	*Palaemonetes kadiakensis*
mud darter	*Etheostoma asprigene*
North American racer	*Coluber constrictor*
northern cricket frog	*Acris crepitans*
northern goshawk	*Accipiter gentilis*
northern harrier	*Circus cyaneus*
northern long-eared bat	*Myotis septentrionalis*
ornate box turtle	*Terrapene ornata*
Ozark minnow	*Notropis nubilus*
paddlefish	*Polyodon spathula*
pallid shiner	*Notropis amnis*
Pecatonica River mayfly	*Acanthametropus pecatonica*
pickerel frog	*Lithobates palustris*
pirate perch	*Aphredoderus sayanus*
prairie ring-necked snake	*Diadophis punctatus arnyi*
prairie vole	*Microtus ochrogaster*
prothonotary warbler	*Protonotaria citrea*
rare tiger beetles	*Cicindela hirticollis, C. macra, C. patruela huberi, C. lepida*
red-shouldered hawk	*Buteo lineatus*
red-headed woodpecker	*Melanerpes erythrocephalus*
river redhorse	*Moxostoma carinatum*
rough-legged hawk	*Buteo lagopus*
savannah sparrow	*Passerculus sandwichensis*
sharp-shinned hawk	*Accipiter striatus*
shoal chub	*Macrhybopsis aestivalis*
short-eared owl	*Asio flammeus*
six-lined racerunner	*Aspidoscelis sexlineata*
smooth softshell turtle	*Apalone mutica*
starhead topminnow	*Fundulus dispar*
white-spangled skimmer	*Libellula cyanea*
swamp darner	*Epiaeschna heros*
timber rattlesnake	*Crotalus horridus*
veery	*Catharus fuscescens*
Wallace's deepwater mayfly	*Spinadis simplex*
weed shiner	*Notropis texanus*
western sand darter	*Ammocrypta clara*
whip-poor-will	*Caprimulgus vociferus*
white-tail deer	*Odocoileus virginianus*
willow flycatcher	*Empidonax traillii*
wood thrush	*Hylocichla mustelina*
wood turtle	*Glyptemys insculpta*
yellow sandshell mussel	*Lampsilis teres*
yellow-headed blackbird	*Xanthocephalus xanthocephalus*

Common Name	Scientific Name
zebra mussel	*Dreissena polymorpha*
Plants	
arrowheads	*Sagittaria sp*
ash	*Fraxinus sp(p)*
aspen	*Populus sp*
basswood	*Tilia americana*
bearberry	*Arctostaphylos uva-ursi*
bent-seeded hop sedge	*Carex tuckermanii*
big blue-stem	*Andropogon gerardii*
bigtooth aspen	*Populus grandidentata*
bishop's-cap	*Mitella diphylla*
black ash	*Fraxinus nigra*
black oak	*Quercus velutina*
black walnut	*Juglans nigra*
bladdernut	*Staphylea trifolia*
blue-joint grass	*Calamagrostis canadensis*
bottlebrush sedge	*Carex hystericina*
box elder	1. *Acer negundo*
broad beech fern	*Phegopteris hexagonoptera*
broad-leaved cat-tail	*Typha latifolia*
bur oak	*Quercus macrocarpa*
buttonbush	*Cephalanthus occidentalis*
Canada moonseed	*Menispermum canadense*
cattails	*Typha spp*
chinquapin oak	*Quercus muhlenbergii*
clustered poppy-mallow	*Callirhoe triangulata*
common blackberry	*Rubus allegheniensis*
common bur-reed	*Sparganium eurycarpum*
common hop sedge	*Carex lupulina*
common spike-rush	*Eleocharis palustris*
common wood-reed	*Cinna arundinacea*
eastern cottonwood	*Populus deltoides*
false-heather	*Hudsonia tomentosa*
false Solomon's-seal	*Smilacina racemosa*
garlic mustard	*Alliaria petiolata*
giant wood fern	*Dryopteris goldiana*
glossy buckthorn	*Rhamnus frangula*
grapes	*Vitis sp*
Gray's sedge	*Carex grayi*
great water-leaf	*Hydrophyllum appendiculatum*
green ash	*Fraxinus pennsylvanica*
green-headed coneflower	*Rudbeckia laciniata*
hackberry	*Celtis occidentalis*
hairy sweet cicely	*Osmorhiza claytonii*
hog-peanut	*Amphicarpaea bracteata*
honey locust	*Gleditsia triacanthos*

Common Name	Scientific Name
hybrid cat-tail	*Typha X glauca*
jack pine	*Pinus banksiana*
Plants	
jeweled shooting star	*Dodecatheon amethystinum*
Kentucky coffee-tree	*Gymnocladus dioica*
lance-leaved buckthorn	*Rhamnus lanceolata*
maidenhair fern	*Adiantum pedatum*
mayapple	*Podophyllum peltatum*
narrow-leaved cat-tail	*Typha angustifolia*
narrow-leaved day-flower	*Commelina erecta*
northern bugleweed	*Lycopus uniflorus*
ostrich fern	*Matteuccia struthiopteris*
partridgeberry	*Mitchella repens*
pickerel-weed	*Pontederia cordata*
poison-ivy	*Toxicodendron radicans*
prairie cord grass	*Spartina pectinata*
prairie fame-flower	*Phemeranthus rugospermus*
prairie ragwort	*Senecio plattensis*
prickly ash	*Zanthoxylum americanum*
purple rocket	*Iodanthus pinnatifidus*
putty root	*Aplectrum hyemale*
raspberry	*Rubus idaeus*
red maple	*Acer rubrum*
red oak	*Quercus rubra*
red osier dogwood	*Cornus stolonifera*
reed canary grass	*Phalaris arundinacea*
river birch	*Betula nigra*
sand cherry	*Prunus pumila*
sand cress	*Arabis lyrata*
sedges	*Cyperus filiculmis* and *C. schweinitzii*
shagbark hickory	*Carya ovata*
Short’s rock-cress	*Arabis shortii*
silky wild-rye	*Elymus villosus*
silver maple	*Acer saccharinum*
slender willow	*Salix petiolaris*
small forget-me-not	*Myosotis laxa*
snow trillium	*Trillium nivale*
spotted Joe-Pye-weed	*Eupatorium maculatum*
spreading chervil	*Chaerophyllum procumbens*
spring-beauty	*Claytonia virginica*
stinging nettle	*Urtica dioica*
sugar maple	*Acer saccharum*
swamp milkweed	*Asclepias incarnata*
swamp white oak	*Quercus bicolor*
sweet-scented Indian-plantain	*Cacalia suaveolens*
sycamore	*Platanus occidentalis*
three-awn grasses	*Aristida* spp

Common Name	Scientific Name
tussock sedge	*Carex stricta*
upland boneset	*Eupatorium sessilifolium*
Plants	
violet bush-clover	*Lespedeza violacea*
Virginia creeper	*Parthenocissus quinquefolia*
Virginia waterleaf	*Hydrophyllum virginianum*
white ash	*Fraxinus americana*
white grass	*Leersia virginica*
white oak	*Quercus alba*
white pine	*Pinus strobus*
wild geranium	*Geranium maculatum*
wild leek	*Allium tricoccum*
wild rice	*Zizania aquatica*
wild sarsaparilla	*Aralia nudicaulis*
willow	*Salix sp*
wood anemone	*Anemone quinquefolia*
wood nettle	*Laportea canadensis*
yellow Indian grass	*Sorghastrum nutans*
bitter-nut hickory	*Carya cordiformis*

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Additional Resources

Numerous online resources are available for learning more about the rare species, natural communities, and ecological concepts contained within this report. These are just a few of the resources that we recommend.

1. **Bureau of Endangered Resources' Animals, Plants, and Communities Web Pages**

   Information for plants, animals, and natural communities on the Wisconsin Working List, as well as Species of Greatest Conservation Need from the Wisconsin Wildlife Action Plan. For reptiles and amphibians, information for more common species is also provided here. At this time, the level of detail available varies among species; some have detailed factsheets while others have only a short paragraph or a map. These pages will continue to evolve as more information becomes available and are the Bureau of Endangered Resources' main source of information for species and communities. ***Dnr.wi.gov/org/land/er/biodiversity/***

2. **Wisconsin Natural Heritage Inventory Working List**

   The Wisconsin Natural Heritage Working List contains species known or suspected to be rare in the state and natural communities native to Wisconsin. It includes species legally designated as "Endangered" or "Threatened" as well as species in the advisory "Special Concern" category. This Web page offers a printable pdf file and a key to the Working List for use in conjunction with the information provided in #1 above. ***Dnr.wi.gov/org/land/er/wlist/***

3. **Ecological Landscapes of Wisconsin Handbook**

   Wisconsin's 16 Ecological Landscapes have unique combinations of physical and biological characteristics such as climate, geology, soils, water, or vegetation. This handbook will contain a chapter for each of these landscapes with detailed information about their ecology, socioeconomics, and ecological management opportunities. An additional introductory chapter will compare the 16 landscapes in numerous ways, discuss Wisconsin's ecology on the statewide scale, and introduce important concepts related to ecosystem management in the state. The full handbook is in development as of this writing, and chapters will be made available online as they are published. Currently, a set of Web pages provide brief Ecological Landscape descriptions, numerous maps, and other useful information, including management opportunities for natural communities and Species of Greatest Conservation Need. ***Dnr.wi.gov/landscapes/***

4. **The Wisconsin Wildlife Action Plan**

   This plan is the result of a statewide effort to identify native Wisconsin animal species of greatest conservation need. The plan also presents priority conservation actions to protect the species and their habitats. The plan itself is available online, and there are several online tools to explore the data within the plan. The Web pages are closely integrated with the pages provided in items #1 and #3 above. The Wildlife Action Plan Web pages are quite numerous, so we recommend the following links as good starting points for accessing the information.

   - the plan itself: ***dnr.wi.gov/org/land/er/wwap/***
   - explore Wildlife Action Plan data: ***dnr.wi.gov/org/land/er/wwap/explore/***
   - Wildlife Action Plan Implementation: ***dnr.wi.gov/org/land/er/wwap/implementation/***

5. **Wisconsin's Biodiversity as a Management Issue – A Report to Department of Natural Resources Managers**

   This now out-of-print report presents a department strategy for conserving biological diversity. It provides department employees with an overview of the issues associated with biodiversity and provides a common point of reference for incorporating the conservation of biodiversity into our management framework. The concepts presented in the report are closely related to the material provided in this report, as well as the other resources listed in this section.
   Dnr.wi.gov/org/es/science/publications/rs915_95.htm

6. **Wisconsin's Statewide Forest Strategy**

   Wisconsin's Statewide Forest Strategy is a collection of many strategies and actions designed to address major issues and priority topics over the next five to ten years. It provides a long-term, comprehensive, coordinated approach for investing resources to address the management and landscape priorities identified in the Statewide Forest Assessment. Several of the strategies contain issues related to biodiversity and ecosystem management.
   Dnr.wi.gov/forestry/assessment/strategy/overview.htm

7. **2010 Wisconsin's Statewide Forest Assessment**

   The goal of this project was to assess the "state of affairs" of Wisconsin's public and private forests and analyze the sustainability of our forested ecosystems. The Statewide Forest Assessment helps to explain trends, identify issues, and present an updated view of the status of forests in Wisconsin. The first chapter deals with biological diversity in Wisconsin's forests, and the major conclusions from this assessment were used to develop the strategies in # 6 above.
   Dnr.wi.gov/forestry/assessment/strategy/assess.htm