Natural Features Inventory and Management Recommendations for Maple River State Game Area

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Michigan Natural Features Inventory
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Michigan Natural Features Inventory


Arrow-arum (*Peltandra virginica*) in The Maple River Floodplain Forest. Photo by Aaron P. Kortenhoven.

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Cover Photo: Wacousta Woods, the Maple River Floodplain Forest, and the Maple River; Maple River State Game Area. Photo By Jesse M. Lincoln.

ACKNOWLEDGEMENTS

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It is also worth acknowledging that this report was completed during the COVID-19 pandemic. Editing and assembling the report was very challenging during a time when we were unable to meet as a team or even occupy our offices. What follows is a testament to a great team and understanding sponsors in the DNR. Thanks to all involved.

Maple River State Game Area provides critical habitat for a myriad of wildlife and is especially important for avian fauna, such as this grackle (*Quiscalus quiscula*). Photo by Aaron P. Kortenhoven.

EXECUTIVE SUMMARY

The Maple River State Game Area (SGA) is a large block of semi-contiguous public land in western Lower Michigan, consisting of 10,002 acres in Clinton, Gratiot, and Ionia Counties. Maple River SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports 1,791 acres of upland forest, 1,795, acres of non-forested wetland, and 3,719 acres of forested wetland. The river and its floodplain are prominent features of Maple River SGA and the numerous wetlands within the game area support a diversity of insect, herptile, avian, mammalian, plant, mussel, and fish species.

Michigan Natural Features Inventory (MNFI) conducted Stage 1 Michigan Forest Inventory in 2013. Surveys for high-quality natural communities were conducted in Maple River SGA in 2017 and for rare animals in 2019 as part of the Integrated Inventory Project. This project is part of a long-term effort by MNFI to document areas of high conservation significance on state lands and provide information to the Michigan Department of Natural Resources, Wildlife Division regarding sustainable management those important areas.

During the Integrated Inventory Project at Maple River SGA, MNFI scientists documented 5 new natural community Element Occurrences (EOs), 3 new rare animal EOs, 14 new rare plant EOs, and provided information for updating 16 existing EOs. In total, 45 EOs and 13 species of greatest conservation need (SGCN) have been documented in Maple River SGA including 11 animal EOs, 24 plant EOs, and 10 natural community EOs. These new EOs constitute a 78% increase in documented rare species and high-quality natural communities within Maple River SGA.

Notable new rare plant EOs include Michigan's only occurrences of Olney's bulrush (*Schoenoplectus americanus*, state endangered) and dwarf spike-rush (*Eleocharis parvula*, state endangered) which are found within Maple River SGA within an inland salt marsh. These rare plants are halophytes that have dramatically declined due to the degradation of this rare natural community type.

Surveys for rare avian species included point-counts for raptors, forest songbirds, and marsh birds. Prothonotary warbler and cerulean warbler were previously documented in the game area and were documented again during the surveys of 2019. A new EO for red-headed woodpecker (*Melanerpes erythrocephalus*, special concern) was documented in the western portion of the game area along the Maple River. Rare raptor surveys were completed at 69 points within the game area and no active red-shouldered hawk (RSHA) nests were seen. An existing marsh wren (*Cistothorus palustris*, special concern) record was updated during marsh bird surveys, with several new locations documented.

MNFI scientists conducted visual encounter surveys, basking surveys, and aquatic funnel trapping surveys for rare amphibians and reptiles. One adult Blanding's turtle (*Emydoidea blandingii*, special concern) was observed and two adult Blanding's turtles were captured in traps in two of the ditches in the East Unit of the game area. Two observations of Butler's gartersnakes (*Thamnophis butleri*, special concern) submitted to Michigan Herp Atlas in 2006 were the basis of a new EO for this species in the East Unit of the game area. These observations of Blanding's turtles and Butler's gartersnakes represented new EOs within Maple River SGA.

Aquatic surveys were performed at 10 sites within Maple River Game Area. A total of 15 unionid mussel species were found including the state endangered lilliput (*Toxolasma parvum*) and state threatened slippershell (*Alasmidonta viridis*). Four species of special concern were also documented: elktoe (*Alasmidonta marginata*), flutedshell (*Lasmigona costata*), paper pondshell (*Utterbackia imbecillis*), and ellipse (*Venustaconcha ellipsiformis*). All six species are considered SGCN. Johnny darter (*Etheostoma nigrum*), one of the fish species known to act as a host for the state endangered lilliput and state threatened slippershell, was observed in Halterman Creek.

MNFI scientists developed a weighted geographic overlay model to inform the prioritization of biodiversity stewardship across state lands. Our modeling efforts identified Maple River SGA as a regionally significant area for harboring biodiversity, providing resilience to change, fostering ecosystem integrity, and delivering ecosystems services.

Maple River SGA supports 5,514 acres of wetlands, including the large floodplain forest along the river. These wetlands are critical for maintaining water quality of the Maple River and the Grand River downstream. Floodplain forests provide a variety of ecosystem services, including habitat for fish and wildlife, temporary storage of floodwaters, sediment trapping, removal of contaminants in water, carbon storage, groundwater recharge, erosion control, and water temperature regulation. These services provide water quality protection of the Maple River, Grand River, and Lake Michigan. By extension, these services benefit the local economies surrounding recreation and the fisheries that rely on the health of those bodies of water.

Land management in an area as ecologically significant as Maple River SGA requires the careful prioritization of stewardship efforts in the most critical ecosystems. We recommend that management efforts to maintain ecological integrity be focused in natural communities to maintain ecosystem services and provide maximum benefit for the numerous rare plant and animal species documented in the area. We also recommend the prioritization of protection and stewardship in sites located along riparian corridors and in forests with vernal pools and other wetland inclusions.

We provide the following management recommendations to protect native biodiversity and ecosystem integrity in order of importance: 1) prevent alterations to hydrology within the floodplain forest and other priority wetlands; 2) minimize forest fragmentation around priority areas identified in this report, especially in and around the floodplain forest along the Maple River; 3) control invasive species within high-quality natural communities; 4) implement prescribed fire in oak-dominated forests; 5) research options for improving stream crossings and habitat restoration for aquatic species; 6) install a turtle fence along US-127; and 7) monitor these activities to facilitate adaptive management.

Maple River State Game Area supports several high-quality natural communities, including mesic southern forests like Wacousta Woods. Photo by Jesse M. Lincoln.

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The landscape surrounding the Maple River State Game Area is dominated by agriculture. This makes it especially important as a refuge for wildlife, particularly migratory birds, such as the indigo bunting (*Passerina cyanea*). Photo by Aaron P. Kortenhoven.

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Numerous sandhill cranes (*Antigone canadensis*) were observed in the East Unit of Maple River State Game Area. Photo by Aaron P. Kortenhoven.

INTRODUCTION

The Maple River State Game Area (SGA) is a large block of semi-contiguous public land in the central Lower Peninsula of Michigan, consisting of 10,002 acres in Clinton, Gratiot, and Ionia Counties (Figure 1). Maple River SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports 1,791 acres of upland forest, 1,795 of non-forested wetland, and 3,719 acres of forested wetland. The river and its floodplain are prominent features of Maple River SGA. The Maple River is a substantial part of the Grand River watershed, the second largest watershed in Michigan. The Maple River occurs entirely within the Maple subwatershed and drains 945 square miles before feeding into the Grand River near Muir, Michigan. Of the Grand River subwatersheds, the Maple subwatershed is the most impacted by development and agriculture. It has the least amount of natural cover and the most agriculture, highlighting the significance of the game area and the riparian systems therein (Figure 2).

As part of the Integrated Inventory Project, Michigan Natural Features Inventory (MNFI) conducted Stage 1 Michigan Forest Inventory (MiFI) in 2013. MNFI used MiFI data to develop a weighted geographic overlay model to identify areas that harbor high native biodiversity, resilience, ecological integrity, and ecosystem services to inform the prioritization of management decisions on state lands. Surveys for high-quality natural communities were conducted in Maple River SGA in 2017 and 2019 and rare animals in 2019. This project is part of a long-term effort by MNFI to document areas of high conservation significance on state lands and provide the Michigan DNR Wildlife Division with information to inform the sustainable management of those areas. The primary goal of this survey effort is to provide resource managers and planners with standardized, baseline information on each natural community and rare species EO and identify the most critical places on state lands for biodiversity stewardship. This baseline information is critical for informing landscape-level biodiversity planning efforts; prioritizing protection, management, and restoration objectives; facilitating site-level decisions about biodiversity stewardship; and monitoring the success of management and restoration.

This report provides an overview of the landscape and historical context of Maple River SGA, summarizes the findings of MNFI's surveys for high-quality natural communities and rare animal species, presents the results of our geographic weighted overlay model to prioritize biodiversity stewardship, and identifies stewardship priorities within the game area. Because the landscape surrounding Maple River SGA has extensive agricultural and rural development, the large area of natural cover within the game area serves as an important reservoir of biodiversity for the local region. Maple River SGA supports several rare avian, reptile, mussel, insect, and plant species. During the natural features inventory of this game area, MNFI scientists documented or updated 4 occurrences of rare birds, 3 rare herptiles, 15 rare mussels, 24 occurrences of rare plants, and 10 high-quality natural communities. Management recommendations are provided for rare species, specific natural communities, and the game area in general.

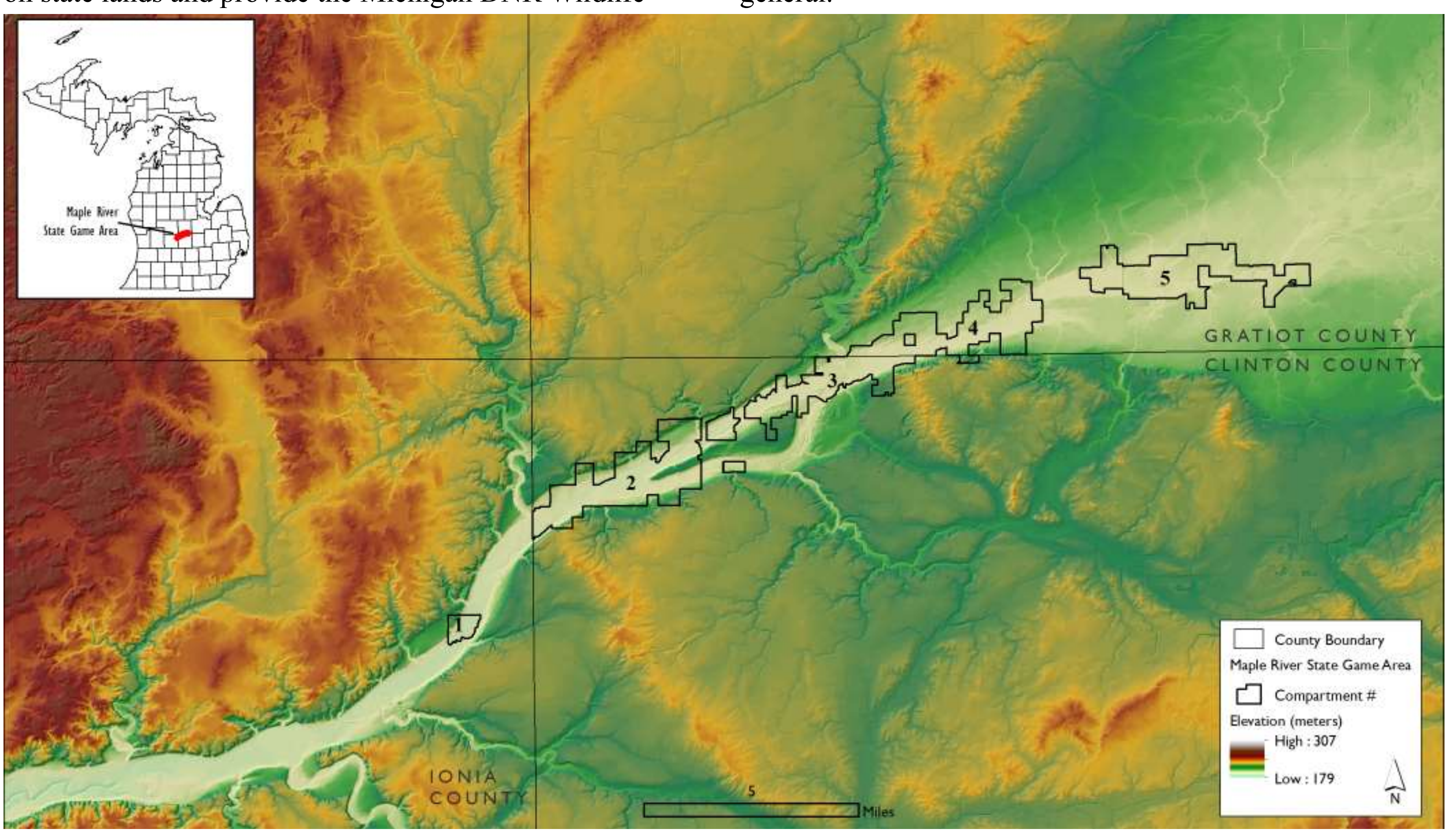


Figure 1. A digital elevation map with the location of Maple River State Game Area in central Michigan.

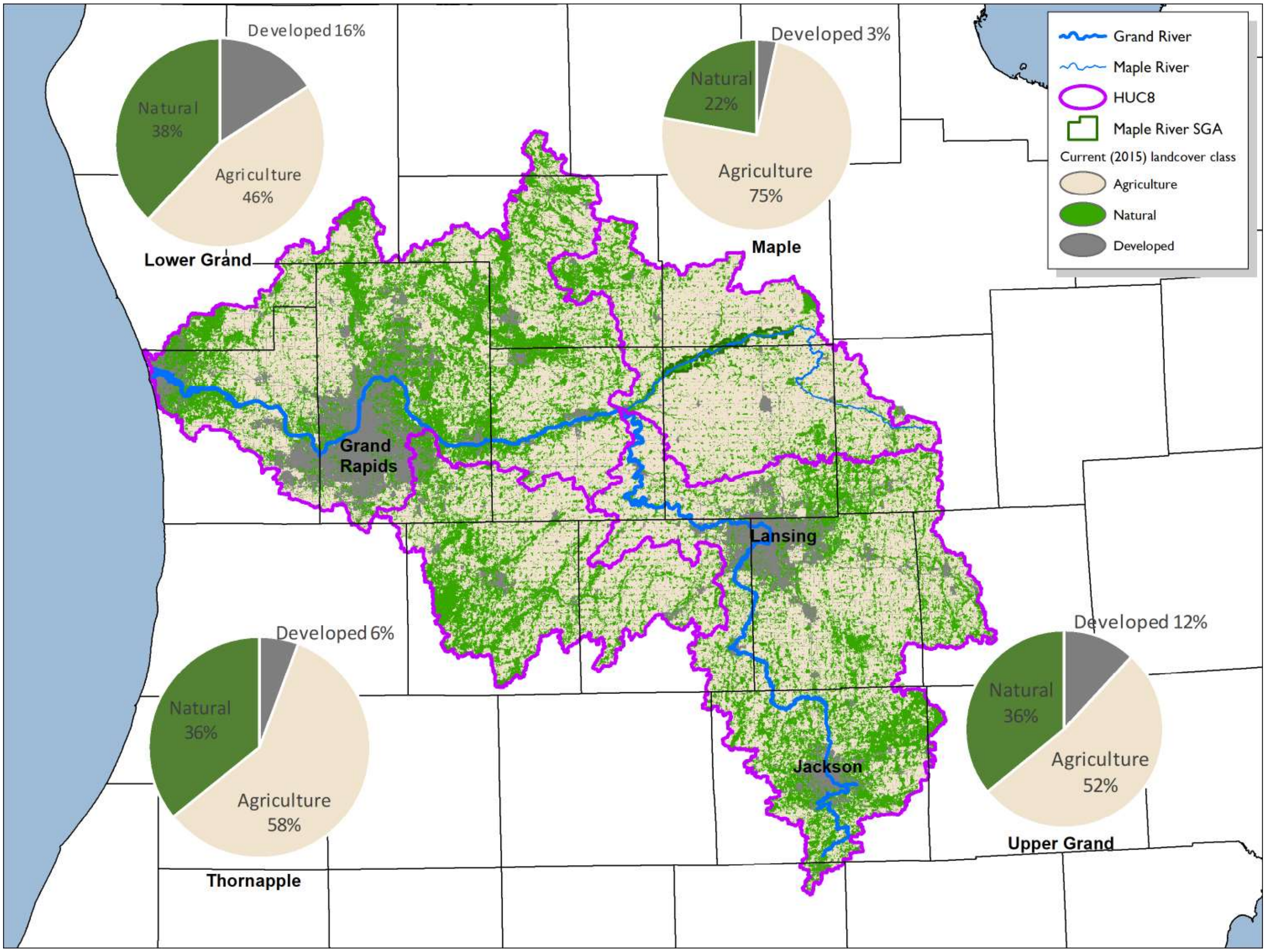


Figure 2. The four major subwatersheds of the Grand River and the proportion of cover types within those subwatersheds.

Maple River State Game Area supports numerous rare species, including the bald eagle (*Haliaeetu leucocephalus*). Photo by Aaron P. Kortenhoven.

Landscape and Historical Context

Ecoregions

Michigan has been subdivided into ecoregions based on climate, glacial features, physiography, soils, and characteristic ecosystems (Albert 1995). This classification system provides a framework for understanding the distribution patterns of species, natural communities, natural disturbance regimes, and anthropogenic activities. The classification is structured with three levels, from broad landscape regions called Sections, down to smaller Subsections and Sub-subsections. Section VI is southern lower Michigan and the western portion of the Maple River SGA lies within the Lansing Sub-subsection (VI.4.1) of the Ionia Subsection (VI.4; Figure 5).

The eastern portion of the game area lies within the Saginaw Bay Lake Plain Subsection (VI.6). The Ionia Subsection is in the central portion of the southern lower peninsula and features loamy till plains and end moraines of various textures. The Lansing Sub-Subsection is characterized by a broad till plain with rich, loamy soils that have been largely converted to agriculture (Figure 4). The gently sloping till plain was formed by material deposited directly by melting ice. One of the characteristics of this landform is an abundance of glacial erratics. These rocks of various sizes were encountered by settlers clearing the land for agriculture and the rock piles of the region are some of the most extensive encountered by MNFI ecologists.

The till plain is broken by several outwash channels, including that of the Maple River and nearby Fish and Pine Creeks. The outwash channels were formed by periodic flood events caused by complex draining of the glaciers.

The Maple River was part of an ancient drainage pathway starting at the proglacial lake at the base of the Saginaw lobe of the glacier flowing to the shoreline of Lake Michigan, which then drained through the Chicago River to the Mississippi Basin (~13-14,000 years ago, Figures 3 and 5; Eschman and Dorr 1970). Historic drainage and shoreline features are responsible for the physiography of the region and the distribution of some rare species.

Locally within the Lansing Sub-subsection, glacial drift is thin enough to permit brine from deep saline aquifers to remain concentrated and emerge at discrete points. The greatest concentration of salt marshes occurred along the floodplain and slopes adjacent to the Maple River and Grand River, where there are Silurian halites. Michigan's only remaining intact salt marshes occur within the Lansing Sub-subsection, along the Maple River in northern Clinton County.

The rock piles throughout the game area were some of the most extensive observed by MNFI scientists. These were most likely created when the land was cleared for agriculture. Photo by Aaron P. Kortenhoven.

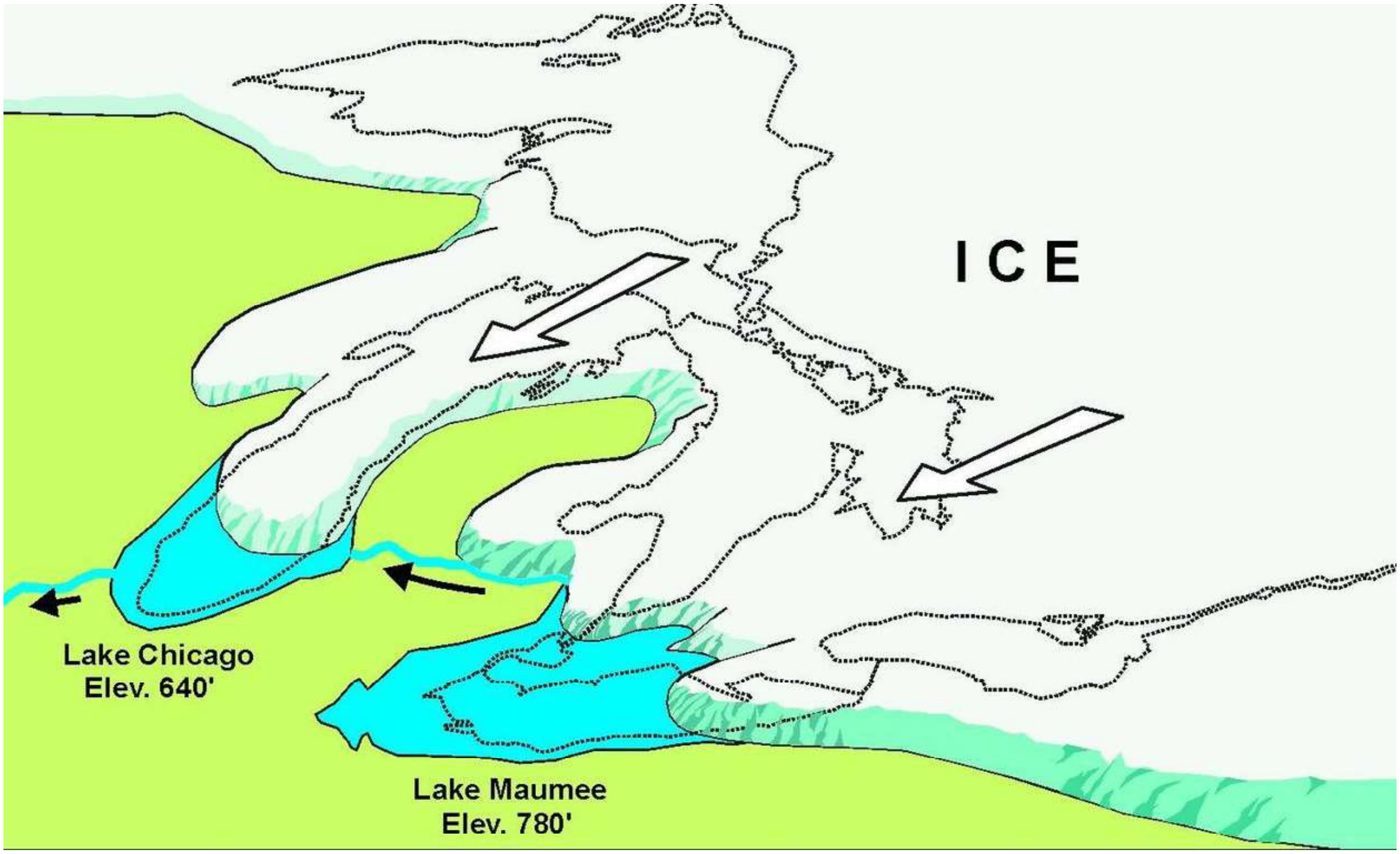


Figure 3. The location of proglacial lakes and drainageways during glacial retreat. At one point, Lake Maumee and the proglacial lake at the snout of the Saginaw Lobe drained through central Michigan and eventually into the Mississippi drainage. This formed the Maple River outwash channel (Eschman and Dorr 1970).

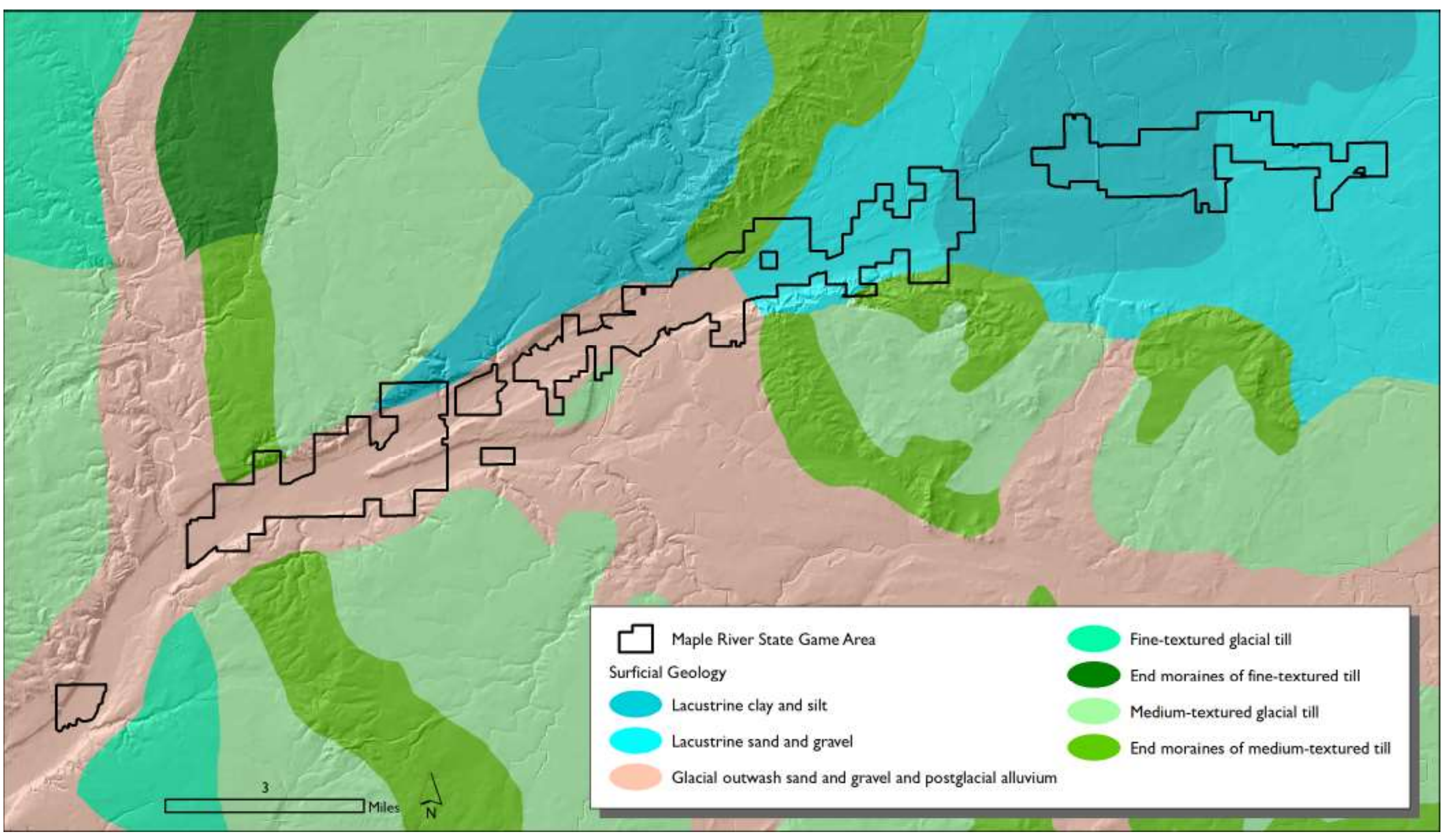


Figure 4. Surficial geology of Maple River State Game Area.

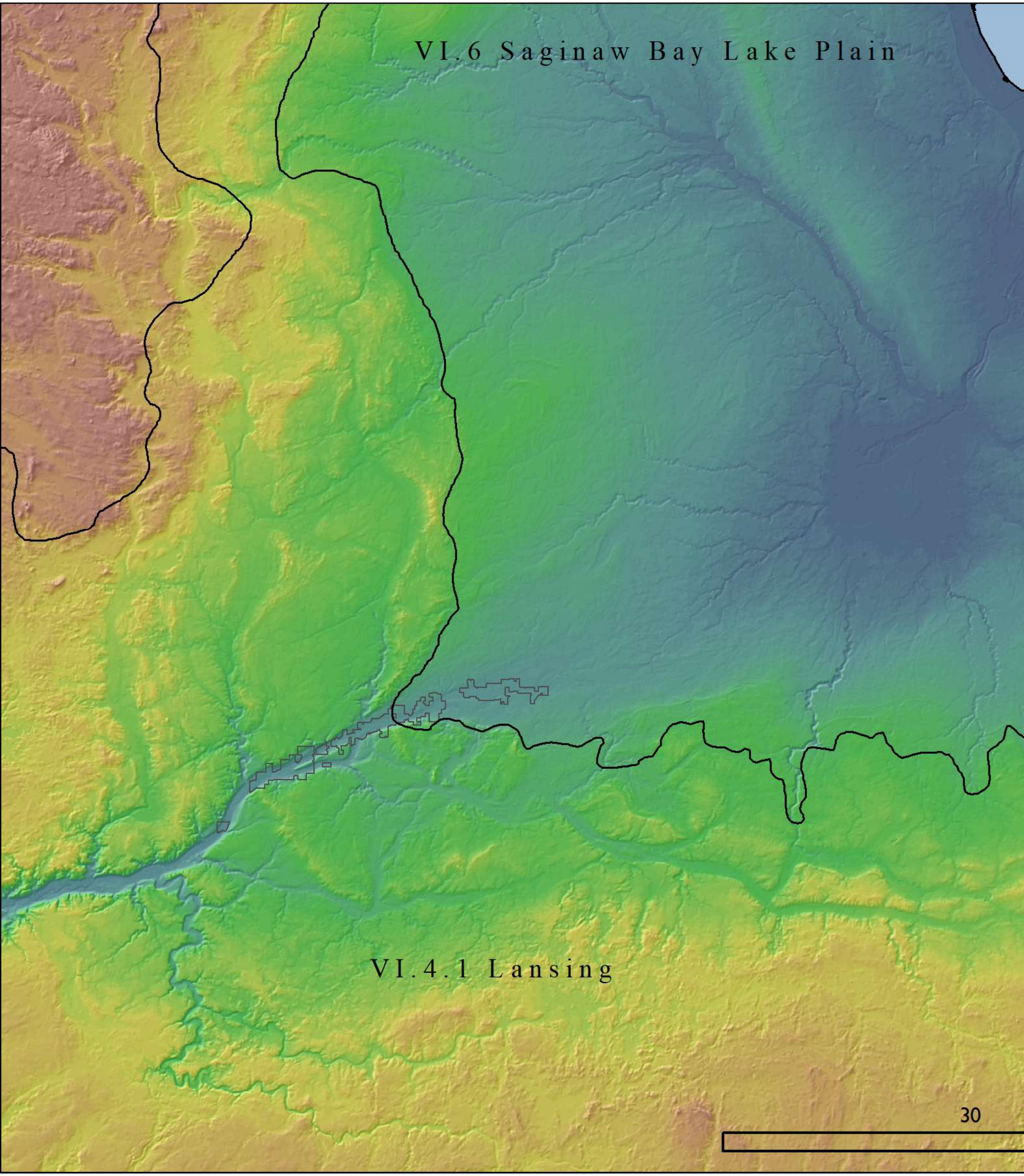
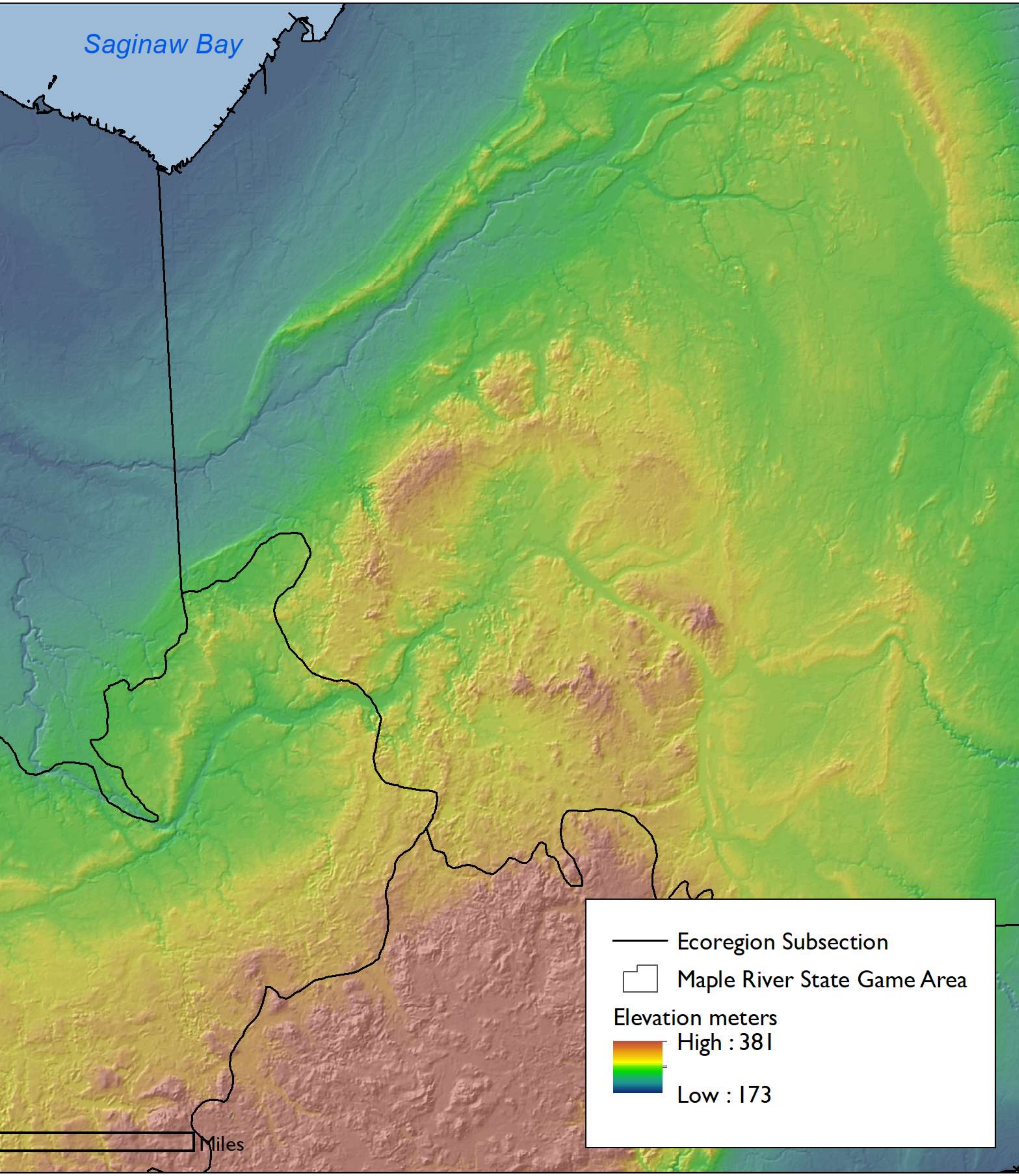


Figure 5. The Ecoregions and Subsections of Michigan and the Maple River State Game Area.



Saginaw Bay
Ecoregion Subsection
Maple River State Game Area
Elevation meters
High : 381
Low : 173
Miles

Salt

Michigan has a complex geological history. Around 420 to 400 million years ago, the state was the site of a shallow sea surrounded by extensive reefs (Figure 6). These ancient reefs comprise the Niagara Escarpment, a limestone formation that extends from northern Wisconsin to western New York. The reef surrounded and restricted water flow into and out of the shallow sea which led to a specific rate of evaporation and the deposition of extensive evaporites. These oceanic evaporites occur as deposits of salt and gypsum throughout the region and in some places, salt deposits are up to 500 ft thick. Salt was concentrated in moraine deposits by glacial actions and salt marshes formed where groundwater or saline aquifers flowed through salt-rich glacial moraine deposits.

Where salt marshes occurred, indigenous peoples hunted game species that were attracted to springs that flowed through salt deposits. Settlers relied on salt to preserve food before refrigeration and salt was so important for the European expansion in Michigan that the state's first geologic surveys of 1837 were tasked with mapping and describing the salt marshes that occurred throughout the state. Douglas Houghton, the state's first geologist, and his assistant, Bela Hubbard, conducted extensive surveys throughout the Grand River watershed, including many areas within the Maple River SGA. The region of Lebanon township in northern Clinton County was originally referred to by indigenous peoples as "Wandaugon," meaning "salt springs" (Ellis 1880).

By the time Houghton's report was submitted to the governor in 1838, all of the documented salt marshes had been excavated or impacted by wells sunk for the extraction of brine (Houghton 1838). Following European expansion, salt has been extensively mined in Michigan and salt extraction has been an important part of the economy since the 1840s. The most recent clear figures of Michigan's salt production are from the 1960s when the state exported 20 to 25% of our nation's salt at an annual value of $42 million (Eschman and Dorr 1970).

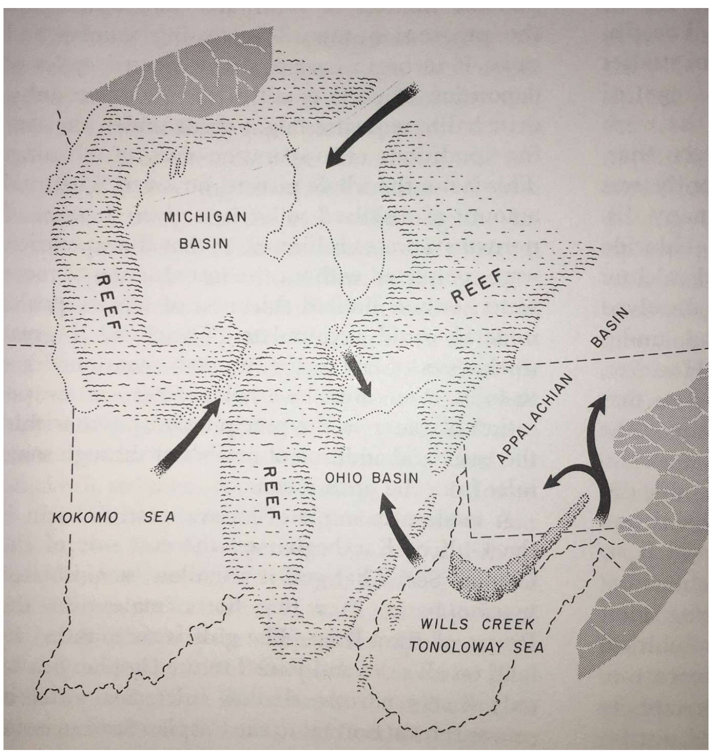
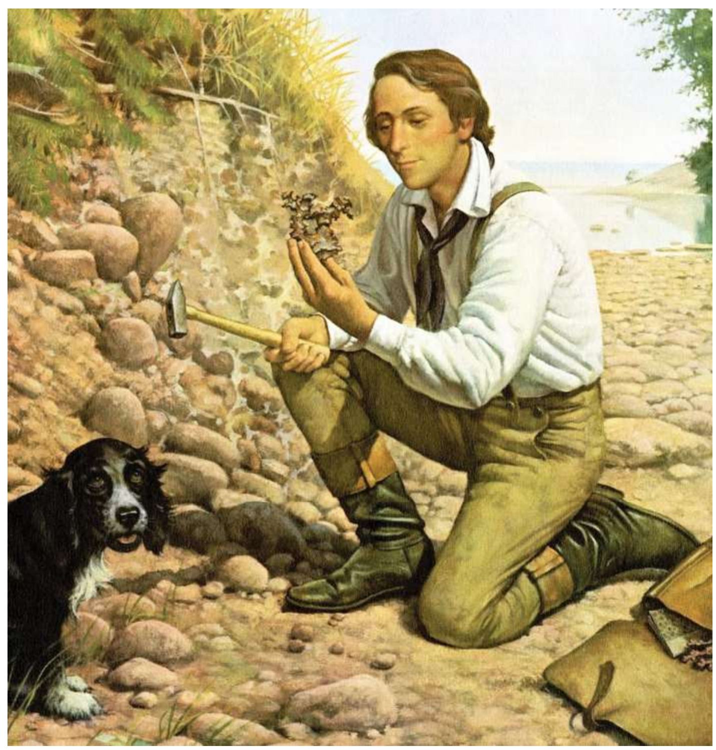


Figure 6. Paleogeography of Michigan and adjacent regions during the Late Silurian, when extensive evaporites were deposited. Reefs isolated the Michigan Evaporite Basin from the open sea, restricting the inflow of normal sea water (Alling and Briggs 1961).



Douglas Houghton was Michigan's first state geologist and responsible for identifying salt deposits in the state. He surveyed the Maple River area with Bela Hubbard in 1837. From A History of Michigan in Paintings by Robert A. Thom.

An inland salt marsh (Hubbard’s Salt Lick, EO ID 7963) with game trails converging on the seep where mineral-rich water is maintaining open conditions. Photo by Jesse M. Lincoln.

Vegetation Circa 1800

Interpretations of the General Land Office (GLO) surveyor notes by MNFI ecologists indicated that the Maple River SGA and surrounding area contained several distinct vegetation assemblages (Comer et al. 1995; Figure 7). The GLO surveys occurred in this area during July 1831 and surveyors recorded information on tree species composition, tree size, and general condition of the lands within and surrounding Maple River SGA. The game area was predominantly forested in 1831, with an estimated 94% of the game area supporting forested ecosystems. The predominant cover types included Mixed Hardwood Swamp (46%), Beech-Sugar Maple Forest (35%), and Oak-Hickory Forest (11%).

Historically, wetlands were a prominent feature within the game area, most notably within the Maple River outwash channel where original surveyors described "low drowned bottoms", "wet bottoms", and "swampy bottoms". Additional wetlands occurred sporadically throughout the game area, particularly in the Beech-Maple Forests adjacent to the floodplain where scours from the draining proglacial lake and outwash events led to numerous vernal pools. Mixed Hardwood Swamp was the most abundant cover type and corresponds to the forested wetlands or floodplain forest along the river. Where the surveyors noted canopy composition of these floodplain forests, silver maple (*Acer saccharinum*; 31%), American elm (*Ulmus americana*; 19%), green ash (*Fraxinus pennsylvanica*; 17%), and black ash (*F. nigra*; 14%) were prevalent canopy dominants with conifers locally present at the interface of the outwash channel and adjacent uplands. Within these floodplain forests, recorded diameters of canopy trees ranged from 10 to 92 cm (4-36 in) with an average of 45 cm (14 in; n = 72).

Upland forests occurred on the slopes along the Maple River outwash channel and on the surrounding till plain. White oak (*Quercus alba*; 29%) was the most prevalent tree species recorded by GLO surveyors in this area. Other common species frequently mentioned included sugar maple (*Acer saccharum*; 18%), beech (*Fagus grandifolia*; 14%), hickory (*Carya* spp.; 5%), white ash (*Fraxinus americana*; 5%), and American elm (5%). Within the areas classified as upland forest, recorded diameters of trees ranged widely from 15 to 92 cm (6-36 in) with an average of 45 cm (17 in; n = 63). Butternut (*Juglans cinerea*) was also described occasionally in the notes though sizes were not recorded.

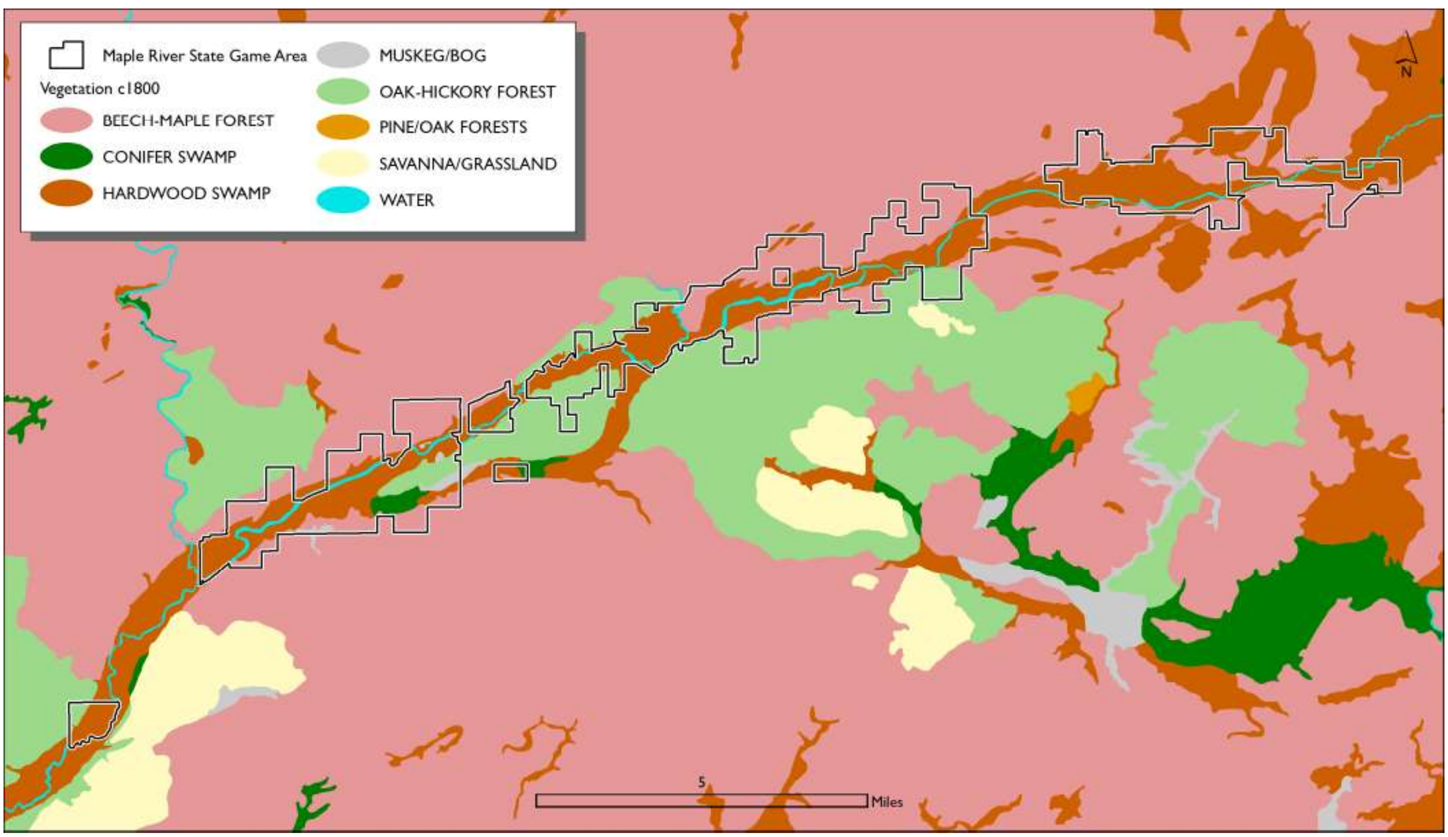


Figure 7. Vegetation of Maple River State Game Area circa 1800 (Comer et al. 1995).

Following the GLO surveys of 1831, Hubbard and Houghton's surveys of 1837 targeted salt marshes throughout the region and provided descriptions of the vegetation and the context within the extensive forested landscape. In addition to the salt marsh descriptions, they also mentioned extensive "oak openings" in the eastern portion of the game area. The preceding GLO surveys were a coarse scale assessment and small expressions of natural communities such as openings were not captured in the GLO notes and therefore not included in the vegetation circa 1800 maps.

The region was occupied by indigenous peoples and fire was often used to manage much of the local region, particularly south of the Maple River SGA in Clinton County (Houghton and Hubbard 1837, Ellis 1880). Therefore, we have concluded that some of the areas mapped as oak forest, particularly in the eastern end of the game area, may have been historically impacted by frequent fire and may have supported open-canopied, oak-dominated savanna systems, such as oak openings.

Forested uplands surrounding the Maple River were characterized by beech-maple forest. Black Maple Forest, pictured above, is one of several areas that most closely resemble descriptions of historic conditions. Photo by Jesse M. Lincoln.

Indigenous Occupancy
Archeological evidence and notes from the GLO surveys indicate a long history of a substantial presence of indigenous cultures in the area: indigenous peoples hunted the game that was attracted to the salt marshes throughout the region; they cultivated extensive agricultural fields along the river; they maintained the prairies and oak openings in the region with fire; they developed “fine sugar maple orchards” in the uplands; they operated “extensive sugar camps” where sap was collected and boiled down into a hard form for storage and trade; and they created “more burial mounds than anywhere else in the state except for Newaygo County” (GLO notes, Houghton and Hubbard 1837, Ellis 1880, Hinsdale 1931, Jessica Yann personal communication 2020).

The earthworks, or burial mounds and gardens, are generally attributed to the Hopewell nation, a sophisticated tribe known to have occupied the region between 600 B.C. and 600-1000 A.D. After the decline of the Hopewell in the region, the Sauk, or Sac and Fox Nation, migrated to the region from central Ohio. Based on oral history, Odawa and Ojibwe peoples of the Anishinaabe Nation usurped the Sauk during intense territorial disputes that resulted in the extirpation of the Sauk from Michigan and a temporary vacancy of central Michigan until just prior to European contact (Ellis 1880, Holt 1932).

The Anishinaabe Nation occupied the upper Great Lakes region and the Odawa and Ojibwe controlled parts of central Michigan at the time of first contact with Europeans. The region surrounding Maple River was well populated and connected to a network of villages (Figure 8). A prominent trail ran from Muir along the south side of the Maple River through a village at the site of Pewamo then to a village which was situated on “the island” just east of Tallman Rd on the south side of the river. The trail also connected to another village known as Maketoquet’s, east of present-day Maple Rapids, before continuing to Saginaw (Hinsdale 1931). However, by the mid-1830s, Anishinaabe band populations were declining as a result of disease from European contact, pressure from European fur trappers, and protracted conflicts with the French, British, United States, and Iroquois (Ellis 1880, Hubbard 1887).

Notes from the 1831 GLO surveys were transcribed onto topographic maps by MNFI ecologists to create the Vegetation of Michigan Circa 1800 Map (Comer et al. 1995). Particularly interesting was the mention of “Fine SM (sugar maple) Orchards”.

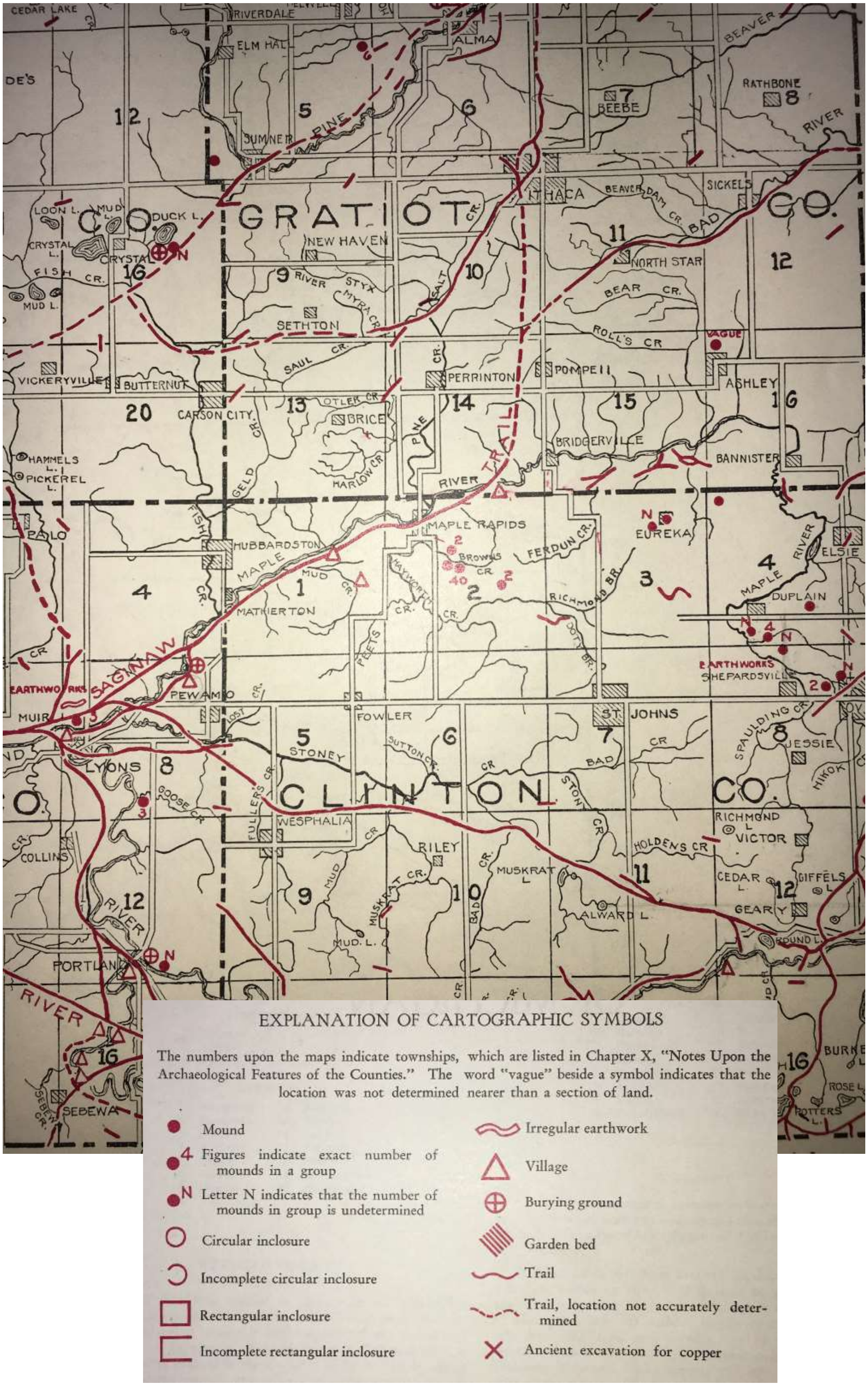


Figure 8. The Archeological Atlas of Michigan indicates numerous trails, villages, and burial mounds in the region encompasing the Maple River State Game Area (Hinsdale 1931).

Changes in Land Cover

The landcover within Maple River SGA (Figures 9 and 10) has changed significantly since the early 1800s due to hydrologic alteration, logging, agriculture, tree disease, non-native insect outbreak, and fire suppression. Currently, forested wetland is the most predominant land cover type in Maple River SGA (37% of the game area; 3,719 ac). Agriculture, non-forested wetlands, and upland forest are the next three most common cover types at 19% (1,915 ac), 18% (1,795 ac) and 18% (1,791), respectively. This is a dramatic shift in composition over the past 200 years as the historic composition was 48% (4,843 ac) forested wetland and only 1% (93 ac) non-forested wetland, though the vegetation circa 1800 map tends to underestimate small-scale open wetlands.

Hydrologic alterations, primarily for agriculture, have driven the conversion of forested wetland to non-forested wetland and agriculture, especially upstream of Maple Rapids. The Maple River was dammed in 1835 at the site of Maple Rapids. Above the dam, the river was dredged and straightened for a small, side-wheel steamboat, named "May Queen", that ran from Maple Rapids to near present-day US-127. The dam was removed in 1903 and the area of the drawdown was then used for agriculture (Ellis 1880).

The Maple River flooding area along US-127 was ditched and diked in 1933 for agriculture. The areas altered by the dams, ditches, and dikes were historically floodplain forest but are now non-forested wetlands. In 1951, the state purchased the East Unit (Compartment 5), which was subject to frequent flooding and had numerous failing dikes. The dike system was updated in 1959 for the purpose of supporting waterfowl migration and expanding hunting opportunities (Maple River State Game Area Master Plan, MDNR 1977). These managed wetlands tend to be dominated by non-native invasive species, such as narrow-leaved cat-tail and reed canary grass. Additionally, the agricultural operations within the game area are a source of dissolved solids and nutrients into the river (Fishbeck et al. 2010).

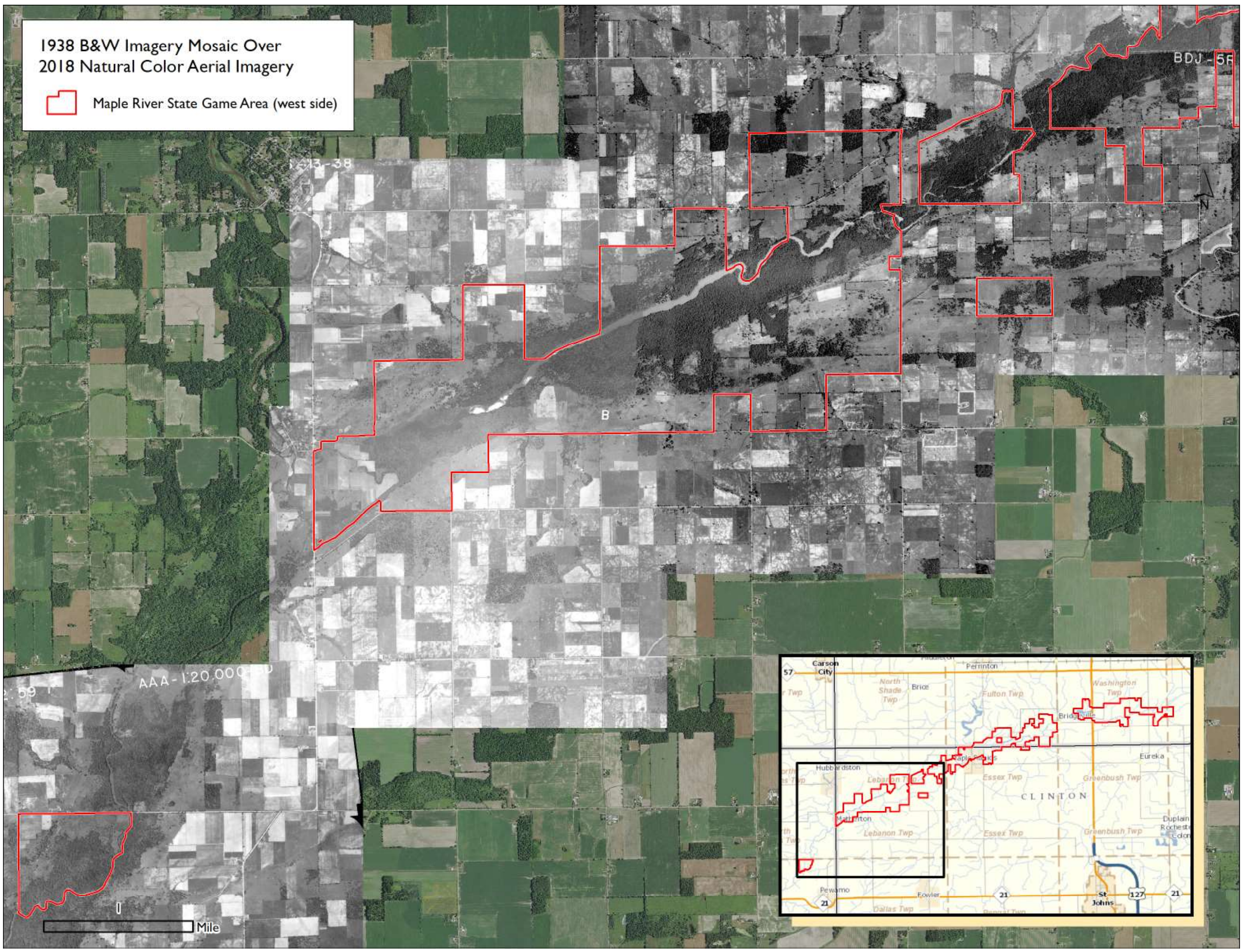


Figure 9. The mosaic of 1938 aerial photographs of the western portion of Maple River State Game Area can inform managers on important conservation targets.

Many areas that were historically forest have been cleared and ditched to support agriculture. The DNR maintains extensive agricultural operations in the East Unit to support game species.

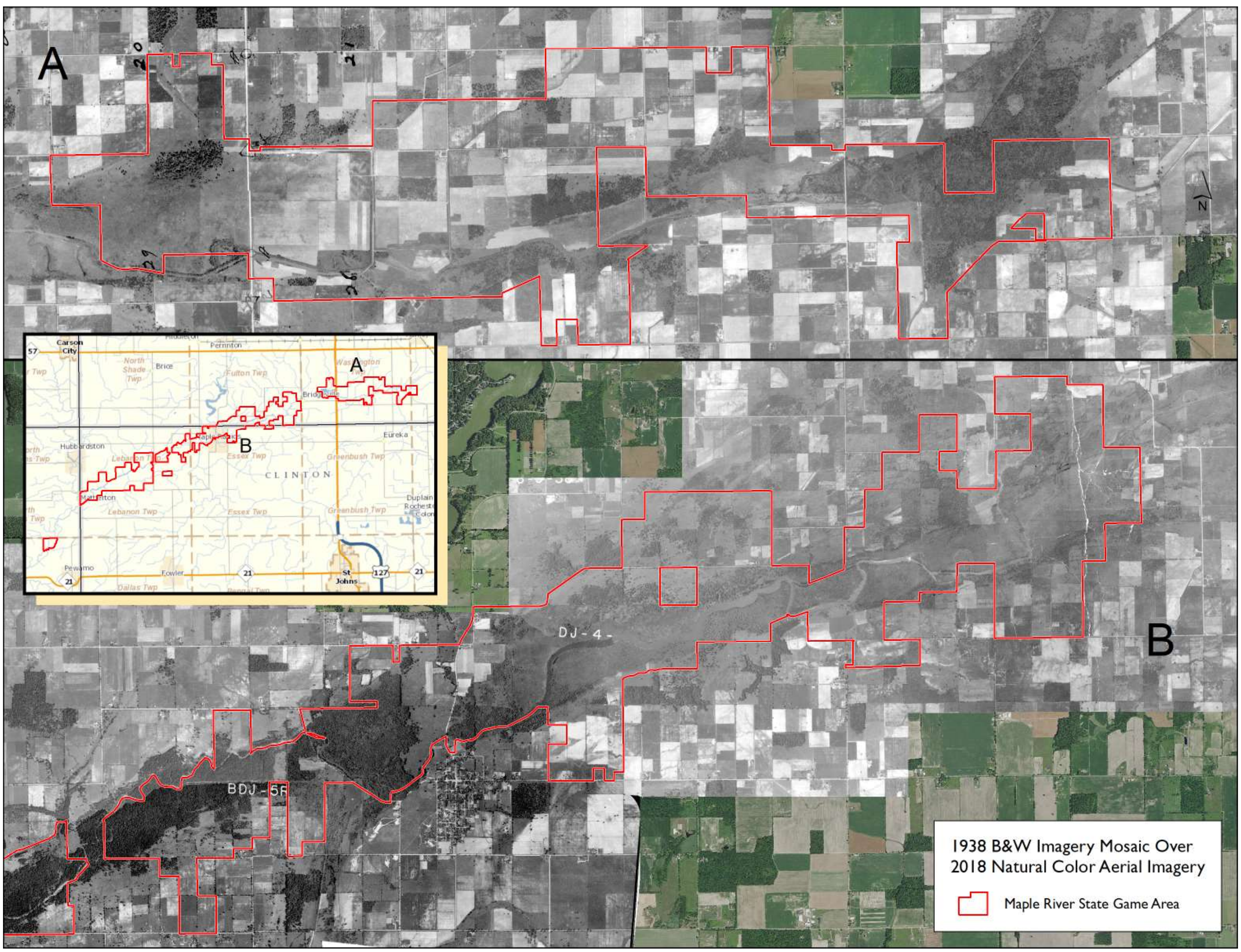


Figure 10. The mosaic of 1938 aerial photographs of the eastern portion of Maple River State Game Area.

The forested wetlands that have not been cleared have also been dramatically altered over past 200 years. The GLO notes documented the canopy of the lowlands along the river as having elm and ash comprising about 50% of the canopy. Though pockets of potentially resistant elm persist throughout the game area, Dutch elm disease has virtually eliminated elm as a dominant overstory tree even though it was historically one of the major dominants in many floodplain forests of Michigan (Barnes and Wagner 2006). In 2002, a new exotic pest, the emerald ash borer (*Agrilus planipennis*), was identified in southeastern Michigan. This Asiatic beetle has killed millions of ash trees and continues to alter the species composition and structure of floodplain forests (USDA Forest Service 2015). Both ash and elm are now generally relegated to the subcanopy of forests. Likewise, butternut was mentioned in the first surveys but has also subsequently been wiped out by a fungal blight. Only one butternut was observed in the game area, a sickly individual in Stand 28 of Compartment 2.

Upland forests have been reduced from 46% of historic cover to 18% of the current cover. Aerial photographs from 1938 (Figure 9, 10, and 11) show how logging, hydrology changes in the floodplain complex, and the expansion of agriculture have contributed to habitat fragmentation and ecological degradation across the landscape. Most of the upland forests in the game area were at one time cleared for agriculture and subsequently reverted to forest after the state took ownership. These forested stands that were cleared for agriculture tend to have the greatest concentrations of invasive species. The imagery from 1938 is particularly useful for the identification of important forest remnants. Areas that were forested in the imagery that have not since been logged have the lowest proportion of invasive species, oldest trees, and the greatest concentration of rare taxa.

Despite the dramatic shifts in composition as a result of anthropogenic disturbance, abundant natural cover remains within Maple River SGA with 18% (1,794 ac) documented as high-quality natural communities, including Michigan's 3rd largest high-quality floodplain forest. In addition, Maple River SGA remains predominantly unfragmented, especially in comparison with the surrounding private land. To gauge landscape integrity, MNFI also developed a land use integrity index that is based on the proportion of land use in a buffer surrounding an area of interest. Stands surrounded by intensive land use (e.g., row crops and residences) receive lower scores and stands surrounded by natural cover (e.g., floodplain forest and rich conifer swamp) receive higher scores. Maple River SGA is characterized by high land use index scores across the game area and especially in comparison with the adjacent private lands (Figure 12).

Emerald ash borer has dramatically altered the structure and composition of the floodplain forest where green ash regularly comprised 50% of the canopy.

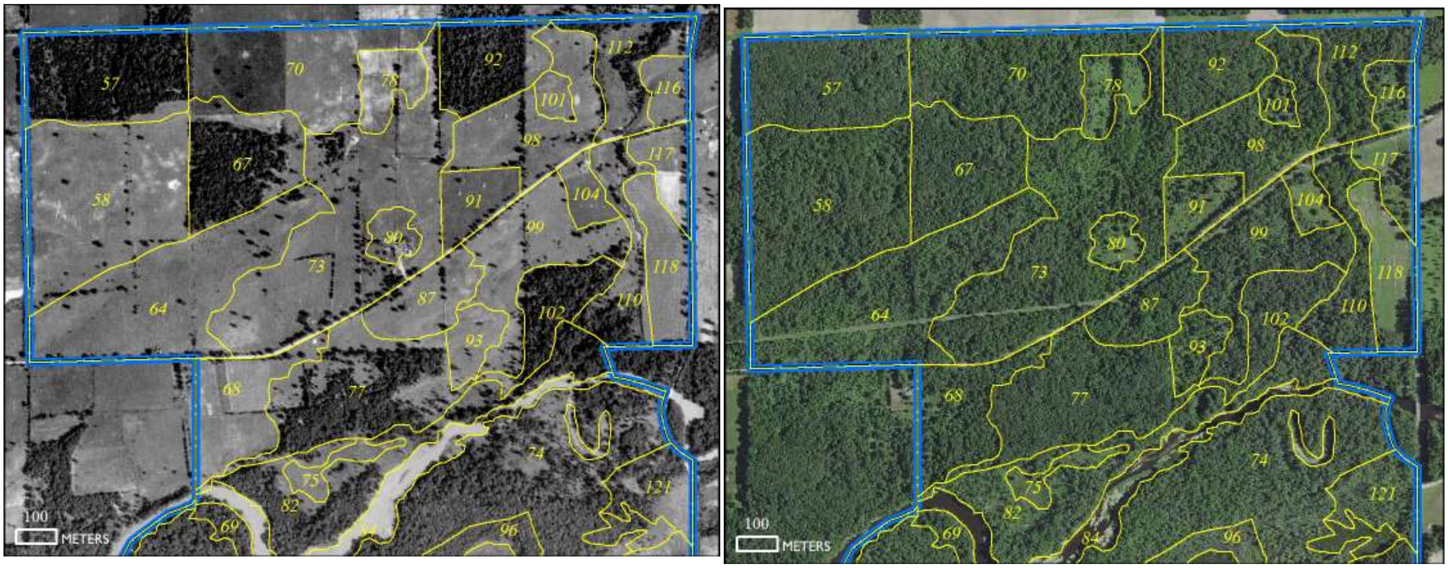


Figure 11. Use of 1938 imagery for identifying areas of high conservation value. Areas that were forested in the 1930s (darker stands on the left) that haven't been logged in the intervening years tend to have fewer invasives, greater native diversity, likely support a greater fungal and soil microbe component, and a higher concentration of migratory birds.

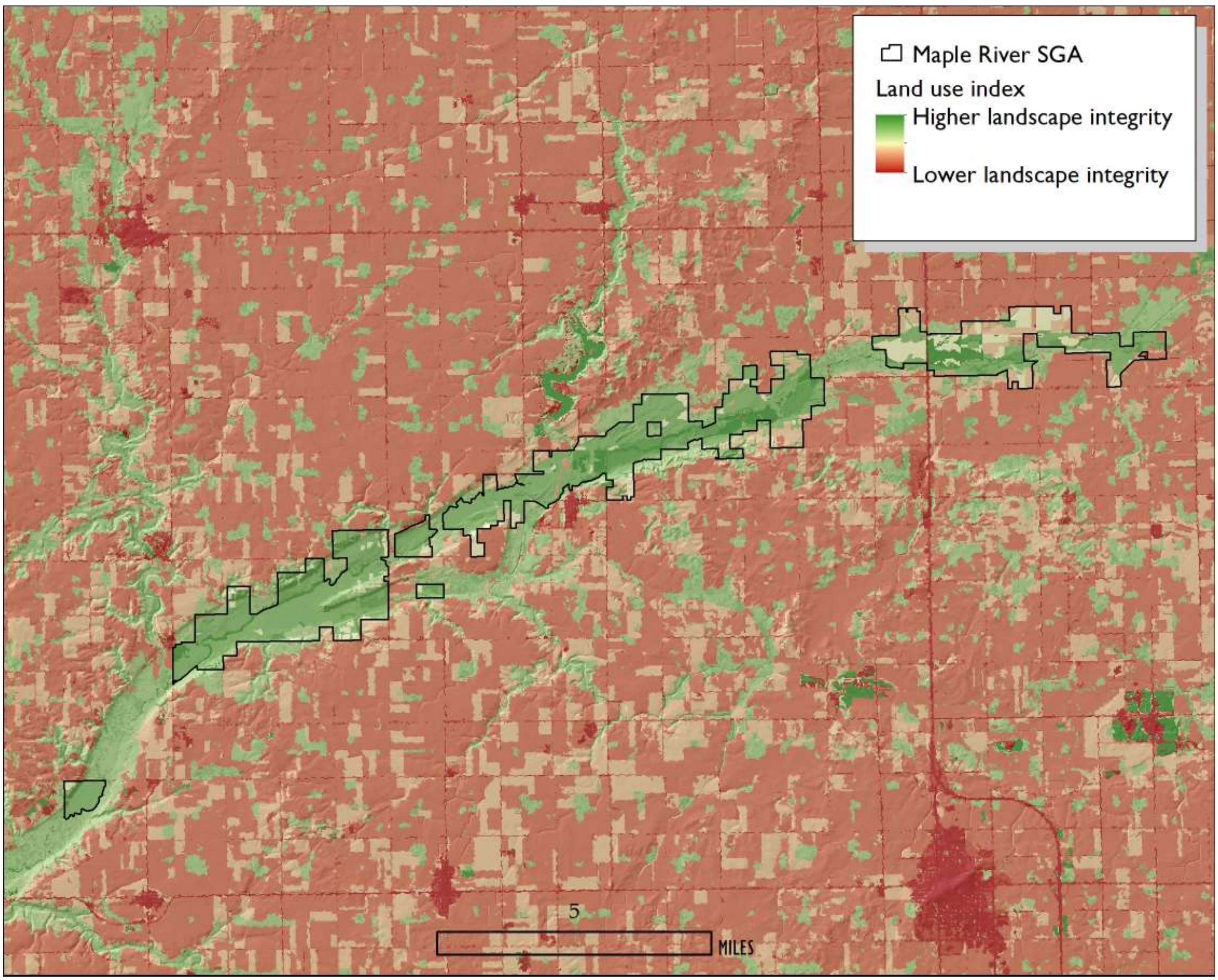


Figure 12. A land use index of Maple River State Game Area. The land use index is based on the proportion of land use in a buffer surrounding an area of interest. Maple River SGA is characterized by high land use index scores across the game area and especially in comparison with the adjacent private lands.

METHODS

Throughout this report, we refer to natural community types and state- and federally-listed rare species as elements and their documented occurrence at a specific location are referred to as an element occurrence or "EO". Ecological and rare species surveys relied on a variety of data resources to determine if potential habitat occurs within the game area, including existing natural community EOs, MiFI cover types, aerial photography, and on-the-ground observations. The documentation of new high-quality natural communities was especially dependent on areas identified during the 2013 MiFI surveys.

We targeted species for rare animal surveys using historical distribution within Michigan, past occurrences in or near Maple River SGA, and the presence of potential habitat. Based on these criteria, rare animal surveys focused on woodland raptors, forest interior songbirds, marsh birds, herptiles, unionid mussels, and insects. Surveys for target animal species were conducted in appropriate potential habitats during time periods when targeted elements were expected to be most active and detectable (e.g., breeding season). Surveys were done to identify new occurrences, update or expand existing occurrences, and revisit historical occurrences of select rare species. Michigan's Wildlife Action Plan (Derosier et al. 2015) identifies species of greatest conservation need (SGCN) and observations of these species were recorded when encountered.

Natural Community Surveys

A natural community is an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape and is predominantly structured by natural processes rather than modern anthropogenic disturbances, such as timber harvest, alterations to hydrology, and fire suppression. Historically, indigenous peoples were an integral part of Michigan's natural communities with many natural community types being maintained by native management practices such as prescribed fire. MNFI's natural community classification recognizes 77 natural community types in Michigan (Kost et al. 2007, Cohen et al. 2015). Protecting and managing representative natural communities is critical to biodiversity conservation because native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over millennia. We evaluated the natural community EOs with Natural Heritage and MNFI methodology, which considers three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008, 2015).

If a site meets defined requirements for these three criteria (MNFI 1988), it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an EO, and given a rank of A to D based on how well it meets the above criteria. MNFI scientists utilized a combination of field surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis to assess natural community size and landscape context.

We conducted qualitative meander surveys of natural communities and detailed the vegetative structure and composition, ecological boundaries, and landscape and abiotic context of exemplary natural communities. We also assessed the current ranking, classification, and delineation of these occurrences. We conducted ecological field surveys of Maple River SGA over the growing season of 2017 with concentrated follow-up surveys occurring in 2019. Vegetative structure and composition, soils, landscape and abiotic context, threats, management needs, and restoration opportunities were all assessed. This information is critical for informing landscape-level planning efforts, facilitating site-level decisions about prioritizing management objectives to conserve native biodiversity, and evaluating the success of restoration actions.

Methods employed during this survey followed the methodology developed during the initial evaluation of Ecological Reference Areas on State Forest land in 2006 and 2007 by MNFI ecologists (Cohen et al. 2008; Cohen et al. 2009).

The ecological field surveys involved:

- compiling comprehensive plant species lists, noting dominant and representative species, and documenting rare species when opportunistically discovered
- describing site-specific structural attributes and ecological processes
- measuring tree diameter at breast height (DBH) of representative canopy trees and aging canopy dominants
- analyzing soils and hydrology
- noting anthropogenic disturbances
- evaluating potential threats to ecological integrity
- ground-truthing aerial photographic interpretation using GPS
- taking digital photos and GPS points at significant locations
- surveying adjacent lands when possible to assess landscape context
- evaluating the natural community classification and mapped ecological boundaries
- assigning or updating element occurrence ranks
- noting management needs and restoration opportunities or evaluating past and current restoration activities and noting additional management needs and restoration opportunities

Following completion of the field surveys, the collected data were analyzed and transcribed to update or create new EO records in MNFI's statewide biodiversity conservation database (MNFI 2020). Natural community boundaries were established or revised and information from these surveys was used to develop site descriptions, threat assessments, and management recommendations.

Floristic data were compiled into the Universal Floristic Quality Assessment Calculator (Reznicek et al. 2014, Freyman et al. 2016) to determine the Floristic Quality Index (FQI) for each natural community EO. The floristic quality assessment is derived from a mean coefficient of conservatism and floristic quality index. Each native species is assigned a value of 0 to 10 based on probability of its occurrence in a natural versus degraded habitat. Species restricted to a specialized or undisturbed habitat are assigned a value of 10, implying the species has extremely strong fidelity to a specific habitat. Native species that are not particular or indicative of natural conditions are assigned a low value of 1. From the total list of plants for an area, a mean C value is calculated and then multiplied by the square root of the total number of plants to calculate the FQI. Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness that they are considered floristically important from a statewide perspective (Herman et al. 2001). Species lists for each site are provided in the Appendix. Rare plants were opportunistically documented during MiFI vegetation surveys or natural community evaluations, included within these comprehensive plant lists, and added or incorporated as element occurrence records.

Bird Surveys

Given the presence of mature forest and observations made during MiFI, we focused bird surveys in the game area on rare songbirds and raptors. Rare raptor surveys focused on red-shouldered hawk (*Buteo lineatus*, state threatened), a DNR featured species. Contiguous forest stands at least 4 ha (10 ac) in area were considered potential habitat for target species. We generated a 250 m x 250 m grid of possible survey points that was overlaid over the potential survey stands. Those points falling within the potential survey stands were used for conducting raptor and songbird surveys.

Because of the high number of potential survey points identified for the game area in 2019, we prioritized the potential survey points based on stand type, age, and density. We did not survey points falling within pine plantations, young aspen stands, or farmstead forests. Points were assigned unique identification numbers and uploaded to a tablet computer for field location. In addition to surveying for rare raptors and songbirds, point-count sampling was used to gather baseline information about the forest bird community, including relative abundance and species richness.

We conducted two-minute raptor surveys at systematically located point count stations (Figure 13; Mosher et al. 1990, Anderson 2007, Bruggeman et al. 2011). Each two-minute point count consisted of one-minute broadcasts of red-shouldered hawk calls and one minute of silent listening. Surveys were conducted between March 3 and March 27, 2019. At each station the following data were recorded: whether a red-shouldered hawk was detected; all other raptor sightings or vocalizations; other bird observations; and other rare animal species detections or

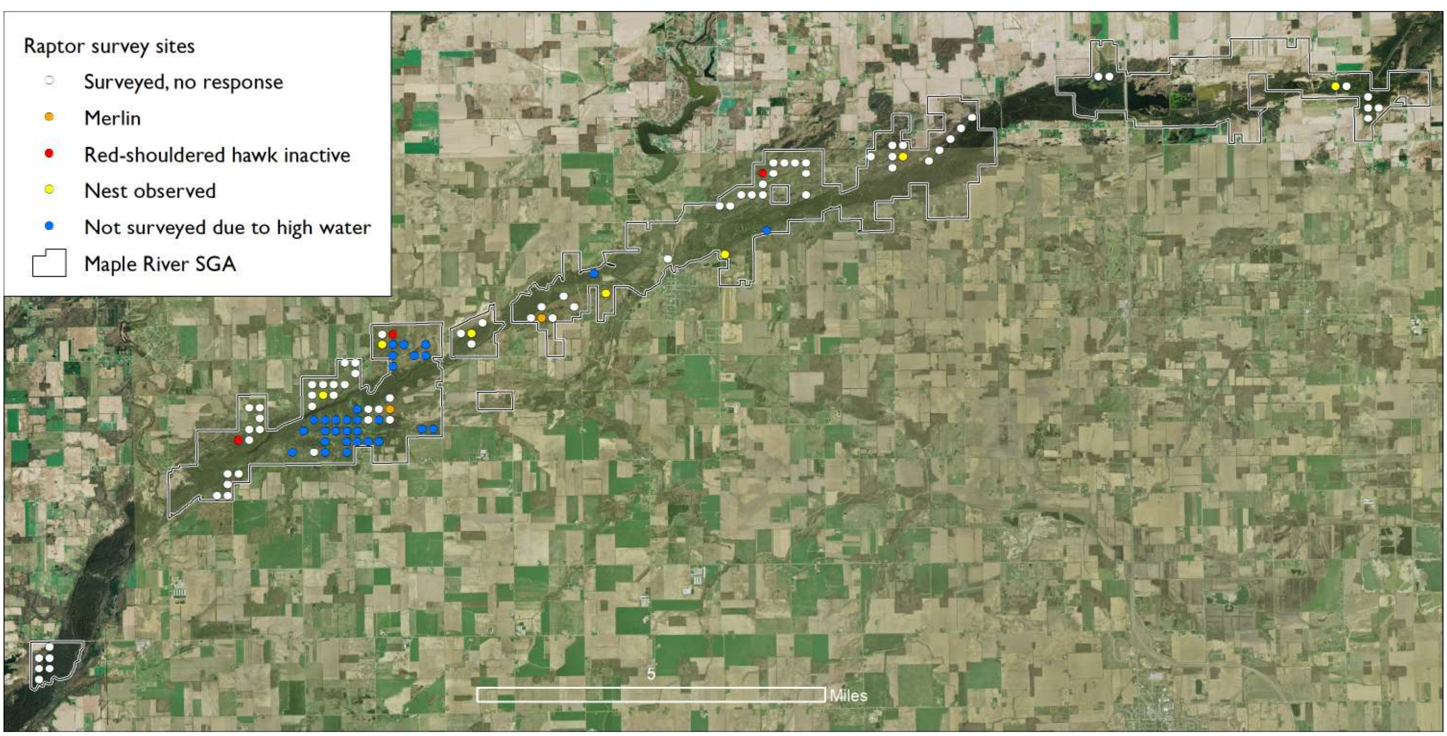


Figure 13. Location of raptor surveys in Maple River State Game Area.

potential habitats. If a rare raptor was observed, the vicinity surrounding the point was searched for potential nests. While walking and driving between station locations, we also visually inspected trees for stick nests.

We targeted prothonotary warbler (*Protonotaria citrea,* state special concern), cerulean warbler (*Setophaga cerulea*, state threatened), hooded warbler (*Setophaga citrina*, state special concern), and Louisiana waterthrush (*Parkesia motacilla*, state threatened) during songbird surveys. Cerulean warbler and prothonotary had been detected in the game area previously and potential habitat for hooded warbler and Louisiana waterthrush was also present. Forest bird point counts were conducted at the same systematically located points used for raptor surveys (Figure 14). Ralph et al. (1995) noted that it is usually more desirable to increase the number of independent point-count stations than to conduct repeated surveys at a smaller number of locations, so we visited each point only once. Surveys were conducted from June 1 to July 10, 2019 from sunrise to 6 hours after sunrise, or until weather condition made it unlikely to detect birds. In addition to documenting observations of the targeted rare species, we collected data on all birds seen or heard during each 10-minute point count. We recorded the species and number of individuals observed during three independent periods (2 minutes, 3 minutes, and 5 minutes) for a total of 10 minutes at each station (Ralph et al. 1995). Use of the three survey periods provides flexibility in making comparisons with other surveys (e.g., North American Breeding Bird Surveys) which adhere to these survey protocols.

Each bird observation was assigned to one of four distance categories (0-25 m, 25-50 m, 50-100 m, and >100 m) based on the estimated distance of the bird from the observer to facilitate future distance analyses and refinement of density and population estimates. At each point-count station, we noted if the site appeared suitable for prothonotary warbler, cerulean warbler, hooded warbler, and Louisiana waterthrush.

Because several impounded wetlands in the game area are managed for wetland birds, we conducted surveys for marsh birds in large areas of emergent wetland. Target species consisted of all species surveyed under the Michigan Marsh Bird Survey (MMBS) protocol (Michigan Bird Conservation Initiative [MiBCI] 2015). Surveys were completed using the Standardized North American Marsh Bird Monitoring Protocol described by Conway (2011) and further refined for Michigan (MiBCI 2015). We surveyed 13 points placed at least 400 m apart within Units A, B, and D. Point count stations were uploaded to a tablet computer used for navigation in the field. Each point was surveyed once during 3-4 June 2019 between 0.5 hour before to three hours after sunrise. We conducted 10-min point counts consisting of a five-min passive listening period followed by one-min broadcast periods for American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), and sora (*Porzana carolina*). The locations of rare species were recorded using GPS or estimated distances and azimuths from point count stations.

In addition to targeting rare forest interior songbirds, MNFI avian surveys also documented numerous common bird species, such as this great-crested flycatcher (*Myiarchus crinitus*). Photo by Aaron P. Kortenhoven.

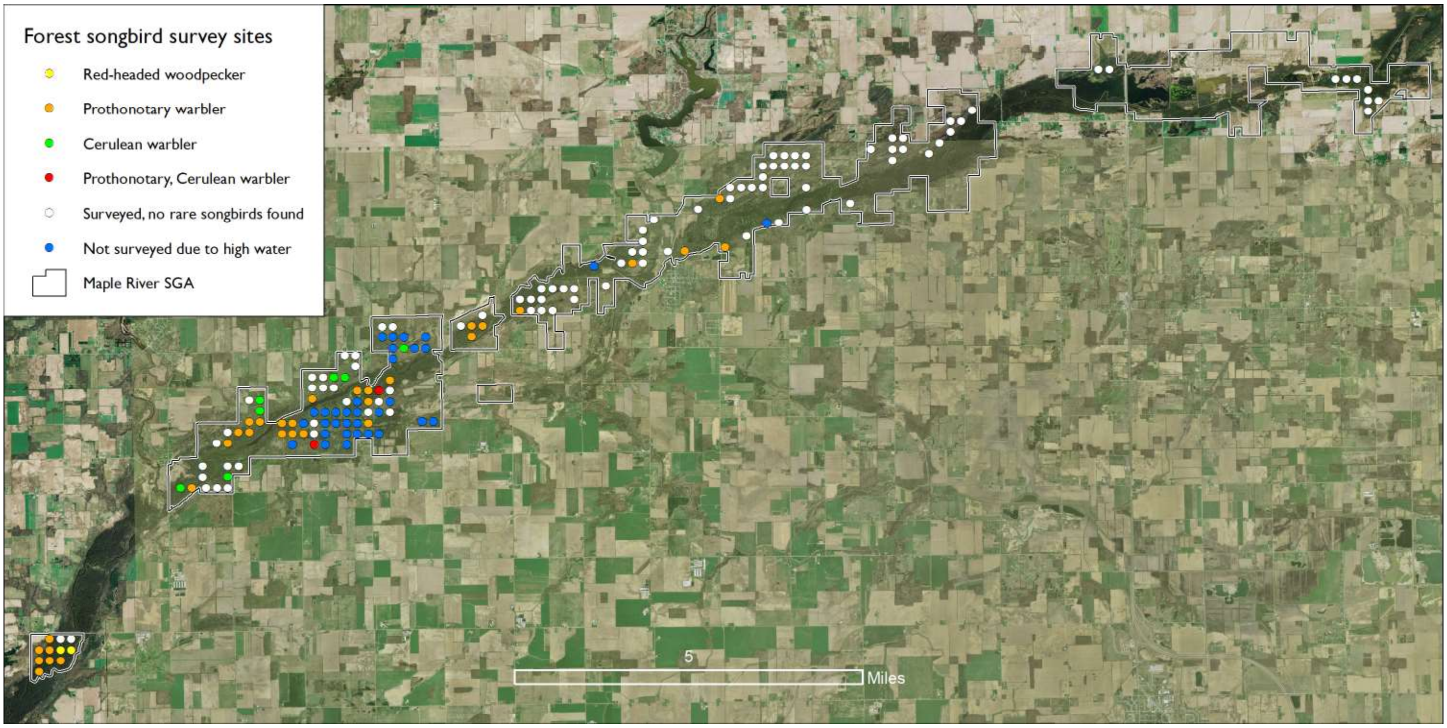


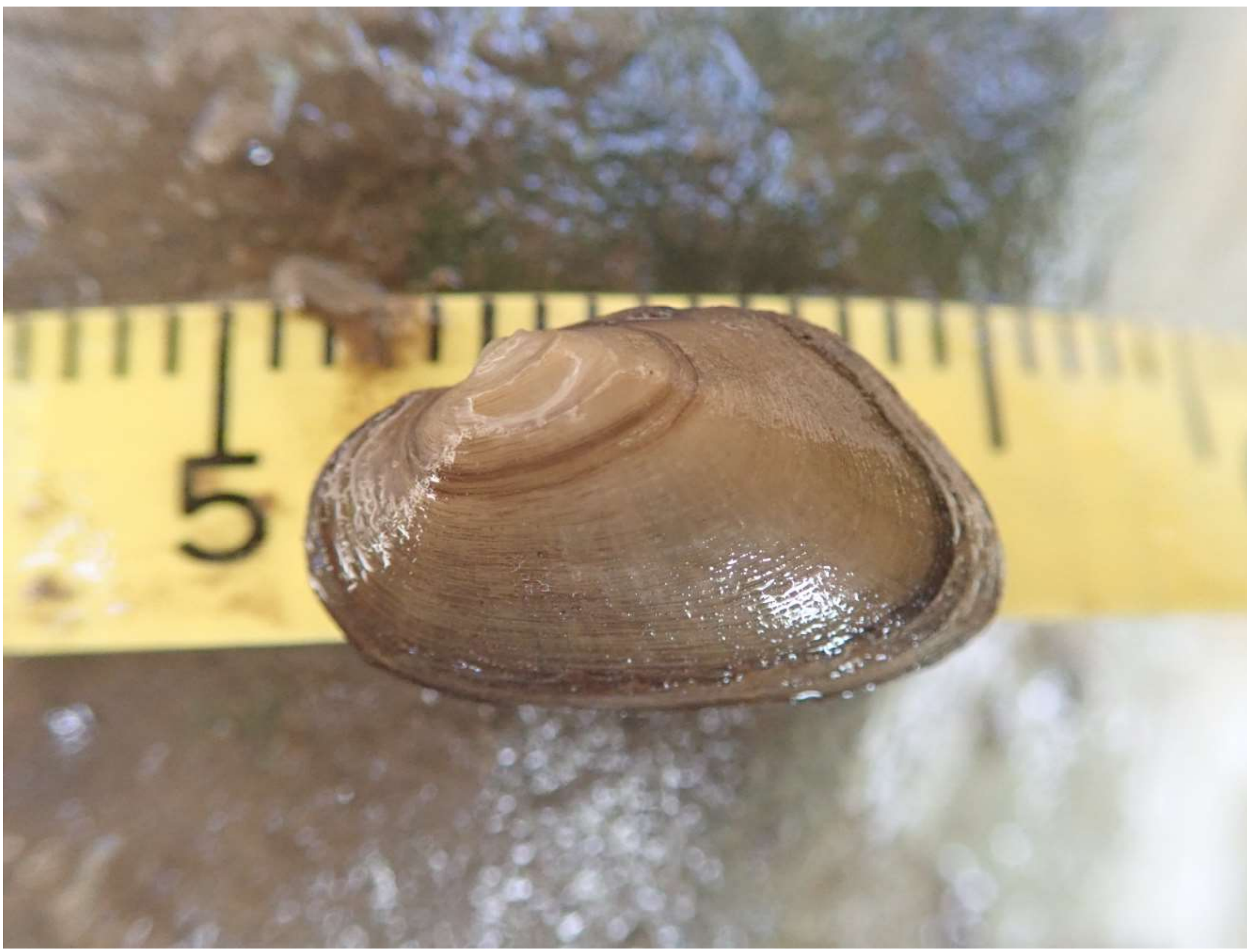
Figure 14. Location of songbird survey sites in Maple River State Game Area.

Several marsh wrens (*Cistothorus palustris*, special concern) were documented in the East Unit of Maple River State Game Area in 2019. Photo by Aaron P. Kortenhoven.

Mussel Surveys

Mussel surveys took place in wadable habitats (less than approximately 70 cm deep; Table 1, Figure 15). In areas where water depth was too great to wade, the riverbanks were scanned visually from a boat for mussel shell middens created by muskrats or other mammalian predators. Distinct shell middens were spotted at two sites. Shells found in middens were identified to species, counted, and returned to where they were found. The search area at wadeable sites was measured to standardize sampling effort among sites and allow unionid mussel density estimates to be made. When possible, the search area extended from bank to bank to include the widest range of microhabitats. Live unionids and shells were located with a combination of visual and tactile means. Glass bottom buckets were used to facilitate visual detection. Tactile searches through the substrate were made to help ensure that buried individuals were being detected, including smaller sized unionid mussels. Live individuals were identified to species and placed back into the substrate anterior end down (siphon end up) in the immediate vicinity of where they were found. Shells were also identified to species. The number of live individuals was determined for each unionid mussel species at each site. Latitude and longitude of each survey site was recorded with handheld Garmin GPS units.

Habitat data were recorded to describe and document stream conditions at the time of the surveys. Substrate within each search area was characterized by estimating percent composition of each of the following six particle size classes (diameter): boulder (>256 mm); cobble (256-64 mm); pebble (64-16 mm); gravel (16-2 mm); sand (2-0.0625 mm); and silt/clay (<0.0625 mm) (Hynes 1970; Appendix 1). Woody debris, aquatic vegetation, exposed solid clay substrate, and eroded banks were noted when observed. The percentage of the search area with pool, riffle, and run habitat, and a rough characterization of current speed were estimated visually (Appendix 3). Conductivity and pH of river water was recorded with an Oakton handheld meter. At selected sites, alkalinity and hardness were measured with LaMotte kits (models 4491-DR-01 and 4824-DR-LT-01; Appendix 2).



Slippershell (*Alasmidonta viridis*), a state threatened mussel found in Hayworth Creek at aquatic survey site 8. Mussels were identified, measured, and photographed during surveys. Photo by Peter J. Badra.

Table 1. Locations of mussel survey sites within Maple River State Game Area, summer 2019.

Site	Waterbody	Access	Latitude (N)	Longitude (W)
1	Halterman Creek	Wilson Rd.	43.13398	-84.49697
2	Collier Creek	Ranger Rd.	43.15322	-84.57167
3	Maple River	DNR boat ramp, W. French Rd.	43.06264	-84.82809
4	Maple River	Boat upstream from DNR boat ramp, W. French Rd.	43.06483	-84.82427
5	Maple River	Boat upstream from DNR boat ramp, W. French Rd.	43.08420	-84.78041
6	Maple River	Boat upstream from DNR boat ramp, W. French Rd.	43.08700	-84.76850
7	Maple River	Boat upstream from DNR boat ramp, W. French Rd.	43.08680	-84.77504
8	Hayworth Creek	Hike N. from corner of W. Hyde Rd./N. Bauer Rd.	43.10498	-84.71494
A	Maple River	W. Maple Rapids Rd.	43.10724	-84.71079
B	Maple River	N. Tallman Rd.	43.08914	-84.75978

Figure 15. Location of mussel survey sites in Maple River State Game Area, summer 2019.

The Maple River at mussel survey Site 7. Photo by Peter J. Badra.

Reptile and Amphibian Surveys

Surveys for rare amphibian and reptile species (i.e., herptiles or herps) in the Maple River SGA focused primarily on the following species: Blanding's turtle (*Emydoidea blandingii*, state special concern), wood turtle (*Glyptemys insculpta*, state special concern), spotted turtle (*Clemmys guttata*, state threatened), eastern box turtle (*Terrapene carolina carolina*, state special concern), pickerel frog (*Lithobates palustris*, state special concern), queen snake (*Regina septemvittata*, state special concern), Butler's gartersnake (*Thamnophis butleri*, state special concern), smooth green snake (*Opheodrys vernalis*, state special concern), and gray ratsnake (*Pantherophis spiloides*, state special concern) (Appendix 11). These species also have been identified as SGCN in Michigan's updated Wildlife Action Plan (Derosier et al. 2015). These species were targeted for surveys because they had been previously documented in or near the game area, or they had potential to occur within the game area because of the species' range within the state and presence of potential habitat. Surveys in 2019 also had potential for detecting several additional amphibian and reptile species and/or SGCN. These included the Blanchard's cricket frog (*Acris blanchardi*, state threatened), blue racer (*Coluber constrictor foxii*), northern ribbonsnake (*Thamnophis sauritus septentrionalis*), northern ring-necked snake (*Diadophis punctatus edwardsii*), and eastern musk turtle (*Sternotherus odoratus*) (Derosier et al. 2015, Appendix 11).

Visual encounter, basking, and aquatic funnel trapping surveys were conducted in areas with suitable or potential habitat for the target herp species (Figure 16). Surveys were conducted from May 13 through September 30, 2019 (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Graeter et al. 2013). Visual encounter surveys were conducted within and/or along the edge of open wetlands and waterbodies, vernal pools, adjacent open uplands (including dikes), and upland and lowland forest stands. Surveys consisted of one or two surveyors walking slowly through areas with suitable habitat for target species, overturning cover objects (e.g., logs/woody debris, rocks, etc.), inspecting retreats, and looking for basking, resting, and/or active individuals on the surface or under cover objects (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Glaudus 2013).

An aquatic funnel trap was setup near the floodplain forest off of Tallman Road. Photo by Yu Man Lee.

Basking surveys consisted of one or two surveyors walking slowly along the Maple River, emergent marshes, vernal pools, and other areas with open water and scanning the habitat with binoculars to look for reptiles and amphibians basking on logs, vegetation, and other structures in the water and along the shoreline (Buhlmann 2013).

Aquatic funnel trapping was conducted along the edge of several emergent and shrubby wetlands and open water areas (e.g., ditches, river backwater areas) in the East Unit and along Tallman Rd. In the East Unit, ten traps consisting of five sets of Promar minnow traps and hoop traps (i.e., one minnow trap and one hoop trap per set) were deployed within each of four reference plots for four consecutive nights (based on Willey and Jones 2014 and Northeast Spotted Turtle Working Group 2019) from September 2 – 6, resulting in a total of 160 trap nights. Along Tallman Rd, five Promar minnow traps were deployed within each of two reference plots for three consecutive nights from September 11 – 14 for a total of 30 trap nights. This resulted in a total of 190 trap nights in 2019.

Visual encounter surveys were conducted en route while checking traps. Herptile surveys were conducted under appropriate weather conditions when target species were expected to be active and/or visible (i.e., generally between 60-80 °F (16-27 °C), wind less than 15 mph, no or light precipitation). Survey sites were visited one to five times during the field season.

Hoop traps are effective at trapping several species. An eastern spiny softshell turtle (*Apalone spinifera*). Photo by Kailyn Atkinson.

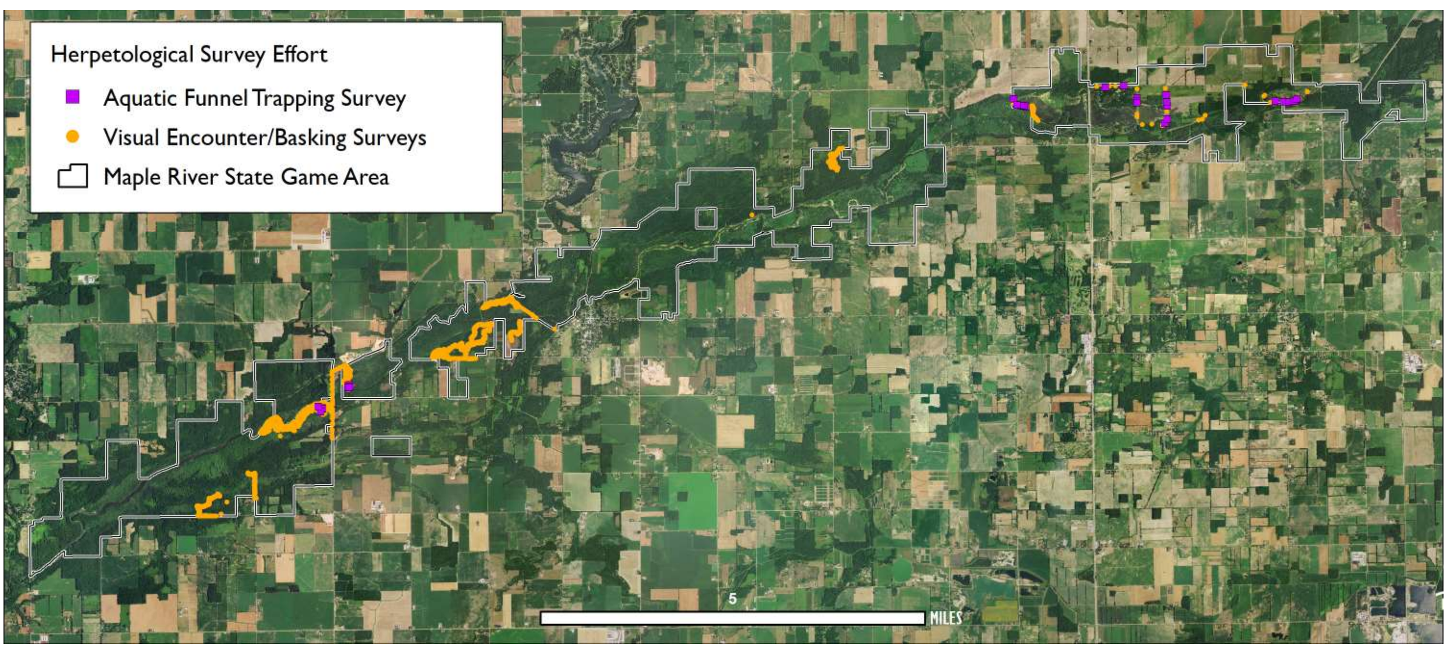


Figure 16. Location of herptile survey sites in Maple River State Game Area, 2019.

Insect Surveys

We conducted surveys for Duke's skipper butterfly (*Euphyes dukesi*, state threatened), angular spittlebug (*Lepyronia angulifera*, state special concern), and regal fern borer moth (*Papaipema speciosissima*, state special concern). We identified target areas for the Duke's skipper during scouting visits in June. The skipper's habitat consists of wet areas where its host plant, wide-leafed sedge (*Carex lacustris*), is abundant (Figure 17; Compartment 2 stands 41, 60, 74, 75 and 82). Diurnal, visual meander surveys were conducted between 9 am and 5 pm during warm, sunny, low-wind conditions in July and August, when adults are flying. Surveys consisted of one or two surveyors slowly walking through areas of suitable habitat, gently disturbing tops of vegetation to flush adults, and looking for butterflies in flight or perched on vegetation.

Angular spittlebug surveys were conducted in inland salt marshes within the Maple River SGA (Figure 17 Compartment 2 - stands 108 and 75). Surveyors conducted sweep-net surveys while slowly walking through areas with spike-rushes (*Eleocharis spp.*), the spittlebug's host plant which are locally abundant in these salt marshes.

Regal fern borer moth surveys occurred at three sites (Figure 17) and involved blacklighting with a standard mercury-vapor and 15-watt UV light powered by a portable generator with a 2 m x 2 m large white sheet over a metal conduit frame as a collecting surface. Moths attracted to the lights were collected directly off the sheet or off the ground near the sheet. Surveys occurred within concentrations of royal fern (*Osmunda regalis*) so that the larval host plants were on all sides of the blacklighting setup to maximize the likelihood of collecting adults. These locations were recorded using a hand-held GPS unit and *Papaipema* moth survey forms were completed for each site.

The first site was in an area of lowland forest vegetation 0.10 miles north of the parking lot off the end of Hinman Road (Figure 17). This site contained a population of between 10 to 15 plants of royal fern. Sampling occurred from 8:00 PM to 12:00 AM on September 9, 2019. Temperatures ranged from 62 to 58 °F. Skies contained between 5 to 100% cloud cover throughout the sampling period.

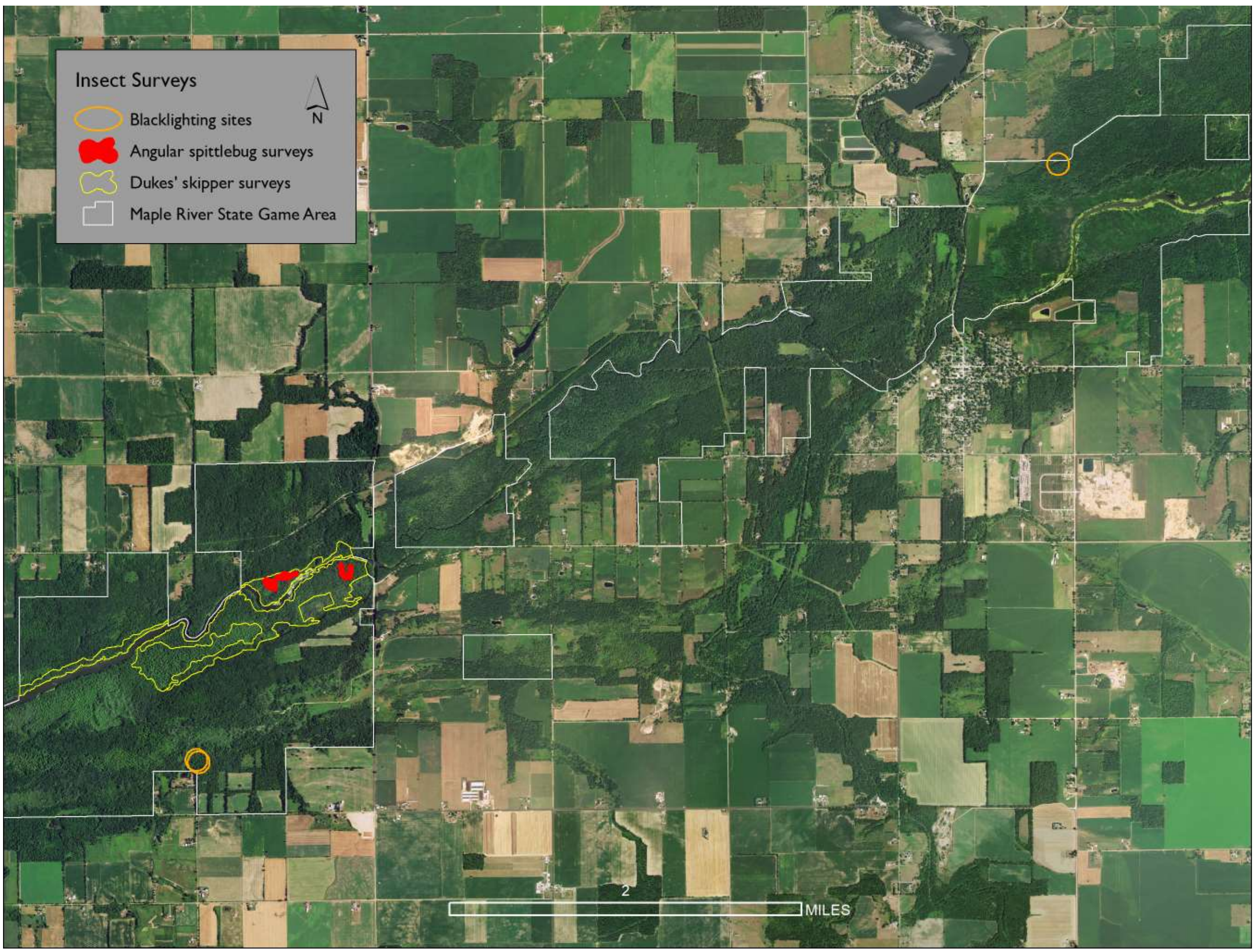


Figure 17. Location of insect survey sites in Maple River State Game Area, 2019.

A second site was again located in lowland forest and sedge meadow habitat 0.11 miles north of the parking lot off the end of Hinman Road. This site contained a population with approximately 10 to 15 royal fern plants. Additional rare *Papaipema* host plants were also discovered here including riverbank wild-rye (*Elymus riparious,* 22 fruiting plants) and tall sunflower (*Helianthus giganteus,*15 flowering/ fruiting plants). A total of four hours of sampling occurred from 8:00 PM to 12:00 AM on September 10, 2019. Temperatures ranged from 78 to 67 °F. Skies were clear with 15 to 25% cloud cover throughout the sampling period.

The third site that was sampled for rare moths was an area of floodplain forest accessed from a parking area off W Maple Road, east of Luce Road. An estimate of between 30 to 50 royal ferns were observed in the immediate area around the blacklighting spot. Heavy rains the previous few days had swollen the Maple River and some lowland flooding had occurred here and inundated some of the royal ferns within the sampling site. This site contained floodplain forest to the south and sampling was again limited to a four-hour window from 7:30 PM to 11:30 PM on September 29, 2019. Temperatures ranged from 70 to 69 °F. Winds were light and cloud cover was at 0% throughout the entire sampling period.

Conducting visual meander surveys for Duke's skipper (*Euphyes dukesi*, state threatened) in a wide-leafed sedge (*Carex lacustris*) opening. Photo by Ashley Cole-Wick.

Blacklighting surveys were conducted for regal fern borer moth (*Papaipema speciosissima*, state special concern). This survey technique involves stretching a sheet across two trees or poles and using an ultraviolet light to attract moths to the sheet. Moths can be collected directly from the sheet. Insects come to light usually in largest numbers on still, dark, cloudy nights when both temperature and humidity are high. Photo by Logan Rowe.

Geographic Weighted Overlay Model

Overview

Over the past two years, MNFI has been using MiFI data as the basis for geographic weighted overlay models to inform the prioritization of management decisions on state lands with models focusing on the prioritization of prescribed fire (Cohen et al. 2018, Cohen et al. 2019a) and invasive species treatment (Cohen et al. 2019b). Geographic weighted overlay models allow users to identify multiple input variables, score and weight those variables based on their importance, and derive an overall score for a place of interest based on the sum of those weighted scores. Through literature review and discussions with colleagues in the DNR, we identified four critical factors for determining a site's priority for biodiversity stewardship: biodiversity, resilience, integrity, and ecosystem services.

A stated bias of our modeling approach is that we believe that places should be prioritized for biodiversity stewardship when they support high biodiversity, are resilient to disturbance, are characterized by high ecosystem integrity, and provide ecosystem services. Since this weighted sums modeling involves the integrated analysis of **B**iodiversity, **R**esilience, **I**ntegrity, and **E**cosystem services, we are referring to it as the **BRIE** analysis. For each of these factors we developed variables to score on a scale of 0 to 5 (with 0 being no priority and 5 being the highest priority). For all stands currently within the MiFI database, these multiple input variables were evaluated, scored, and weighted to generate an overall priority score for each stand (Figure 18).

Crosswalk

A critical step in our modeling process and assigning of input variables to stands was the crosswalk of MiFI stands to natural community types. For each stand we generated an intersection with numerous spatial data layers. We used information gleaned from this intersection as well as stand-level data to assign a natural community type to as many stands as possible. Stand-level information that was useful for determining a crosswalk included canopy closure, stand age, upland/lowland classification, and percent cover by strata. In addition, many stands include an on-site classification to natural community type that is included within the general comments field in MiFI.

Biodiversity

To gauge a stand's biodiversity, we focused on two variables that evaluate a stand's rarity (natural community rarity and rare species occurrence) and one variable that evaluates native species richness. Stands that intersect with natural community element occurrences were scored based on the natural community type's state and global rarity ranks with rarer ecosystems receiving higher priority scores. Rare species occurring within stands resulted in the increase in the biodiversity score.

We developed a natural community richness variable to account for a stand's contribution to native species diversity and diversity of ecological processes. For each natural community type, we assigned a score based on that natural community type's average species richness and diversity of ecosystem processes. Those stands that were crosswalked to a natural community type were assigned that natural community type's natural community species richness score, with higher scores for ecosystems characterized by higher diversity.

Resilience

To evaluate a stand's resilience, we employed two variables, climate resilience and natural community resilience. A stand's resilience to climate change was evaluated using The Nature Conservancy's recent climate resilience model (Anderson et al. 2016). Stands that occur within areas identified by the resilience analysis as being resilient to climate change were given higher priority scores: these areas are characterized by a diversity of landforms and high landscape connectivity. The natural community resilience variable was derived by evaluating each natural community type's resilience to disturbance and resistance to invasive species encroachment. For each natural community type, we assigned a score based on that natural community type's ability to respond to disturbance and resist invasive encroachment. Those stands that were crosswalked to a natural community type were assigned that natural community type's natural community resilience score, with higher scores for ecosystems characterized by greater resilience to disturbance and resistance to invasive infestation.

Integrity

To evaluate a stand's integrity, we developed six variables, four that characterize the landscape surrounding a stand, and two that assess the ecological integrity of the stand. The landscape integrity variables include land use classification adjacent to the stand, the management designation of the stand, the temporal continuity of the stand, and the buffer surrounding a stand. We developed a land use index based on NatureServe's landscape scale ecological integrity metric (Faber-Langendoen et al. 2016). This metric score is based on the proportion of land use in a surrounding 500 meter buffer. Stands surrounded by intensive land use (e.g., urban centers and parking lots) receive lower scores, and stands surrounded by natural cover (e.g., a prairie fen surrounded by an oak-hickory forest) receive higher scores. For the management designation variable, we assigned higher scores for stands that occur within special management designations (e.g., conservation opportunity areas, ecological reference area, and high conservation value areas).

For the temporal continuity variable, we conducted a change analysis of circa 1800 vegetation to current land cover. We identified areas of "unchanged cover" and assigned these areas higher priority scores. For the buffer variable we measured the percentage of buffer adjacent to each stand classified as "natural cover" and assigned higher scores for stands with a higher percentage of natural cover.

Stand level integrity was evaluated by assessing two variables, natural community element occurrence rank and stand age. For stands that intersect with natural community element occurrences in the MNFI database, we used the element occurrence rank or integrity score to assign a stand level score of ecological integrity with sites with higher integrity rankings getting higher scores. For forested stands, we also used stand age to evaluate stand integrity, with older forested stands receiving higher priority scores (Valdes et al. 2020).

Ecosystem Services

The final variable that was developed for this model was an ecosystem services variable. For each natural community type, we assigned an ecosystem services score based on ten factors that gauge contribution to provisioning, regulating, supporting, and cultural services. These ten ecosystem service factors are water filtration, carbon sequestration, pollinator habitat, recreation, subsistence foraging, coastal shoreline buffer, cultural value, flood protection, nutrient cycling, and regulation of climate and air quality. Those stands that were crosswalked to a natural community type were assigned that natural community type's ecosystem services score, with higher scores for ecosystems characterized by greater contribution to these ten servicing factors. Results from the BRIE analysis are presented on page 79 (Figure 29, pg. 80).

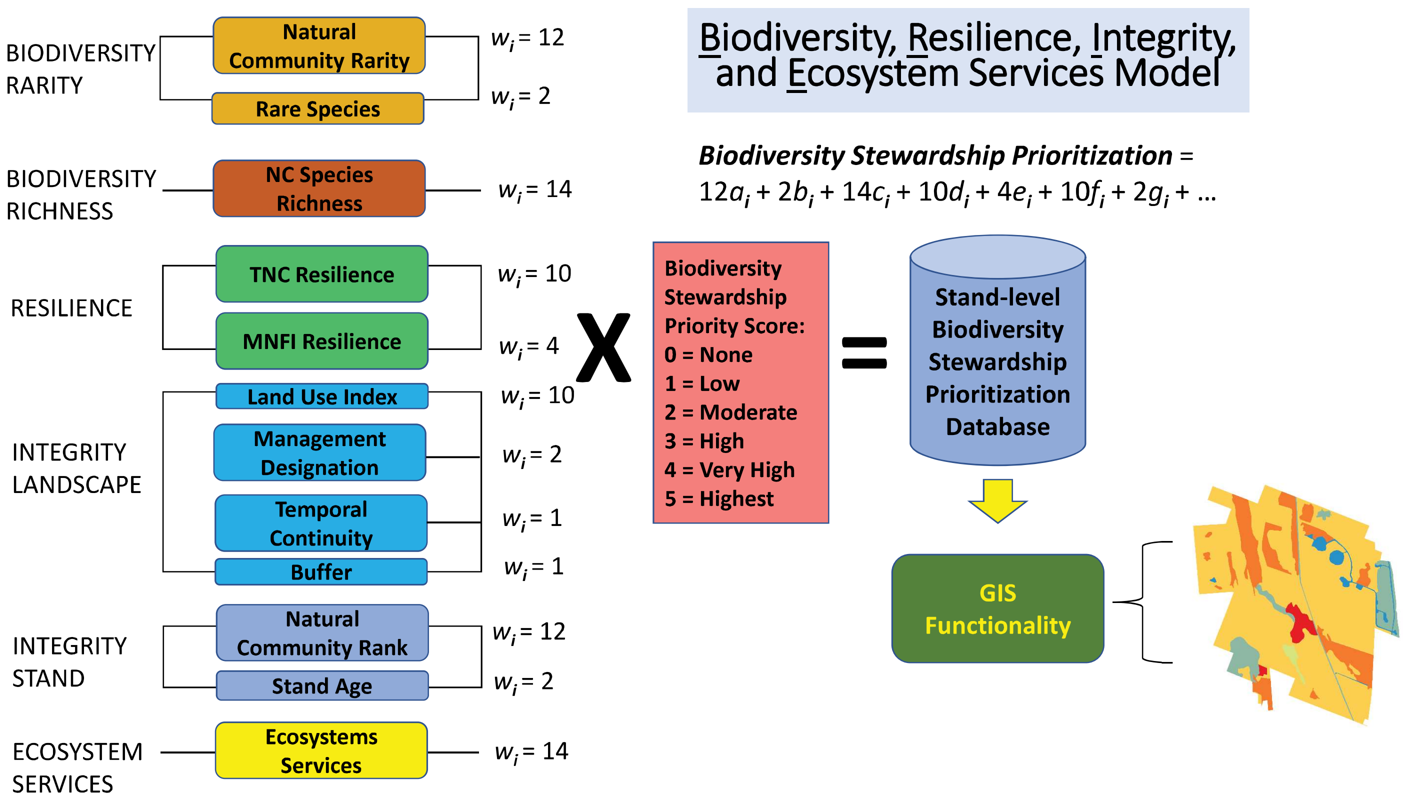


Figure 18. Geographic weighted overlay model to identify priority areas for biodiversity stewardship on state lands.

RESULTS

Before 2019, 27 element occurrences (EOs) were documented within Maple River SGA composed of 22 rare species occurrences and 5 high-quality natural communities. Of those rare species occurrences, 6 were birds, 1 was a rare herptile, 5 were mussels, and 10 were plant EOs. During surveys completed for the Integrated Inventory Project at Maple River SGA, MNFI scientists documented 5 new natural community EOs (Table 2, Figure 19), 1 new bird EO (Table 3, Figure 23), 1 new rare mussel EO (Table 4, Figure 24), 1 new herptile EO (Table 5, Figure 25), 14 new rare plant EOs (Table 6, Figures 26, 27, 28), and provided information for updating 16 existing EOs. Data compiled on these EOs were entered into MNFI's Natural Heritage Database (MNFI 2020). These new EOs constitute a 78% increase in EO records within Maple River SGA.

Natural Communities

MNFI ecologists documented 5 new high-quality natural communities in the Maple River SGA (Table 2, Figure 19). Previous survey efforts had documented 2 floodplain forests and 3 inland salt marshes in the game area. The following 4 natural community types are represented in the 10 element occurrences surveyed: floodplain forest (2 EOs), inland salt marsh (3 EOs), mesic southern forest (3 EOs), rich conifer swamp (1 EO), and wet-mesic flatwoods (1 EO). The following site summaries contain a detailed discussion for each of the ten natural community EOs organized alphabetically by community type and EO name. For each natural community type, the Global and State Rank is provided and these ranks are explained in Appendix 5. Natural community distribution maps are also provided in the Appendices when not included in the description of each site.

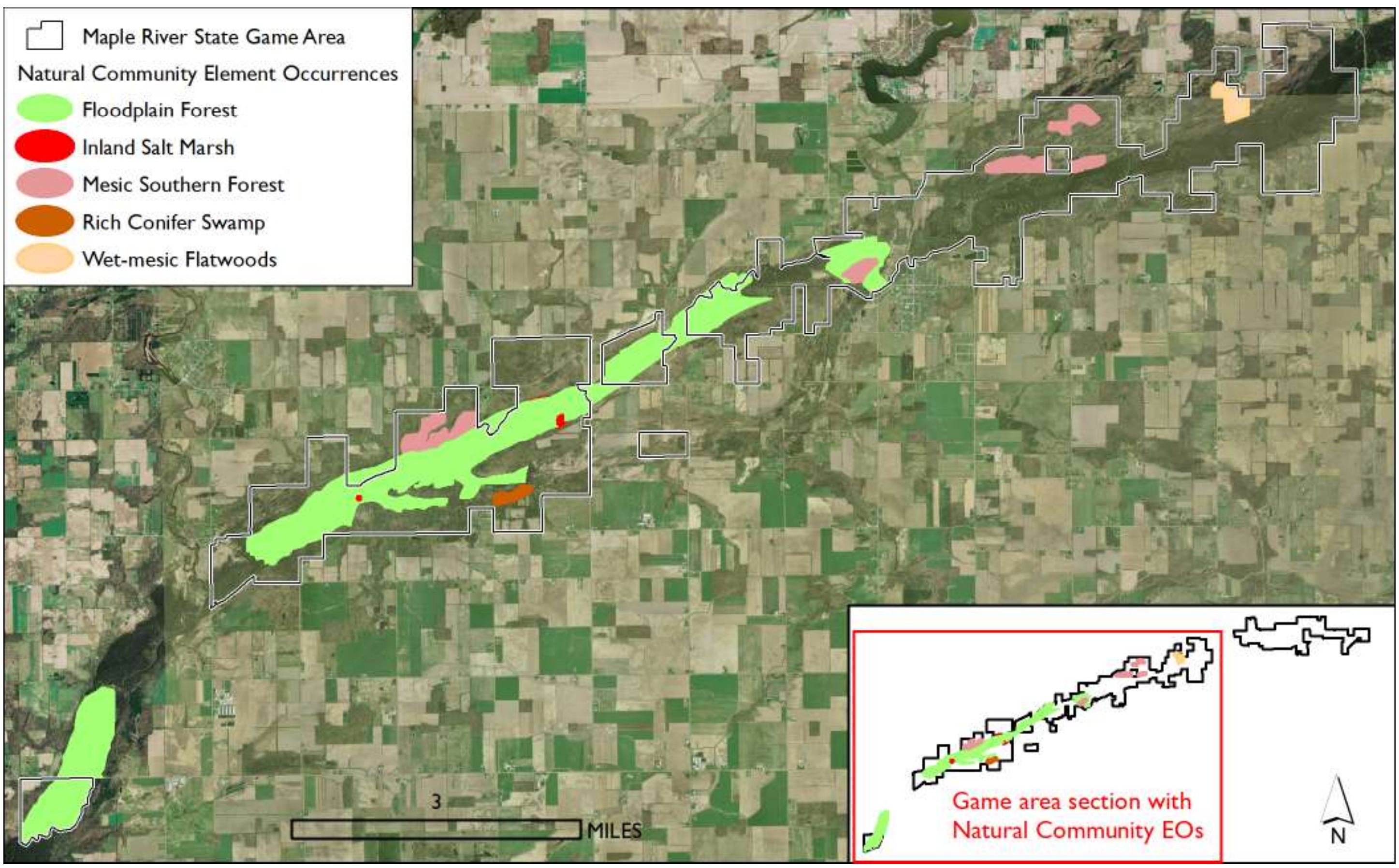


Figure 19. Natural community element occurrences in Maple River State Game Area.

Table 2. Natural community element occurrences for the Maple River State Game Area. An asterisk indicates that a particular natural community EO was newly documented during the 2017 surveys.

Site Name	EO ID	Rank	Size (Ac)	First Visited	Last Visited	Compartment	Stands
Floodplain Forest							
Maple River Floodplain	13315	B/BC	1469	2001	2017	2 and 3	Numerous
Nickle Plate Floodplain	13463	B/BC	419	2001	2017	1	4
Inland Salt Marsh							
Clinton-Saltworks (Salt Marsh #1)	9928	D	3.9	1837	2017	2	75
Hubbard's Salt Lick (Salt Marsh #2)	7963	CD	6.5	1983	2017	2	100
Western Salt Marsh	13616	C	0.1	2003	2017	2	29
Mesic Southern Forest							
Alger Woods*	23662	C	121	2019	2019	4	8, 13, 19, 22, 34
Black Maple Forest*	23119	BC	77	2017	2017	2	35 and 51
Wacousta Woods*	23170	C	29	2017	2017	3	68
Rich Conifer Swamp							
Hinman Cedar Swamp*	23122	CD	22	2016	2017	2	79
Wet-Mesic Flatwoods							
Wilson Woods*	23184	C	49	2017	2017	4	70

The floodplain forest along the Maple River constitutes the third largest documented high-quality floodplain forest in Michigan. The Clinton-Saltworks inland salt marsh is visible across the river. Photo by Jesse M. Lincoln.

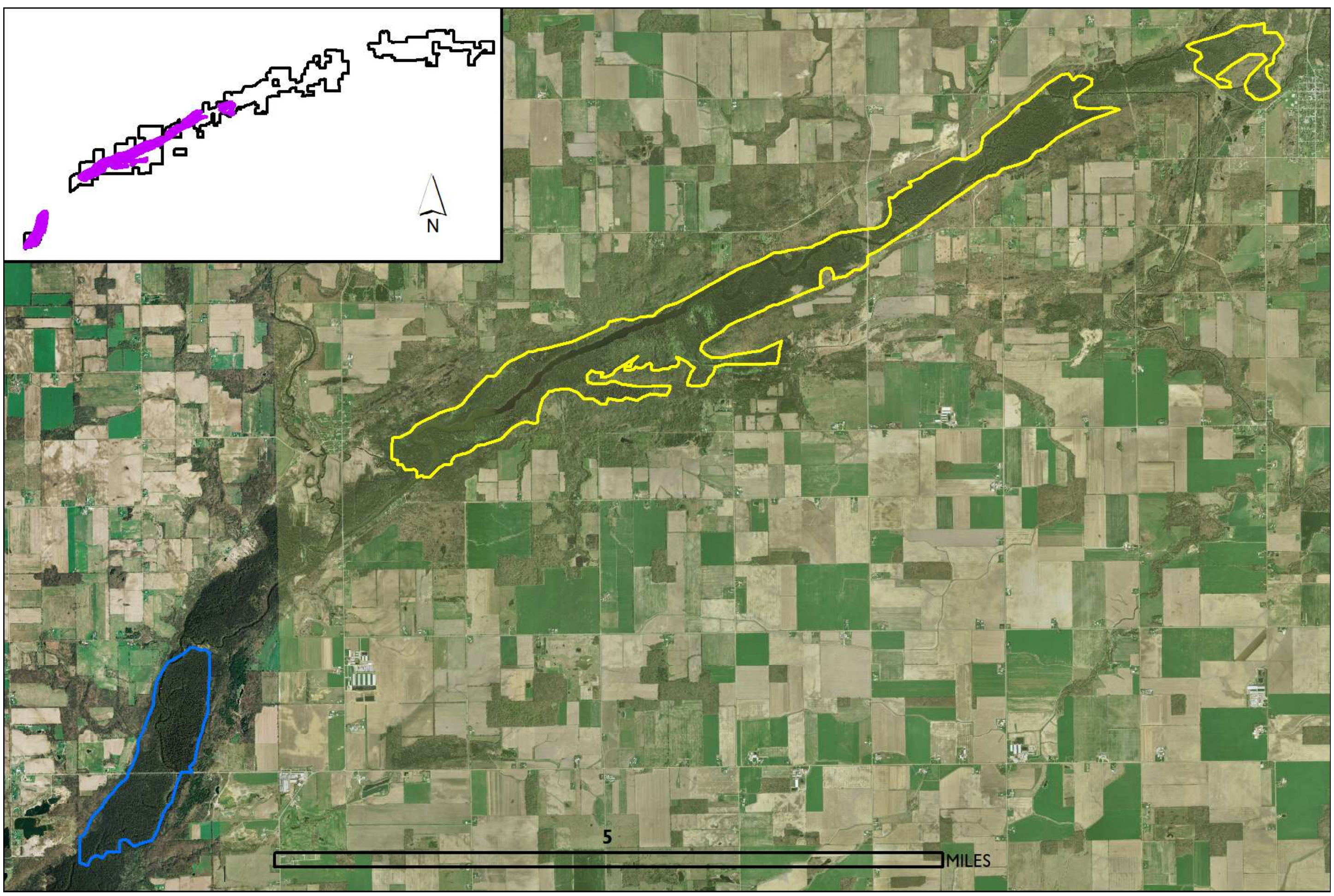
Floodplain Forest (G3? S3, likely vulnerable globally and vulnerable within state)

Maple River Floodplain and Nickle Plate Floodplain

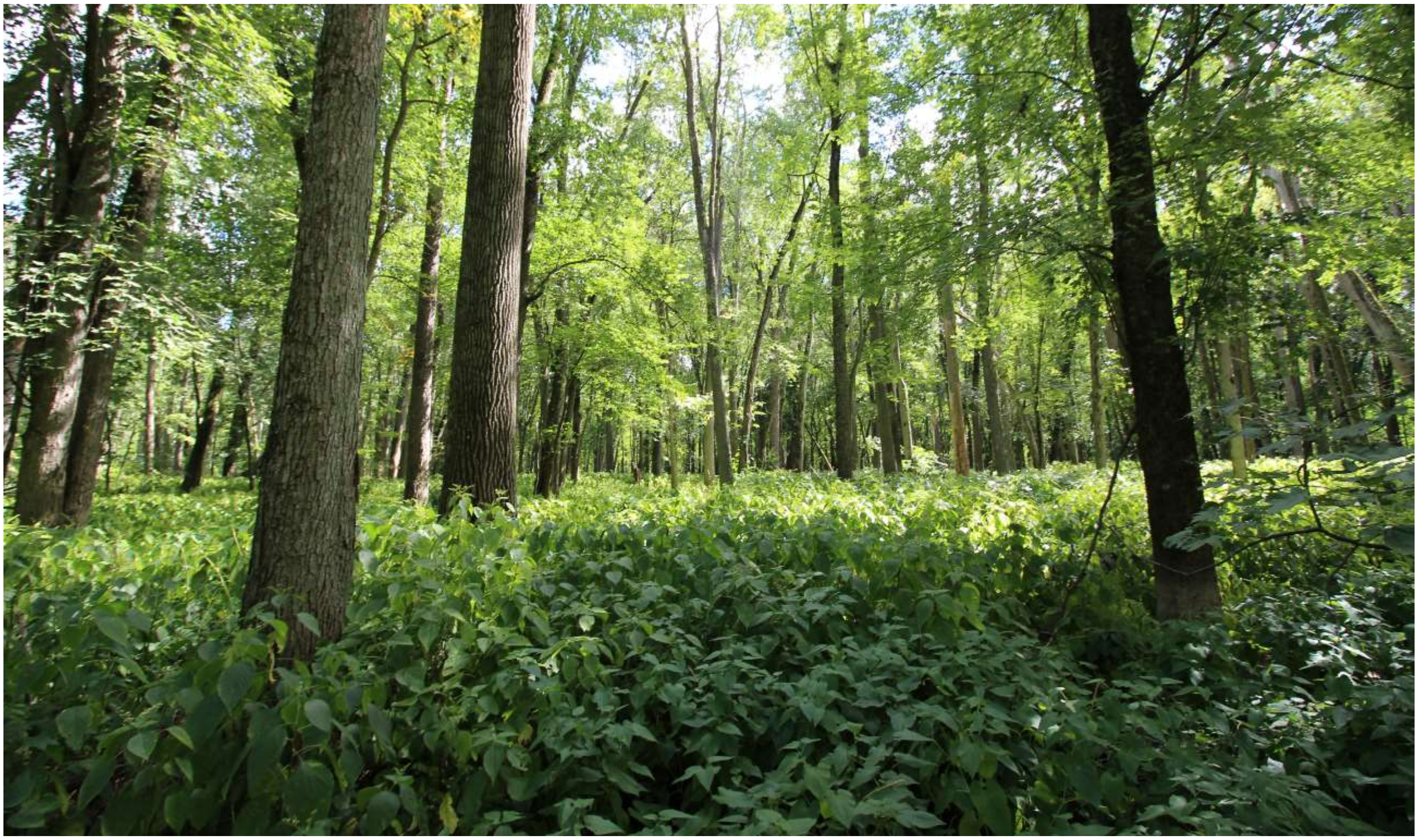
EO ID Number	EO Rank	Size (acres)	Compartment	Stand
13315 (Update) 13463 (Update)	B/BC	1887	1, 2, 3	numerous

There are two floodplain forest EOs within Maple River SGA. These are separated by over 3,600 m of unsuitable land cover or private property that we were unable to survey. Therefore, these are maintained as separate records based on Natural Heritage Methodology. However, they are very similar, so their descriptions are combined here for simplicity.

There is a long history of indigenous peoples throughout the area and activity was likely concentrated along the floodplains. Though none were detected during surveys, mounds and historic garden beds were documented throughout the region and were known to occur within the river valley. The area was likely used by indigenous peoples for farming and hunting and there was a trail from the Grand River to Saginaw that ran along the south side of the river. An established village was on “the island” near the salt marshes, on the south side of the river.



Aerial imagery of Maple River Floodplain (yellow) and Nickle Plate Floodplain (blue, lower left).


The floodplain forest along the Maple River is dominated by silver maple (*Acer saccharinum*). Photo by Jesse M. Lincoln.


Much of the forest is seasonally inundated by over-the-bank flooding. Photo by Aaron P. Kortenhoven.

Glacial floods scoured the outwash channel to form the river valley and ground moraine features persist locally within the outwash channel (Figure 1, pg 1.). These isolated areas of ground moraine feature mesic southern forest characterized by black maple (*Acer nigrum*), red oak (*Quercus rubra*), bur oak (*Q. macrocarpa*), and occasionally blue ash (*Fraxinus quadrangulata*). Surrounding uplands of mesic to dry-mesic southern forest are typically younger than the floodplain forest and are characterized by more non-native species, though several high-quality upland oak-maple forests persist within the game area. Three inland salt marshes occur adjacent to floodplain, near “the island” west of Tallman Road.

The Maple River is a major tributary of the Grand River, occurring in the central lower peninsula. The Maple River Floodplain forest is the largest documented floodplain forest in the Grand River watershed and Michigan’s third largest high-quality example. Several distinct blocks of high-quality floodplain forest occur over 11.5 miles within the outwash channel of Maple River. The system experiences annual flooding in late winter and early spring and fall flooding has become increasingly frequent. There was a major flood in 2013 during which the river did not recede to its banks until July. The floodplain’s hydrology appears to be minimally altered within the EO and fragmentation and road density is low relative to areas outside of the game area. Semi-annual over-the-bank flooding has generated complex patterns of sediment erosion and deposition, including infrequent meander scars. Soils within the floodplain are highly variable as a result of the dynamic hydrology. One sample from a typical first bottom was characterized as an alkaline (pH 7.5) mix of fine loam and muck with bands of sand to about 2 ft, then alkaline (pH 7.0-7.5) clay with gleying. Erosion of the streambed leads to trees falling into the river creating important aquatic structural diversity. In addition, there is an accumulation of coarse woody debris throughout the floodplain associated with windthrow and tree disease. Flooding in the winter leads to extensive ice scour on many of the trees, creating multi-stemmed canopy trees. Stagnant pools of water with exposed mud and small rivulets contribute to habitat diversity and occur throughout. There are localized areas of levee along the channel of the Maple River, but these are generally not continuous and often subtle.

Floristic composition and vegetative structure within the floodplain forest are influenced by proximity to the river, which impacts periodicity and duration of inundation as well as sediment deposition. Photo by Jesse M. Lincoln.

The extensive floodplain forest along the Maple River provides habitat for numerous rare species and a critical buffer to the river. Photo by Jesse M. Lincoln.

Many areas of the floodplain feature dense buttonbush (*Cephalanthus occidentalis*) thickets that are nearly impenetrable. Photo by Jesse M. Lincoln.

This extensive and variable floodplain forest is characterized by expansive first bottom forest dominated by large (typically between 40 and 110 cm DBH), mature (80 to 140 years old) silver maple (*A. saccharinum*). Green ash (*F. pennsylvanica*) and American elm (*Ulmus americana*) were historically canopy codominants but have been relegated to the subcanopy and understory due to emerald ash borer and Dutch Elm Disease, respectively. Green ash generally occupied about 30% of the canopy, though its dominance was greater in wetter areas, such as meander scars and oxbows. Cottonwood (*Populus deltoides*), swamp white oak (*Q. bicolor*), bur oak, black willow (*Salix nigra*), basswood (*Tilia americana*), shellbark hickory (*Carya laciniosa*), Kentucky coffeetree (*Gymnocladus dioicus*), and sycamore (*Platanus occidentalis*) are important but infrequent canopy components. The first bottom ranges from 50 to 95% canopy coverage. Where ash was more prevalent or where there is more prolonged standing water from flooding, the canopy closure is around 50%. Areas of levee have more abundant shrubs and more bur oak, hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), and sycamore in the canopy. Some trees are very large: there was a 114 cm DBH bur oak, a 165 cm DBH cottonwood, and a 216 cm DBH silver maple observed during surveys. The oldest silver maples were aged to 140 years old. A 79 cm DBH swamp oak was aged to 103 years, though some of the larger oaks appear to be much older.

Generally, the subcanopy and understory of the forest features silver maple, green ash, elm, and basswood. Throughout the floodplain complex, there are expansive areas with a sparse canopy dominated by buttonbush (*Cephalanthus occidentalis*). Additional understory shrubs include spicebush (*Lindera benzoin*), nannyberry (*Viburnum lentago*), prickly ash (*Zanthoxylem americanum*), musclewood (*Carpinus caroliniana*), elderberry (*Sambucus canadensis*), and hawthorn (*Crataegus mollis*).

The floodplain forest is accumulating coarse woody debris. Photo by Jesse M. Lincoln.

The herbaceous components of the forested areas are complex and variable. Characteristic species include sensitive fern (*Onoclea sensibilis*), wood nettle (*Laportea canadensis*), lizards-tail (*Saururus cernuus*), Virginia wild-rye (*Elymus virginicus*), sedges (*Carex muskingumensis, C. crinata, C. tuckermanii, C. grayi, C. lacustris, C. lupulina*), wood reedgrass (*Cinna arundinacea*), water-parsnip (*Sium suave*), northern bugle weed (*Lycopus uniflorus*), fringed loosestrife (*Lysimachia ciliata*), arrow-arum (*Peltandra virginica*), smartweed (*Persicaria spp.*), and many others.

Four rare plant species have been documented within the floodplain forest: Davis' sedge (*Carex davisii*, state special concern), Cat-tail sedge (*Carex typhina*, state threatened), beak grass (*Diarrhena obovata*, state threatened), and heart-leaved plantain (*Plantago cordata*, state endangered). Invasive species are infrequent but locally dominant within the floodplain forest and include reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), moneywort (*Lysimachia nummularia*), multiflora rose (*Rosa multiflora*), and common cocklebur (*Xanthium strumarium*).

These sites were visited four times during the 2017 field season. The floristic quality assessments for both EOs were compiled and a total of 136 plant species were documented with 12 non-native species observed (Appendix 12). The total floristic quality index (*FQI*) was 50.1. A previous MNFI survey documented 186 plant species with 11 non-native species and a FQI of 53.7 (Goforth et al. 2002).

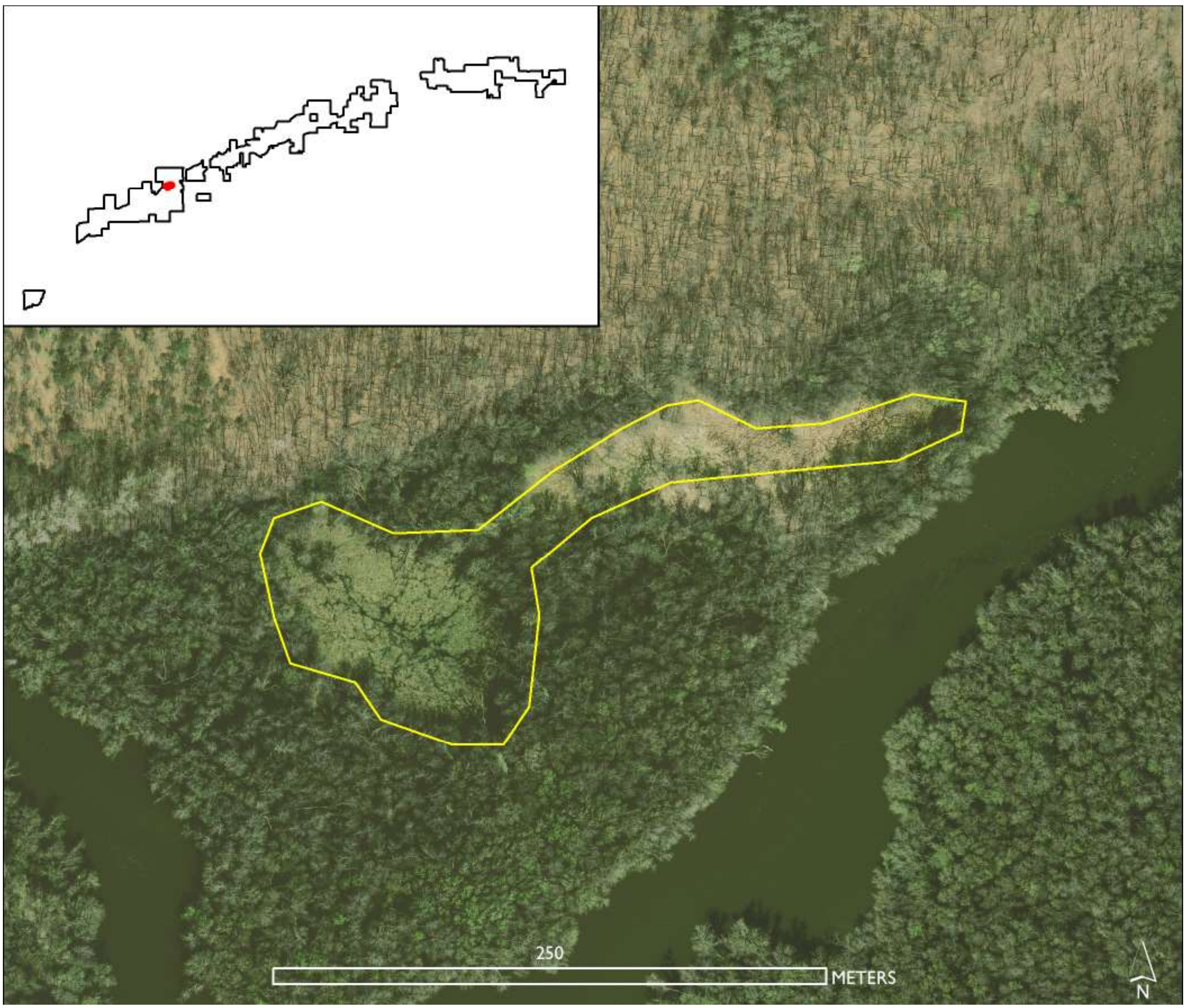
Emerald ash borer has killed nearly all of the ash in the canopy of the floodplain forest. Drone photography at this particular point in the species' decline allows scientists to elucidate how significant a component ash was to the forest canopy. Photo by Jesse M. Lincoln.

Inland Salt Marsh (G1 S1, critically imperiled globally and within the state)

Clinton-Saltworks (Maple River Salt Marsh #1)

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
9928 (Update)	D	3.9	2	75

This is a small salt marsh at the base of an upland rise along the northern boundary of the Maple River outwash channel within the floodplain forest complex. This marsh was excavated by operations of the Clinton-Saltworks, a small settlement just north of the site that was established in the early 1800s to extract salt from the area salt marshes. The marsh has presumably been dramatically altered from these efforts to extract salt-rich water. No obvious evidence of these operations remains, but Douglas Houghton of the first geologic survey took inventory of every known salt marsh in 1837. Houghton's notes from the first survey in 1837: "An attempt has been made to sink a crib in the upper marsh (the eastern portion) where brackish water in small quantities was discharged at the surface, but in consequence of the difficulty of clearing the excavation from water, the undertaking was abandoned, and it is now proposed to bore and sink tubes". By the time he wrote his geological reports, this had been done. "Since my visit to the place, I am informed, a shaft has been sunk… to a depth of about forty feet, and has been attended by a considerable increase of the saline contents of the water."



Aerial imagery of Clinton-Saltworks (Salt Marsh #1)

The open conditions of the marsh are presumably maintained by the constant flow of cold, mineral-rich groundwater. There are two distinct zones in the marsh, an eastern (Houghton described as the upper) and a western zone. The eastern zone is the portion that is, or at least was, influenced by salt seepage and supported populations of Olney's bulrush (*Schoenoplectus americanus*, state endangered) and dwarf spike-rush (*Eleocharis parvula*, state endangered), two halophytes characteristic of inland salt marshes that were last documented within this marsh in 1982. The marsh in the eastern zone no longer has any obvious salt seeps or halozones and is generally dominated by reed canary grass and narrow-leaved cat-tail.

The western zone is dominated by reed canary grass, native reed (*Phragmites australis* sups. *americanus*), river bulrush (*Bolboschoenus fluviatilis*), and locally by Canada bluejoint (*Calamagrostis canadensis*). The eastern and western zones are separated by sparse silver maple and dead green ash. Other native species occur throughout the marsh, including white grass (*Leersia virginica*), sedge (*Carex lacustris*), wood reedgrass (*Cinna arundinacea*), Lake Ontario aster (*Symphyotrichum ontarionsis*), and stinging nettle (*Urtica dioica*).

Invasive species are a substantial component of the vegetation and their increase in dominance has potentially led to the local extirpation of halophytes from this site. There is no mention of cat-tail or reed canary grass in the earliest notes from Houghton and Hubbard (1837) and the non-native species are now dominant. Native vegetation is locally abundant, though generally appears to be losing ground to invasive species.

The site was surveyed and well-documented by MNFI Ecologist Kim Chapman in 1985. Chapman documented populations of Olney's bulrush and dwarf spike-rush in the small halozone in the eastern portion of the marsh (Chapman et al. 1985). These characteristic halophytes were not observed during surveys in 2017 but survey efforts should continue, considering the Michigan populations of both species are now restricted to one inland salt marsh (Hubbard's Salt Lick) in Maple River SGA. Survey efforts for the rare species should be focused in the eastern end of the open marsh. This is one of only three occurrences of inland salt marsh remaining in the state and despite the degraded condition, this site will continue to be maintained in the MNFI database due to the rarity of the community type, the extensive historic efforts to describe them, and the potential for populations of characteristic halophytic vegetation to persist.

This site was visited once during the 2017 field season. A total of 16 plant species were documented with 14 native species and 2 non-native species (Appendix 13). The total FQI was 16.

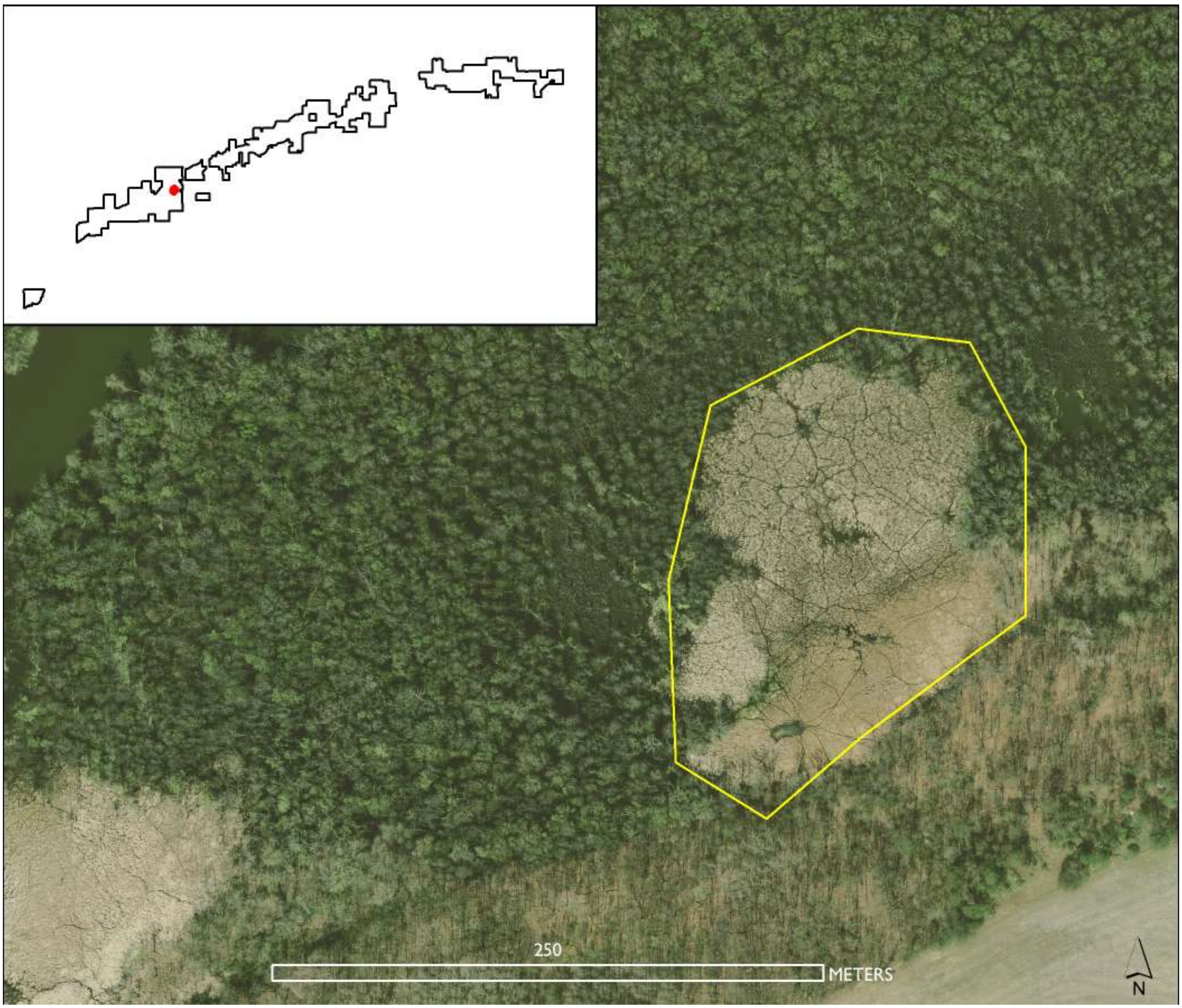
Clinton-Saltworks inland salt marsh. Photo by Jesse M. Lincoln.

Hubbard's Salt Lick (Maple River Salt Marsh #2)

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
7963 (Update)	CD	6.5	2	100

This site occurs at the base of an upland rise, known locally as "the island" which is along the southern boundary of the Maple River outwash channel. This is a treeless marsh extending into the floodplain from the base of a north-facing slope, on the south side of the river. This marsh appears to be above the typical height of seasonal floodwaters and is not obviously influenced by the hydrology of the river. The flow of cold, mineral-rich groundwater is presumably what maintains the open conditions and green ash (now mostly dead from ash borer) gradually increases in density and height away from the areas of constant seepage.

There are three distinct zones in the marsh: the halozone, a seep zone, and a cat-tail zone. The large area most influenced by the salt-rich seepage is the halozone. It is positioned closest to the base of the slope in the southern half of the marsh. This zone is dominated by Olney's bulrush and narrow-leaved cat-tail. Within this halozone is a 10 m x 10 m seep zone. The seep is permanently saturated and becomes inundated in the spring and during rains at which time the mucky area can contain standing water up to ½ m deep. This zone is perturbed and maintained by animals seeking the salt. Animal trails radiate in all directions from this muck flat and there have been recent tracks observed during several documented visits to the site. This disturbance likely maintains the exposed muck



Aerial imagery of Hubbard's Salt Lick (Salt Marsh #2)

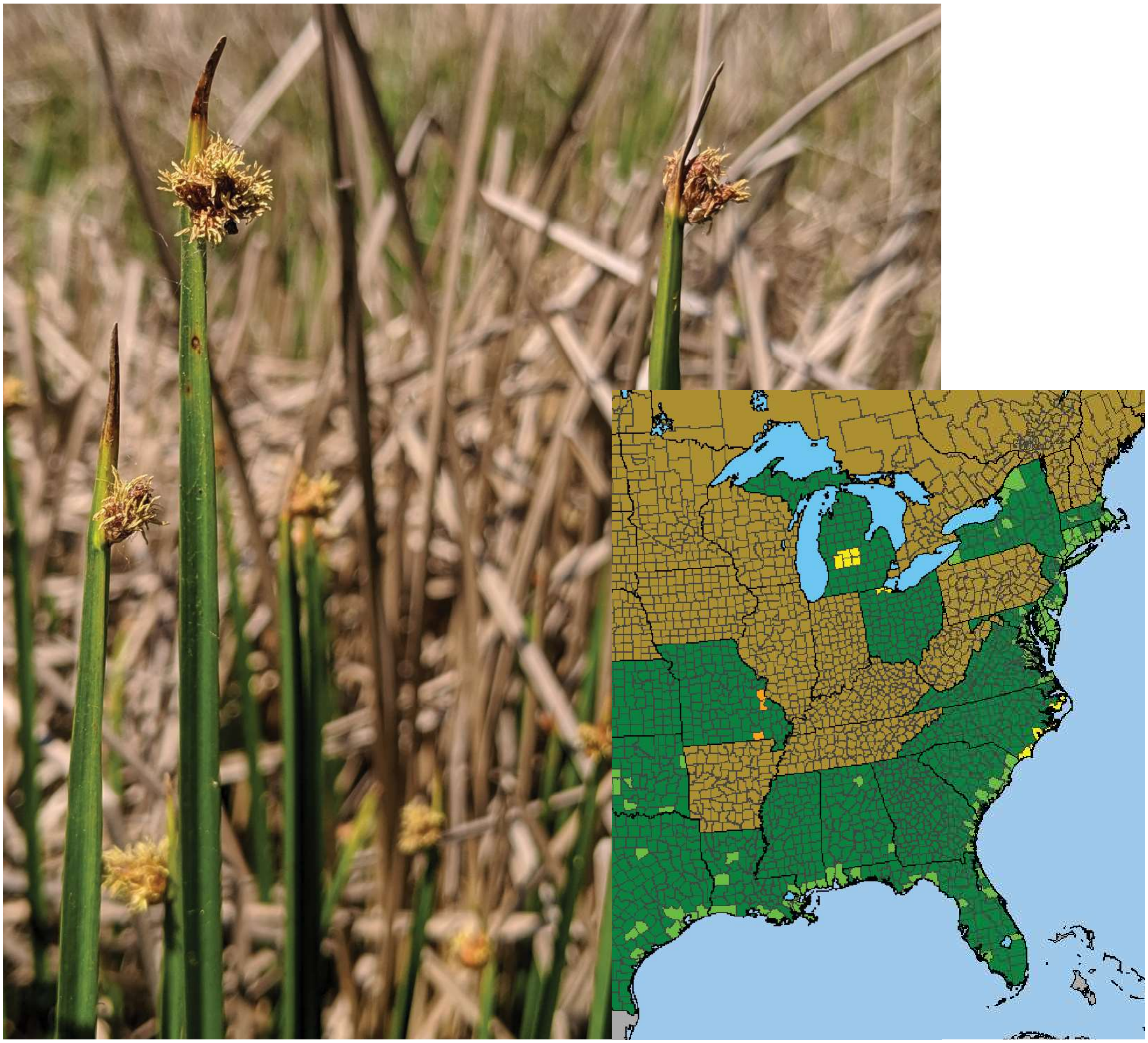
Hubbard's Salt Lick inland salt marsh. Photo by Jesse M. Lincoln.

The zonation of the salt marsh is apparent from a drone. The zone on the left is the halozone where mineral-rich groundwater is seeping from the base of the moraine. The numerous game trails are evident and heading to a small mucky seep where the mineral-rich water mixes with mud and wildlife uses it as a natural salt lick. A monoculture of narrow-leaved cat-tail (*Typha angustifolia*) occurs on the right and if not treated, likely threatens the integrity of this site as well as the rare halophytes it harbors. Photo by Jesse M. Lincoln.

and this is where dwarf spike-rush occurs. Additional species are interspersed throughout the halozone and locally abundant, including boneset (*Eupatorium perfoliatum*), joe-pye-weed (*Eutrochium maculatum*), water-parsnip, blue-joint, and wild mint (*Mentha canadensis*).

The third zone begins at a clear boundary where the salt concentration is presumed to be markedly decreased and at which point cat-tail becomes overwhelmingly dominant and twice as tall as it is within the halozone. Few additional plant species occur within this cat-tail zone except for some sparse shrubs and stunted trees and there is a thick layer of cat-tail thatch from years of litter buildup. This litter, or thatch accumulation, dramatically reduces species composition and allows mono-dominance. Any invasive species control measures need to address this accumulation of thatch. Fire can potentially be used to remove the litter once the cat-tails have been cut and herbicided.

This site was visited once during the 2017 field season. A total of 14 plant species were documented with 12 native species and 2 non-native species (Appendix 14). The total FQI is 15.7.



Olney's bulrush (*Schoenoplectus americanus*, state endangered) is rare in Michigan and its eastern distribution is generally restricted to the Atlantic and Gulf Coast (map by Kartesz 2018). Dark green indicates the species is present in the state. Light green indicates the species is present in the county and not rare. Yellow indicates the species is present in the county and rare. Orange indicates the species has been extirpated from the county. Photo by Nathan Martineau.

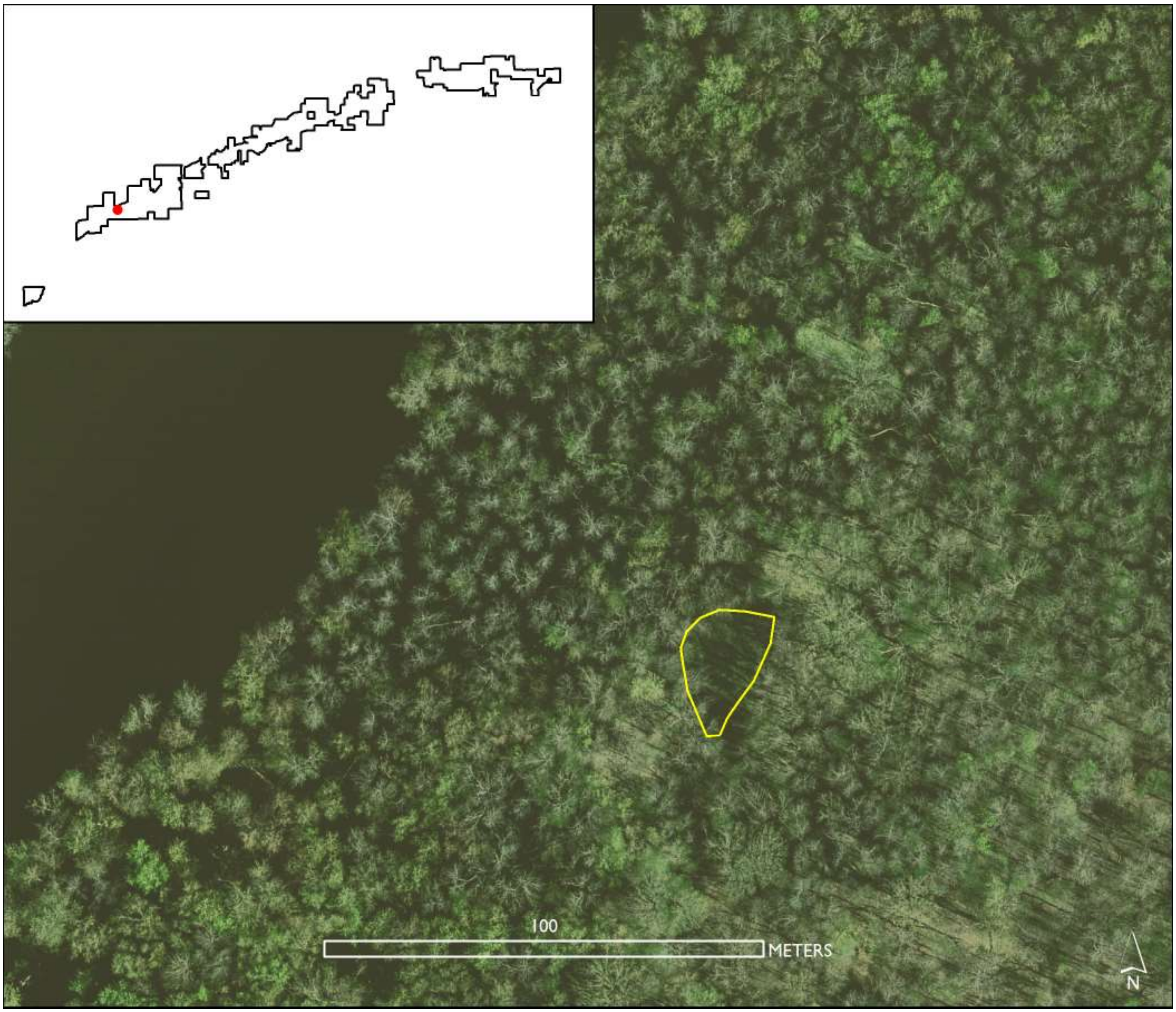
The state's last known population of dwarf spike-rush (*Eleocharis parvula*, state endangered) is relegated to the seep in the halozone of Hubbard's Salt Lick. Photo by Jesse M. Lincoln.

The boundary between the cat-tail zone (left) and the halozone (right) is made clear by the height difference of cat-tail. Photo by Jesse M. Lincoln.

Western Salt Marsh (Maple River Floodplain)

EO ID Number	EO Rank	Size (acres)	Compartments	Stands
13616 (Update)	C	0.1	2	29

This is a small salt marsh within the floodplain forest complex and is the only remaining salt marsh that has not been altered by salt extraction. Though the marsh is small and not obviously a salt marsh as it lacks halophytes, it does have a briny odor and flavor and water tested from the seep in 2003 had high elevations of minerals characteristic of salt deposits. The opening within the floodplain forest is maintained by a constant seepage and is periodically impacted by over-the-bank flooding of the Maple River. The seep holds standing water in an approximately 20 m x 20 m pool with boulders strewn throughout. These boulders within the seep are generally covered with muck and duckweed (*Lemna minor*).



Aerial imagery of Western Salt Marsh (Maple River Floodplain).

Native vegetation is locally dominant, though appears to be losing ground to reed canary grass. Characteristic halophytes were not observed but survey efforts should continue, considering the limited distribution of native halophytes in Michigan. At the margins of the water is a zone dominated by graminoids, particularly cut grass (*Leersia oryzoides*), hardstem bulrush (*Schoenoplectus acutus*), blue-joint, and reed canary grass. Additional species in this zone include southern blue flag (*Iris virginica*), barnyard grass (*Echinochloa muricate*), *Carex lacustris*, river bulrush, false nettle (*Boehmeria cylindrica*), common beggar-ticks (*Bidens frondosa*), water dock (*Rumex verticillatus*), lizard's-tail, narrow-leaved cat-tail, and water-parsnip. Characteristic woody species of the floodplain occur at the margins, including buttonbush and green ash. Efforts to control reed canary grass within this marsh are warranted.

This site was visited once during the 2017 field season. A total of 23 plant species were documented with 21 native species and 2 non-native species (Appendix 15). The total FQI is 19.7.

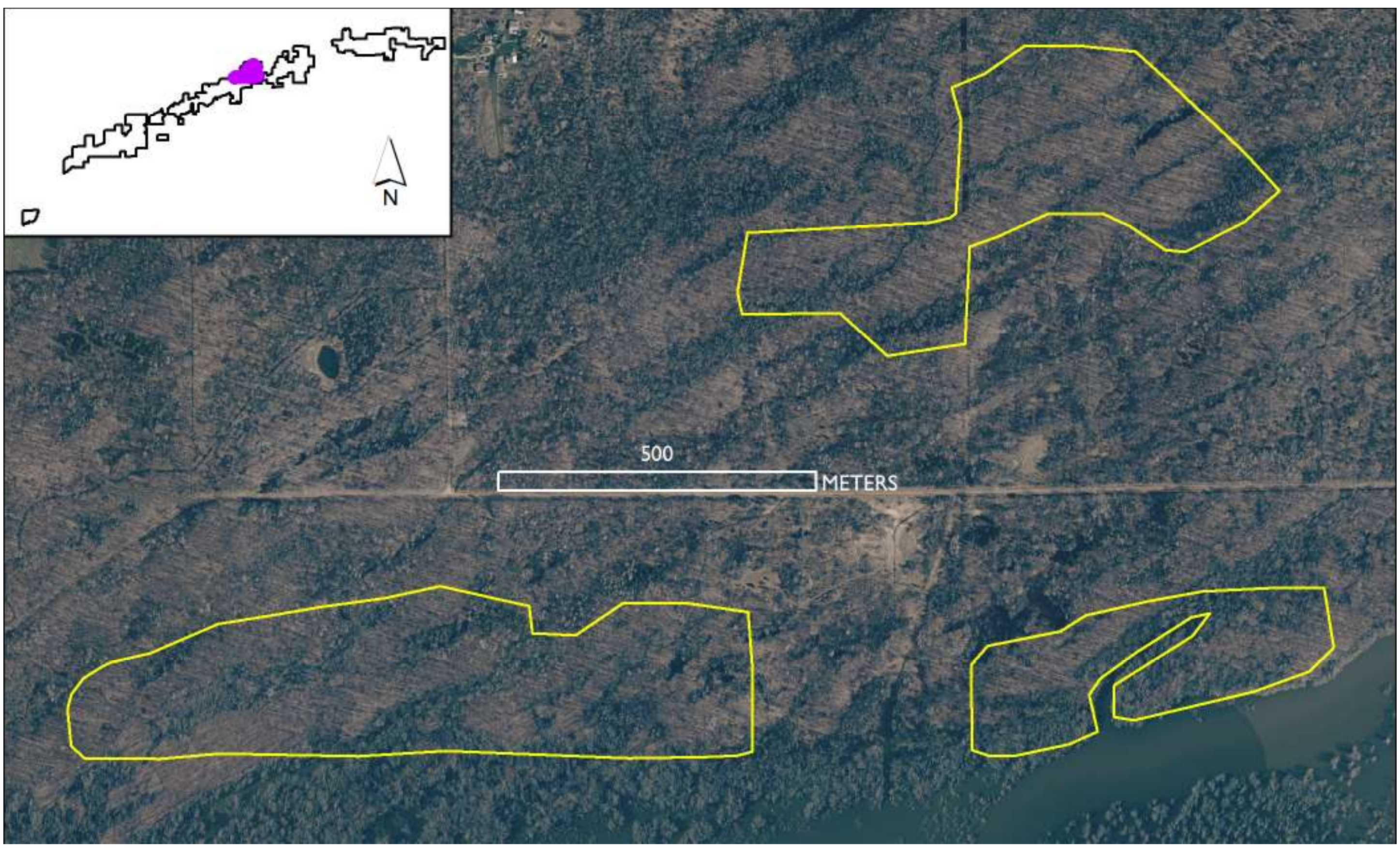
Western Salt Marsh. Photo by Jesse M. Lincoln.

Mesic Southern Forest (G2/G3 S3, imperiled to vulnerable globally and vulnerable within state)

Alger Woods

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
23662 (New)	C	121	4	8, 13, 19, 34, 38, and 22

Alger Woods is a maple-oak forest occurring as three separate polygons on the broad, post-glacial alluvium plain that characterizes the eastern portion of Maple River SGA and much of the Saginaw Bay Lake Plain subsection. The forest occurs above zones impacted by annual flooding of the Maple River. The site was first surveyed in 2013 when the river was at flood stage and does not appear to be inundated during significant flooding events. Fire does not appear to have been a historic disturbance factor, based on landscape context and species composition. The primary disturbance factors after emerald ash borer are windthrow and deer herbivory. The site is accruing coarse woody debris with most snags and downed logs likely due to the recent loss of ash. There are distinct and unusual sloughs throughout the forest that function as vernal pools (visible in site map below). These sloughs appear to have been caused by floods from the receding glacier that scoured the landscape and carved the Maple River outwash channel to the west. The canopy composition is variable and driven by proximity to the numerous and extensive vernal pools. A soil sample taken from the site has 1” of duff over slightly acidic (pH 6.5) sandy loam with organics to a depth of 4”. Below is slightly acidic (pH 6.5-6) coarse loamy sand with ~1” rocks. Large glacial erratics occur throughout.



Aerial imagery of Alger Woods.

The forest remnants occur within a relatively fragmented landscape. Alger Woods occurs adjacent to relatively degraded floodplain forest to the south and the remainder of the local landscape within the adjacent game area is relatively young forest impacted by clearing and alterations to hydrology. The forest was altered by logging in the late 1800s and has a reduced canopy composition from disease and insect outbreak. Parts of the forest may have been grazed as there are some areas with old fences. There are invasive species of concern, particularly autumn olive and multiflora rose, and there are areas of reduced herbaceous layer as a result of deer herbivory and historic grazing.

Alger Woods is characterized by large mature trees, a low component of invasive species relative to many other forests in the region, and relatively high species diversity. Community structure and floristic composition are driven by natural processes: locally saturated soils, windthrow, and accumulation of large-diameter coarse woody debris.

The diverse, closed canopy is characterized by large (40 to 111 cm DBH), maturing (~120-year-old) trees, with sugar maple, red oak, white oak, chinquapin oak (*Q. muehlenbergii*), bur oak, and black maple as the canopy tree species dominant throughout. Beech (*Fagus grandifolia*), bitternut (*Carya cordiformis*) and shellbark hickory, black cherry (*Prunus serotina*), and basswood are also important canopy constituents. White oak and sugar maple are more dominant in areas of deeper sand.

Alger Woods, mesic southern forest. Photo by Jesse M. Lincoln.

American elm occurs in the subcanopy but was likely historically prevalent in the canopy. White ash and green ash were both important canopy constituents but have since succumbed to emerald ash borer. Sugar and black maple, red oak, ironwood (*Ostrya virginiana*), and ashes generally dominate the subcanopy and understory. Additional significant subcanopy and understory species include hawthorn (*Crataegus mollis*), witch-hazel (*Hamamelis virginiana*), prickly-ash (*Zanthoxylum americanum*), and red mulberry (*Morus rubra*, state threatened). This was a new county record for red mulberry and the populations documented in the Maple River SGA represent the northernmost extent of the species in Michigan. Low shrubs include multiflora rose (*Rosa multiflora*), running strawberry-bush (*Euonymus obovatus*), and wild gooseberry (*Ribes cynosbati*).

The herbaceous layer is relatively diverse with spring ephemerals being prevalent. There was significant diversity associated with moisture gradients along vernal pools and sloughs. Characteristic herbaceous species include sedges (*Carex woodii* and *Cx pedunculata*), wild geranium (*Geranium maculatum*), may-apple (*Podophyllum peltatum*), Canada mayflower (*Mainthemum canadensis*), clusterd-leaved tick-trefoil (*Hylodesmum glutinosum*), long-awned wood grass (*Brachyelytrum erectum*), jumpseed (*Persicaria virginiana*), violets (*Viola canadensis, V. pubescens,* and *V. rostrata*), bloodroot (*Sanguinaria canadensis*), Virginia wild-rye (*Elymus virginicus*), ostrich fern (*Matteuccia struthiopteris*), woodland bluegrass (*Poa sylvestris*), and white lettuce (*Prenanthes alba*). A population of *Carex lupuliformis* (state endangered) was also documented from the edge of a vernal pool in the northernmost polygon (Stand 22).

This site was visited once during the 2019 field season. A total of 84 plant species were documented with 82 native species and 2 non-native species (Appendix 16). The total FQI is 44.9.

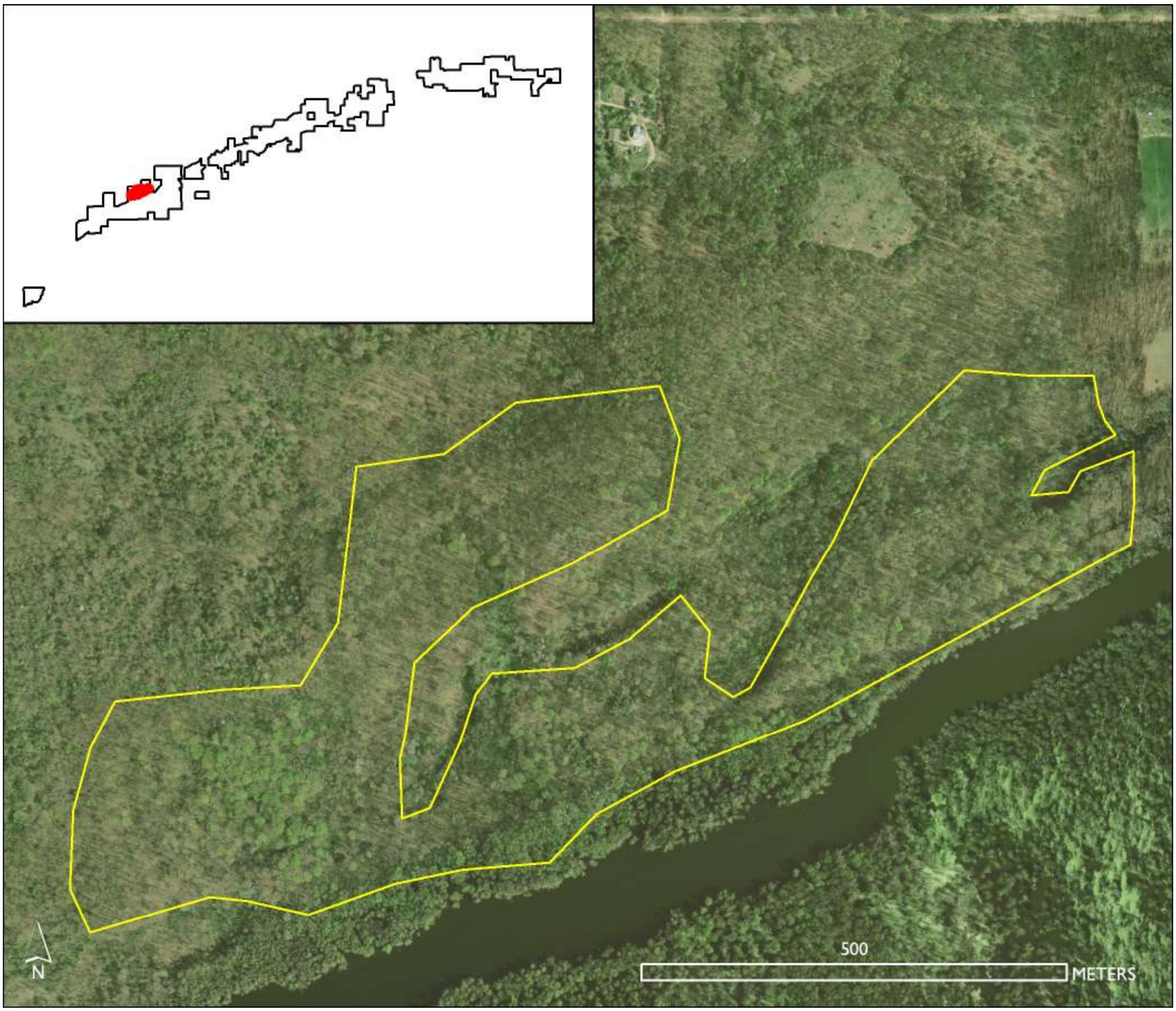
Alger Woods features several vernal pools that support aquatic vegetation. Photo by Nathan Martineau.

A large vernal pool in Alger Woods (Stand 22) supports a population of state threatened sedge (*Carex lupuliformis*). Photo by Nathan Martineau.

Black Maple Forest

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
23119 (New)	BC	77	2	35 and 51

This is a maple-dominated forest occurring on the south-facing slopes of the Maple River outwash channel. Although it is within the outwash channel, the forest occurs above zones impacted by annual flooding of the Maple River. This forest also does not flood during significant flooding events (this forest was first observed during the flood of 2013) and has no resemblance to the typical floodplain forest structure and composition. The soils are variable, but an area dominated by black maple and beech was sampled and the top 8” was acidic (pH 5.5-6.0) and is characterized as loamy sand with dark organics over slightly acidic (pH 6.5) fine sand with gravel. Glacial erratics are abundant, some being quite large (>3 ft across).



Aerial imagery of Black Maple Forest.

Black Maple Forest supports a very high degree of plant diversity. Photo by Jesse M. Lincoln.

Though the site has been altered by emerald ash borer and Dutch elm disease, this forest is characterized by relatively high species diversity with community structure and, with the exception of tree disease, canopy composition is driven by natural processes, especially windthrow and accumulation of large-diameter coarse woody debris. The forest features extensive areas of large, mature trees and a diverse herbaceous layer, especially compared to the surrounding forested uplands. The composition of the diverse canopy corresponds to variations in the aspect of the slopes, proximity to river, and extent of saturated soils, which are prevalent in areas near vernal pools, at the base of the slopes, and along rivulets. Some of the largest trees may be over 200 years old and the site is accruing coarse woody debris, though many snags and downed logs are likely due to the recent loss of ash and elm. Some elms appear to be resistant and persist in the canopy. Additional disturbance factors include windthrow and deer herbivory. Small inclusions in the western portion of the forest were likely selectively logged and grazed historically as the trees are somewhat smaller and there is a higher proportion of red oak in the canopy.

The diverse, closed canopy is characterized by large (40-100 cm DBH), maturing (~130-year-old) trees, with black and sugar maple as the canopy dominants. Red oak, beech, white oak, black cherry, red maple, hackberry, bitternut and shagbark hickory (*Carya ovata*), chinquapin oak, basswood, bur oak, cottonwood, and black walnut are important canopy constituents. Bur oak, swamp white oak, cottonwood, and silver maple tend to be more dominant along the margins of vernal pools and along the interface with the floodplain. Elm occurs locally in the canopy but was likely more prevalent historically. White ash and green ash were both important canopy constituents but have since succumbed to the invasion of emerald ash borer. Canopy ash appears to have constituted around 5 to 10% of the canopy, with white ash on the drier slopes and green ash at the base of the slopes nearer the river and towards zones of saturated soils near the floodplain of the Maple River and also along streams and seeps.

The large number of vernal pools drives diversity. Some years these can be dry with very little vegetation. Other years these can be inundated for most of the growing season and support a range of aquatic species. Photo by Jesse M. Lincoln.

Maples, ironwood, and musclewood generally dominate the subcanopy and understory, though ash and elm are important constituents. Additional subcanopy and understory species include hackberry, bitternut hickory, basswood, and beech. Low shrubs include spicebush, running strawberry-bush, prickly gooseberry, witch-hazel, and bladdernut (*Staphylea trifolia*).

Herbaceous vegetation is diverse as there are zones that are saturated for much of the year and others that are sandier and drier. Some characteristic herbaceous species include sedges (*Cx woodii, Cx typhina, Cx laxiflora, Cx hirtifolia, Cx grayi, Cx gracilima*), wild geranium, zig-zag goldenrod (*Solidago flexicaulis*), doll's-eyes (*Actaea pachypoda*), violets (*Viola canadensis, V. pubescens,* and *V. rostrata*), sensitive fern (*Onoclea sensibilis*), and jumpseed. Cat-tail sedge is state threatened and occurs in vast colonies with hundreds of individuals concentrated around vernal pools and areas of permanently saturated soils along vernal pools, seeps, and small rivulets.

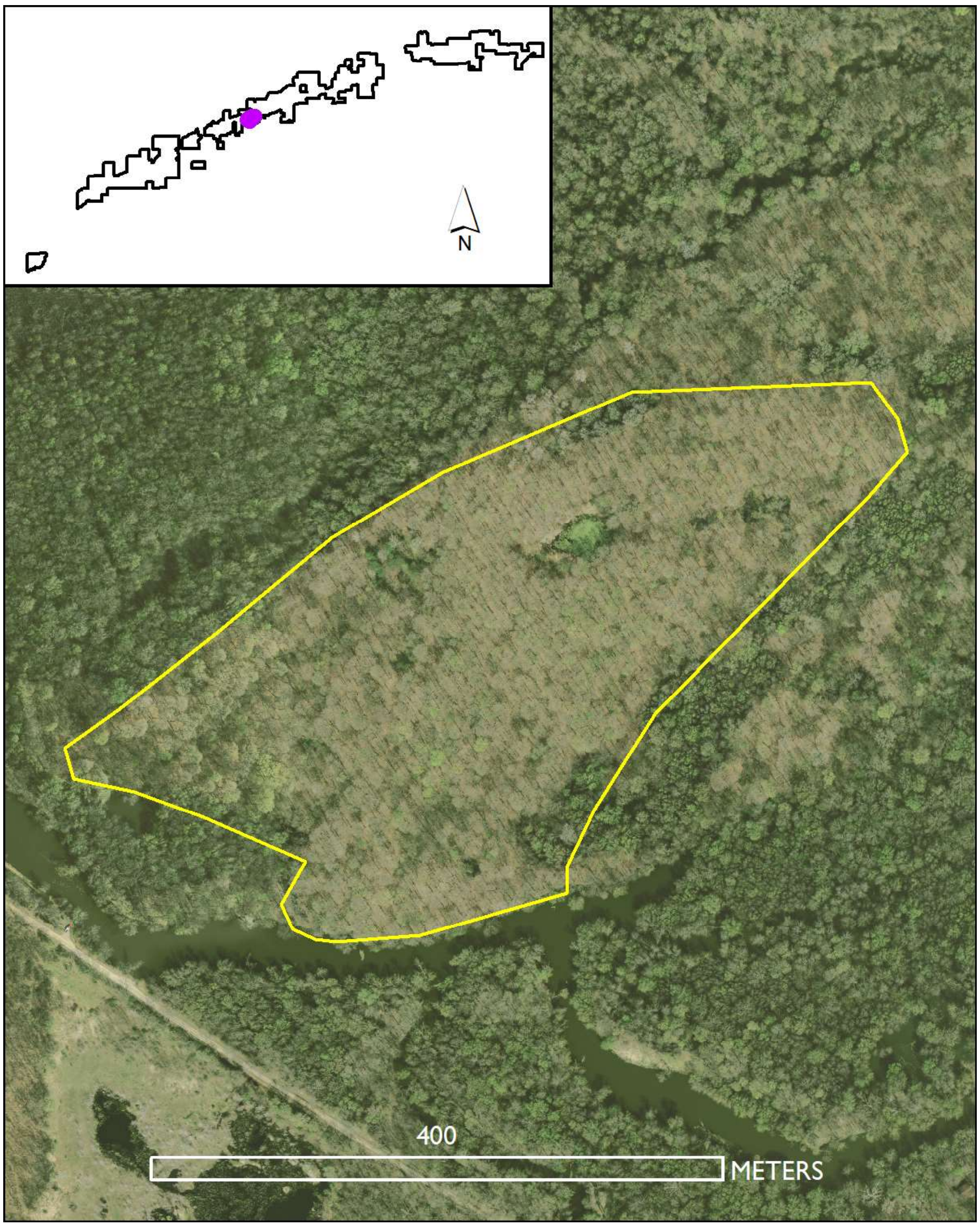
This site was visited once during the 2017 field season. A total of 114 plant species were documented with 110 native species and 4 non-native species (Appendix 17). The total FQI is 50.2.

Cat-tail sedge (*Carex typhina*, state threatened) is locally abundant along the margins of vernal pools throughout Black Maple Forest. Photo by Nathan Martineau.

Wacousta Woods

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
23170 (New)	C	29	3	68

Wacousta Woods is a small deciduous forest with an unusually high diversity of tree species occurring on a small upland rise within the Maple River outwash channel. It is surrounded by floodplain forest and while it is within the outwash channel, the forest occurs above zones impacted by annual flooding. The site was first surveyed in 2013 during a major flood and does not flood during such events. There are very large glacial erratics throughout. A soil sample was taken from an area with slightly acidic (pH 6.5) sandy loam with organics to a depth of 3", then slightly acidic (pH 6.0-6.5) coarse loamy sand with ~1/2" to 1" diameter rocks throughout. The site is accruing coarse woody debris, though most snags and downed logs are likely due to the recent loss of ash. Wacousta Woods is characterized by relatively high species diversity with community structure and composition driven by natural processes, particularly windthrow, the accumulation of large-diameter coarse woody debris, and deer herbivory.



Aerial imagery of Wacousta Woods.

The contrast between the canopy of Wacousta Woods and the surrounding floodplain forest is stark in autumn. Photo by Jesse M. Lincoln.

Wacousta Woods, mesic southern forest. Photo by Jesse M. Lincoln.

There were 17 tree species observed in the canopy of Wacousta Woods, which is especially diverse for such a small forest. The closed canopy is characterized by 40 to 80 cm DBH, maturing (~100-year-old) trees, with black and sugar maple as the canopy dominants. Beech, red oak, white oak, bitternut and shagbark hickory, basswood, blue ash, and hackberry are important canopy constituents. Elm occurs locally in the canopy but was likely more prevalent historically. White ash and green ash were both important canopy constituents but have since been eliminated from the forest canopy as a result of the invasion of emerald ash borer. Ashes appear to have constituted around 5% of the canopy, with white ash in drier areas and green ash in zones of saturated soils near the floodplain and also along vernal pools. Blue ash appears to be less affected by emerald ash borer and the trees remaining in the canopy appear healthy. Blue ash is potentially the species least preferred by the borer and therefore may soon succumb when white and green ash are no longer present on the landscape.

Maple, ironwood, and ash generally dominate the subcanopy and understory. Additional significant subcanopy species include hackberry, bitternut hickory, basswood, and beech. Low shrubs include black raspberry (*Rubus occidentalis*), multiflora rose, running strawberry-bush, Japanese barberry (*Berberis thunbergii*), and prickly gooseberry.

The herbaceous layer was not particularly diverse, though this site was surveyed late in the season and there was a late-summer drought. Characteristic herbaceous species include sedges (*Carex pedunculata* and *Cx woodii*), jumpseed, white avens (*Geum canadense*), Virginia wild-rye, and bottlebrush grass (*Elymus hystrix*).

This site was visited once during the 2017 field season. Because of the late-season drought, only 39 plant species were documented with 36 native species and 3 non-native species (Appendix 18). The total FQI is 25.0. The forest should be revisited earlier in the year to create a more complete species list.

Wacousta Woods supports a very high degree of tree species, particularly relative to its small size. Photo by Jesse M. Lincoln.

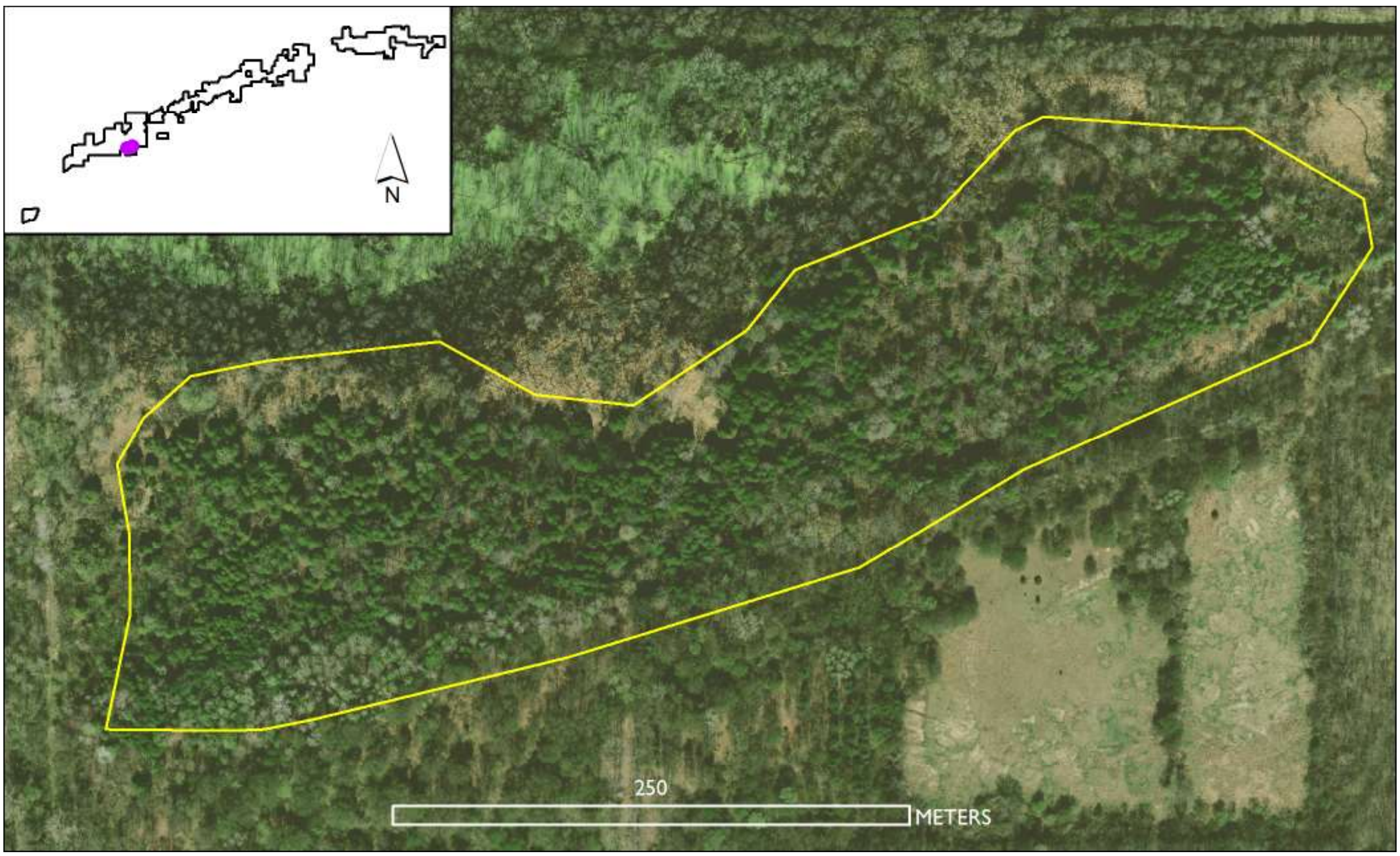
Wacousta Woods, mesic southern forest. Photo by Jesse M. Lincoln.

Rich Conifer Swamp (G4 S3, apparently secure globally and vulnerable within state)

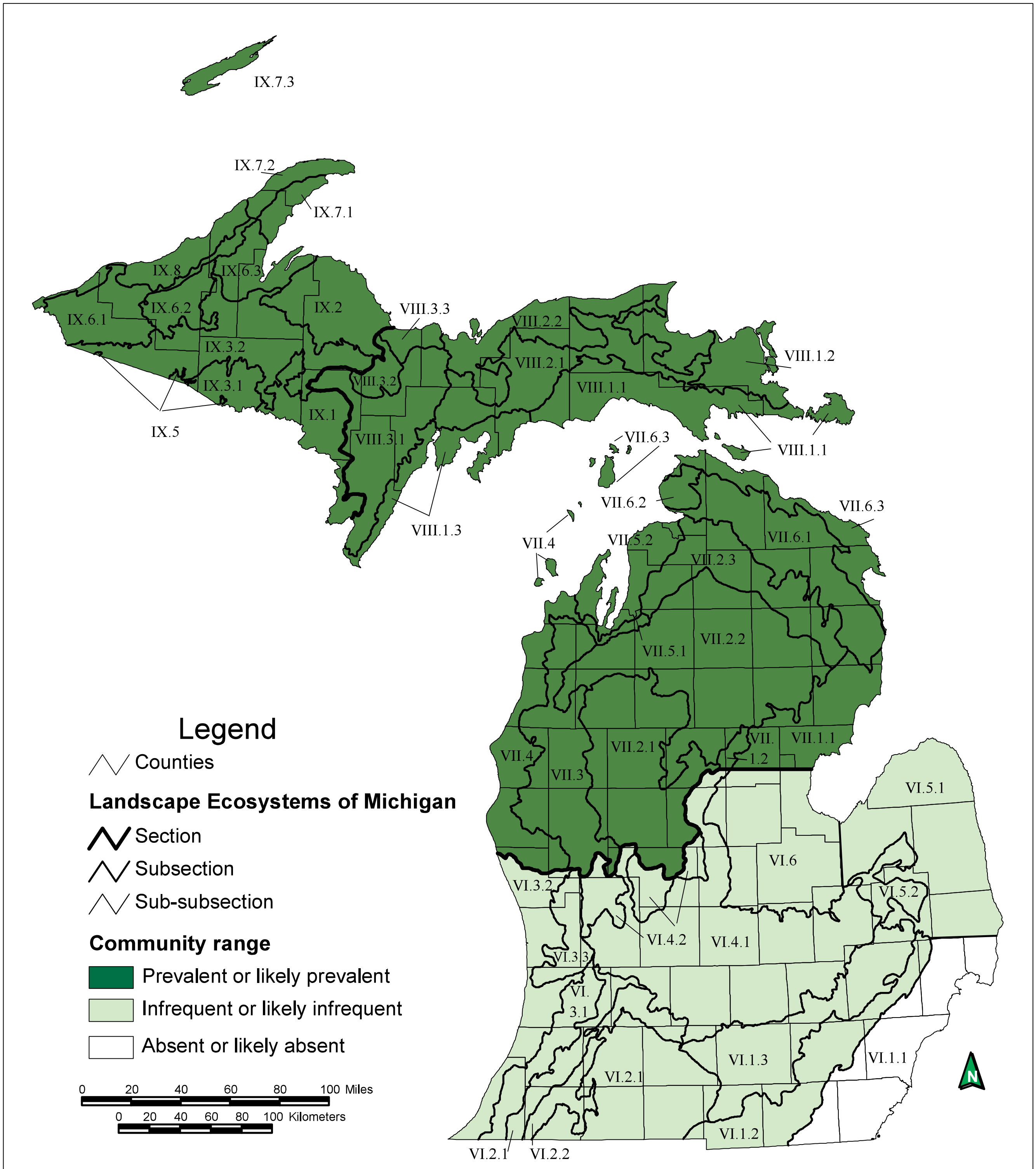
<u>Hinman Cedar Swamp</u>

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
23122 (New)	CD	22	2	79

This cedar forest is a backswamp within the Maple River outwash channel and occurs at the base of a gradual north-facing slope. The swamp is above zones impacted by annual floods and is not inundated during significant flooding events. Hinman Cedar Swamp is small and within a fragmented landscape but it is unique for the region as it is more typical of forested wetlands north of the climatic tension zone. Community structure and composition is largely driven by a constant flow of cold, minerotrophic groundwater causing numerous seeps that form deep, circumneutral to alkaline (pH 7.0-7.5) sapric peats with little vegetation. The saturated soils facilitate windthrow, causing an abundance of large-diameter coarse woody debris. Tip-ups generate hummock-hollow microtopography which leads to variability in soil moisture and drives floristic composition and increases diversity. Additional disturbances include deer herbivory, emerald ash borer, and Dutch elm disease.



Aerial imagery of Hinman Cedar Swamp.



MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Rich Conifer Swamp

Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 166 pp.

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Figure 20. Statewide distribution of rich conifer swamp. The natural community type becomes increasingly infrequent southward, making even small occurrences of the community type important for conservation efforts.

Canopy trees are around 110 years old and canopy coverage is variable (50-90% coverage). As a result of the cold, saturated soils, canopy trees are relatively small (30-75 cm DBH). Northern white cedar (*Thuja occidentalis*) is dominant, which is particularly uncommon this far south. Deciduous trees occur throughout, including American elm, red maple (*Acer rubrum*), quaking aspen (*Populus tremuloides*), and occasionally black walnut and basswood. Black ash (*Fraxinus nigra*) was also historically a significant codominant in the canopy and there were several standing dead black ash throughout the swamp. Common constituents of the subcanopy and understory are American elm, red maple, black ash, and northern white cedar. Characteristic shrubs include elderberry (*Sambucus canadensis*), autumn-olive (*Elaegnus umbellata*), prickly gooseberry, black raspberry, and a few poison sumac (*Toxicodendron vernix*).

The herbaceous layer is relatively diverse and patchy with patterns corresponding to degree of saturation of the peats. The accumulation of coarse woody debris at various stages of rot is also driving vegetation patterns. Characteristic species include woodnettle, skunk cabbage (*Symplocarpus foetidus*), cinnamon fern (*Osmundastrum cinnamomeum*), hog-peanut (*Amphicarpaea bracteata*), lady fern (*Athyrium felix-femina*), spotted touch-me-not (*Impatiens capensis*), bishop's-cap (*Mitella diphylla*), bulblet fern (*Cystopteris bulbifera*), honewort (*Cryptotaenia canadensis*), enchanter's-nightshade (*Circaea canadensis*), and tall bellflower (*Campanulastrum americanum*).

This site was visited once during the 2017 field season. A total of 92 plant species were documented with 88 native species and 4 non-native species (Appendix 19). The total FQI is 38.4.

Windthrow is frequent in Hinman Cedar Swamp, driving structural and compositional diversity. Photo by Jesse M. Lincoln.

Hinman Cedar Swamp occurs adjacent to the floodplain forest at the base of a moraine where there is a constant seepage of cold, mineral-rich groundwater. Photo by Jesse M. Lincoln.

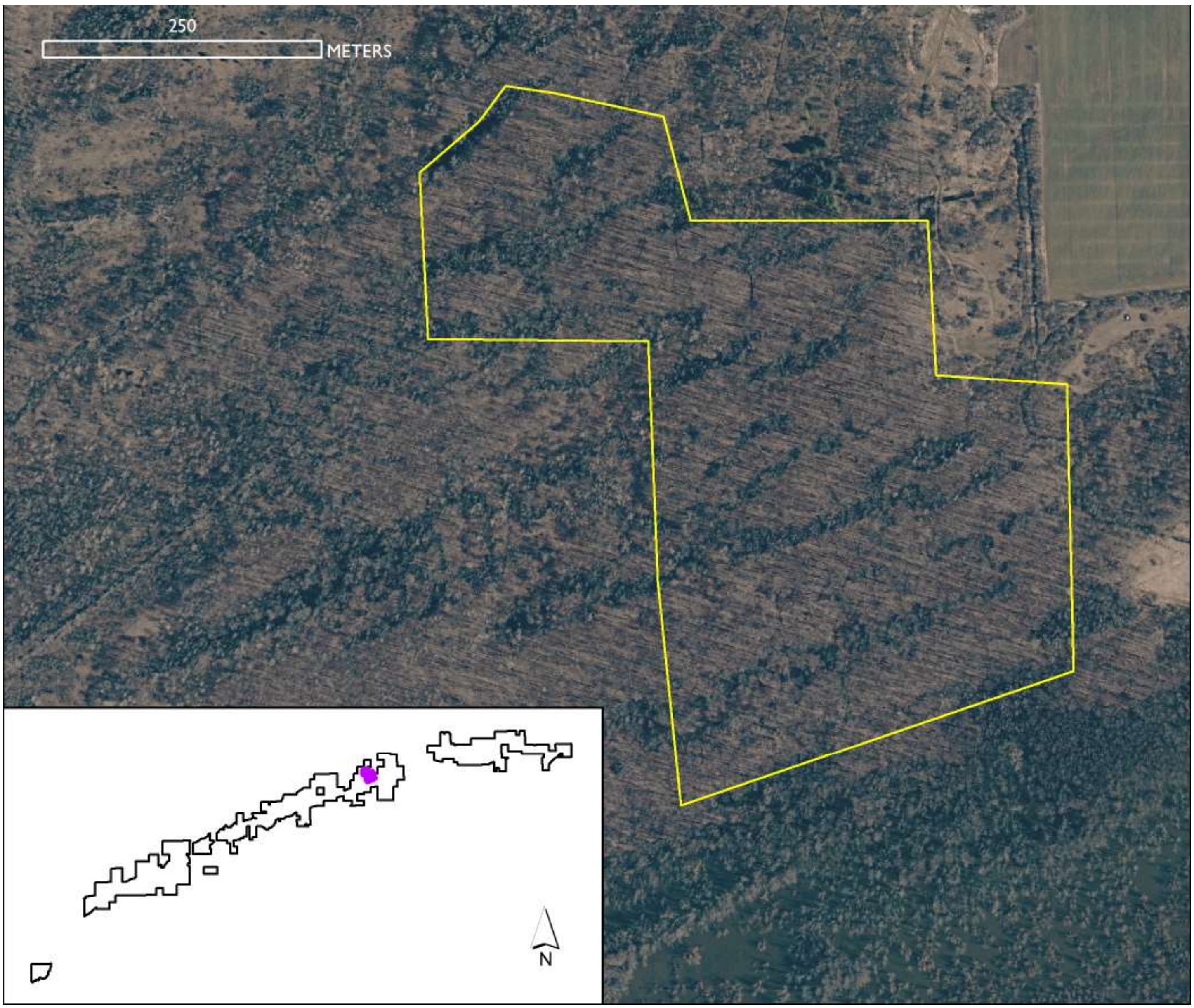
The herbaceous layer of Hinman Cedar Swamp is diverse and complex with zonation driven by windthrow, tip-ups, and areas of constant groundwater seepage. Photo by Jesse M. Lincoln.

Wet-Mesic Flatwoods (G2/G3 S2, imperiled to vulnerable globally and imperiled within state)

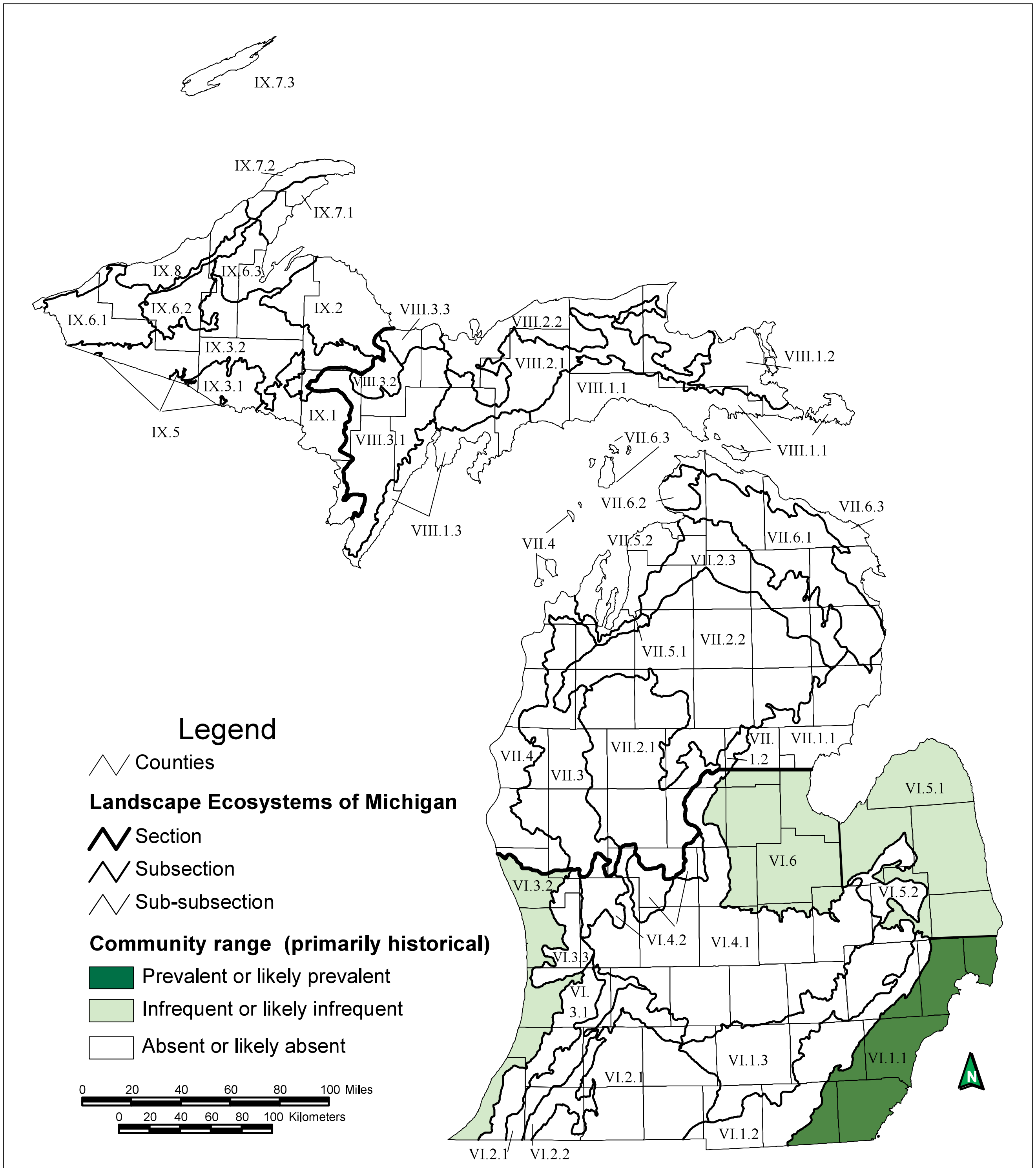
Wilson Woods

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
23184 (New)	C	49	4	70

This is an oak-hickory forest that occurs on the broad, post-glacial alluvium plain that characterizes the eastern portion of Maple River SGA. This is the first documented occurrence of this community type in the Saginaw Bay Lake Plain subsection, though some flatwoods likely occur in Shiawassee State Game Area. This community type is more typical of southeast Michigan and remnants have been documented occurring on lakeplain in southeast and southwest Michigan (Slaughter et al. 2010). The forest occurs above zones impacted by annual flooding of the Maple River and does not flood during significant flooding events associated with the river. Despite extensive ditching throughout the region, seasonal inundation is common due to low relief and an underlying impervious clay layer. Diversity in canopy composition is driven by microtopography and fine-scale gradients in soil moisture and variability in soil moisture throughout the growing season. Soil conditions range spatially and temporally from inundated to saturated to droughty. The soils are slightly acidic (pH 6.0-6.5) coarse, loamy sand with gravel overlying a clay pan at 18”. Glacial erratics are abundant, with some being quite large (>3 ft across).



Aerial imagery of Wilson Woods.



MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Wet-mesic Flatwoods

Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 166 pp.

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Figure 21. Statewide distribution of wet-mesic flatwoods. Wilson Woods is the first documented wet-mesic flatwoods from the Saginaw Bay Lake Plain subsection. Because it is so infrequent in the region, protecting even small occurrences of the natural community type is important for local biodiversity conservation efforts.

Some of the largest trees may be old growth and the site is accruing coarse woody debris, though much is due to the recent loss of ash. The community structure and floristic composition of Wilson Woods is driven by natural processes, including seasonal inundation and saturation, windthrow, and deer herbivory. The closed canopy is characterized by 40 to 100 cm DBH, maturing (~140-year-old) trees, with bur oak, white oak, swamp white oak, and red oak as dominants. Black maple, sugar maple, silver maple, cottonwood, basswood, bitternut hickory, shagbark hickory, and chinquapin oak are important canopy associates. The numerous vernal pools are surrounded by bur oak, swamp white oak, cottonwood, and silver maple. Elm occurs locally in the subcanopy but was likely more prevalent historically. Green and white ash were locally important canopy constituents (5 to 10% of the canopy), with green ash being more dominant around vernal pools. Both species have totally succumbed to the invasion of emerald ash borer and are absent from the canopy. Maples, ironwood, and musclewood generally dominate the subcanopy and understory though ash and elm occur throughout. Low shrubs include spicebush, running strawberry bush, prickly gooseberry, and witch-hazel.

Herbaceous vegetation is diverse as there are zones that are saturated for much of the year and others that are sandier and drier. Characteristic herbaceous species include sedges (*Cx woodii, Cx muskingumensis, Cx gracilima*), violets, sensitive fern, Virginia wild-rye, bottlebrush grass, and jumpseed.

This site was visited once during the 2017 field season. Because it was a relatively late-season survey, only 58 plant species were documented with 56 native species and 2 non-native species (Appendix 20). The total FQI is 32.7 and it is worth revisiting earlier in the year to create a more robust species list.

Additional flatwoods were observed but did not meet the standards for inclusion as EOs (Figure 22). Considering the rarity of the system and the lack of natural cover in the watershed, drawing attention to these relatively high-quality stands is warranted, particularly for the application of prescribed fire.

Wilson Woods is dominated by large diameter oaks. Photo by Jesse M. Lincoln.

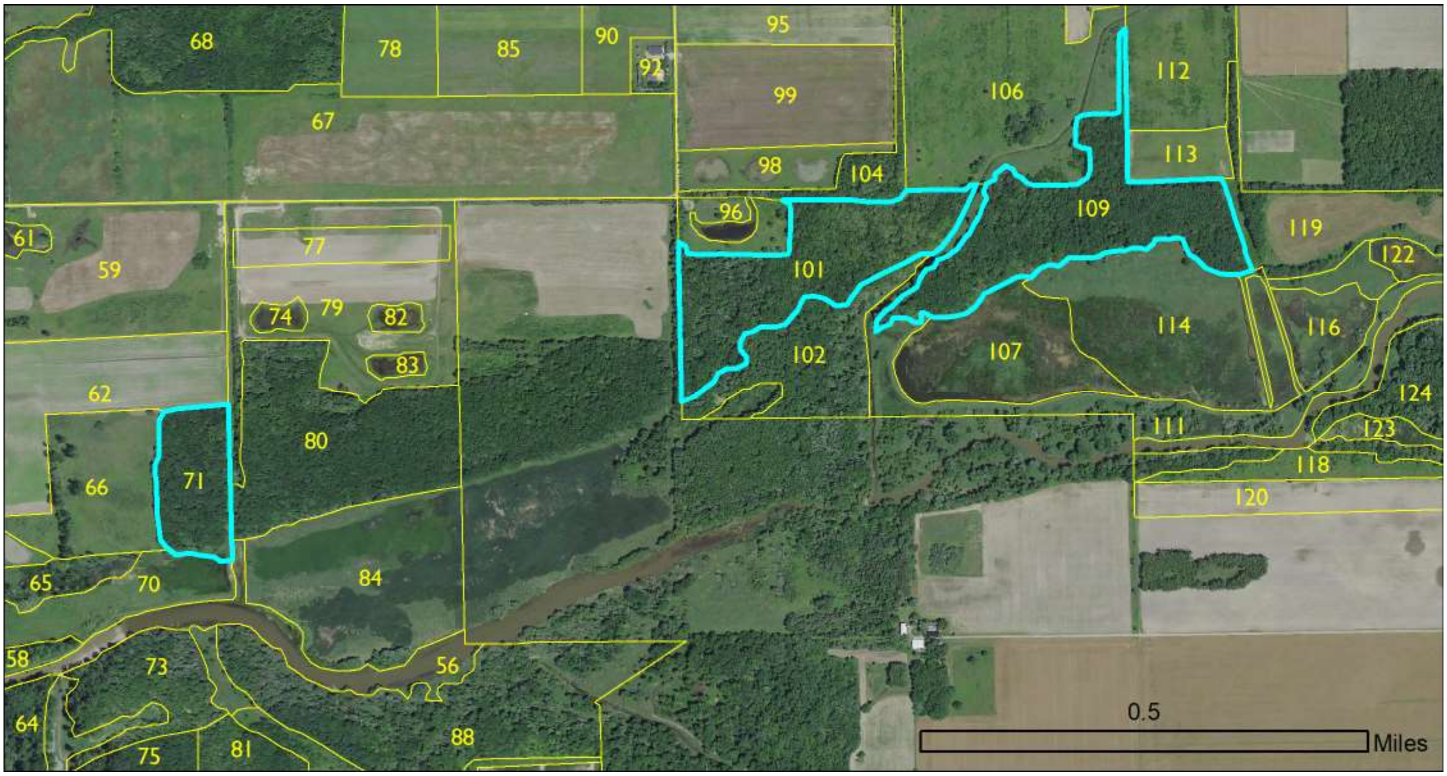


Figure 22. Additional flatwoods of conservation value occur in Compartment 5 in Stands 71, 101, and 109. These have concentrations of rare plants and vernal pools and should be prioritized for late-season prescribed burns.

The areas of flatwoods identified for conservation generally have an abundance of vernal pools and support rare species. Based on descriptions by Houghton and Hubbard from 1837 and the abundance of indigenous peoples in the region, these sites may have been burned historically and should be prioritized for fall or winter burns. Above is Compartment 5, Stand 71. Photo by Jesse M. Lincoln.

Birds

We completed rare raptor surveys at 69 points within the game area (Figure 13, pg. 18). Red-shouldered hawks were detected at 3 (3%) of the points visited. No active RSHA nests were seen. One red-tailed hawk nest was recorded from Compartment 3, Stand 8.

Forest songbird surveys were conducted at 137 points within forested stands (Figure 14, pg. 20). One hundred and nine singing male prothonotary warblers were recorded at 30 survey points within the Maple River floodplain. These prothonotary warbler observations were considered part of the existing EO (EO ID 2327) for this species. We recorded 17 singing male cerulean warblers at 10 points within Maple River SGA (Figure 23). These cerulean warbler observations are considered part of the existing EO (EO ID 9622). The only newly documented bird EO from these survey efforts was of red-headed woodpecker. Three vocalizing red-headed woodpeckers were recorded at two adjacent points and entered into the Natural Heritage database (Table 3, Figure 23).

We recorded a total of 69 bird species during forest songbird at the Maple River SGA (Appendix 10). The seven most commonly detected species were: eastern wood-pewee (*Contopus virens*; 61% of points), red-bellied woodpecker (*Melanerpes carolinus*; 53% of the points) red-eyed vireo (*Vireo olivaceus*; 49% of points), American robin (*Turdus migratorius*; 41 % of the points), and song sparrow (*Melospiza melodia*; 41% of the points). The following twenty species were regularly observed (20-39% of points surveyed): rose-breasted grosbeak (*Pheucticus ludovicianus*), common grackle (*Quiscalus quiscula*), northern cardinal (*Cardinalis cardinalis*), great-crested flycatcher (*Myiarchus crinitus*), white-breasted nuthatch (*Sitta carolinensis*), Acadian flycatcher (*Empidonax virescens*), blue jay (*Cyanocitta cristata*), Baltimore oriole (*Icterus galbula*), brown-headed cowbird (*Molothrus ater*), downy woodpecker (*Picoides pubescens*), blue-gray gnatcatcher (*Polioptila caerulea*), scarlet tanager (*Piranga olivacea*), tufted titmouse (*Baeolophus bicolor*), red-winged blackbird (*Agelaius phoeniceus*), prothonotary warbler (*Protonotaria citrea*), wood thrush (*Hylocichla mustelina*), hairy woodpecker (*Picoides villosus*), yellow warbler (*Setophaga petechia*), yellow-billed cuckoo (*Coccyzus americanus*), and mourning dove (*Zenaida macroura*). Thirteen (19%) of the species were detected at 10 to 19% of the survey points and 31 species (45%) were detected at less than 10% of the survey points. On average, we recorded 10.4 bird species per point count station.

Table 3. Rare bird element occurrences and birds of special conservation status found within Maple River State Game Area. State status abbreviation are as follows: SC, state special concern; T, state threatened, and; E, state endangered. Rank abbreviations are as follows: BC, good to fair viability; C, fair viability; D, poor estimated viability; H, historic record, and; E, verified extant but with insufficient information to rank viability.

Common Name	Scientific Name	EO ID	EO Rank	State Status	Featured Species	SGCN	JV Focal species	Year First Observed	Year Last Observed
Listed Species									
Henslow's sparrow	*Ammodramus henslowii*	2776	E	E		X	X	2000	2001
Grasshopper sparrow	*Ammodramus savannarum*	16610	D	SC		X	X	2007	2007
Short-eared owl	*Asio flammeus*	23008	H	E		X		1993	1997
American bittern	*Botaurus lentiginosus*	13380	E	SC		X		2003	2003
Marsh wren	*Cistothorus palustris*	13381	C	SC				2003	2019
Bald eagle	*Haliaeetus leucocephalus*	1647	E	SC		X		2001	2017
Bald eagle	*Haliaeetus leucocephalus*	7381	H	SC		X		1993	1996
Bald eagle	*Haliaeetus leucocephalus*	19096	E	SC		X		2012	2012
Bald eagle	*Haliaeetus leucocephalus*	21584	E	SC		X		2017	2017
Red-headed woodpecker	*Melanerpes erythrocephalus*	23671	E	SC	X	X	X	2019	2019
Osprey	*Pandion haliaetus*	5054	E	SC	X	X		2002	2002
Osprey	*Pandion haliaetus*	21913	E	SC	X	X		2016	2017
Prothonotary warbler	*Protonotaria citrea*	2327	BC	SC		X	X	2000	2019
Prothonotary warbler	*Protonotaria citrea*	16440	BC	SC		X	X	2006	2019
King rail	*Rallus elegans*	1878	C	E		X		1998	1998
Cerulean warbler	*Setophaga cerulea*	9622	C	T		X	X	2000	2019
Unlisted Species									2019
Wood duck	*Aix sponsa*				X		X		2019
Mallard	*Anas platyrhynchos*				X				2019
Veery	*Catharus fuscescens*				X		X		2019
Pileated woodpecker	*Dryocopus pileatus*				X				2019
Wood thrush	*Hylocichla mustelina*				X				2019
Wild Turkey	*Meleagris gallopavo*				X				2019
Easter bluebird	*Sialia sialis*				X				2019

Maple River State Game Area harbors substantial habitat for several rare bird species, including red-headed woodpecker (*Melanerpes erythrocephalus*, top) and prothonotary warbler (*Protonotaria citrea*, bottom). Photos by Aaron P. Kortenhoven.

Thirteen points were surveyed for marsh birds in the game area during 2019. Prior to our surveys, EOs had been documented within the game area for American bittern (EO ID 13380), king rail (EO ID 1878), and marsh wren (EO ID 13381). We reconfirmed the presence of marsh wren in the game area and added new locations within Units B and D. Although king rail and American bittern were not detected during surveys, potential habitat remains for these species. We observed 15 marsh wrens (*Cistothorus palustris*, special concern) at six (46%) of the survey points.

Several other bird species were documented in Maple River SGA while conducting marsh bird surveys in 2019. Swamp sparrow was the most common species observed during surveys, being detected at 69% of the survey points. Canada goose (*Branta canadensis*) was observed at 46% and great blue heron (*Ardea herodias*) at 38% of the survey points. Double-crested cormorant (*Phalacrocorax auritus*) and sandhill crane (*Grus canadensis*) were observed at 23% of the points. Osprey (*Pandion haliaetus*, special concern), Pied-billed grebe (*Podilymbus podiceps*), Virginia rail, sedge wren (*Cistothorus platensis*), and mallard (*Anas platyrhynchos*) were detected at 15% of the survey points, and wood duck (*Aix sponsa*), great egret (*Ardea alba*), and Caspian tern (*Hydroprogne caspia*, state threatened) were only observed at a single survey station and not likely to be nesting in the game area.

Several of the bird species detected in 2019 have special conservation status (Table 3). Five species are considered featured species for habitat management by the Wildlife Division of the MDNR. These featured species are wood duck (*Aix sponsa*), red-headed woodpecker (*Melanerpes erythrocephalus*), pileated woodpecker (*Dryocopus pileatus*), wood thrush, and wild turkey (*Meleagris gallopavo*). Red-shouldered hawk, red-headed woodpecker, veery, and wood thrush are also considered SGCN (Derosier et al. 2015), as are prothonotary warbler and cerulean warbler. In addition, we observed four species (red-headed woodpecker, veery, wood thrush, and cerulean warbler) that are considered focal species for conservation efforts under the Landbird Habitat Conservation Strategy (Potter et al. 2007) of the Upper Mississippi River and Great Lakes Region Joint Venture.

Additional species detected during past surveys of grasslands and wetlands, but not detected in 2019, also have special status. Past survey work focusing on grasslands documented Henslow's sparrow (*Ammodramus henslowii*, state endangered) and grasshopper sparrow (*Ammodramus savannarum*, state special concern). Henslow's sparrow is also a Joint Venture focal species (Potter et al. 2007). These grassland birds were recorded in the state game area east of US-127 in an area containing several grass plantings. American bittern and king rail were recorded in past surveys of the managed marsh impoundments and are both considered Joint Venture focal species for the Wetland Habitat Conservation Strategy (Soulliere et al. 2018). American bittern is also a statewide featured species for habitat management by the MDNR.

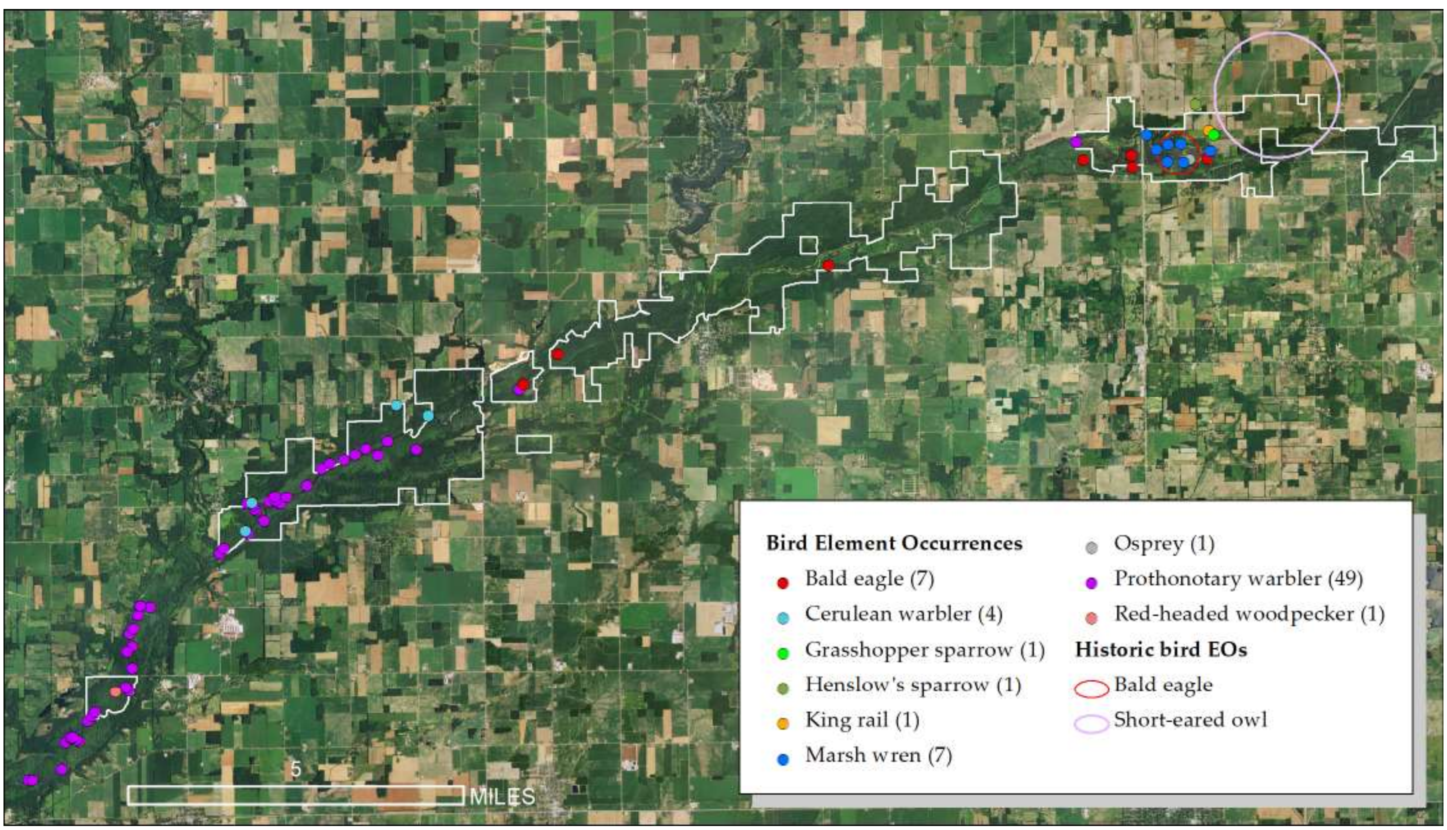


Figure 23. Location of rare bird element occurrences in the Maple River State Game Area

Excellent habitat for cerulean warblers (*Setophaga cerulea*, state threatened) exists throughout the floodplain forest of the Maple River State Game Area. Photo by Aaron P. Kortenhoven.

Sandhill cranes (*Antigone canadensis*) were frequently observed in the East Unit of the Maple River State Game Area. Photo by Aaron P. Kortenhoven.

Mussels

Mussel surveys documented one new EO and updated and geographically expanded five existing EOs (Table 4, Figure 24). Aquatic surveys were performed at eight sites within Maple River SGA and visual searches of the riverbank occurred at two locations (Table 1, Figure 15, pg. 22). A total of 15 unionid mussel species were found including one state endangered and one state threatened species, and four species of special concern (Table 4). These six species are also SGCN. Eight of the 15 species found were represented by live individuals and seven by shells only. Stream substrate at aquatic survey sites was generally favorable for native mussels except for Sites 5 and 6, which were dominated by silt and sand respectively (Appendix 1). Aquatic vegetation and woody debris were present at most sites, providing cover and habitat structure for potential host fish (Appendix 3).

Two shells of the state endangered lilliput (*Toxolasma parvum*) were found at Site 4 in the main stem of the Maple River. These shells were part of a shell midden, likely created by muskrats, along with shells from seven other species. The lilliput occurrence is significant because the species is critically imperiled (S1; Badra et al. 2014) and only 27 records remain in the state, with many of these being historical occurrences in waterbodies heavily impacted by habitat alteration and zebra mussels. Based on historical (pre-1960) records from the University of Michigan Museum of Zoology Mollusk Collection, lilliput was present in eight of Michigan's 58 major watersheds (8-digit HUC) and 12 counties, but the species has only been found in eight counties since 2000. Johnny darter (*Etheostoma nigrum*), host fish for lilliput and slippershell, were found at mussel survey Sites 1 and 8. Fish species known to be suitable hosts for Lilliput are Johnny darter, green sunfish (*Lepomis cyanellus*), warmouth (*Lepomis gulosus*), orangespotted sunfish (*Lepomis humilis*), bluegill (*Lepomis macrochirus*), and white crappie (*Pomoxis annularis*).

Four shells of the state threatened slippershell (*Alasmidonta viridis*) were found at Site 8 in Hayworth Creek. Slippershell (state threatened) was present in 36 of Michigan's 58 major watersheds historically, and at least 22 watersheds since 1989. Although records for slippershell are relatively widespread in Michigan, the species is considered imperiled/vulnerable (S2S3; Badra et al. 2014) and most recent records for this species, including our 2019 Maple River observations, are of empty shells.

Marks made by a predator on a Wabash pigtoe (*Fusconaia flava*) shell found at aquatic survey site 4. Photo by Peter J. Badra.

Table 4. Rare mussel element occurrences within Maple River State Game Area. Status abbreviations are as follows: E, federally endangered and/or state endangered; T, state threatened; SC, species of special concern. Element occurrence (EO) rank abbreviations are as follows: E, verified extant; H, historical.

Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Rank	Year First Observed	Year Last Observed	Survey Site #	EOs	in SGA
Elktoe	*Alasmidonta marginata*	SC		18171	E	2001	2001	>5km away from site 8		x
Elktoe	*Alasmidonta marginata*	SC		23675	E	2019	2019	8	new	x
Slippershell	*Alasmidonta viridis*	T		17820	E	1934	2010	>5km away from site 8		x
Slippershell	*Alasmidonta viridis*	T		23677	E	2019	2019	8	new	x
Rainbow	*Cambarunio iris*	SC		18448	H	1934	1934	US-127		x
Rainbow	*Cambarunio iris*	SC		18449	H	1934	1934	Maple Rapids		x
Snuffbox	*Epioblasma triquetra*	E	E	402	E	2001	2001	0.8km upstream of SGA		
Creek heelsplitter	*Lasmigona compressa*	SC		20976	H	1934	1934			x
Flutedshell	*Lasmigona costata*	SC		21119	E	1934	2011		parentEO	x
Flutedshell	*Lasmigona costata*	SC		23678	E	2019	2019	8	subEO	x
Black sandshell	*Ligumia recta*	E		19465	E	2010	2010	Maple Rapids		x
Round pigtoe	*Pleurobema sintoxia*	SC		18336	H	1934	1934	US-127		x
Lilliput	*Toxolasma parvum*	E		23680	E	2019	2019	4	new	x
Paper pondshell	*Utterbackia imbecillis*	SC		18093	H	1934	1934	downstream of SGA	subEO	
Paper pondshell	*Utterbackia imbecillis*	SC		23681	E	2019	2019	3	subEO	x
Paper pondshell	*Utterbackia imbecillis*	SC		23682	E	2019	2019	4	subEO	x
Paper pondshell	*Utterbackia imbecillis*	SC		23683	E	2019	2019	5	subEO	x
Paper pondshell	*Utterbackia imbecillis*	SC		23684	E	2019	2019	6	subEO	x
Paper pondshell	*Utterbackia imbecillis*	SC		23685	E	2019	2019	7	parentEO	x
Paper pondshell	*Utterbackia imbecillis*	SC		23686	E	2019	2019	A	subEO	x
Paper pondshell	*Utterbackia imbecillis*	SC		23687	E	2019	2019	B	subEO	x
Ellipse	*Venustaconcha ellipsiformis*	SC		18049	H	1934	1934			x
Ellipse	*Venustaconcha ellipsiformis*	SC		23679	E	2019	2019	8	new	x

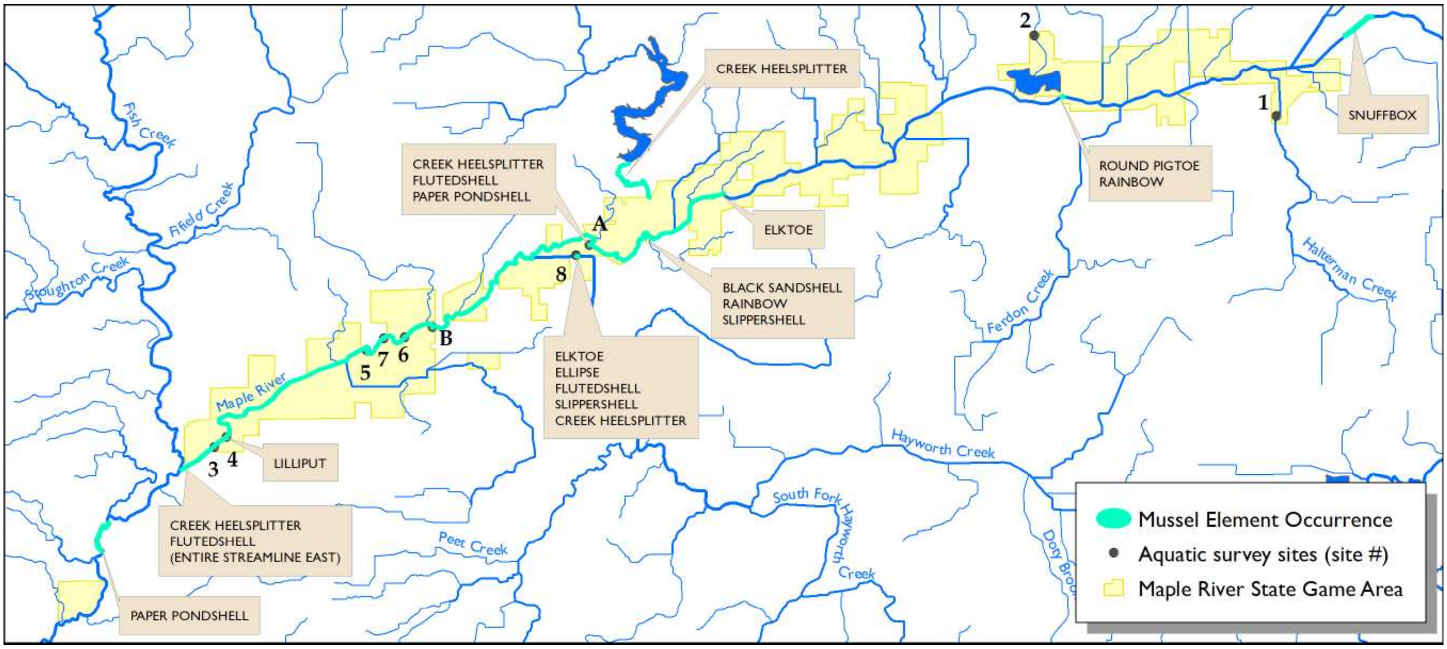


Figure 24. Location of rare mussel EOs in the Maple River State Game Area.

Native mussel shells in a midden created by a muskrat (*Ondatra zibethicus*) or other predator at aquatic survey site 4 along the Maple River. Photo by Peter J. Badra.

Although no snuffbox (*Epioblasma triquetra*, federally endangered) were found in this survey, there is potential for the species to occur within Maple River SGA. Live snuffbox were documented as close as 8.5 river miles (14 km) downstream of Hubbardston Rd. in 2016. There is a historical record for snuffbox 0.5 miles (800 m) upstream of Maple River SGA and a 2001 record for live snuffbox 11.4 miles (18.2 km) upstream of the SGA. Known fish hosts for slippershell are Johnny darter, mottled sculpin (*Cottus bairdi*), and banded sculpin (*Cottus carolinae*).

No zebra mussels (*Dreissena polymorpha*) or Asian clams (*Corbicula fluminea*) were found at any sites surveyed. Live aquatic snails (Gastropoda) were noted at five of the eight sites (Appendix 4). Fingernail clams (Sphaeriidae) were observed at five survey sites and Crayfish (Decapoda) were noted at only two sites. Johnny darter (*Etheostoma nigrum*), one of the fish species known to act as a host for the state endangered lilliput and state threatened slippershell, was observed at Site 1 in Halterman Creek and Site 8. Largemouth bass (*Micropterus salmoides*) was noted at two sites in the Maple River main stem.

A very unusual shell was found at Site 7 (photo below). This individual apparently grew into a unique shape because of past injury and/or parasite. Though the shell is most likely an abnormal pimpleback (*Cyclonaias pustulosa*), Wabash pigtoe (*Fusconaia flava*), or round pigtoe (*Pleurobema sintoxia*), its shape resembles Ohio pigtoe (*Pleurobema cordatum*), a species not considered native to Michigan despite the existence of several historical museum records. One of these occurrences, recorded by Dr. R.J. Kirkland pre-1900 and housed in the New Brunswick Museum mollusk collection, is from the Grand River Watershed (Wabasis Creek) about 25 miles west of Maple River SGA (New Brunswick Museum 2020). Though this shell found at Site 7 has been compared to specimens at the University of Michigan Museum of Zoology mollusk collection and the opinions of five other mussel biologists were solicited, its identification is still unknown. Due to the abnormal shape of the shell, genetic evidence would likely be needed in order to confidently identify it to species.

An unusual, unidentifiable mussel shell found in the Maple River at aquatic survey site 7. This shell likely grew into an abnormal form because of an injury or parasite. Photo by Peter J. Badra.

Lilliput (*Toxolasma parvum*, left), a state endangered mussel found in a shell midden at aquatic survey site 4 along the Maple River. A non-native Chinese mysterysnail (*Cipangopaludina chinensis*, right) found along the banks of the Maple River. Photos by Peter J. Badra.

Aquatic survey site 8. Photo by Peter J. Badra.

Reptiles and Amphibians

Amphibian and reptile surveys in the Maple River SGA in 2019 documented one rare reptile species and ten common amphibian and reptile species (Table 5, Figure 25, Appendix 11). One Blanding's turtle was observed partially submerged in water on August 26 during visual encounter/ basking surveys, and two large adult male Blanding's turtles were captured on September 3 and 5 during aquatic funnel trapping surveys. These observations represented a new Blanding's turtle EO in the Michigan Natural Heritage Database. This population was ranked as having fair estimated viability, which means based on available information regarding this population's current condition, size, and landscape context, it is believed to have a fair probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years. This EO was ranked as having fair estimated viability due to the small number of Blanding's turtle observations that have been documented at this site, lack of evidence of population recruitment occurring, and landscape context dominated by agricultural lands, rural residential homes, and roads including US-127.

We detected the following common amphibian and reptile species during herptile surveys in 2019: northern leopard frog (*Lithobates pipiens*), green frog (*Lithobates clamitans*), eastern gray treefrog (*Hyla versicolor*), eastern American toad (*Anaxyrus americanus americanus*), wood frog (*Lithobates sylvaticus*), western chorus frog (*Pseudacris triseriata triseriata*), eastern snapping turtle (*Chelydra serpentina serpentina*), northern map turtle (*Graptemys geographica*), painted turtle (*Chrysemys picta*), and eastern spiny softshell (*Apalone spinifera spinifera*) (Appendix 11). Painted turtles were the most abundant turtle species captured during aquatic funnel trapping surveys in Maple River SGA, with 146 captures including adults and subadults or juveniles. Twenty-one snapping turtles and one eastern spiny softshell also were captured during trapping surveys. Painted turtles and northern map turtles were the most abundant species observed during basking surveys. Northern leopard frogs and wood frogs were the most abundant species documented during MNFI's visual encounter surveys. They were commonly observed on the dikes and trails around the large emergent wetlands in the East Unit and/or in the extensive floodplain forest along the Maple River west of Tallman Road.

Additionally, reports of rare amphibian and reptile species from the Michigan Herp Atlas (Michigan Herp Atlas 2019) confirmed the occurrence of Blanding's turtles and added a new element occurrence of Butler's gartersnake in Maple River SGA (Figure 25). An adult Blanding's turtle was observed basking on a log in a wetland on May 13, 2018 in the same area in which the species was documented during MNFI's herptile surveys in 2019. Two observations of Butler's gartersnakes were reported on April 15 and July 8, 2006 from the same general area in which Blanding's turtles have been found in the game area. The viability of the Butler's gartersnake EO was ranked as extant given lack of available information to estimate viability of this population at this time.

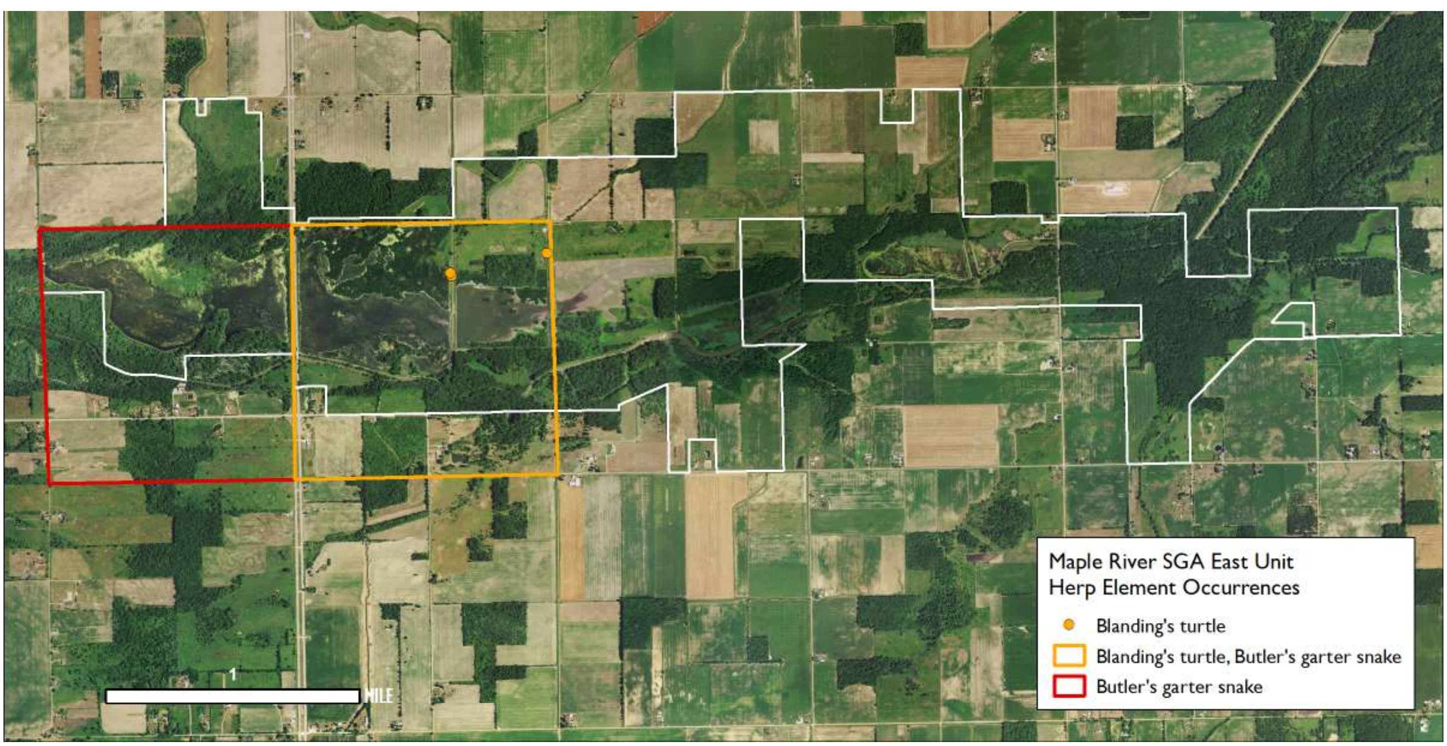


Figure 25. Location of rare herptiles documented in Maple River State Game Area.

Table 5. Rare reptile element occurrences within Maple River State Game Area. Status abbreviation of SC signifies a species of special concern. Element occurrence rank abbreviations of C signifies fair viability and a rank of E signifies verified extant but with insufficient information to rank viability.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Blanding's Turtle	*Emydoidea blandingii*	SC	23625	C	2018	2019
Butler's Gartersnake	*Thamnophis butleri*	SC	23626	E	2006	2006

Butler's gartersnake. Photo by Josh Vandermuelen, Creative Commons.

Insects

No rare insects were found during 2019 surveys and none had been documented prior to 2019, although habitat exists for all targets. The best chance for a rare insect species to occur within the game area is the regal fern borer as the SGA is within the core range of this species. For Duke's skipper, the Maple River SGA is about 80 miles north of the next nearest known location (Jackson County) and therefore may be outside the range for this butterfly. The inland salt marshes that we surveyed for angular spittlebug appear to be too degraded to support sufficient host plant habitat for the species. However, the key area in Hubbard's Salt Lick (EO ID 7963; Compartment 2 Stand 100) was not surveyed, so future surveys should target the halozone within this marsh.

We identified several non-target butterfly and skipper species during diurnal surveys, including least skipperling (*Ancyloxypha numitor*), red-spotted purple (*Limenitis arthemis*), American lady (*Vanessa virginiensis*), painted lady (*Vanessa cardui*), pearl crescent (*Phyciodes tharos*), silver spotted skipper (*Epargyreus clarus*), summer azure (*Celastrina neglecta*), monarch (*Danaus plexippus*), red admiral (*Vanessa atalanta*), cabbage white (*Pieris rapae*), Appalachian brown (*Satyrodes appalachia*), eastern comma (*Polygonia comma*), Dion skipper (*Euphyes dion*), and broad-winged skipper (*Poanes viator*), the last of which is a new county record.

Though no target rare moth species (*Papaipema speciosissima)* were observed at any of the sites, we identified two non-target *Papaipema* species. At Site 1, two adult *Papaipema arctivorens* (burdock borer moth) were collected. At Site 2, two *Papaipema arctivorens* and one *Papaipema nebris* were collected, neither of which are rare in Michigan. However, habitat and larval host plants for *P. speciosissima* remain in the area so it is possible the moth occurs here. It could occur anywhere in the game area where populations of their larval host plants (*Osmundia* sp.) are abundant.

Plants

Prior to the MiFI surveys there were 10 existing rare plant EOs. During this project, 15 additional rare plant EOs were opportunistically documented during MiFI vegetation surveys or natural community evaluations (Table 5, Figures 24, 25, and 26). The Maple River watershed is near the northern extent of many plant species' ranges and plant collections made during ecological surveys resulted in new county records for dozens of species, including some rare taxa. Olney's bulrush and dwarf spike-rush are halophytes and their populations in Michigan are restricted to the inland salt marshes (Figure 26). Hubbard's Salt Lick is the last place in the state where these species remain, though they had historically been documented in the Clinton-Saltworks inland salt marsh EO across the river. Several species are associated with the floodplain forest, including Davis' sedge, Cattail sedge, beak grass, and heart-leaved plantain (Figure 26). Other species are associated with flatwoods in the East Unit, including *Carex squarrosa*, pumpkin ash, and red mulberry (Figure 28). The remaining rare species are generally associated with mature upland forests, including twinleaf, broad-leaved puccoon, *Carex lupuliformis*, and ginseng (Figures 26 and 27).

Twinleaf (*Jeffersonia diphylla*, state threatened) from a mesic southern forest. Photo by Nathan Martineau.

Table 6. Rare plant element occurrences within Maple River State Game Area. Status abbreviations are as follows: E, state endangered; T, state threatened; SC, species of special concern. EO rank abbreviations are as follows: A, excellent estimated viability; AB, excellent to good estimated viability; B, good estimated viability; BC, good to fair estimated viability; C, fair estimated viability; CD, fair to poor estimated viability; D, poor estimated viability; and H, historic record.

Scientific Name	Common Name	EOID	State Status	Rank	Last Observed Date	Compartment	Stand
Carex davisii	Davis' sedge	13357	SC	C	2001	4	8
Carex lupuliformis	False hop sedge	**19817	T	AB	2013	4	22
*Carex squarrosa**	Sedge	**20127	SC	B	2013	5	101
*Carex squarrosa**	Sedge	**20128	SC	CD	2013	5	55
*Carex squarrosa**	Sedge	**20129	SC	CD	2013	5	141, 142
Carex typhina	Cattail sedge	7634	T	H	1960	2	74, 96
Carex typhina	Cattail sedge	**13438	T	A	2016	2	24, 29 35, 51
Carex typhina	Cattail sedge	**20130	T	B	2019	2	98
Diarrhena obovata	Beak grass	13356	T	C	2003	4	9, 10
Eleocharis parvula	Dwarf spike-rush	1006	E	H	1982	2	75
Eleocharis parvula	Dwarf spike-rush	23672	E	BC	2019	2	100
Fraxinus profunda	Pumpkin ash	**20121	T	D	2013	5	88
Jeffersonia diphylla	Twinleaf	4602	SC	B	2013	2	102
Jeffersonia diphylla	Twinleaf	16059	SC	B	2006	3	104
Jeffersonia diphylla	Twinleaf	**20123	SC	C	2016	2	28
Lithospermum latifolium	Broad-leaved puccoon	**20126	SC	CD	2016	2	28
*Morus rubra**	Red mulberry	**19804	T	C	2013	4	39
*Morus rubra**	Red mulberry	**20133	T	CD	2013	5	46, 55
*Morus rubra**	Red mulberry	**20134	T	C	2013	5	101, 109
Panax quinquefolius	Ginseng	**19730	T	CD	2013	2	76
Plantago cordata	Heart-leaved plantain	12244	E	B	2019	1	4
Schoenoplectus americanus	Olney's bulrush	1668	E	H	1837	5	11
Schoenoplectus americanus	Olney's bulrush	3605	E	H	1982	2	75
Schoenoplectus americanus	Olney's bulrush	**23349	E	BC	2019	2	100

* denotes a record that is the first documented occurrence of the species in that county

** denotes a new record as a result of Integrated Inventory

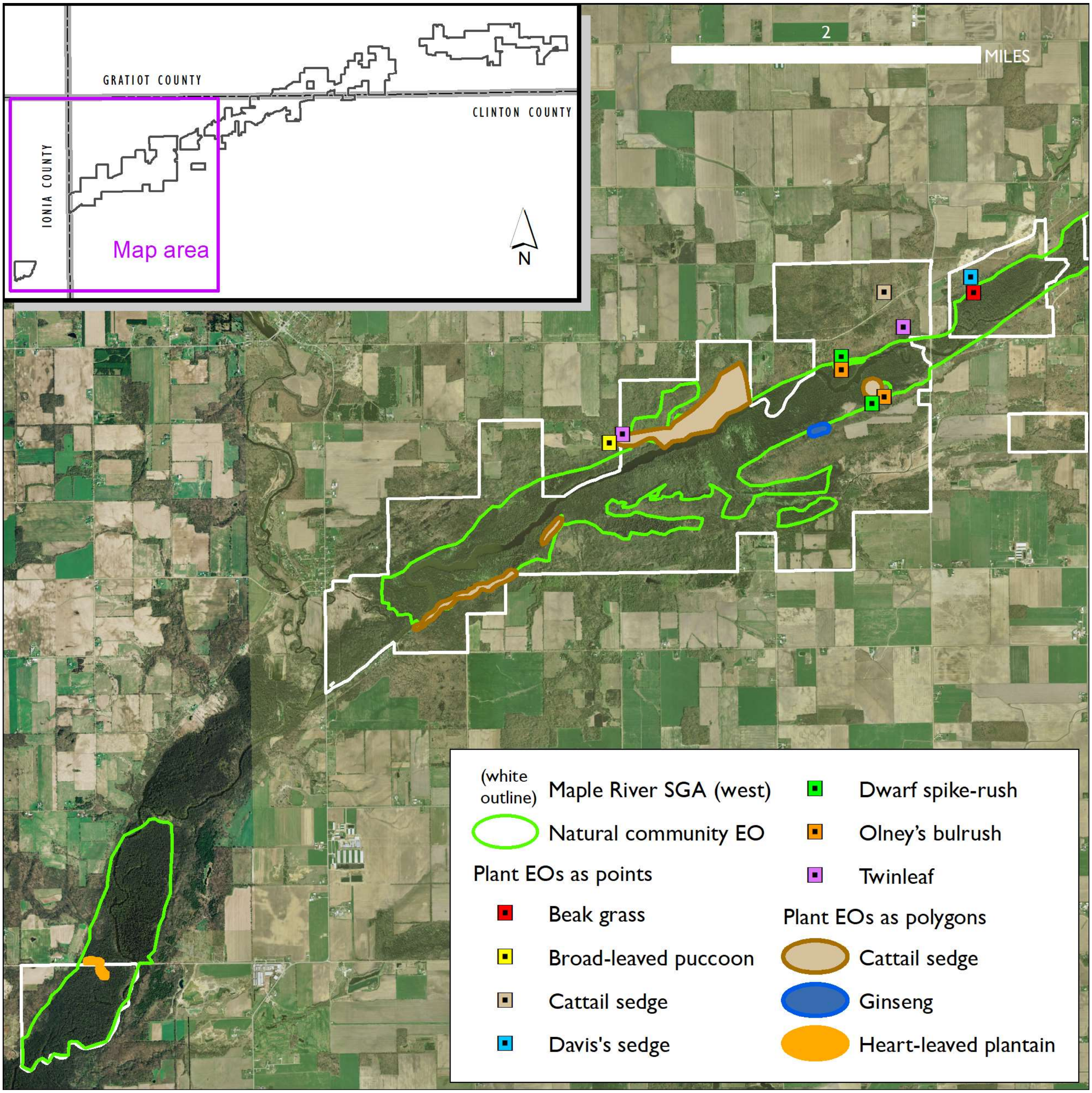


Figure 26. Location of rare plants in the western portion of Maple River State Game Area.

Heart-leaved plantain (*Plantago cordata*, state threatened) has been documented from the Nickle Plate Floodplain Forest in Compartment 1, Stand 4. Photo by Nathan Martineau.

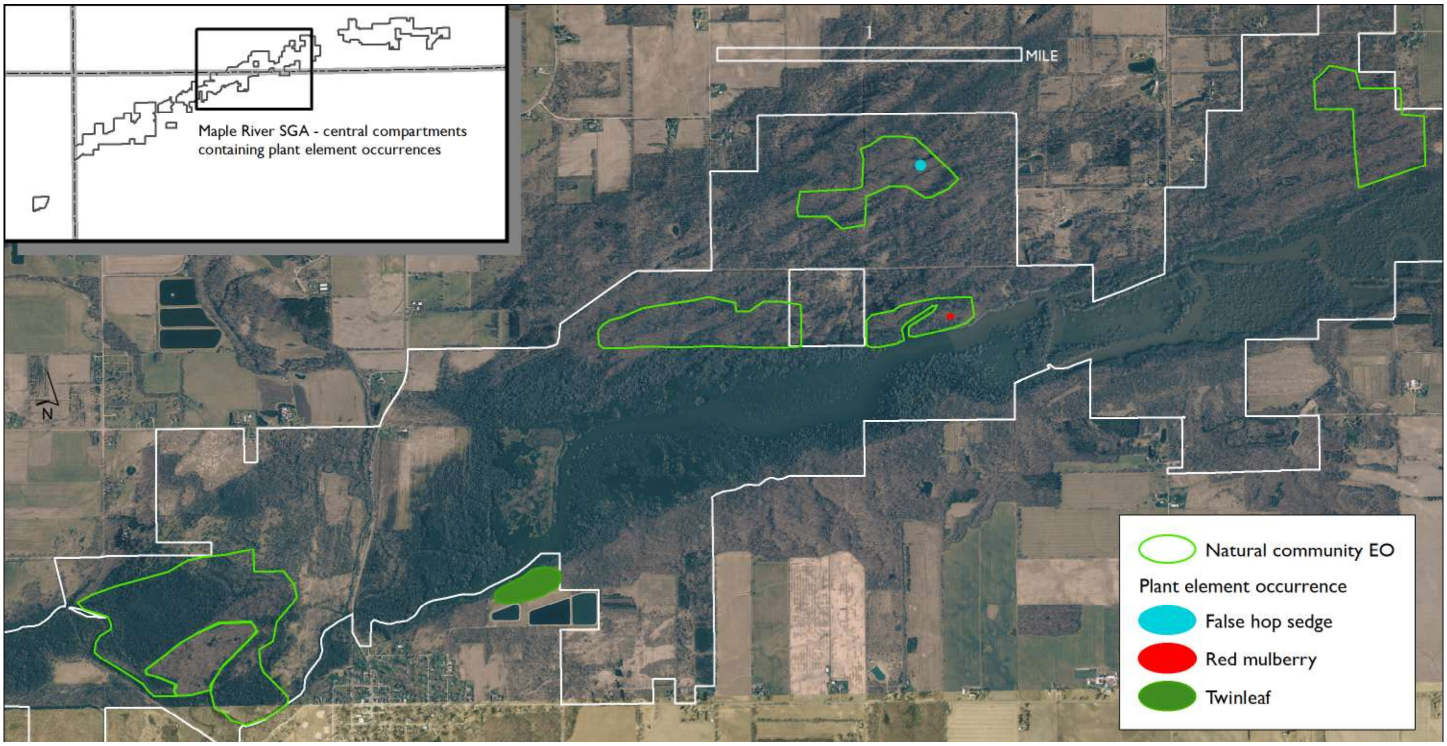
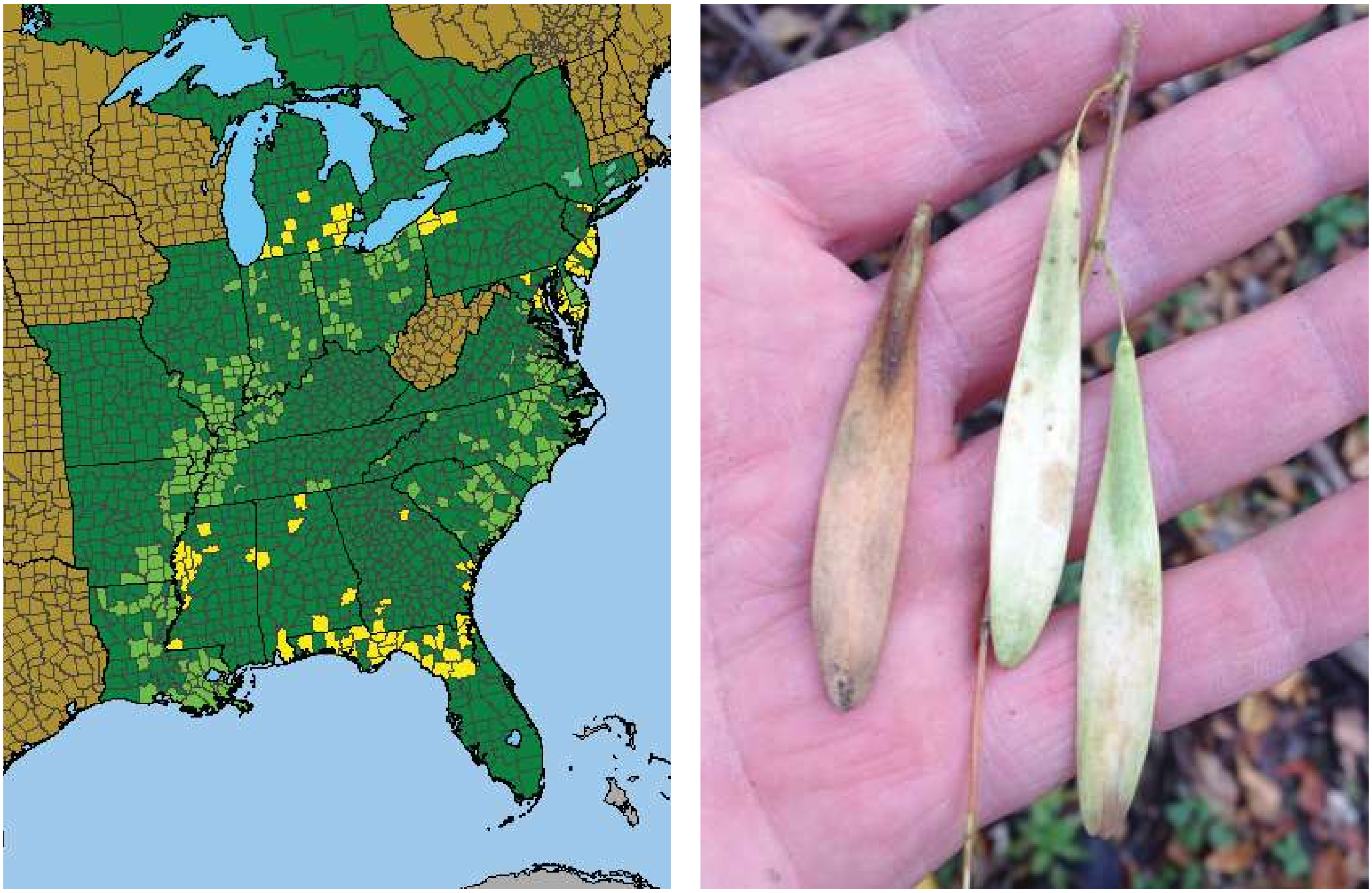


Figure 27. Location of rare plants in the central portion of Maple River State Game Area.



The distribution of pumpkin ash (*Fraxinus profunda*, state threatened; left) features populations along the Mississippi River valley and the Atlantic and Gulf Coast (map by Kartesz 2018). Dark green indicates the species is present in the state. Light green indicates the species is present in the county and not rare. Yellow indicates the species is present in the county and rare. The population documented during ecological surveys represents the northern extent of the species' range. It is characterized by very large samaras (right). Photo by Jesse M. Lincoln.

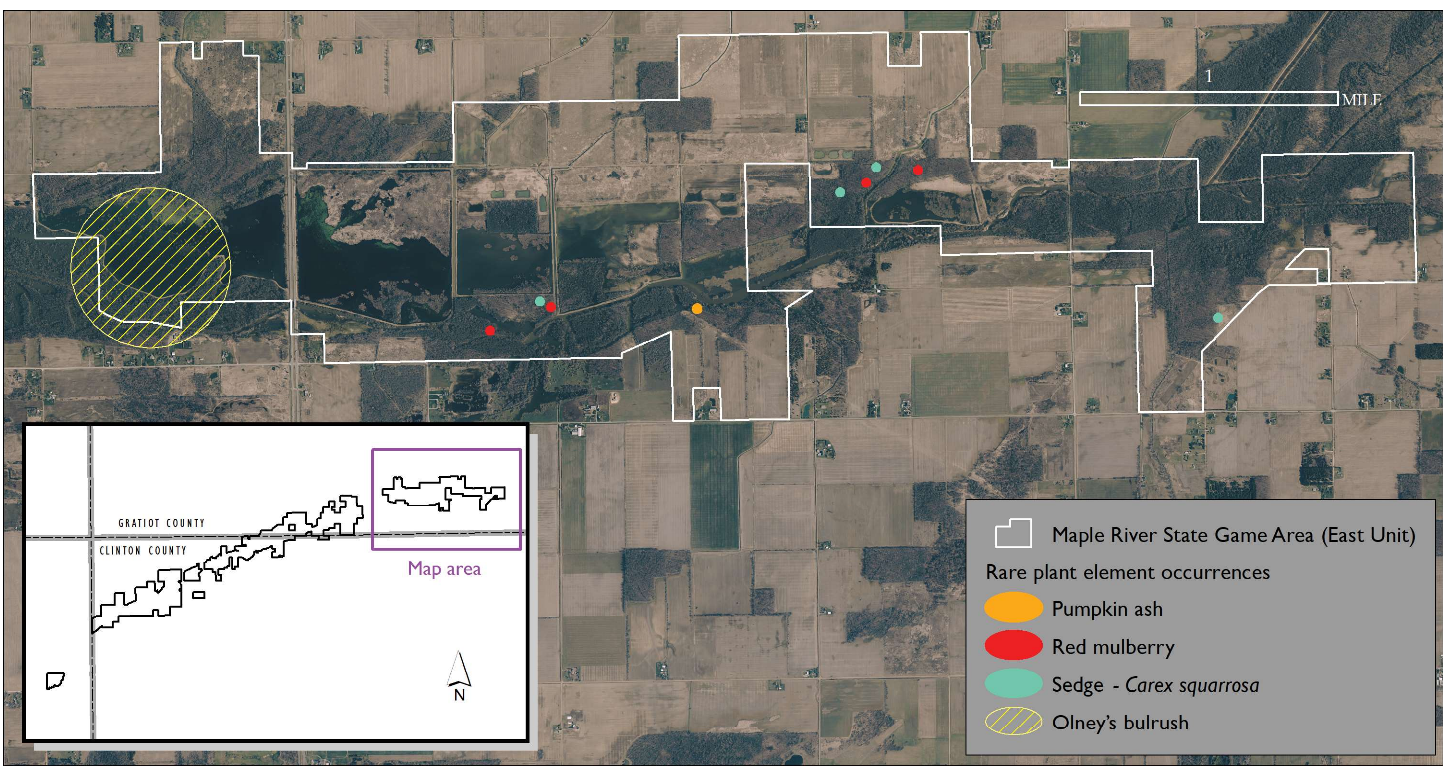


Figure 28. Location of rare plants in the East Unit.

Geographic Weighted Overlay Model

We generated a weighted overlay model to identify stewardship priorities by selecting input variables that capture a stand's biodiversity, resilience, integrity, and ecosystem services. Each input variable was assigned a score from 0 to 5, multiplied by a weighting factor based on our assessment of the importance of that variable, and then all scores were summed to derive a biodiversity stewardship score for each stand. To visualize the scoring, the scores were assigned colors on a blue to red color gradient with higher scores corresponding to reds and displayed within a GIS (Figure 29). This geographic weighted overlay model or BRIE analysis can be used to evaluate and display an area's contribution to biodiversity, resilience, integrity, and ecosystem services. This type of integrated analysis can help inform decisions about allocation of limited resources for biodiversity stewardship and landscape level conservation planning. The calculation of a score for each stand's priority for biodiversity stewardship allows for aggregation of the information to larger scales (e.g., groups of stands, compartments, state game areas, and region). Figure 29 illustrates that the Maple River SGA is regionally a critical area for biodiversity stewardship. Over 15% of the game area received the highest class of score for the BRIE analysis. In comparison, the proportion of stands receiving the highest class of score for all other state lands in southern Michigan was markedly lower (2%). This model dramatically highlights the importance of this game area for harboring biodiversity, providing resilience to change, fostering ecosystem integrity at multiple scale, and delivering ecosystem services.

The Maple River State Game Area provides a myriad of ecosystem services in a landscape dominated by agriculture and human development. Photo by Jesse M. Lincoln.

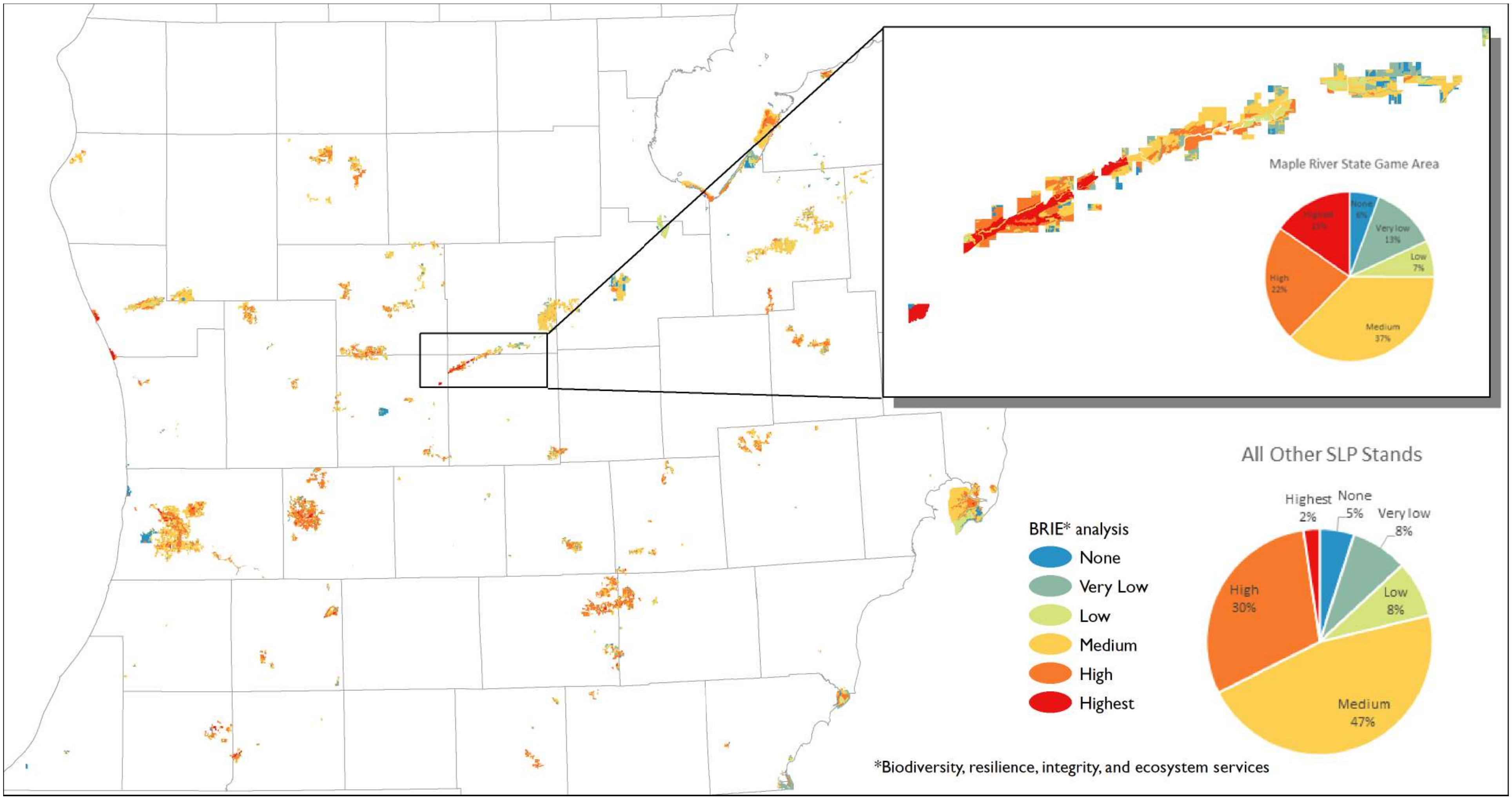


Figure 29. Geographic weighted overlay model for Maple River State Game Area and nearby public lands. MNFI scientists developed a weighted geographic overlay model to inform the prioritization of biodiversity stewardship across state lands. Input variables that capture a stand's biodiversity, resilience, integrity, and ecosystem services were assigned a score from 0 to 5, multiplied by a weighting factor based on our assessment of the importance of that variable, and then all scores were summed to derive a biodiversity stewardship score for each stand. To visualize the scoring, the scores were assigned colors on a blue to red color gradient with higher scores corresponding to hotter colors. Our modeling efforts identified Maple River SGA as a regionally significant area for harboring biodiversity, providing resilience to change, fostering ecosystem integrity, and delivering ecosystem services.

DISCUSSION

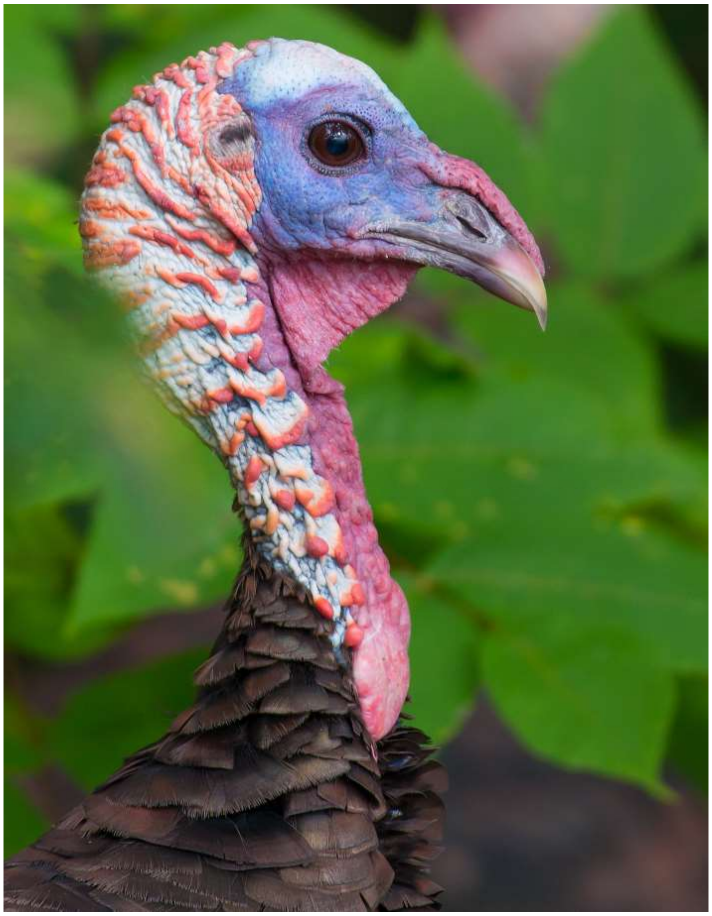
As stated within the DNR's Maple River State Game Area Master Plan, this game area was acquired by the state of Michigan for the following reasons: to preserve and manage wildlife; to preserve wetlands along the Maple River; to develop and maintain wetland habitat for hunters and non-hunters; to retain flood waters from the Maple River and abate downstream flooding; to hold water for groundwater recharge; to provide upland habitat and wildlife recreation; to provide an area that is open to hunting; and to provide for other consumptive and non-consumptive activities that do not conflict with previously stated needs (Maple River State Game Area Master Plan, MDNR 1977). Our report and management recommendations for the Maple River SGA are intended to inform decisions around meeting those stated objectives, particularly the preservation of wetlands and rare wildlife.

Land management in an area as ecologically significant as Maple River SGA requires careful prioritization of stewardship efforts in the most critical ecosystems to protect native biodiversity and ecosystem functioning. Stewardship actions within the game area should focus on the highest quality examples of the rarest natural community types and the largest sites. Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading, and invasive plants are much easier to eradicate when their population is small and not yet well-established.

Generally, we recommend that management efforts to maintain ecological integrity and native biodiversity be focused in natural communities that provide potential habitat for numerous rare plant and animal species. To that end, we provide the following management recommendations for your consideration.

We believe the main management needs in order of importance are to: 1) prevent alterations to hydrology within the floodplain forest and other priority wetlands; 2) prevent fragmentation and maintain the extent and canopy closure of high-quality forests, especially floodplain forest along the Maple River; 3) control invasive species within high-quality natural communities; 4) implement prescribed fire in oak-dominated forests; 5) research options for improving stream crossings and habitat restoration for aquatic species; 6) install a turtle fence along US-127; and 7) monitor these activities to facilitate adaptive management. Fundamentally, our primary recommendations are to simply prevent alterations and anthropogenic disturbance to important wetlands and forested natural features. The following discussion section has been organized around these management recommendations. In addition, based on our experience researching and surveying this game area, we provide recommendations for future survey needs.

Maple River State Game Area was established to meet a range of conservation goals, including supporting game species, like ring-necked pheasant (*Phasianus colchicus*), which were observed in the East Unit of the game area where fields have been planted to warm season grasses. Photo by Aaron P. Kortenhoven.



Maple River State Game Area supports populations of game and non-game species, such as turkey (*Meleagris gallopavo*) (photo by Aaron P. Kortenhoven) and the state special concern sedge, *Carex squarrosa* (Photo by Nathan Martineau).

Maple River State Game Area provides opportunities to view wildlife. Photo by Jesse M. Lincoln.

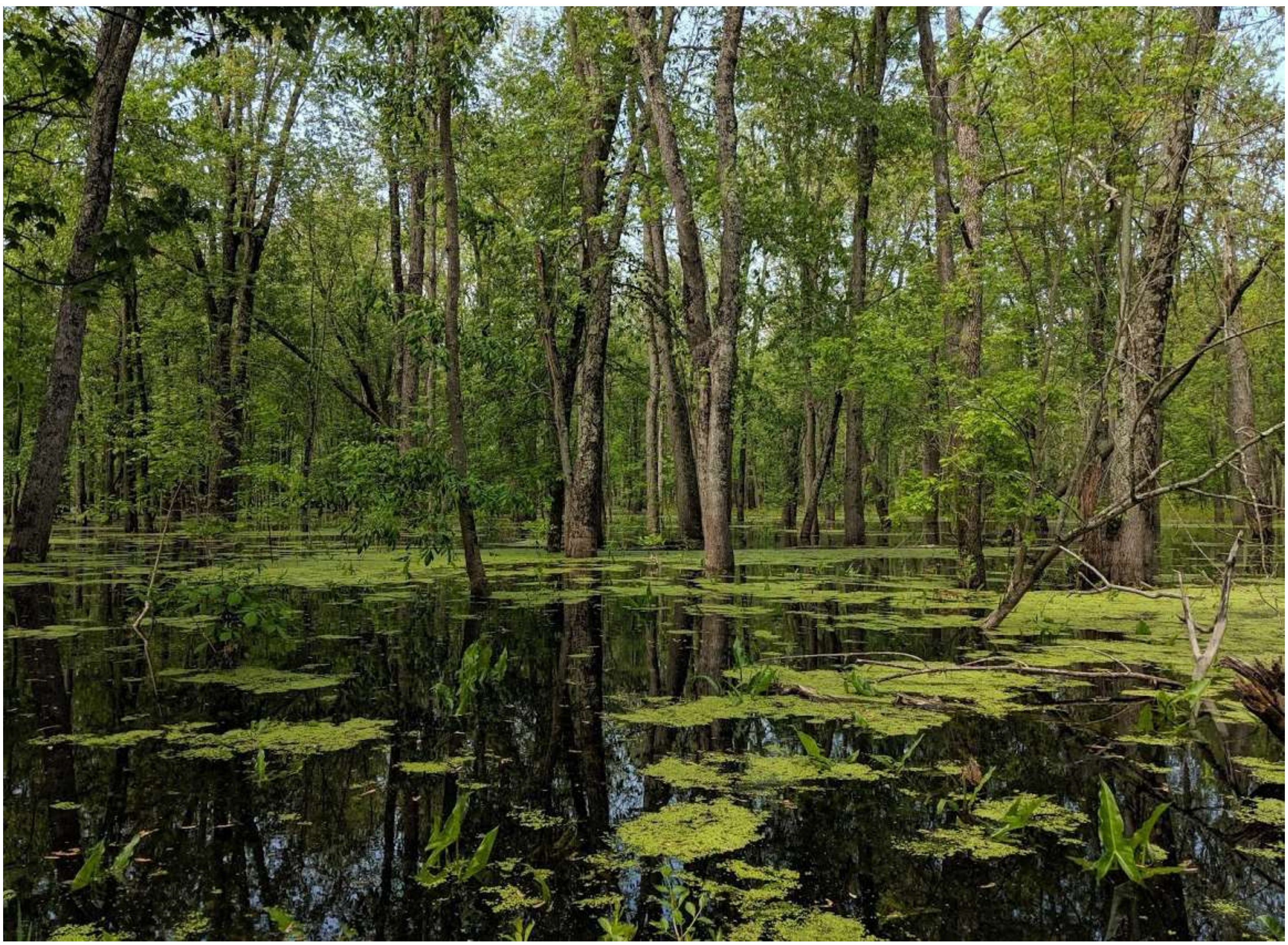
The Value of Wetlands

Wetland preservation has been identified as a critical step toward maintaining and improving water quality for the watershed (Fishbeck et al. 2010). Maple River SGA supports 5,514 acres of wetlands, including numerous vernal pools, managed wetlands in the East Unit, and the largest documented floodplain forest in the Grand River watershed. Wide, contiguous riparian corridors with complex community zonation may harbor twice the number of species occurring in adjacent upland areas (Gregory et al. 1991, Goforth et al. 2002).

Beyond supporting biodiversity, there are many additional ecosystem services associated with riparian systems, including habitat and climate refugia for fish and wildlife, temporary storage of floodwaters, sediment trapping, removal of contaminants from water through physical and biological processes, carbon storage, groundwater recharge, erosion control, and water temperature regulation with cooler water temperatures occurring along floodplains due to shading of the river and tributaries. Undisturbed floodplain systems can incorporate nutrients from agricultural operations, removing inorganic compounds from the water column and mitigating algal blooms.

These services provide water quality protection to the Maple River, the Grand River, and by extension, Lake Michigan. They also benefit the local economies surrounding tourism, recreation, and fisheries that rely on the health of those bodies of water (Sather and Smith 1984, Elder 1985, Russi et al. 2013, Klatt et al. 2018). Therefore, maintaining and protecting the integrity of wetlands, especially the high-quality floodplain forest along the river, is our primary management recommendation.

Floodplain forests are especially valuable for wildlife, particularly in fragmented landscapes. These forests provide travel corridors in a fragmented landscape and critical nesting habitat for prothonotary warbler, cerulean warbler, and other Neotropical migrant songbirds. We regularly observed cerulean and prothonotary warblers, species known to occur in landscapes dominated by mature deciduous forest. Prothonotary warbler is a riparian zone obligate species. Given high numbers of cerulean and prothonotary warblers recorded during surveys, we conclude that Maple SGA is an important nesting area for these two species.



The floodplain forests are important contributors to ecosystem services, particularly flood abatement and nutrient sequestration in the context of an extensively developed landscape. Photo by Aaron P. Kortenhoven.

Table 7. Important element occurrences of floodplain forest relative to the Maple River and other sites in the Grand River watershed. The Maple River floodplain complex is the third largest documented floodplain forest in the state and the largest documented in the Grand River watershed.

Site	EOID	River	Watershed	County	Size (ac)	Rank	Last Surveyed
Maple River and Nickle Plate Floodplain Forest Maple River State Game Area	13315, 13463	Maple River	Grand	Ionia, Clinton	1887	BC	2017
Dickerson Floodplain Flat River State Game Area	19964	Dickerson Creek	Grand	Montcalm	347	C	2014
Miller's Creek Ravine	12850	Miller Creek	Grand	Kent	10	CD	1989
Rogue River Floodplain Rogue River State Game Area	20545	Rogue River	Grand	Kent	90	CD	2015
Onondaga Floodplain Forest	13786	Grand River	Grand	Ingham, Jackson	598	BC	2009
Ottawa Marsh (Big Daily Bayou) Allegan State Game Area	20502	Kalamazoo River	Kalamazoo	Allegan	1686	B	2015
Manistee River State Game Area	13437	Manistee River	Manistee	Manistee	2670	BC	2003
The Muskegon Floodplain Muskegon State Game Area	22025	Muskegon River	Muskegon	Muskegon	3752	BC	2016
Sarett Nature Center	13369	Paw Paw River	Paw Paw	Berrien	1118	BC	2010
Big South Branch Pere Marquette River -- Newaygo County Huron Manistee National Forest	15895	Big South Branch Pere Marquette River	Pere Marquette	Newaygo, Oceana	1674	AB	2010
Pere Marquette Main and South Branch Huron-Manistee National Forest	3145, 11962	Pere Marquette River	Pere Marquette	Mason	1850	AB	2010
White River -- Camp Owassippe	8096	White River	White	Muskegon	1637	AB	2010

MNFI scientists documented cerulean warblers (*Setophaga cerulea*, state threatened) throughout the floodplain forests along the Maple River. The populations in the game area are at the edge of their range. The Maple River SGA occurs in a landscape dominated by agriculture and provides critical nesting habitat for this and other migratory birds. Photo by Aaron P. Kortenhoven.

Maple River's position within a landscape dominated by agriculture, adds to its importance for migratory songbirds that rely on forest interior and floodplain forest for breeding habitat. Forest management at Maple River SGA should consider the habitat needs of the rare songbird species we observed. Because the rare songbird species recorded use mature deciduous forest and mature floodplain forest we recommend managing for mature stands of riparian forest and adjacent upland forest.

Forested wetlands play important roles in structuring and maintaining aquatic communities. Forested riparian buffers limit movement of soils and nutrients from land surfaces to stream channels, limit water temperature fluctuations, and provide the primary energy base for invertebrate food webs. Maintaining forested wetlands is critical for supporting the habitat of rare and other native mussels documented from Maple River SGA. Maintaining extensive, mature forests while providing small areas of open uplands, particularly near the river and wetlands, would benefit amphibians and reptiles in the game area. Though no rare insects were documented during the surveys, there is extensive habitat within forested wetlands that could harbor rare insect populations.

We developed an analysis to quantify the importance of the game area and the forested wetlands therein to biodiversity, ecosystem resilience, ecosystem integrity, and ecosystem services. Our geographic weighted overlay model identifies critical areas on state land that may support high levels of biodiversity, resilience, integrity, and ecosystems services. Maple River SGA stands out as regionally critical for biodiversity stewardship because it serves as an important reservoir of biodiversity for the local region, provides resilience to change, fosters ecosystem integrity at multiple scales, and delivers ecosystem services (Figure 30). Because the landscape surrounding Maple River SGA is impacted by agriculture and rural development (Figure 12, pg. 16), the large area of natural cover within the game area amplifies the game areas contribution to these ecological factors. Maintaining the forest canopy of mature forest systems will help ensure that high-quality habitat remains for the diverse array of plants and animals, including the many rare species and SGCN that utilize this important area. The conservation significance of these forests is heightened by the documentation of numerous vernal pools within these forests and the recording of 69 bird species during point-count surveys, of which 15 are SGCN and 10 are DNR featured species (Table 3, pg. 65; and Appendix 10).

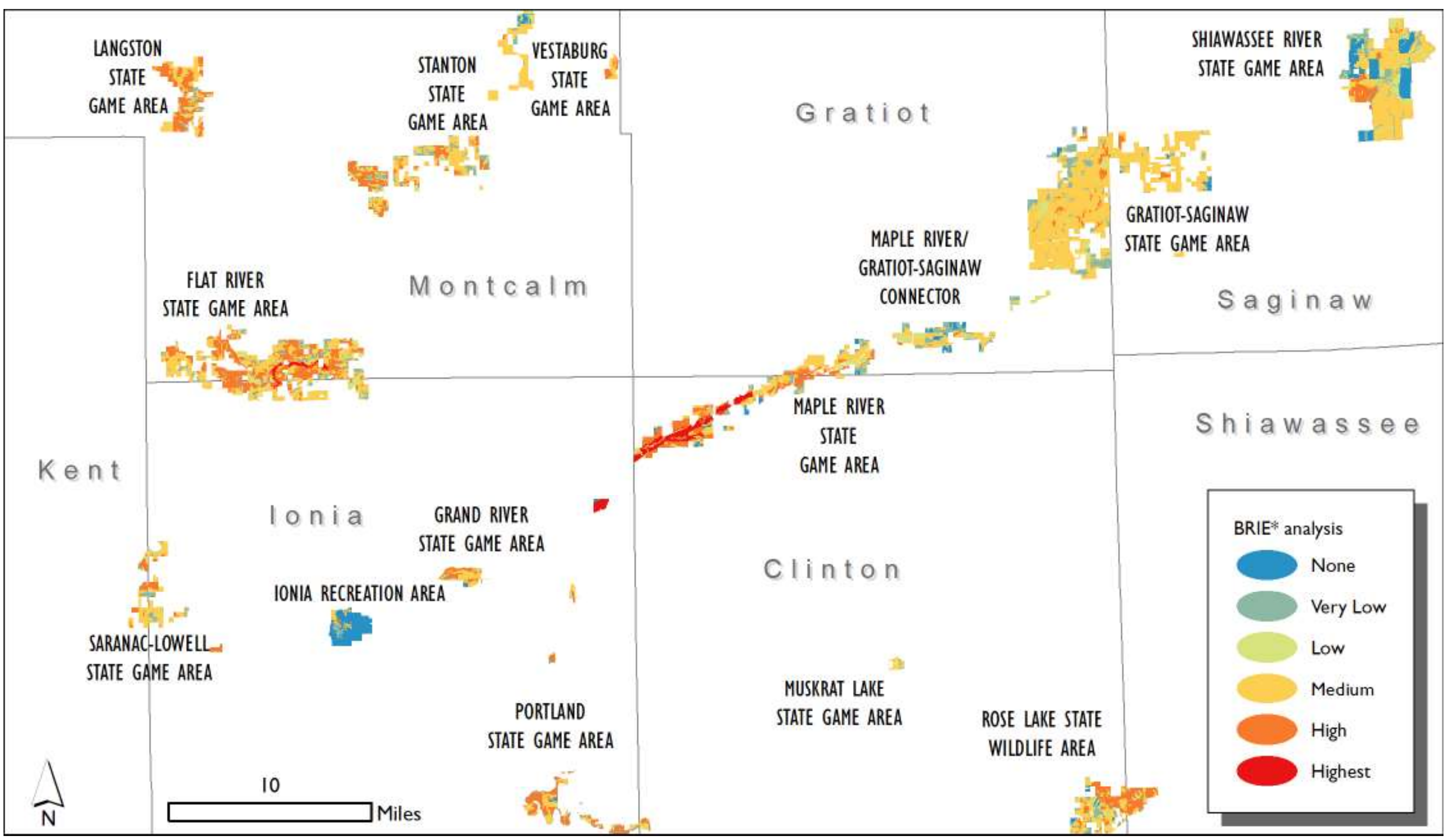


Figure 30. Analysis of Maple River State Game Area's biodiversity, resilience, integrity, and ecosystem services (BRIE) contributions to the landscape relative to other state game areas in the region. MNFI developed this model to inform the prioritization of biodiversity stewardship across state lands.

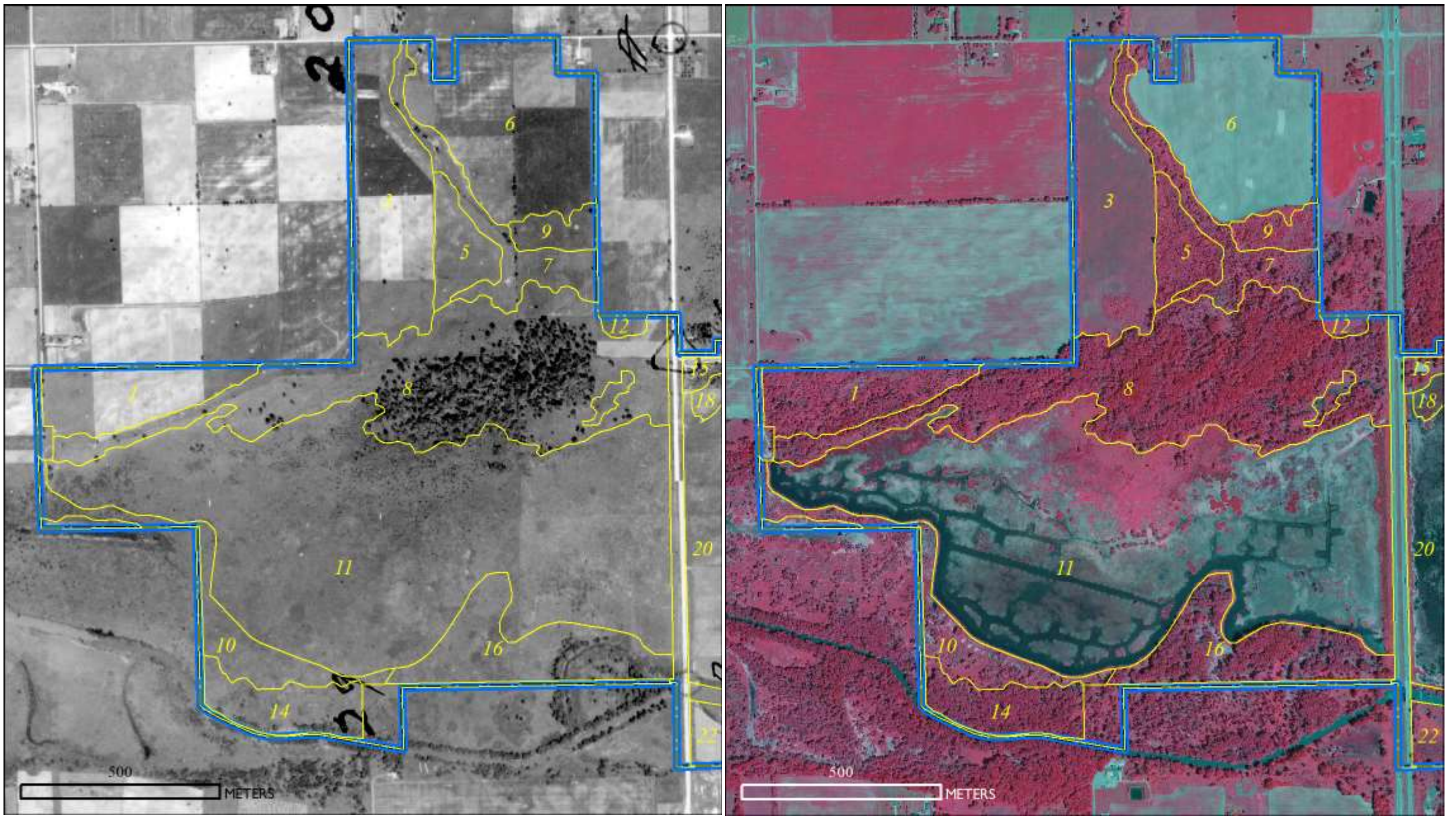


Figure 31. 1938 imagery showing hydrological changes (left). Alterations to the morphology of the river are obvious by the straightened channel and the old meander visible in Stand 16. Subsequent dredging occurred in Stand 11, visible in current imagery (right). These changes fundamentally alter the species composition and successional trajectory of the wetlands. Wetlands altered in this way tend to be dominated by non-native invasive species, such as reed canary grass (*Phalaris arundinacea*) and narrow-leaved cat-tail (*Typha angustifolia*).

Extensive ditches accelerate water across the landscape, thereby decreasing water quality and depleting groundwater aquifers. This is exacerbated by a lack of buffers of natural cover between agricultural fields and ditches. Compartment 5, Stand 38; photo by Jesse M. Lincoln.

Habitat Fragmentation

The structure and processes of riparian ecosystems are determined by their interface with adjacent ecosystems (Tepley et al. 2004). Biodiversity refugia potential of riparian corridors within fragmented landscapes can be predicted based on width and contiguity of the natural cover (Goforth et al. 2002). Wider, more contiguous riparian corridors will provide the greatest benefits to long-term biodiversity conservation in fragmented landscapes (Goforth et al. 2002). Therefore, minimizing forest fragmentation by maintaining and expanding high-quality, closed-canopy forested conditions is our second priority management recommendation. Although the Maple River SGA is relatively unfragmented compared to the surrounding landscape, anthropogenic disturbance has fragmented forests within the game area. The effects of forest fragmentation on native plants and animals and ecosystem processes are drastic (Heilman et al. 2002). Local population extinctions within fragments are accelerated by reduced habitat and population size. Native plant diversity within forested fragments is threatened by low seedling survivorship, infrequent seed dispersal, high levels of herbivory, and growing prevalence of invasive species and native weeds, which thrive along the increasing edges and disperse throughout fragmented landscapes along roads and trails (Brosofske et al. 2001, Heilman et al. 2002, Hewitt and Kellman 2004).

Activities that reduce the cover of mature forest or increase fragmentation will reduce the value of Maple River SGA to forest-interior nesting songbirds. These forests currently support populations of prothonotary and cerulean warblers but these species require extensive, closed canopy, mature forests. However, these and other Neotropical migrants are particularly susceptible to nest parasitism from brown-headed cowbirds (*Molothrus ater*). Cowbirds thrive in fragmented landscapes and reduce the reproductive success of forest-breeding songbirds through nest parasitism (Robinson et al. 1995). Cowbirds were observed at 29% of the point-count stations surveyed. Efforts to reduce forest fragmentation (i.e. edge habitat) could decrease nest parasitism by brown-headed cowbirds on rare and declining forest songbirds. Because the rare songbirds recorded use mature deciduous forest and mature floodplain forest, we recommend managing for mature stands of riparian forest and adjacent upland forest. The maintenance and expansion of mature forest blocks within the game area would benefit these rare species, and other forest-interior species, such as Acadian flycatcher and wood thrush. Though a failure to detect RSHA does not equate to its absence, we did not document any active red-shouldered hawk nests within the game area in 2019. Considering the contiguous, mature forests along the river, we found it surprising to not record this species breeding within Maple River SGA. However,

Though forest fragmentation within the game area is relatively low, the surrounding landscape, visible along the horizon of this photo, features a high-degree of fragmentation and extensive agriculture. Photo by Jesse M. Lincoln.

the game area is largely restricted to the river's outwash channel, leading to a narrow block of natural cover with even the largest forests having relatively close proximity to agricultural land and edge habitat. Hawk activity varies across years and future surveys will better elucidate hawk usage of the game area and if reduced fragmentation can encourage residency.

Fragmentation, particularly logging of forests and forested wetlands can have deleterious impacts on aquatic systems. The potential for timber harvest to affect stream habitat and aquatic animal communities is well documented. Increases in sedimentation or sediment load in rivers as a result of timber harvest can lead to changes in abundance of fish (Broadmeadow and Nisbet 2004; Nislow and Lowe 2006) and invertebrates (Noel et al. 1986; Brown et al. 1997). Changes in the amount of instream coarse woody debris caused by timber harvest can affect stream habitat (Smokorowski and Pratt 2007) and aquatic animal communities (Bilby and Ward 1991). Maintaining riparian buffers along streams is a commonly used and important practice to mitigate impacts to aquatic species and ecosystems (Olson et al. 2007). Maple River SGA currently provides natural riparian buffers that contribute to the viability of listed mussel populations such as lilliput and slippershell within the SGA and federally endangered snuffbox populations downstream of the SGA. Excessive sedimentation can impact native mussel populations directly (Brim-Box and Mossa 1999) and also indirectly if habitat for fish hosts is degraded by timber harvest. A single brook stickleback (*Culaea inconstans*) was found in Collier Creek at site 2 while performing mussel surveys. This species is typically found in small streams with cold, clear water and aquatic vegetation. Though the conservation status of brook stickleback is apparently secure in Michigan, the species is intolerant of turbid water and could potentially be impacted by timber harvest in riparian areas around streams.

Preventing fragmentation and degradation of forests with vernal pools is also a critical aspect of protecting water quality and conserving biodiversity. Vernal pools are generally isolated, temporary pools of water or wetlands in shallow depressions, primarily in forested ecosystems (Thomas et al. 2010). Usually small, vernal pools contribute important ecosystem services including nutrient cycling, water storage and infiltration, groundwater recharge, and flood control (Colburn 2004, Calhoun and deMaynadier 2008). In addition, vernal pools provide important benefits for maintaining water quality by absorbing sheet flow and sequestering nutrients and solids. Vernal pools also provide critical habitat for over 550 animal species in the northeastern U.S., including amphibians and invertebrates that are specialized for life in vernal pools and dependent on these unique habitats for their survival (Colburn 2004). The forests of Maple River SGA have an unusually high concentration of vernal pools. Forest management should focus on protecting the vernal pool's physical basin. Additionally, fragmentation of forests surrounding the vernal pool should avoided to maintain habitat for associated species, particularly pond-breeding amphibians (Calhoun and deMaynadier 2008). Activities that disturb soils or tree canopies within and immediately adjacent to vernal pools should be avoided.

Table 8. Forested stands with conservation value where additional habitat fragmentation should be avoided.

Location	Size (Ac)	Conservation Value	Location	Size (Ac)	Conservation Value
Compartment 1			***Compartment 4***		
Stand 3	45	Buffer to high-quality floodplain forest	Stand 12	55	Mature forest, forested wetlands, buffer for adjacent highquality forest
			Stand 30	24	Mature forest, forested wetlands, buffer for adjacent highquality forest
Compartment 2			Stand 82	35	Mature forest, buffer for floodplain forest
Stand 13	70	Several vernal pools and buffer to high-quality floodplain forest	Stand 91	72	Forested wetland
Stand 52	54	Mature forest within floodplain			
Stand 71	41	Mature forest, manage with fire	***Compartment 5***		
Stand 57	22	Mature forest	Stand 8	74	Some large, old trees
Stand 67	18	Mature forest	Stand 55	15	Forested wetland, rare species
Stand 92	13	Mature forest	Stand 46	17	Forested wetland, rare species
Stand 112	12	Riparian area	Stand 64	19	Forested wetland
Stand 102	10	Rare species habitat	Stand 71	8	Mature trees, vernal pools
			Stand 101	20	Mature forest, vernal pools, unusual community type, rare species, manage with prescribed fire
Compartment 3			Stand 102	12	Forested wetland along river
Stand 28	23	Mature forest	Stand 109	24	Mature forest, vernal pools, unusual community type, rare species, manage with prescribed fire
Stand 35	40	Mature forest, many vernal pools	Stand 124	21	Foreted wetland, elm in canopy
Stand 104	56	Mature forest	Stand 130	45	Foreted wetland along river
			Stand 138	70	Forested wetland along river
			Stand 141	25	Unusual communty type with rare species

Construction of roads and landings and applications of chemicals (e.g., herbicides and/or pesticides) should be avoided within a 30-meter (100 ft) buffer around a vernal pool and minimized within the adjacent landscape (Calhoun and deMaynadier 2008). The State of Michigan's sustainable soil and water quality practices for forest lands recommend maintaining at least 70% canopy closure within a 30-meter (100 ft or 1.4 ac) buffer, preventing disturbance within the vernal pool depression, and limiting use of heavy equipment within 30 meters (100 ft) of the pool to when the soil is dry or frozen to avoid creating deep ruts (MDNR and MDEQ 2018).

Large, ancient woodlands host the greatest biodiversity and are particularly important for conservation. Forest patches that have been forested for a long time will likely be more-species rich than recently established forests, due to slow immigration of forest specialists (Valdes et al. 2020). Dampening the effects of forest fragmentation can be realized by preventing timber harvest in large blocks of mature, contiguous forest and adjacent stands. The delivery of some ecosystem services may decline with low habitat connectivity within an intensively managed landscape matrix as a result of biocides and fertilizers. Additionally, more ancient forest patches have higher topsoil carbon storage potential. Loss of area, increased isolation, and greater exposure to human disturbances along forest edges are leading causes of biodiversity loss and reduced ecosystem functioning (Haddad et al. 2015, Valdes et al 2020). We recommend the following specific actions to minimize fragmentation and degradation of important forests: prevent logging in the floodplain and high-quality forest EOs; establish buffers of 150 ft along slopes, wetlands, and known high-quality sites; prevent impacts to small order streams and vernal pools; avoid timber harvest in forests over 100 years old, particularly if they are near documented high-quality natural communities (See Table 8); and treat invasive species within areas of the highest quality, mature forest and areas where timber harvest is planned.

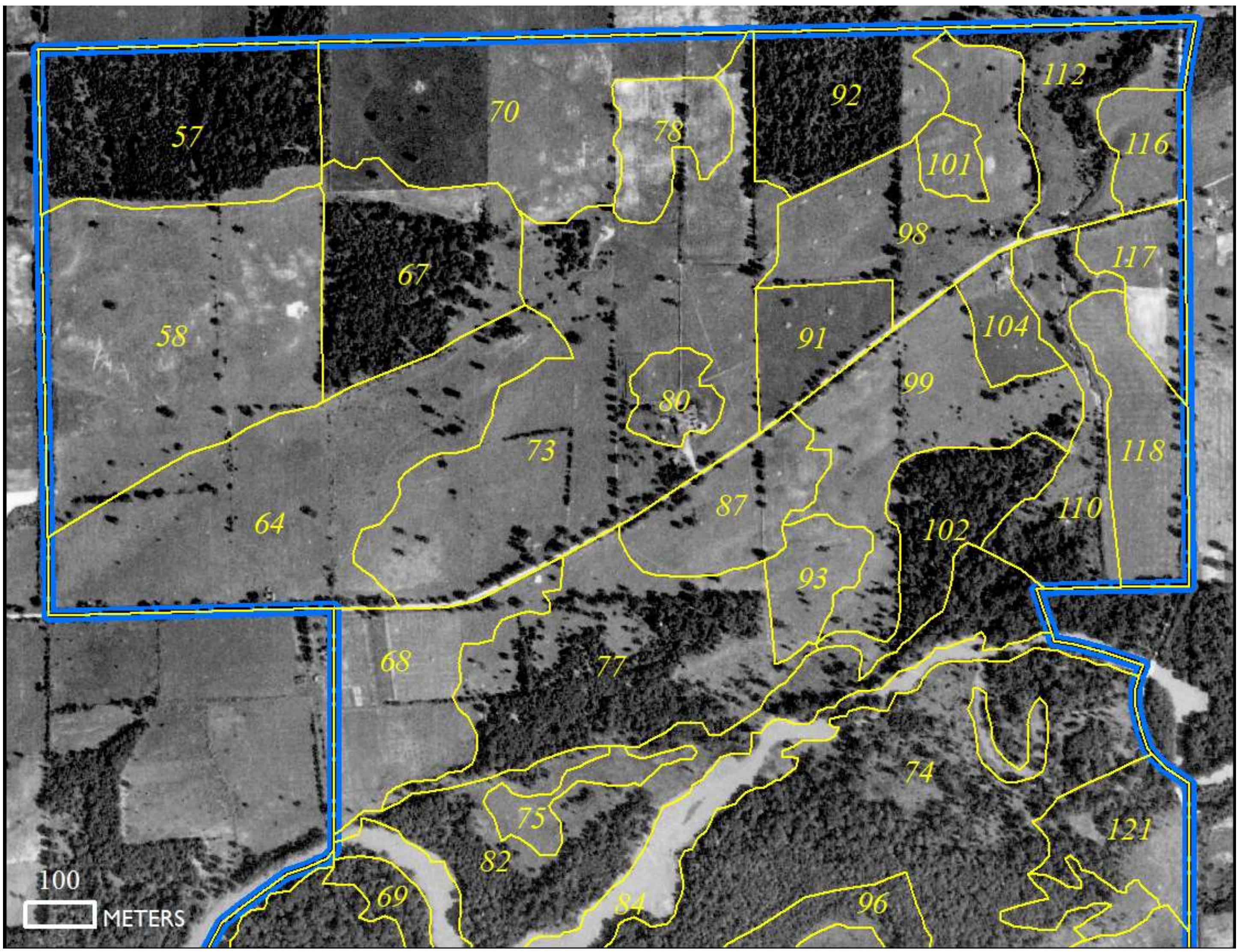


Figure 32. Use of imagery from 1938 for identifying areas of high conservation value. Areas that were forested in the 1930s (darker stands) that haven't been logged in the intervening years tend to have fewer invasives, greater native diversity, likely support a more substantial fungal and soil microbe component, and a higher concentration of migratory birds.

Addressing Invasive Species

Biological invasions are a critical driver of ecosystem degradation and the global decline of biodiversity (Vitousek et al. 1996, Kennedy et al. 2002). Invasive plants affect ecosystem processes through their patterns of resource acquisition and degrade native biodiversity by altering the fundamental structure and function of ecosystems and even triggering trophic cascades (Ehrenfield 2010). Non-native invasive species often have no natural predators and can therefore spread aggressively. By out-competing and replacing native species, invasive species can change floristic composition of natural communities, alter vegetative structure, and reduce native species diversity; often causing local or even complete extinction of some native species (Harty 1986).

Invasive species can also upset delicately balanced ecological processes such as trophic relationships, interspecific competition, nutrient cycling, soil erosion, hydrologic balance, solar insolation, and disturbance regimes (Bratton 1982). In addition, invasive species compromise pollinator services, change microclimates, despoil recreational resources, and degrade the economy of the Great Lakes states (Zavaleta 2000, Pimentel et al. 2005, Huang and Asner 2009, Ehrenfeld 2010). Environmental damages and losses caused by invasive species within the United States were estimated to be over $120 billion per year (Pimentel et al. 2005). Invasive infestations are projected to increase as the landscape continues to be fragmented (Vila and Ibanez 2011) and the climate changes.

According to the DNR's original Maple River State Game Area Master Plan, the state purchased and planted 9,000 multiflora rose and 5,029 autumn olive (MDNR 1977). The impounded wetlands maintained for migratory waterfowl have been colonized by the invasive narrow-leaved cat-tail. Many abandoned agricultural fields are dominated by reed canary grass. To reduce the risk of introducing problematic species, we recommend the DNR instate a policy to plant only species known to be native to the region, particularly focusing on Michigan genotypes when available.

Of particular concern is the degraded condition of the inland salt marshes as a result of colonization by invasive species. Inland salt marshes are the rarest natural community type in Maple River SGA and this community type supports populations of rare plants. The marshes have been invaded by reed canary grass and narrow-leaved cat-tail and the populations of rare plants are now only known to occur at this site in Michigan. The difficulty of treating these non-native species, the degree of invasion, the sensitivity of the community type to herbicides, the

Hubbard's Salt Lick (EO ID 7963) supports the only remaining populations of Olney's bulrush (*Schoenoplectus americanus*, state endangered) and dwarf spike-rush (*Eleocharis parvula*, state endangered) known to occur in Michigan. The site is being invaded by narrow-leaved cat-tail (*Typha angustifolia*) and should be prioritized for research to develop methods for treating this invasive species. Great care should be taken to avoid impacting the populations of rare plants. Photo by Jesse M. Lincoln.

risk of damaging populations of rare species, and the lack of professionals with experience restoring this community type in Michigan leads to a need for comprehensive research on how to best address the invasive species in the inland salt marshes at Maple River SGA. The order of restoration priority is as follows: 1) Hubbard's Salt Lick (EO ID 7963), as it still supports the remaining populations of rare halophytes; 2) Clinton-Saltworks (EO ID 9928), as it supported populations of rare halophytes as recently as 1982; and 3) the Western Salt Marsh (EO ID 13616). We suggest that research focus on manual cutting of narrow-leaved cat-tail followed by hand wicking of cut stems in areas of marsh with low densities of narrow-leaved cat-tail (i.e., the halozone and seep zone). Within areas that are now monodominant stands of narrow-leaved cat-tail, we suggest consideration of a more aggressive approach of using mechanical harvesters followed by herbicide application. In addition, accumulated thatch needs to be reduced in denser areas of narrow-leaved cat-tail, potentially by burning.

Throughout the game area, we encourage a multi-faceted approach to invasive species control and emphasize that improving the landscape context surrounding the high-quality natural areas is critical and that reducing background levels of invasive species will reduce the propagule pressure for these invaders. This is best facilitated with preventing alteration to hydrology in wetlands and preventing additional habitat fragmentation around high-quality natural communities. Invasive species management at Maple River SGA should focus on prevention and then the control of populations of pernicious invasive species within high-quality natural communities and the immediately surrounding areas. Additionally, evaluating forests for risk of invasive species should occur before logging operations proceed. Timber harvest in fragmented landscapes can significantly increase populations of invasive species, thereby detrimentally affecting attributes of forest ecosystems, including biological diversity, forest productivity, water and soil quality, contribution to the carbon cycle, and other socioeconomic values (Pimentel et al. 2000).

Many of the managed wetlands in the East Unit are overwhelmingly dominated by non-native invasive species such as narrow-leaved cat-tail (*Typha angustifolia*) and reed canary grass (*Phalaris arundinacea*). It is not immediately obvious how to address these populations and we recommend that treatment of invasive species be focused in high-quality natural communities. Photo by Jesse M. Lincoln.

Within Maple River SGA, the most pronounced impact from invasive species occurs within wetlands where reed canary grass and narrow-leaved cat-tail threaten the long-term health of the floodplain forest and populations of rare plants. Managers can mitigate the threat of invasive species by lessening inputs of pollution and agricultural runoff through wetland restoration, reduced fertilizer application, and development of buffer strips in agricultural plantings. These actions can reduce the potential for invasive species to take over areas of native vegetation. MNFI has developed a prioritization list of invasive species that pose a serious risk to native biodiversity and we also recommend prioritizing the treatment of these species when feasible (Table 9). Newly establishing invasive species should be removed as rapidly as possible, before they infest additional areas. Invasive species abstracts, which include detailed management guidelines, can be obtained at the following website: http://mnfi.anr.msu.edu/invasive-species/best-control-practice-guides.cfm.

Table 9. Invasive species that pose a significant risk to natural communities in Michigan. This list was generated considering the following factors: likelihood to invade high-quality habitat, ability to form monospecific areas, allelopathic proclivities, likelihood to be documented in existing EO records, and a capacity to treat the species. Emboldened species are those of greatest concern.

Scientific Name	Common Name
Ailanthus altissima	Tree of heaven
Berberis thunbergii	Japanese barberry
Celastrus orbiculatus	Oriental bittersweet
Centaurea stoebe	Spotted knapweed
Elaeagnus umbellata	Autumn olive
Frangula alnus	Glossy buckthorn
Phragmites australis var. australis	Phragmites, common reed
Rhamnus cathartica	Common buckthorn
Rosa multiflora	Multiflora rose
Typha angustifolia	Narrow leaved cat-tail
Vincetoxicum nigrum	Black swallow-wort
Gypsophila spp.	Baby's breath
Alnus glutinosa	Black alder
Torilis japonica	Hedge-parsley
Phalaris arundinacea	Reed canary grass
Fallopia japonica	Japanese knotweed
Fallopia sachalinensis	Giant knotweed
Mycelis muralis	Wall lettuce

Fire as an Ecological Process

Resources for burning are limited and should be prioritized for high-quality, fire-dependent oak forests and areas immediately adjacent to these systems in the East Unit (Figure 22, pg. 64). Fire was likely not a frequent disturbance in the area but a history of extensive occupancy by indigenous peoples, a prevalence of oak systems in the East Unit, and Houghton's descriptions of "oak openings" in the area suggest it was at least occasionally burned. Land managers should consider applying prescribed fire in oak-dominated stands to achieve management goals of oak regeneration. Fire-suppressed sites should be burned using a fire-return interval of three to five years. MNFI has developed a model for assessing prescribed fire needs on state game areas (Figure 33). This model suggests that most of the uplands within Maple River SGA do not support fire-dependent ecosystems. Historically, human-set fires were probably restricted to specific times of the year and relatively small areas within the local landscape. Prescribed fire is often seasonally restricted to spring but the oak forests in Maple River are often very wet in the spring and would likely not support conditions conducive for prescribed burns. Therefore, we recommend implementing prescribed fire in the fall.

Although prescribed fire typically improves the overall quality of habitat for many animal species, its impact on rare animals should be considered when planning a burn. Many areas are already divided by wetlands or ditches and can be burned in alternate years or seasons to protect populations of fire-sensitive species. This allows unburned units to serve as refugia for immobile invertebrates and slow-moving herptile species. We suggest burning relatively large areas and striving for patchy burns by burning either when fuels are somewhat patchy or when weather conditions will not support hot, unbroken fire lines (such as can occur under atypically warm, dry weather and steady winds). These unburned patches may then serve as refugia, which can facilitate recolonization of burned patches by fire-sensitive species.

Figure 33. Prescribed fire needs assessment in the East Unit. The fire return interval is generally low but areas of identified flatwoods (Figure 22, pg. 64) should be evaluated for application of prescribed fire. These wet-mesic flatwoods are dominated by oak species that depend on fire for regeneration.

Hydrologic Restoration

There are 20 dams in the upper portion of the Maple River Watershed including Elsie Dam on the main stem. These dams lead to alteration of hydrologic flow regime and are barriers to host fish passage. Restoring connectivity within the Maple River and associated watersheds could potentially improve the viability of lilliput, slippershell, snuffbox, and other aquatic fauna by allowing for migration to new habitats and transportation of mussels between populations via host fish movement. Gene flow among populations prevents negative impacts from inbreeding and genetic isolation of populations (Watters 1996; Haag 2012). It may be feasible to remove dams that are not currently providing beneficial use to the public. In addition, there may be opportunity to more closely match dam flows to natural stream flow patterns, for dams occurring within or upstream of the SGA.

Poor stream crossings, such as culverts that are too small or that are perched above stream water level, can also interfere with fish passage. They can contribute to erosion and create flooding hazards as well. Seven poor stream crossings were identified within and upstream of Maple River SGA in past stream crossing surveys (Fishbeck et al. 2010). Upgrades to these stream crossings within Maple River SGA could benefit listed mussel populations as well as the river ecosystem as a whole.

The 2010 Maple River Watershed Plan (Fishbeck et al. 2010) identified 32 point-source discharges permitted in the upper watershed, including 17 concentrated animal feeding operations. Sections of the Maple River and tributaries within the SGA were reported as impaired due to excessive nutrient loadings in 2007 and are impaired by an exceedance of the phosphorus total maximum daily load (MDEQ 2008). The source of these nutrients is primarily agricultural land use.

If there are opportunities to add agricultural land to Maple River SGA and convert it to more natural land cover, this could help reduce nutrient and sediment loading to the Maple River. In addition, there may be potential to promote use of grass buffer strips and USDA Conservation Reserve Program on private lands adjacent to the SGA or within the Upper Maple River Watershed.

The upper Maple River watershed is characterized by extensive agricultural operations with ditched streams and no natural buffer between crops and the waterways. Photo by Jesse M. Lincoln.

Alterations to the vegetative structure and hydrology of wetlands can significantly impact habitat quality and suitability for amphibians and reptiles. Many of the emergent wetlands within Maple River SGA, particularly in the East Unit, are dominated by open water and dense stands of non-native narrow-leaved cat-tails. Encouraging more plant and structural diversity (e.g., grasses and sedges, floating logs/woody debris or other structures for basking) within these wetlands and providing wetland habitats with fluctuating and/or varying water levels (i.e., mix of shallow water and deeper water areas) where possible would likely benefit the diversity of amphibian and reptile species in the game area as well. However, dramatic and sudden alterations to the hydrology of wetland and aquatic habitats during late fall and winter should be avoided, especially significantly lowering the water table as this could lead to mortality of overwintering amphibians and reptiles. Controlling woody encroachment and maintaining early-successional conditions within open or emergent wetlands, particularly in the East Unit, also would sustain suitable habitat for these species. Maintaining good water quality in wetland habitats is critical to the area's populations of reptiles and amphibians.

Wildlife Fence

Road mortality and predation, particularly nest predation, can be significant threats to turtle populations in highly fragmented landscapes and anthropogenically disturbed habitats (Lee 2005, Lee 2006, Lee 2007, Lee and Monfils 2008, Lincoln et al. 2019). Turtles are characterized by long life spans (>50 years), delayed sexual maturity, small clutch size, low reproductive success, and high adult survival rates. Given these life history traits, turtles require high annual survivorship of adults and juveniles to maintain stable populations (Congdon et al. 1993). The loss of even a few breeding age female turtles due to road mortality, predation, or other factors can be devastating to local populations. Additionally, turtles existing as "ghost populations," containing only old adult turtles and no juveniles or recruitment, are not uncommon. The combined pressures of increased adult mortality and decreased recruitment can lead to local extirpations. Several dead turtles were observed on the road along US-127 in the East Unit of the Maple River SGA during MNFI's surveys. Installing barrier fencing along US-127 or an ecopassage under the highway could reduce turtle and other herp road mortalities (Yanes et al. 1995, Dodd et al. 2004, Aresco 2005, Lee and Monfils 2008).

MNFI scientists observed several dead turtles along US-127. A wildlife fence could be installed to mitigate turtle mortality as a result of car strikes. Photo by Yu Man Lee.

Several predated turtle nests were observed on the dikes in the East Unit of the game area. Suitable nesting habitats, especially those that are safe from nest predators, may be limited in the Maple River SGA given the level of habitat fragmentation and disturbance within and adjacent to the game area. Maintaining, restoring or creating open, sandy areas near wetlands and away from roads would provide suitable turtle nesting habitat that is potentially safe from predators. Control of meso-predators (e.g., raccoons) in nesting areas, particularly during the turtle nesting season, would help reduce predation of turtle nests and enhance reproductive success and population recruitment.

Monitoring

We strongly encourage the implementation of monitoring within the high-quality natural communities and throughout actively managed areas to gauge the success of restoration activities at reducing invasive species populations. In addition, periodic early-detection surveys should be implemented to allow for the identification of invasive species that have yet to establish a stronghold within Maple River SGA. For example, maples are susceptible to the Asian longhorned beetle (*Anolophora glabripennis*) and early detection surveys should be implemented immediately, especially considering that maples are now the dominant tree species in the floodplain forest following the loss of ash and elm. The loss of maple from the watershed will have devastating consequences on the natural communities and consequently the water quality of the river.

Another non-native invasive species, the Chinese mystery snail was introduced to North America in the late 1800s for the food market. It is currently found in at least 37 states including several major watersheds in Michigan. Chinese mystery snails can impact native mussel and snail species. They have been shown to reduce the density of native snail species in mesocosm experiments and, when co-occurring with rusty crayfish (*Faxonius rusticus*), can lead to extirpations of native snails (Johnson et al. 2009). Chinese mystery snail is also a host for the parasite *Aspidogaster conchicola*, which can spread to native unionid mussels (Hueher and Etges 1977). Monitoring should be implemented for this species to determine if it is spreading and having a deleterious impact on native mussel populations.

Considering the importance of this game area for neotropical migrants and the potential impacts of forest fragmentation, monitoring for rare birds should also be continued. We recommend conducting songbird point counts periodically to monitor use of the game area by rare species and track overall forest bird assemblages. Periodic surveys would allow us to determine if the stands where cerulean warbler and prothonotary warbler were observed continue to be occupied. Periodic surveys would also provide an opportunity to monitor the effects of management actions on these and other species of management interest.

A wildlife fence along US-31 in Muskegon substantially reduced turtle mortality along the roadway. A similar structure could be installed along US-127 to reduce turtle mortality in the Maple River State Game Area. Photo by Yu Man Lee.

Future Survey Needs

In addition to the above identified monitoring needs, we suggest additional surveys to build off of our natural features inventory of the game area. Many of the rare species that we targeted are cryptic by nature and difficult to document in a single field season.

Although we did not detect hooded warbler in 2019, suitable nesting habitat was observed and there is potential for this species to occur within the game area. Because rare species are often not detected even when present, additional surveys will help determine if rare songbirds occur at sites where the habitat appeared suitable, but they were not observed.

Although no snuffbox (*Epioblasma triquetra*, federally endangered) were found in this survey, there is potential for the species to occur within Maple River SGA. Live snuffbox were documented as close as 8.5 river miles (14 km) downstream of Hubbardston Rd. in 2016. There is a historical record for snuffbox 0.5miles (800 m) upstream of Maple River SGA and a 2001 record for live snuffbox 11.4 miles (18.2 km) upstream of the SGA. Generally, much of the Maple River is too deep to wade and the area of mussel habitat surveyed was a very small proportion of habitat available in Maple River SGA. Future aquatic surveys utilizing a team of divers could cover habitat that is too deep to survey by wading.

Additional surveys are needed to determine the status, distribution, and management needs of rare herptile species and other SGCN that have been documented or have potential to occur within the Maple River SGA. Many herptile species are cryptic and difficult to detect in the field, particularly if they are rare. Targeted surveys in the floodplain forest and featured high-quality forests are recommended to determine if additional rare herptile species and SGCN occur in the game area, particularly surveys targeting pickerel frogs, queen snakes, Kirtland's snakes, gray ratsnakes, smooth greensnakes, northern ribbonsnakes, northern ring-necked snakes, and blue racers. Additional surveys to clarify the status, distribution, extent, and estimated viability of the Blanding's turtle and Butler's gartersnake populations would inform management of these species within the game area and statewide. Surveys to identify areas with critical habitats for these species (e.g., nesting and/or overwintering areas) and assess threats to these populations and critical habitats (e.g., road mortality, adult mortality, nest predation, vegetative succession or woody encroachment in turtle nesting areas) would help inform and guide management efforts.

The Geologic Surveys of 1837 detailed several additional salt marshes in the Grand River watershed. Based on the notes of Houghton and Hubbard, two areas in the game area likely supported characteristic salt marsh vegetation historically. These are stands 63 and 84 in Compartment 5 (Figure 34). MiFI surveys were conducted in 2013 and did not find any characteristic vegetation. However, Houghton's notes were not closely examined to attribute locations in his notes to specific stands until the writing of this report in early 2020 and more deliberate surveys of these two stands are recommended.

Finally, rare insects were not detected during these surveys. However, due to the extensive nature of the floodplain forest and the potential for restoration to improve conditions in the salt marshes, additional surveys should be conducted. Although we did not find any rare insect target species during surveys, we did document 14 species of diurnal lepidopterans during surveys, including a new county record for the broad-winged skipper. This species uses the same habitat and host plant (*Carex lacustris*) as the Duke's skipper. The skipper's host plant was abundant throughout the floodplain forest, however MRSGA may be too far north for the rare Duke's skipper. It is possible that the regal fern borer moth may occupy parts of Maple River SGA.

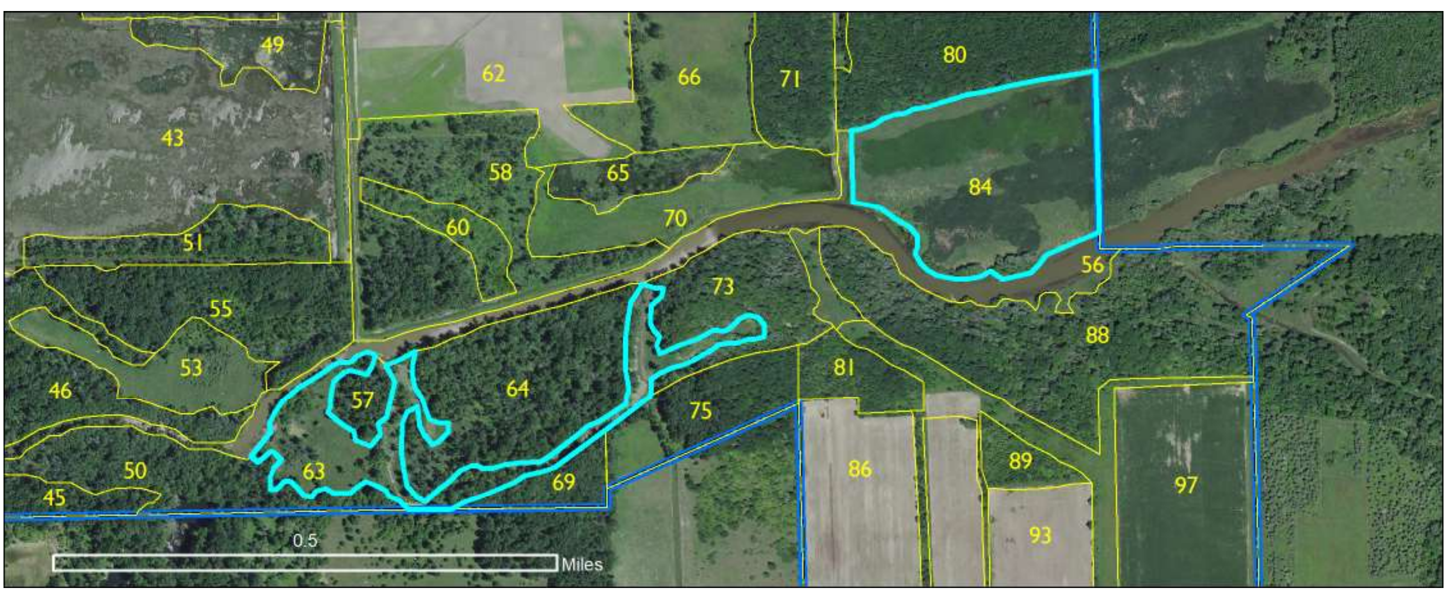


Figure 34. Areas identified for future salt marsh surveys should be focused in Stands 63 and 84 of the East Unit.

CONCLUSIONS

The Maple River watershed has been more impacted by development than any other tributary of the Grand River. Forests have been cleared, streams ditched, and wetlands converted to agriculture. All of these actions have substantial impacts on the region's water quality. Maple River State Game Area has been identified as a critical component of the watershed's green infrastructure. Extensive networks of green infrastructure like the Maple River SGA, provide the highest return of ecosystem service, including maintenance of water quality, recharging groundwater aquafers that are the source of residential drinking water, management of storm water, flood mitigation, and the protection of the economically-significant fisheries that rely on the health of the river. By supporting high-quality ecosystems, the game area provides critical services to a substantially degraded landscape.

In this report, scientists from Michigan Natural Features Inventory detail important high-quality natural communities and populations of several rare species of plants and animals that were documented during surveys in Maple River SGA. Our geographic weighted overlay modeling efforts to prioritize critical state lands for biodiversity stewardship have identified Maple River SGA as a regionally significant area for supporting biodiversity, promoting ecological resilience, maintaining ecological integrity, and providing ecosystem services. To maintain the game area's critical contribution to biodiversity protection, resilience, ecological integrity, and ecosystems services (especially water quality), we recommend that managers prioritize actions around sustaining the unique natural communities and populations of rare animals and plants by the following actions: preventing alterations to hydrology of high-quality natural communities; preventing and reducing forest fragmentation around the high-quality natural communities; treating invasive species; restoring hydrology and implementing practices to protect and improve water quality; applying prescribed fire; installing fencing along US-127 to project wildlife from road mortality; and monitoring these stewardship actions to inform future management actions.

This is a unique piece of public land and with thoughtful stewardship of its natural resources, it will continue to provide a myriad of benefits to hunters and non-hunters for generations to come.

Maple River State Game Area is a vital refuge for biodiversity in a landscape dominated by agriculture. Protecting the myriad of natural communities will prevent local extinctions of rare species and prevent common species from becoming rare. The game area cradles the river and protects our waters. Few places in the southern half of Michigan's lower peninsula can match the conservation potential of the Maple River State Game Area. Photo of a yellow-throated vireo (*Vireo flavifrons*) by Aaron P. Kortenhoven.

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APPENDICES

Appendix 1. Percentage of each substrate particle size class estimated visually at each aquatic survey site. Diameter of each size class: boulder (>256mm), cobble (256-64mm), pebble (64-16mm), gravel (16-2mm), sand (2-0.0625mm), silt/clay (<0.0625mm).

Site #	Boulder	Cobble	Pebble	Gravel	Sand	Silt
1		1		25	50	24
2		2	3	5	40	50
3	2	13			35	50
4		80			10	10
5						100
6					80	20
7		10	30	30	20	10
8				20	70	10

Appendix 2. Water chemistry measures taken at aquatic survey sites. Water samples were collected July 16 and September 4-5 and 20, 2019. Sites 3-6 were located in the same reach in the Maple River main stem. Water chemistry was assumed to be similar for these sites so measures were not taken at sites 4-6.

Site #	pH	Conductivity (µS)	Alkalinity (mg/l $CaCO_3$)	Hardness (mg/l)	Water temp. (C)
1	8.25	691		304	21.3
2	8.24	773		336	21.1
3	8.55	710	252	276	22.2
4					
5					
6					
7	8.50	757	272	296	20.7
8	8.47	765			19.3

Sites 3-6 same long reach in main stem close together, water chem assumed to be the same

Appendix 3. Physical habitat characteristics at aquatic survey sites.

Site #	Current speed (m/second)	Aquatic vegetation?	Woody debris?	Eroded banks?	%Pool	%Riffle	%Run
1	0.14	Y	Y	Y	10		90
2	0.20	N	Y	Y	40	10	50
3	0.05	Y	Y	N			100
4	near zero	Y	Y	N			100
5	zero	Y	Y	N			100
6	0.33	Y	Y	N			100
7	0.20	Y	Y	N			100
8	0.50	Y	Y	Y			100

Appendix 4. Incidental finds at aquatic survey sites, including aquatic snails and limpets (Gastropoda), fingernail clams (Sphaeriidae), crayfish, and fish. native bivalves is noted. (E= State Endangered, T= State threatened, SC= species of special concern)

Common Name	Species/Taxa	1	2	3	4	5	6	7	8
Snails	Gastropoda	X	X		X		X		X
Mud amnicola	*Amnicola limosus*				x				
Pointed campeloma	*Campeloma decisum*	x							x
Liver elimia	*Elimia livescens*		x		x				
Two-ridge rams-horn	*Helisoma anceps*				x				x
Blunt ambersnail	*Oxyloma retusa*				x				
Tadpole physa	*Physella gyrina*				x				x
Thicklip ramshorn	*Planorbella armigera*				x				
Marsh pondsnail	*Stagnicola elodes*				x				
Striped whitelip snail	*Webbhelix multilineata*								x
Limpets	Gastropoda								
Oblong ancylid	*Ferrissia parallela*			x	x				
Fingernail clams	Sphaeriidae	X			X		X	X	X
Crayfish	Decapoda	X							X
Virile crayfish	*Faxonius virilis*	x							
Fish	Osteichthyes	X	X				X	X	X
Johnny darter	*Etheostoma nigrum*	x							x
Brook stickleback	*Culaea inconstans*		x						
Largemouth bass	*Micropterus salmoides*						x	x	

Appendix 5. Global and State Element Ranking Criteria.

Global and State Element Ranking Criteria

GLOBAL RANKS

G1 = critically imperiled: at very high risk of extinction due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors.

G2 = imperiled: at high risk of extinction due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors.

G3 = vulnerable: at moderate risk of extinction due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors.

G4 = apparently secure: uncommon but not rare; some cause for long-term concern due to declines or other factors.

G5 = secure: common; widespread.

GU = currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

GX = eliminated: eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.

G? = incomplete data.

STATE RANKS

S1 = critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2 = imperiled in the state because of rarity due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

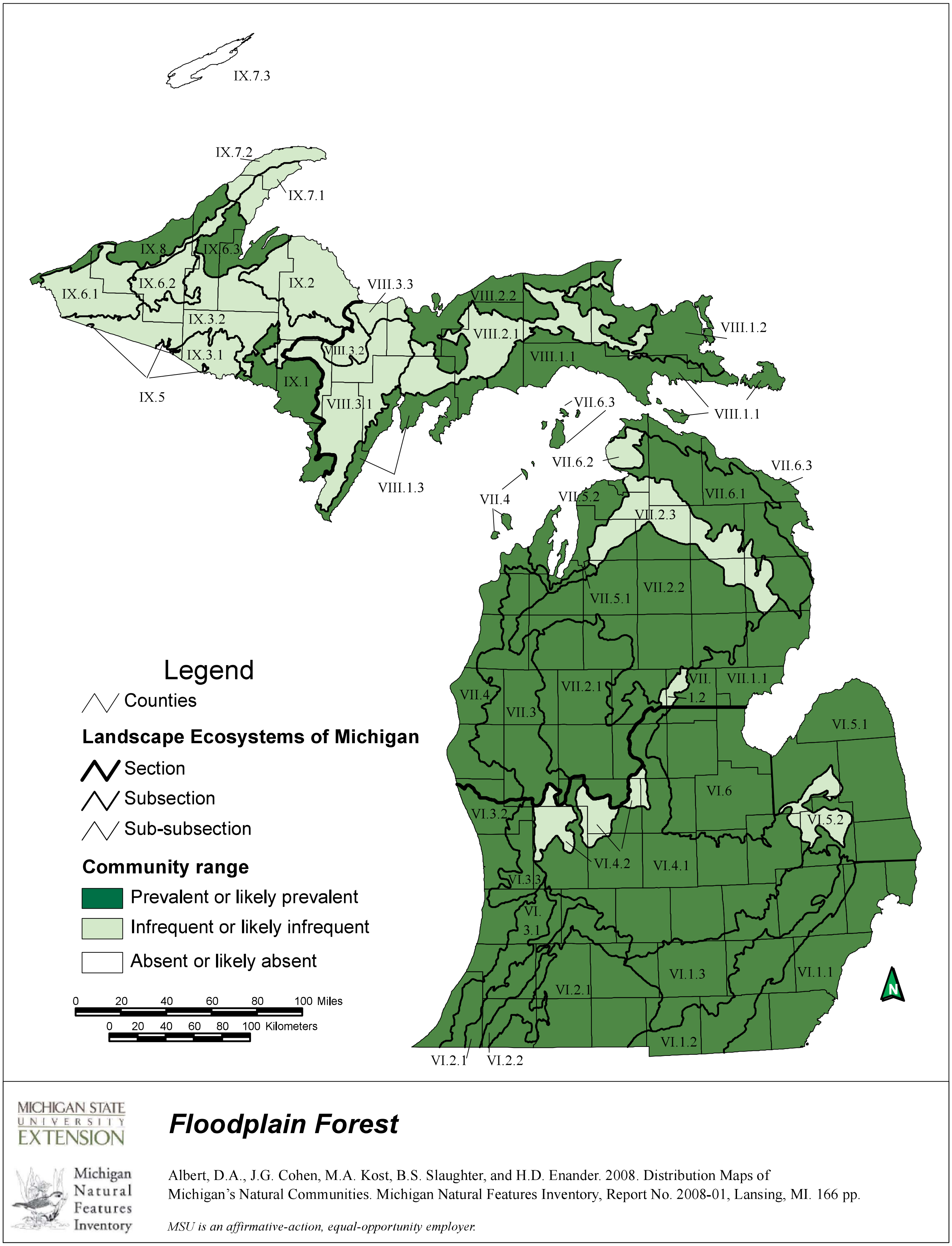
S3 = vulnerable in the state due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 = uncommon but not rare; some cause for long-term concern due to declines or other factors.

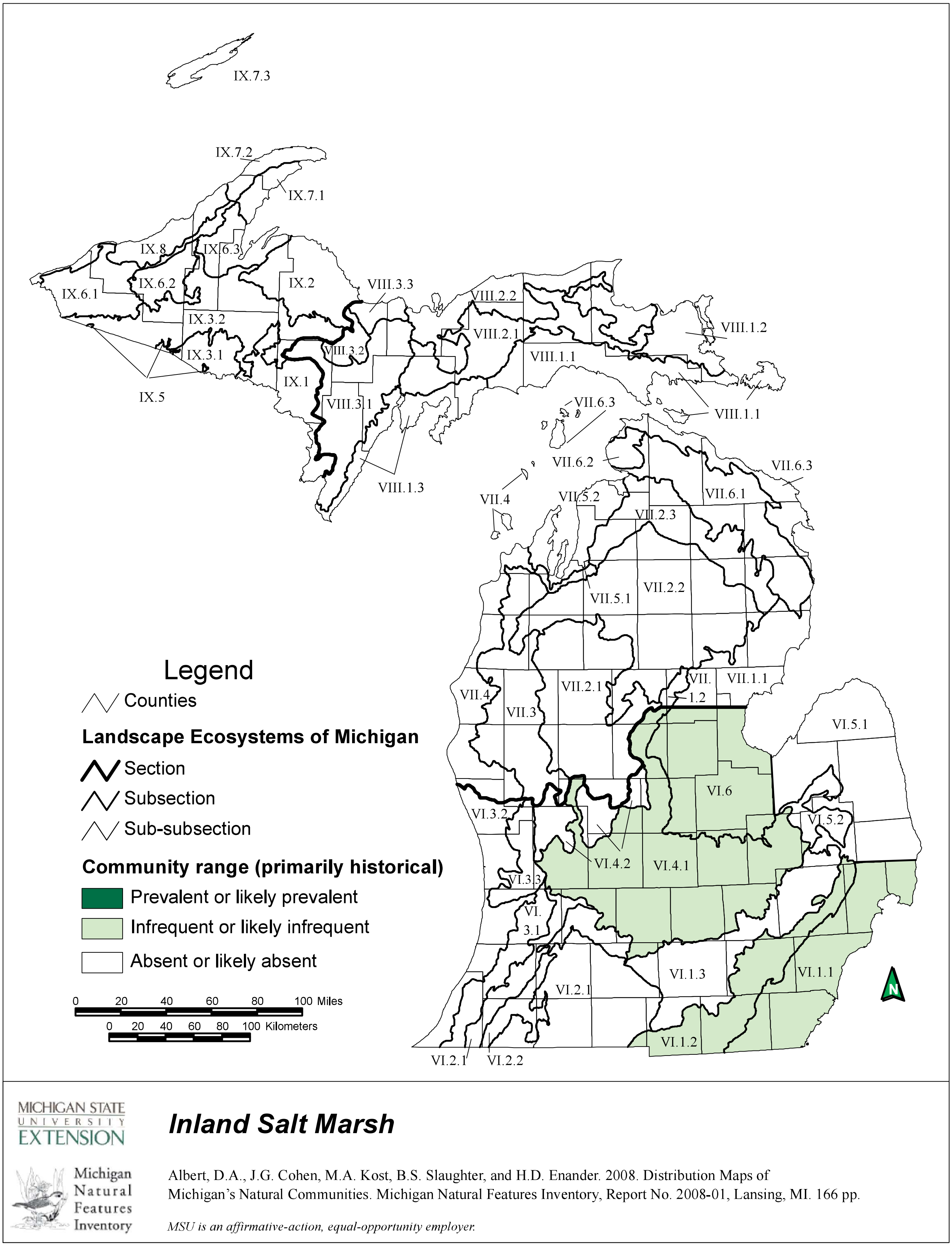
S5 = common and widespread in the state.

SX = community is presumed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

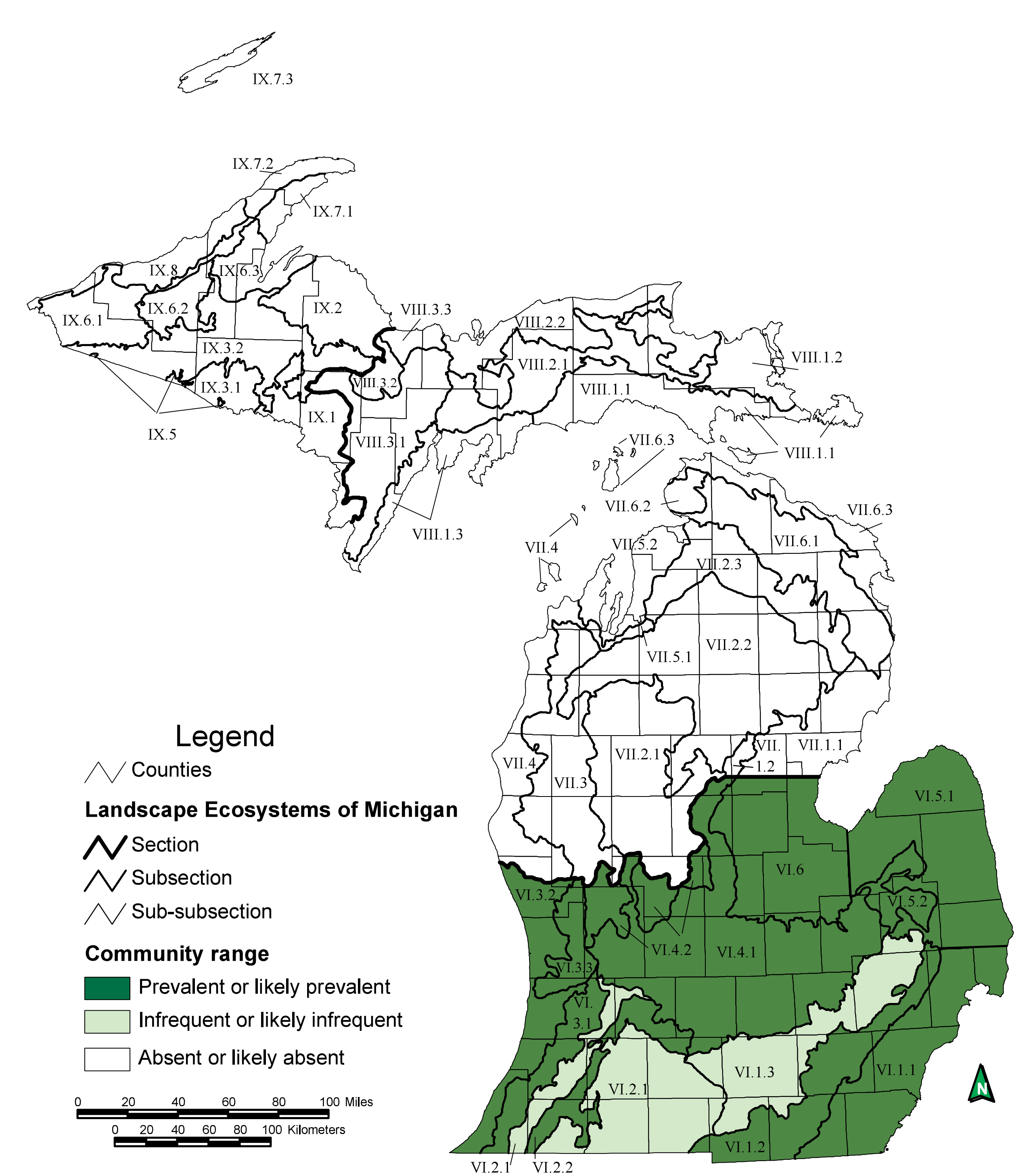
S? = incomplete data.



Appendix 6. Statewide distribution of floodplain forests.



Appendix 7. Statewide distribution of inland salt marshes.



Mesic Southern Forest

Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 166 pp.

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Appendix 8. Statewide distribution of mesic southern forests.

Appendix 9. Numbers of live unionid mussels (#), relative abundance (RA), and density (D, indvs./m2) recorded at each aquatic survey site. The number shells of rare species are given in parentheses (S(#)) if only shells were found at a site. Presence/absence of non-native bivalves is noted. (E= State Endangered, T= State threatened, SC= species of special concern)

		1	2	3			4	5	6		
Common name	Species	#	#	#	RA	D	#	#	#	RA	D
Elktoe (SC)	*Alasmidonta marginata*										
Slippershell (T)	*Alasmidonta viridis*										
Threeridge	*Amblema plicata*			S			S				
Pimpleback	*Cyclonaias pustulosa*						S		S		
Spike	*Eurynia dilatata*										
Wabash pigtoe	*Fusconaia flava*						S		S		
Plain pocketbook	*Lampsilis cardium*										
Fatmucket	*Lampsilis siliquoidea*			3	0.500	0.025	S		1	0.250	0.003
Flutedshell (SC)	*Lasmigona costata*										
Giant floater	*Pyganodon grandis*			1	0.167	0.008	S		S		
Mapleleaf	*Quadrula quadrula*			1	0.167	0.008	S		S		
Strange floater	*Strophitus undulatus*										
Lilliput (E)	*Toxolasma parvum*						S(2)				
Paper pondshell (SC)	*Utterbackia imbecillis*			1	0.167	0.008	S	S(7)	3	0.750	0.008
Ellipse (SC)	*Venustaconcha ellipsiformis*										
	Total # individuals and density	0	0	6		0.050	0	0	4		0.010
	# species live	0	0	4			0	0	2		
	# species live or shell	0	0	5			8	1	6		
	Area searched (m^2)	127	90	120			Midden	120	400		
Asian clams	*Corbicula fluminea*										
Zebra mussels	*Dreissena polymorpha*										

		7			8			A	B
Common name	Species	#	RA	D	#	RA	D	#	#
Elktoe (SC)	*Alasmidonta marginata*				S(1)				
Slippershell (T)	*Alasmidonta viridis*				S(4)				
Threeridge	*Amblema plicata*	S							
Pimpleback	*Cyclonaias pustulosa*								
Spike	*Eurynia dilatata*	S							
Wabash pigtoe	*Fusconaia flava*	S*			1	0.077	0.005		
Plain pocketbook	*Lampsilis cardium*				2	0.154	0.010		
Fatmucket	*Lampsilis siliquoidea*	1	0.111	0.007	9	0.692	0.045		
Flutedshell (SC)	*Lasmigona costata*				1	0.077	0.005		
Giant floater	*Pyganodon grandis*	5	0.556	0.033					
Mapleleaf	*Quadrula quadrula*	S							
Strange floater	*Strophitus undulatus*				S				
Lilliput (E)	*Toxolasma parvum*								
Paper pondshell (SC)	*Utterbackia imbecillis*	3	0.333	0.020				S(1)	S(4)
Ellipse (SC)	*Venustaconcha ellipsiformis*				1	0.077	0.005		
	Total # individuals and density	9		0.060	13		0.065	0	0
	# species live	3			5			0	0
	# species live or shell	7			8			1	1
	Area searched (m^2)	~150			200			Riverbank	Riverbank
Asian clams	*Corbicula fluminea*								
Zebra mussels	*Dreissena polymorpha*								

* Unusual shell due to injury or parasite, identification not confirmed, likely a Pimpleback, Wabash pigtoe, or round pigtoe (*Pleurobema sintoxia*)

Appendix 10. All bird species observed during surveys in Maple River State Game Area.

Common Name	Scientific Name	State Status	Featured Species	SGCN	JV Focal Species	Prop. of Points
Acadian flycatcher	*Empidonax virescens*					0.30
American crow	*Corvus brachyrhynchos*					0.13
American goldfinch	*Spinus tristis*					0.12
American redstart	*Setophaga ruticilla*					0.15
American robin	*Turdus migratorius*					0.41
Bald eagle	*Haliaeetus leucocephalu*					0.01
Baltimore oriole	*Icterus galbula*					0.29
Belted kingfisher	*Megaceryle alcyon*					0.02
Black and white warbler	*Mniotilta varia*					0.01
Black-billed cuckoo	*Coccyzus erythropthalmus*				X	0.01
Black-capped chickadee	*Poecile atricapillus*					0.15
Blue jay	*Cyanocitta cristata*					0.30
Blue-gray gnatcatcher	*Polioptila caerulea*					0.27
Brown creeper	*Certhia americana*					0.15
Brown thrasher	*Toxostoma rufum*					0.01
Brown-headed cowbird	*Molothrus ater*					0.28
Canada goose	*Branta canadensis*					0.07
Cedar waxwing	*Bombycilla cedrorum*					0.04
Cerulean warbler	*Setophaga cerulea*	T		X	X	0.06
Chipping sparrow	*Spizella passerina*					0.01
Common grackle	*Quiscalus quiscula*					0.36
Common swift	*Apus apus*					0.02
Common yellowthroat	*Geothlypis trichas*					0.18
Cooper's hawk	*Accipiter cooperii*					0.01
Downy woodpecker	*Picoides pubescens*					0.28
Eastern bluebird	*Sialia sialis*					0.01
Eastern kingbird	*Tyrannus tyrannus*					0.01
Eastern screech owl	*Megascops asio*					0.01
Eastern towhee	*Pipilo erythrophthalmus*					0.09
Eastern wood-pewee	*Contopus virens*					0.61
Field sparrow	*Spizella pusilla*					0.02
Gray catbird	*Dumetella carolinensis*					0.18
Great Blue Heron	*Atlanta herodias*				X	0.08
Great crested flycatcher	*Myiarchus crinitus*					0.33
Hairy woodpecker	*Picoides villosus*					0.21
House wren	*Troglodytes aedon*					0.05
Indigo bunting	*Passerina cyanea*					0.15
Killdeer	*Charadrius vociferus*					0.03
Least flycatcher	*Empidonax minimus*					0.02
Mallard	*Anas platyrhynchos*					0.02
Mourning dove	*Zenaida macroura*					0.20
Northern cardinal	*Cardinalis cardinalis*					0.33
Northern flicker	*Colaptes auratus*					0.11
Ovenbird	*Seiurus aurocapilla*					0.16
Pied-billed grebe	*Podilymbus podiceps*					0.02
Pileated woodpecker	*Dryocopus pileatus*		X			0.07
Prothonotary warbler	*Protonotaria citrea*	SC		X	X	0.24

Appendix 10 (continued). All bird species observed during surveys in Maple River State Game Area.

Common Name	Scientific Name	State Status	Featured Species	SGCN	JV Focal Species	Prop. of Points
Red-bellied woodpecker	*Melanerpes carolinus*			X		0.53
Red-eyed vireo	*Vireo olivaceus*					0.49
Red-headed woodpecker	*Melanerpes erythrocephalus*	SC			X	0.01
Red-tailed hawk	*Buteo jamaicensis*					0.01
Red-winged blackbird	*Agelaius phoeniceus*					0.25
Rose-breasted grosbeak	*Pheucticus ludovicianus*					0.37
Ruby-throated hummingbird	*Archilochus colubris*					0.03
Sandhill crane	*Antigone canadensis*				X	0.09
Scarlet tanager	*Piranga olivacea*					0.26
Song sparrow	*Melospiza melodia*					0.41
Tree swallow	*Tachycineta bicolor*					0.05
Tufted titmouse	*Baeolophus bicolor*					0.26
Veery	*Catharus fuscescens*			X	X	0.02
Warblering vireo	*Vireo gilvus*					0.11
White-breasted nuthatch	*Sitta carolinensis*					0.31
Wild turkey	*Meleagris gallopavo*		X			0.02
Wood duck	*Aix sponsa*		X			0.12
Wood thrush	*Hylocichla mustelina*		X	X	X	0.24
Yellow warbler	*Setophaga petechia*					0.20
Yellow-billed cuckoo	*Coccyzus americanus*					0.20
Yellow-throated vireo	*Vireo flavifrons*					0.17

Appendix 11. All reptile and amphibian species observed during surveys in Maple River State Game Area.

Maple River State Game Area

Amphibian/ Reptile	Common Name[1,3]	Scientific Name[1]	US Status	State Status	WAP SGCN[2]	Rare Species Targeted for 2019 Surveys	Species Observed in 2019 by MNFI and/or Others	Species Observed Prior to 2019	General Habitat Description[3,4]
Amphibian	Eastern American Toad	*Anaxyrus [Bufo] americanus americanus*					X		Open forests, forest edges, prairies, marshes, and meadows, suburban yards ad agricultural areas; usually buried in moist soil or leaf litter or beneath logs or rocks.
Amphibian	Western Chorus Frog *	*Pseudacris triseriata triseriata*					X		Marshes, wet meadows, swales, and other open habitats, also mesic forests and swamp forests
Amphibian	Gray Treefrog (Eastern & Cope's)	*Hyla versicolor* / *Hyla chrysoscelis*					X	X	Temporary ponds, swamps, floodings, shallow edges of permanent lakes, and sloughs, surrounded by forested or open habitats; deciduous or mixed forests, farm woodlots, swamps, old fields, suburban yards - anywhere with suitable breeding ponds adjacent to trees or shrubs.
Amphibian	Green Frog	*Lithobates [Rana] clamitans*					X	X	Ponds, lakes, swamps, sloughs, impoundments, and slow streams; more tolerant of open, sparsely vegetated sites than the Bullfrog.
Amphibian	Wood Frog	*Lithobates [Rana] sylvaticus*					X	X	Moist, forested habitats (deciduous, coniferous, and mixed); breeding - vernal ponds, floodings, forested swamps, and quiet stream backwaters
Amphibian	Northern Leopard Frog *	*Lithobates [Rana] pipiens*					X		Open wetland habitats including marshes, bogs, lake and stream edges, and sedge meadows, and adjacent open uplands including hay fields, lawns; breed in shallow temporary ponds, stream backwaters, and marsh pools
Reptile	Eastern Snapping Turtle	*Chelydra serpentina serpentina*					X		Permanent waterbodies including shallow, weedy Great Lakes inlets and bays; muddy ponds, lakes, sloughs and slow streams with dense aquatic vegetation
Reptile	Blanding's Turtle	*Emydoidea blandingii*		SC	X	X	X	X	Shallow, weedy waters - ponds, marshes, forested and shrub swamps, wet meadows, lake inlets/coves, rivers backwaters, embayments, sloughs, vernal pools
Reptile	Northern Map Turtle	*Graptemys geographica*					X		Larger lakes, rivers, reservoirs, oxbow sloughs, open marshes, Great Lakes bays and inlets; also smaller lakes and streams and ponds
Reptile	Painted Turtle	*Chrysemys picta*					X		Quiet, slow-moving permanent water bodies with soft bottom substrates, abundant aquatic vegetation, and basking sites; temporarily occupy vernal ponds, imoundments, ditches and faster streams and rivers
Reptile	Eastern Spiny Softshell	*Apalone spinifera spinifera*					X		Rivers and larger streams, inland lakes, reservoirs, protected bays and river mouths; can tolerate fairly swift currents; prefer sandy or muddy substrates and open habitats with little aquatic vegetation; rarely leave vicinity of water
Reptile	Butler's Gartersnake	*Thamnophis butleri*		SC	X	X		X	Wet meadows and prairies, marshy pond and lake borders, and other moist habitats

Key:

U.S. Status: LE = Federally Endangered; LT = Federally Threatened; C = Federal Candidate

State Status: E = State Endangered; T = State Threatened; SC = State Special Concern

WAP SGCN - Wildlife Action Plan Species of Greatest Conservation Need

* - Species was a SGCN prior to 2015 but was removed from the list of SGCN by the Michigan DNR in 2015.

Sources:

[1]Crother, B. I. (ed.). 2012. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, With Comments Regarding Confidence In Our Understanding. SSAR Herpetological Circular 39:1-92.

[2]Derosier, A. L., S. K. Hanshue, K. E. Wehrly, J. K. Farkas, and M. J. Nichols. 2015. Michigan's Wildlife Action Plan. Michigan Department of Natural Resources, Lansing, MI. http://www.michigan.gov/dnrwildlifeaction

[3]Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, MI. 378 pp.

[4]Harding, J.H. and J.A. Holman. 1992. Michigan Frogs, Toads, and Salamanders. Michigan State University, Cooperative Extension Service, East Lansing, MI. 144 pp.

[5]Yoder, T. 2007. Unique Herpetofauna of Murphy Lake State Game Area, Tuscola County, Michigan:Northern Dusky Salamander (*Desmognathus fuscus*) and Six-lined Racerunner(*Aspidoscelis sexlineata*).
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Appendix 12. Plant species observed in Maple River and Nickle Plate Floodplain Forests (EO IDs 13315 and 13463, pg 31) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
silver maple	Acer saccharinum	ACESAI	native	2	-3
giant ragweed	Ambrosia trifida	AMBTRI	native	0	0
green dragon	Arisaema dracontium	ARIDRA	native	8	-3
jack-in-the-pulpit	Arisaema triphyllum	ARITRI	native	5	0
swamp milkweed	Asclepias incarnata	ASCINC	native	6	-5
swamp tickseed	Bidens comosa	BIDCOM	native	5	-3
false nettle	Boehmeria cylindrica	BOECYL	native	5	-5
ear-leaved brome	Bromus latiglumis	BROLAT	native	6	-3
tall bellflower	Campanulastrum americanum	CAMAME	native	8	0
cuckoo-flower	Cardamine pratensis	CARPRA	native	10	-5
sedge	Carex crinita	CXCRIN	native	4	-5
sedge	Carex grayi	CXGRAY	native	6	-3
sedge	Carex intumescens	CXINTU	native	3	-3
sedge	Carex lacustris	CXLACU	native	6	-5
sedge	Carex lupulina	CXLUPA	native	4	-5
sedge	Carex muskingumensis	CXMUSK	native	6	-5
sedge	Carex scabrata	CXSCAB	native	4	-5
sedge	Carex stipata	CXSTIP	native	1	-5
sedge	Carex stricta	CXSTRI	native	4	-5
sedge	Carex tuckermanii	CXTUCK	native	8	-5
cat-tail sedge	Carex typhina	CXTYPH	native	9	-5
blue-beech	Carpinus caroliniana	CARCAO	native	6	0
bitternut hickory	Carya cordiformis	CARCOR	native	5	0
shellbark hickory	Carya laciniosa	CARLAC	native	9	-3
shagbark hickory	Carya ovata	CAROVA	native	5	3
hackberry	Celtis occidentalis	CELOCC	native	5	0
buttonbush	Cephalanthus occidentalis	CEPOCC	native	7	-5
turtlehead	Chelone glabra	CHEGLB	native	7	-5
wood reedgrass	Cinna arundinacea	CINARU	native	7	-3
swamp thistle	Cirsium muticum	CIRMUT	native	6	-5
virgins bower	Clematis virginiana	CLEVIR	native	4	0
gray dogwood	Cornus foemina	CORFOE	native	1	0
red-osier	Cornus sericea	CORSER	native	2	-3
hawthorn	Crataegus mollis	CRAMOL	native	2	0
honewort	Cryptotaenia canadensis	CRYCAN	native	2	0
common dodder	Cuscuta gronovii	CUSGRO	native	3	-3
wild yam	Dioscorea villosa	DIOVIL	native	4	0
barnyard grass	Echinochloa muricata	ECHMUR	native	1	-5
wild-cucumber	Echinocystis lobata	ECHLOB	native	2	-3
canada wild rye	Elymus canadensis	ELYCAN	native	5	3
riverbank wild-rye	Elymus riparius	ELYRIP	native	8	-3
silky wild-rye	Elymus villosus	ELYVIL	native	5	3
virginia wild-rye	Elymus virginicus	ELYVIR	native	4	-3
false rue-anemone	Enemion biternatum	ENEBIT	native	8	0
cinnamon willow-herb	Epilobium coloratum	EPICOL	native	3	-5

Appendix 12 (continued). Plant species observed in Maple River and Nickle Plate Floodplain Forests (EO IDs 13315 and 13463, pg 31) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
helleborine	Epipactis helleborine	EPIHEL	non-native	0	0
scouring rush	Equisetum hyemale	EQUHYE	native	2	0
joe-pye-weed	Eutrochium maculatum	EUTMAC	native	4	-5
green-stemmed joe-pye-weed	Eutrochium purpureum	EUTPUR	native	5	0
false buckwheat	Fallopia scandens	FALSCA	native	2	0
red ash	Fraxinus pennsylvanica	FRAPEN	native	2	-3
pumpkin ash	Fraxinus profunda	FRAPRO	native	9	-5
blue ash	Fraxinus quadrangulata	FRAQUA	native	8	3
rough bedstraw	Galium asprellum	GALASP	native	5	-5
kentucky coffee-tree	Gymnocladus dioicus	GYMDIO	native	9	3
cow-parsnip	Heracleum maximum	HERMAX	native	3	-3
virginia waterleaf	Hydrophyllum virginianum	HYDVIR	native	4	0
spotted touch-me-not	Impatiens capensis	IMPCAP	native	2	-3
southern blue flag	Iris virginica	IRIVIR	native	5	-5
wood nettle	Laportea canadensis	LAPCAN	native	4	-3
cut grass	Leersia oryzoides	LEEORY	native	3	-5
white grass	Leersia virginica	LEEVIR	native	5	-3
cardinal-flower	Lobelia cardinalis	LOBCAR	native	7	-5
stalked water horehound	Lycopus rubellus	LYCRUB	native	8	-5
northern bugle weed	Lycopus uniflorus	LYCUNI	native	2	-5
fringed loosestrife	Lysimachia ciliata	LYSCIL	native	4	-3
moneywort	Lysimachia nummularia	LYSNUM	non-native	0	-3
swamp-candles	Lysimachia terrestris	LYSTER	native	6	-5
tufted loosestrife	Lysimachia thyrsiflora	LYSTHY	native	6	-5
ostrich fern	Matteuccia struthiopteris	MATSTR	native	3	0
moonseed	Menispermum canadense	MENCAE	native	5	0
white mulberry	Morus alba	MORALB	non-native	0	3
red mulberry	Morus rubra	MORRUB	native	9	3
sensitive fern	Onoclea sensibilis	ONOSEN	native	2	-3
cinnamon fern	Osmunda cinnamomea	OSMCIN	native	5	-3
witch grass	Panicum capillare	PANCAP	native	0	0
virginia creeper	Parthenocissus quinquefolia	PARQUI	native	5	3
arrow-arum	Peltandra virginica	PELVIR	native	6	-5
mild water-pepper	Persicaria hydropiperoides	PERHYS	native	5	-5
ladys-thumb	Persicaria maculosa	PERMAC	non-native	0	0
smartweed	Persicaria punctata	PERPUN	native	5	-5
jumpseed	Persicaria virginiana	PERVIR	native	4	0
reed canary grass	Phalaris arundinacea	PHAARU	native	0	-3
fog-fruit	Phyla lanceolata	PHYLAN	native	6	-5
false dragonhead	Physostegia virginiana	PHYVIA	native	8	-3
clearweed	Pilea pumila	PILPUM	native	5	-3
heart-leaved plantain	Plantago cordata	PLACOR	native	10	-5
cottonwood	Populus deltoides	POPDEL	native	1	0
self-heal	Prunella vulgaris	PRUVUL	native	0	0
swamp white oak	Quercus bicolor	QUEBIC	native	8	-3

Appendix 12 (continued). Plant species observed in Maple River and Nickle Plate Floodplain Forests (EO IDs 13315 and 13463, pg 31) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
bur oak	Quercus macrocarpa	QUEMAC	native	5	3
bristly crowfoot	Ranunculus pensylvanicus	RANPEN	native	6	-5
wild black currant	Ribes americanum	RIBAME	native	6	-3
prickly or wild gooseberry	Ribes cynosbati	RIBCYN	native	4	3
yellow cress	Rorippa palustris	RORPAL	native	1	-5
multiflora rose	Rosa multiflora	ROSMUL	non-native	0	3
swamp rose	Rosa palustris	ROSPAL	native	5	-5
black raspberry	Rubus occidentalis	RUBOCC	native	1	5
dwarf raspberry	Rubus pubescens	RUBPUB	native	4	-3
cut-leaf coneflower	Rudbeckia laciniata	RUDLAC	native	6	-3
pale dock	Rumex altissimus	RUMALT	native	2	-3
water dock	Rumex verticillatus	RUMVER	native	7	-5
common arrowhead	Sagittaria latifolia	SAGLAT	native	4	-5
black willow	Salix nigra	SALNIG	native	5	-5
black snakeroot	Sanicula odorata	SANODO	native	2	0
lizards-tail	Saururus cernuus	SAUCER	native	9	-5
marsh skullcap	Scutellaria galericulata	SCUGAL	native	5	-5
mad-dog skullcap	Scutellaria lateriflora	SCULAT	native	5	-5
water-parsnip	Sium suave	SIUSUA	native	5	-5
bristly greenbrier	Smilax hispida	SMIHIS	native	5	0
bittersweet nightshade	Solanum dulcamara	SOLDUL	non-native	0	0
late goldenrod	Solidago gigantea	SOLGIG	native	3	-3
swamp goldenrod	Solidago patula	SOLPAT	native	6	-5
common bur-reed	Sparganium eurycarpum	SPAEUR	native	5	-5
smooth hedge nettle	Stachys tenuifolia	STATEN	native	5	-3
bladdernut	Staphylea trifolia	STATRI	native	9	0
long-leaved chickweed	Stellaria longifolia	STELOF	native	5	-3
panicled aster	Symphyotrichum lanceolatum	SYMLAN	native	2	-3
calico aster	Symphyotrichum lateriflorum	SYMLAT	native	2	0
lake ontario aster	Symphyotrichum ontarionis	SYMONT	native	6	0
swamp aster	Symphyotrichum puniceum	SYMPUN	native	5	-5
wood-sage	Teucrium canadense	TEUCAN	native	4	-3
purple meadow-rue	Thalictrum dasycarpum	THADAS	native	3	-3
marsh fern	Thelypteris palustris	THEPAL	native	2	-3
basswood	Tilia americana	TILAME	native	5	3
poison-ivy	Toxicodendron radicans	TOXRAD	native	2	0
american elm	Ulmus americana	ULMAME	native	1	-3
stinging nettle	Urtica dioica	URTDIO	native	1	0
white vervain	Verbena urticifolia	VERURT	native	4	0
nannyberry	Viburnum lentago	VIBLEN	native	4	0
le contes violet	Viola affinis	VIOAFF	native	2	-3
marsh violet	Viola cucullata	VIOCUC	native	5	-5
summer grape	Vitis aestivalis	VITAES	native	6	3
river-bank grape	Vitis riparia	VITRIP	native	3	0
common cocklebur	Xanthium strumarium	XANSTR	non-native	0	0

Appendix 13. Plant species observed in Clinton-Saltworks Inland Salt Marsh (EO ID 9928, pg 37) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
swamp milkweed	*Asclepias incarnata*	ASCINC	native	6	-5
bulrush	*Bolboschoenus fluviatilis*	BOLFLU	native	6	-5
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
sedge	*Carex lacustris*	CXLACU	native	6	-5
wood reedgrass	*Cinna arundinacea*	CINARU	native	7	-3
virginia wild-rye	*Elymus virginicus*	ELYVIR	native	4	-3
red ash	*Fraxinus pennsylvanica*	FRAPEN	native	2	-3
white grass	*Leersia virginica*	LEEVIR	native	5	-3
sensitive fern	*Onoclea sensibilis*	ONOSEN	native	2	-3
reed canary grass	*Phalaris arundinacea*	PHAARU	non-native	0	-3
reed	*Phragmites australis var. americanus*	PHRAUM	native	5	-3
swamp white oak	*Quercus bicolor*	QUEBIC	native	8	-3
new england aster	*Symphyotrichum novae-angliae*	SYMNOV	native	3	-3
lake ontario aster	*Symphyotrichum ontarionis*	SYMONT	native	6	0
narrow-leaved cat-tail	*Typha angustifolia*	TYPANG	non-native	0	-5
stinging nettle	*Urtica dioica*	URTDIO	native	1	0

Appendix 14. Plant species observed in Hubbard's Salt Lick Inland Salt Marsh (EO ID 7963, pg 39) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
dwarf spike-rush	*Eleocharis parvula*	ELEPAR	native	10	-5
boneset	*Eupatorium perfoliatum*	EUPPER	native	4	-3
joe-pye-weed	*Eutrochium maculatum*	EUTMAC	native	4	-5
red ash	*Fraxinus pennsylvanica*	FRAPEN	native	2	-3
white grass	*Leersia virginica*	LEEVIR	native	5	-3
great blue lobelia	*Lobelia siphilitica*	LOBSIP	native	4	-3
wild mint	*Mentha canadensis*	MENCAS	native	3	-3
reed canary grass	***Phalaris arundinacea***	**PHAARU**	**non-native**	**0**	**-3**
olneys bulrush	*Schoenoplectus americanus*	SCHAME	native	10	-5
water-parsnip	*Sium suave*	SIUSUA	native	5	-5
late goldenrod	*Solidago gigantea*	SOLGIG	native	3	-3
lake ontario aster	*Symphyotrichum ontarionis*	SYMONT	native	6	0
narrow-leaved cat-tail	***Typha angustifolia***	**TYPANG**	**non-native**	**0**	**-5**

Appendix 15. Plant species observed in Western Inland Salt Marsh (EO ID 13616, pg 43) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
common beggar-ticks	*Bidens frondosa*	BIDFRO	native	1	-3
false nettle	*Boehmeria cylindrica*	BOECYL	native	5	-5
bulrush	*Bolboschoenus fluviatilis*	BOLFLU	native	6	-5
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
sedge	*Carex lacustris*	CXLACU	native	6	-5
buttonbush	*Cephalanthus occidentalis*	CEPOCC	native	7	-5
barnyard grass	*Echinochloa muricata*	ECHMUR	native	1	-5
virginia wild-rye	*Elymus virginicus*	ELYVIR	native	4	-3
red ash	*Fraxinus pennsylvanica*	FRAPEN	native	2	-3
southern blue flag	*Iris virginica*	IRIVIR	native	5	-5
cut grass	*Leersia oryzoides*	LEEORY	native	3	-5
common duckweed	*Lemna minor*	LEMMIN	native	5	-5
moneywort	***Lysimachia nummularia***	**LYSNUM**	**non-native**	**0**	**-3**
reed canary grass	***Phalaris arundinacea***	**PHAARU**	**non-native**	**0**	**-3**
swamp white oak	*Quercus bicolor*	QUEBIC	native	8	-3
water dock	*Rumex verticillatus*	RUMVER	native	7	-5
lizards-tail	*Saururus cernuus*	SAUCER	native	9	-5
hardstem bulrush	*Schoenoplectus acutus*	SCHACU	native	5	-5
mad-dog skullcap	*Scutellaria lateriflora*	SCULAT	native	5	-5
water-parsnip	*Sium suave*	SIUSUA	native	5	-5
lake ontario aster	*Symphyotrichum ontarionis*	SYMONT	native	6	0
poison-ivy	*Toxicodendron radicans*	TOXRAD	native	2	0
narrow-leaved cat-tail	***Typha angustifolia***	**TYPANG**	**non-native**	**0**	**-5**

Appendix 16. Plant species observed in Alger Woods Mesic Southern Forest (EO ID 23662, pg 45) during 2019 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
black maple	Acer nigrum	ACENIG	native	4	3
sugar maple	Acer saccharum	ACESAU	native	5	3
maidenhair fern	Adiantum pedatum	ADIPED	native	6	3
spreading dogbane	Apocynum androsaemifolium	APOAND	native	3	5
jack-in-the-pulpit	Arisaema triphyllum	ARITRI	native	5	0
long-awned wood grass	Brachyelytrum erectum	BRAERE	native	7	5
spring cress	Cardamine bulbosa	CARBUL	native	4	-5
cut-leaved toothwort	Cardamine concatenata	CARCON	native	5	3
two-leaved toothwort	Cardamine diphylla	CARDIP	native	5	3
sedge	Carex albursina	CXALBU	native	5	5
sedge	Carex bromoides	CXBROM	native	6	-3
sedge	Carex gracillima	CXGRAA	native	4	3
sedge	Carex grayi	CXGRAY	native	6	-3
sedge	Carex laxiflora	CXLAXF	native	8	0
sedge	Carex lupuliformis	CXLUPS	native	10	-5
sedge	Carex lupulina	CXLUPA	native	4	-5
sedge	Carex pedunculata	CXPEDU	native	5	3
curly-styled wood sedge	Carex rosea	CXROSE	native	2	5
sedge	Carex sparganioides	CXSPAR	native	5	3
sedge	Carex stipata	CXSTIP	native	1	-5
sedge	Carex swanii	CXSWAN	native	4	3
sedge	Carex tuckermanii	CXTUCK	native	8	-5
sedge	Carex woodii	CXWOOD	native	8	3
blue-beech	Carpinus caroliniana	CARCAO	native	6	0
bitternut hickory	Carya cordiformis	CARCOR	native	5	0
shellbark hickory	Carya laciniosa	CARLAC	native	9	-3
buttonbush	Cephalanthus occidentalis	CEPOCC	native	7	-5
spring-beauty	Claytonia virginica	CLAVIR	native	4	3
hawthorn	Crataegus mollis	CRAMOL	native	2	0
squirrel-corn	Dicentra canadensis	DICCAN	native	7	5
wild yam	Dioscorea villosa	DIOVIL	native	4	0
evergreen woodfern	Dryopteris intermedia	DRYINT	native	5	0
bottlebrush grass	Elymus hystrix	ELYHYS	native	5	3
false rue-anemone	Enemion biternatum	ENEBIT	native	8	0
beech-drops	Epifagus virginiana	EPIVIR	native	10	5
robins-plantain	Erigeron pulchellus	ERIPUL	native	5	3
yellow trout lily	Erythronium americanum	ERYAME	native	5	5
running strawberry-bush	Euonymus obovatus	EUOOBO	native	5	3
wild strawberry	Fragaria virginiana	FRAVIR	native	2	3
white ash	Fraxinus americana	FRAAME	native	5	3
northern bedstraw	Galium boreale	GALBOR	native	3	0
white wild licorice	Galium circaezans	GALCIR	native	4	3
yellow wild licorice	Galium lanceolatum	GALLAN	native	4	5
fragrant bedstraw	Galium triflorum	GALTRR	native	4	3
wild geranium	Geranium maculatum	GERMAC	native	4	3
white avens	Geum canadense	GEUCAN	native	1	0
witch-hazel	Hamamelis virginiana	HAMVIR	native	5	3
clustered-leaved tick-trefoil	Hylodesmum glutinosum	HYLGLU	native	5	5
spotted touch-me-not	Impatiens capensis	IMPCAP	native	2	-3
moneywort	**Lysimachia nummularia**	**LYSNUM**	**non-native**	**0**	**-3**

Appendix 16 (continued). Plant species observed in Alger Woods Mesic Southern Forest (EO ID 23662, pg 45) during 2019 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
canada mayflower	Maianthemum canadense	MAICAN	native	4	3
false spikenard	Maianthemum racemosum	MAIRAC	native	5	3
ostrich fern	Matteuccia struthiopteris	MATSTR	native	3	0
indian cucumber-root	Medeola virginiana	MEDVIR	native	10	3
moonseed	Menispermum canadense	MENCAE	native	5	0
red mulberry	Morus rubra	MORRUB	native	9	3
sensitive fern	Onoclea sensibilis	ONOSEN	native	2	-3
rough-leaved rice-grass	Oryzopsis asperifolia	ORYASP	native	6	5
ironwood; hop-hornbeam	Ostrya virginiana	OSTVIR	native	5	3
virginia creeper	Parthenocissus quinquefolia	PARQUI	native	5	3
wild blue phlox	Phlox divaricata	PHLDIV	native	5	3
lopseed	Phryma leptostachya	PHRLEP	native	4	3
woodland bluegrass	Poa sylvestris	POASYL	native	8	0
may-apple	Podophyllum peltatum	PODPEL	native	3	3
christmas fern	Polystichum acrostichoides	POLACR	native	6	3
white lettuce	Prenanthes alba	PREALB	native	5	3
wild black cherry	Prunus serotina	PRUSER	native	2	3
white oak	Quercus alba	QUEALB	native	5	3
swamp white oak	Quercus bicolor	QUEBIC	native	8	-3
bur oak	Quercus macrocarpa	QUEMAC	native	5	3
chinquapin oak	Quercus muehlenbergii	QUEMUE	native	5	3
red oak	Quercus rubra	QUERUB	native	5	3
multiflora rose	**Rosa multiflora**	**ROSMUL**	**non-native**	**0**	**3**
bloodroot	Sanguinaria canadensis	SANCAA	native	5	3
black snakeroot	Sanicula odorata	SANODO	native	2	0
bristly greenbrier	Smilax hispida	SMIHIS	native	5	0
bladdernut	Staphylea trifolia	STATRI	native	9	0
early meadow-rue	Thalictrum dioicum	THADIO	native	6	3
basswood	Tilia americana	TILAME	native	5	3
poison-ivy	Toxicodendron radicans	TOXRAD	native	2	0
american elm	Ulmus americana	ULMAME	native	1	-3
canada violet	Viola canadensis	VIOCAN	native	5	3
yellow violet	Viola pubescens	VIOPUB	native	4	3
prickly-ash	Zanthoxylum americanum	ZANAME	native	3	3

Appendix 17. Plant species observed in Black Maple Forest Mesic Southern Forest (EO ID 23119, pg 49) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C
black maple	Acer nigrum	ACENIG	native	4
red maple	Acer rubrum	ACERUB	native	1
sugar maple	Acer saccharum	ACESAU	native	5
wild leek	Allium tricoccum	ALLTRI	native	5
wood anemone	Anemone quinquefolia	ANEQUI	native	5
green dragon	Arisaema dracontium	ARIDRA	native	8
jack-in-the-pulpit	Arisaema triphyllum	ARITRI	native	5
wild-ginger	Asarum canadense	ASACAN	native	5
lady fern	Athyrium filix-femina	ATHFIL	native	4
marsh-marigold	Caltha palustris	CALPAR	native	6
spring cress	Cardamine bulbosa	CARBUL	native	4
two-leaved toothwort	Cardamine diphylla	CARDIP	native	5
pink spring cress	Cardamine douglassii	CARDOU	native	6
sedge	Carex albursina	CXALBU	native	5
sedge	Carex bromoides	CXBROM	native	6
sedge	Carex hirtifolia	CXHIRI	native	5
sedge	Carex laxiflora	CXLAXF	native	8
sedge	Carex pedunculata	CXPEDU	native	5
sedge	Carex pensylvanica	CXPENS	native	4
sedge	Carex sprengelii	CXSPRE	native	5
sedge	Carex woodii	CXWOOD	native	8
blue-beech	Carpinus caroliniana	CARCAO	native	6
bitternut hickory	Carya cordiformis	CARCOR	native	5
shagbark hickory	Carya ovata	CAROVA	native	5
giant blue cohosh	Caulophyllum giganteum	CAUGIG	native	5
blue cohosh	Caulophyllum thalictroides	CAUTHA	native	5
hackberry	Celtis occidentalis	CELOCC	native	5
turtlehead	Chelone glabra	CHEGLB	native	7
enchanters-nightshade	Circaea canadensis	CIRCAN	native	2
spring-beauty	Claytonia virginica	CLAVIR	native	4
goldthread	Coptis trifolia	COPTRI	native	5
gray dogwood	Cornus foemina	CORFOE	native	1
squirrel-corn	Dicentra canadensis	DICCAN	native	7
dutchmans-breeches	Dicentra cucullaria	DICCUC	native	7
autumn-olive	**Elaeagnus umbellata**	**ELAUMB**	**non-native**	**0**
bottlebrush grass	Elymus hystrix	ELYHYS	native	5
virginia wild-rye	Elymus virginicus	ELYVIR	native	4
false rue-anemone	Enemion biternatum	ENEBIT	native	8
beech-drops	Epifagus virginiana	EPIVIR	native	10
harbinger-of-spring	Erigenia bulbosa	ERIBUL	native	10
robins-plantain	Erigeron pulchellus	ERIPUL	native	5
yellow trout lily	Erythronium americanum	ERYAME	native	5
running strawberry-bush	Euonymus obovatus	EUOOBO	native	5
american beech	Fagus grandifolia	FAGGRA	native	6
false mermaid	Floerkea proserpinacoides	FLOPRO	native	7
wild strawberry	Fragaria virginiana	FRAVIR	native	2
white ash	Fraxinus americana	FRAAME	native	5
black ash	Fraxinus nigra	FRANIG	native	6
white wild licorice	Galium circaezans	GALCIR	native	4
fowl manna grass	Glyceria striata	GLYSTR	native	4

Appendix 17 (continued). Plant species observed in Black Maple Forest Mesic Southern Forest (EO ID 23119, pg 49) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C
witch-hazel	Hamamelis virginiana	HAMVIR	native	5
sharp-lobed hepatica	Hepatica acutiloba	HEPACU	native	8
round-lobed hepatica	Hepatica americana	HEPAME	native	6
wild geranium	Geranium maculatum	GERMAC	native	4
cow-parsnip	Heracleum maximum	HERMAX	native	3
canada waterleaf	Hydrophyllum canadense	HYDCAE	native	7
spotted touch-me-not	Impatiens capensis	IMPCAP	native	2
black walnut	Juglans nigra	JUGNIG	native	5
wood nettle	Laportea canadensis	LAPCAN	native	4
michigan lily	Lilium michiganense	LILMIC	native	5
spicebush	Lindera benzoin	LINBEN	native	7
red honeysuckle	Lonicera dioica	LONDIO	native	5
common wood rush	Luzula multiflora	LUZMUL	native	5
moneywort	**Lysimachia nummularia**	**LYSNUM**	**non-native**	**0**
false spikenard	Maianthemum racemosum	MAIRAC	native	5
starry false solomon-seal	Maianthemum stellatum	MAISTE	native	5
ostrich fern	Matteuccia struthiopteris	MATSTR	native	3
moonseed	Menispermum canadense	MENCAE	native	5
bishops-cap	Mitella diphylla	MITDIP	native	8
sensitive fern	Onoclea sensibilis	ONOSEN	native	2
hairy sweet-cicely	Osmorhiza claytonii	OSMCLI	native	4
ironwood; hop-hornbeam	Ostrya virginiana	OSTVIR	native	5
virginia creeper	Parthenocissus quinquefolia	PARQUI	native	5
wild blue phlox	Phlox divaricata	PHLDIV	native	5
may-apple	Podophyllum peltatum	PODPEL	native	3
downy solomon seal	Polygonatum pubescens	POLPUB	native	5
christmas fern	Polystichum acrostichoides	POLACR	native	6
cottonwood	Populus deltoides	POPDEL	native	1
big-tooth aspen	Populus grandidentata	POPGRA	native	4
white lettuce	Prenanthes alba	PREALB	native	5
wild black cherry	Prunus serotina	PRUSER	native	2
choke cherry	Prunus virginiana	PRUVIR	native	2
white oak	Quercus alba	QUEALB	native	5
swamp white oak	Quercus bicolor	QUEBIC	native	8
bur oak	Quercus macrocarpa	QUEMAC	native	5
chinquapin oak	Quercus muehlenbergii	QUEMUE	native	5
red oak	Quercus rubra	QUERUB	native	5
small-flowered buttercup	Ranunculus abortivus	RANABO	native	0
swamp buttercup	Ranunculus hispidus	RANHIS	native	5
hooked crowfoot	Ranunculus recurvatus	RANREC	native	5
prickly or wild gooseberry	Ribes cynosbati	RIBCYN	native	4
multiflora rose	**Rosa multiflora**	**ROSMUL**	**non-native**	**0**
black raspberry	Rubus occidentalis	RUBOCC	native	1
wild red raspberry	Rubus strigosus	RUBSTR	native	2
great water dock	Rumex orbiculatus	RUMORB	native	9
elderberry	Sambucus canadensis	SAMCAN	native	3
bloodroot	Sanguinaria canadensis	SANCAA	native	5
black snakeroot	Sanicula odorata; s. gregaria	SANODO	native	2
carrion-flower	Smilax illinoensis	SMIILL	native	4
bluestem goldenrod	Solidago caesia	SOLCAE	native	6

Appendix 17 (continued). Plant species observed in Black Maple Forest Mesic Southern Forest (EO ID 23119, pg 49) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C
zigzag goldenrod	Solidago flexicaulis	SOLFLE	native	6
bladdernut	Staphylea trifolia	STATRI	native	9
calico aster	Symphyotrichum lateriflorum	SYMLAT	native	2
skunk-cabbage	Symplocarpus foetidus	SYMFOE	native	6
common dandelion	**Taraxacum officinale**	**TAROFF**	**non-native**	**0**
early meadow-rue	Thalictrum dioicum	THADIO	native	6
basswood	Tilia americana	TILAME	native	5
common trillium	Trillium grandiflorum	TRIGRA	native	5
american elm	Ulmus americana	ULMAME	native	1
canada violet	Viola canadensis	VIOCAN	native	5
yellow violet	Viola pubescens	VIOPUB	native	4
long-spurred violet	Viola rostrata	VIOROS	native	6
common blue violet	Viola sororia	VIOSOR	native	1
prickly-ash	Zanthoxylum americanum	ZANAME	native	3

Appendix 18. Plant species observed in Wacousta Woods Mesic Southern Forest (EO ID 23170, pg 53) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	W
black maple	Acer nigrum	ACENIG	native	3
silver maple	Acer saccharinum	ACESAI	native	-3
sugar maple	Acer saccharum	ACESAU	native	3
japanese barberry	**Berberis thunbergii**	**BERTHU**	**non-native**	3
sedge	Carex albursina	CXALBU	native	5
sedge	Carex muskingumensis	CXMUSK	native	-5
sedge	Carex pedunculata	CXPEDU	native	3
sedge	Carex woodii	CXWOOD	native	3
bitternut hickory	Carya cordiformis	CARCOR	native	0
shagbark hickory	Carya ovata	CAROVA	native	3
hackberry	Celtis occidentalis	CELOCC	native	0
bottlebrush grass	Elymus hystrix	ELYHYS	native	3
virginia wild-rye	Elymus virginicus	ELYVIR	native	-3
running strawberry-bush	Euonymus obovatus	EUOOBO	native	3
american beech	Fagus grandifolia	FAGGRA	native	3
blue ash	Fraxinus quadrangulata	FRAQUA	native	3
white avens	Geum canadense	GEUCAN	native	0
fowl manna grass	Glyceria striata	GLYSTR	native	-5
motherwort	**Leonurus cardiaca**	**LEOCAR**	**non-native**	5
ostrich fern	Matteuccia struthiopteris	MATSTR	native	0
ironwood; hop-hornbeam	Ostrya virginiana	OSTVIR	native	3
virginia creeper	Parthenocissus quinquefolia	PARQUI	native	3
jumpseed	Persicaria virginiana	PERVIR	native	0
pokeweed	Phytolacca americana	PHYAME	native	3
clearweed	Pilea pumila	PILPUM	native	-3
may-apple	Podophyllum peltatum	PODPEL	native	3
wild black cherry	Prunus serotina	PRUSER	native	3
white oak	Quercus alba	QUEALB	native	3
bur oak	Quercus macrocarpa	QUEMAC	native	3
red oak	Quercus rubra	QUERUB	native	3
prickly or wild gooseberry	Ribes cynosbati	RIBCYN	native	3
multiflora rose	**Rosa multiflora**	**ROSMUL**	**non-native**	3
black raspberry	Rubus occidentalis	RUBOCC	native	5
early figwort	Scrophularia lanceolata	SCRLAN	native	3
bristly greenbrier	Smilax hispida	SMIHIS	native	0
basswood	Tilia americana	TILAME	native	3
poison-ivy	Toxicodendron radicans	TOXRAD	native	0
american elm	Ulmus americana	ULMAME	native	-3
canada violet	Viola canadensis	VIOCAN	native	3

Appendix 19. Plant species observed in Hinman Cedar Swamp Rich Conifer Swamp (EO ID 23122, pg 57) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	W
red maple	Acer rubrum	ACERUB	native	0
red baneberry	Actaea rubra	ACTRUB	native	3
white snakeroot	Ageratina altissima	AGEALT	native	3
hog-peanut	Amphicarpaea bracteata	AMPBRA	native	0
wild sarsaparilla	Aralia nudicaulis	ARANUD	native	3
jack-in-the-pulpit	Arisaema triphyllum	ARITRI	native	0
wild-ginger	Asarum canadense	ASACAN	native	5
lady fern	Athyrium filix-femina	ATHFIL	native	0
yellow rocket	Barbarea vulgaris	BARVUL	non-native	0
common beggar-ticks	Bidens frondosa	BIDFRO	native	-3
ohio horse mint	Blephilia ciliata	BLECIL	native	5
false nettle	Boehmeria cylindrica	BOECYL	native	-5
long-awned wood grass	Brachyelytrum erectum	BRAERE	native	5
marsh-marigold	Caltha palustris	CALPAR	native	-5
marsh bellflower	Campanula aparinoides	CAMAPA	native	-5
sedge	Carex bromoides	CXBROM	native	-3
sedge	Carex scabrata	CXSCAB	native	-5
hackberry	Celtis occidentalis	CELOCC	native	0
water hemlock	Cicuta maculata	CICMAC	native	-5
wood reedgrass	Cinna arundinacea	CINARU	native	-3
enchanters-nightshade	Circaea canadensis	CIRCAN	native	3
virgins bower	Clematis virginiana	CLEVIR	native	0
goldthread	Coptis trifolia	COPTRI	native	-3
honewort	Cryptotaenia canadensis	CRYCAN	native	0
common dodder	Cuscuta gronovii	CUSGRO	native	-3
bulblet fern	Cystopteris bulbifera	CYSBUL	native	-3
spinulose woodfern	Dryopteris carthusiana	DRYCAR	native	-3
wild-cucumber	Echinocystis lobata	ECHLOB	native	-3
autumn-olive	Elaeagnus umbellata	ELAUMB	non-native	3
bottlebrush grass	Elymus hystrix	ELYHYS	native	3
cinnamon willow-herb	Epilobium coloratum	EPICOL	native	-5
boneset	Eupatorium perfoliatum	EUPPER	native	-3
joe-pye-weed	Eutrochium maculatum	EUTMAC	native	-5
false buckwheat	Fallopia scandens	FALSCA	native	0
black ash	Fraxinus nigra	FRANIG	native	-3
fragrant bedstraw	Galium triflorum	GALTRR	native	3
wild geranium	Geranium maculatum	GERMAC	native	3
white avens	Geum canadense	GEUCAN	native	0
fowl manna grass	Glyceria striata	GLYSTR	native	-5
beggars lice	Hackelia virginiana	HACVIR	native	3
spotted touch-me-not	Impatiens capensis	IMPCAP	native	-3
pale touch-me-not	Impatiens pallida	IMPPAL	native	-3
southern blue flag	Iris virginica	IRIVIR	native	-5
black walnut	Juglans nigra	JUGNIG	native	3
wood nettle	Laportea canadensis	LAPCAN	native	-3
cut grass	Leersia oryzoides	LEEORY	native	-5
white grass	Leersia virginica	LEEVIR	native	-3
great blue lobelia	Lobelia siphilitica	LOBSIP	native	-3
northern bugle weed	Lycopus uniflorus	LYCUNI	native	-5
fringed loosestrife	Lysimachia ciliata	LYSCIL	native	-3
canada mayflower	Maianthemum canadense	MAICAN	native	3
false spikenard	Maianthemum racemosum	MAIRAC	native	3
starry false solomon-seal	Maianthemum stellatum	MAISTE	native	0
wood millet	Milium effusum	MILEFF	native	3

Appendix 19 (continued). Plant species observed in Hinman Cedar Swamp Rich Conifer Swamp (EO ID 23122, pg 57) during 2017 surveys.

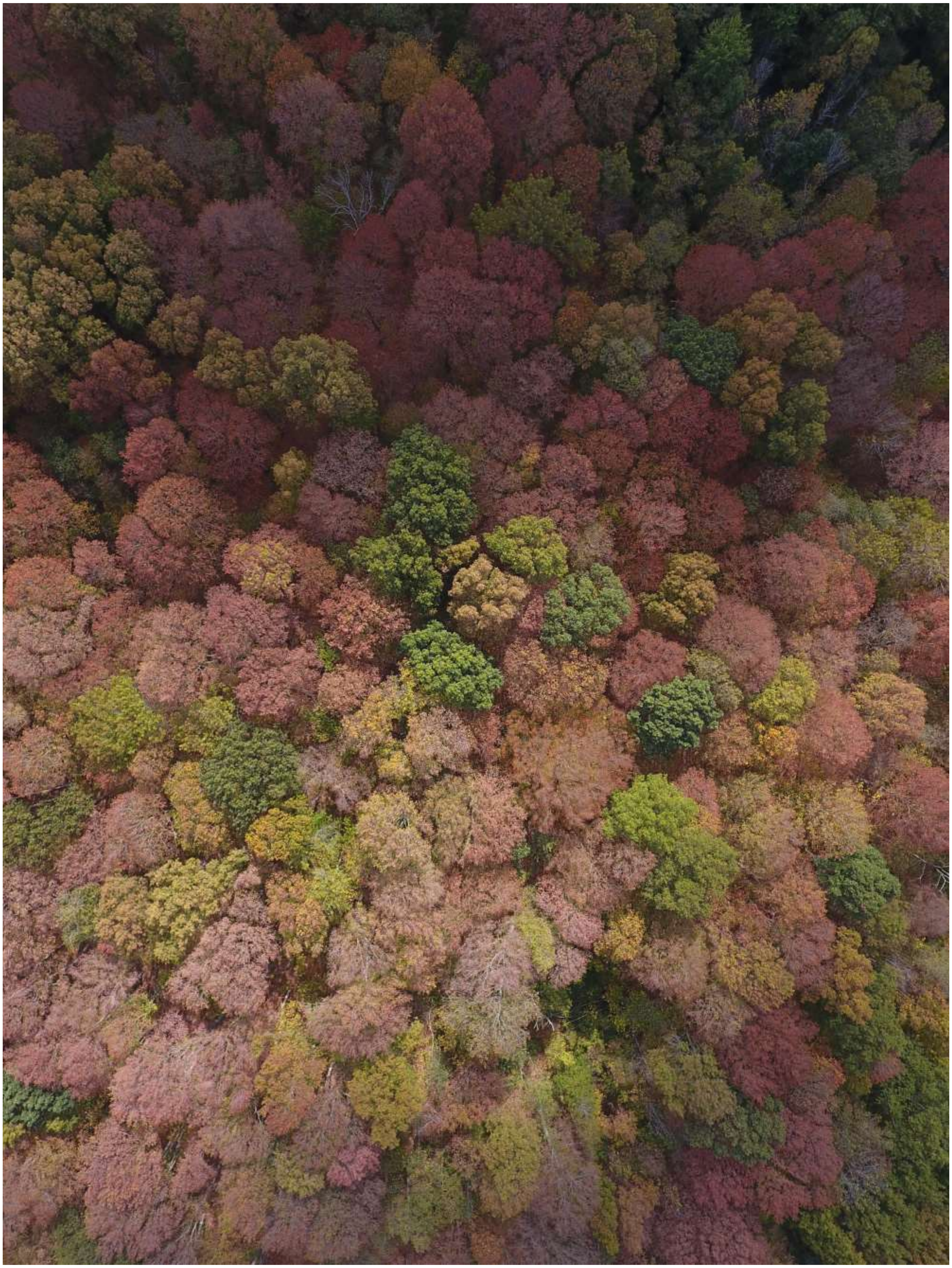
Common Name	Scientific Name	Acronym	Native?	W
bishops-cap	Mitella diphylla	MITDIP	native	3
naked miterwort	Mitella nuda	MITNUD	native	-3
sensitive fern	Onoclea sensibilis	ONOSEN	native	-3
hairy sweet-cicely	Osmorhiza claytonii	OSMCLI	native	3
cinnamon fern	Osmunda cinnamomea	OSMCIN	native	-3
royal fern	Osmunda regalis	OSMREG	native	-5
virginia creeper	Parthenocissus quinquefolia	PARQUI	native	3
jumpseed	Persicaria virginiana	PERVIR	native	0
lopseed	Phryma leptostachya	PHRLEP	native	3
downy solomon seal	Polygonatum pubescens	POLPUB	native	5
quaking aspen	Populus tremuloides	POPTRE	native	0
tall white lettuce	Prenanthes altissima	PREALT	native	3
self-heal	Prunella vulgaris	PRUVUL	native	0
choke cherry	Prunus virginiana	PRUVIR	native	3
swamp buttercup	Ranunculus hispidus	RANHIS	native	0
hooked crowfoot	Ranunculus recurvatus	RANREC	native	-3
prickly or wild gooseberry	Ribes cynosbati	RIBCYN	native	3
multiflora rose	Rosa multiflora	ROSMUL	non-native	3
black raspberry	Rubus occidentalis	RUBOCC	native	5
dwarf raspberry	Rubus pubescens	RUBPUB	native	-3
cut-leaf coneflower	Rudbeckia laciniata	RUDLAC	native	-3
great water dock	Rumex orbiculatus	RUMORB	native	-5
mad-dog skullcap	Scutellaria lateriflora	SCULAT	native	-5
bittersweet nightshade	Solanum dulcamara	SOLDUL	non-native	0
late goldenrod	Solidago gigantea	SOLGIG	native	-3
rough-leaved goldenrod	Solidago rugosa	SOLRUG	native	0
calico aster	Symphyotrichum lateriflorum	SYMLAT	native	0
skunk-cabbage	Symplocarpus foetidus	SYMFOE	native	-5
purple meadow-rue	Thalictrum dasycarpum	THADAS	native	-3
arbor vitae	Thuja occidentalis	THUOCC	native	-3
basswood	Tilia americana	TILAME	native	3
poison-ivy	Toxicodendron radicans	TOXRAD	native	0
star-flower	Trientalis borealis	TRIBOR	native	0
common trillium	Trillium grandiflorum	TRIGRA	native	3
american elm	Ulmus americana	ULMAME	native	-3
marsh violet	Viola cucullata	VIOCUC	native	-5
dog violet	Viola labradorica	VIOLAB	native	0
river-bank grape	Vitis riparia	VITRIP	native	0

Appendix 20. Plant species observed in Wilson Woods Wet-Mesic Flatwoods (EO ID 23184, pg 61) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
black maple	Acer nigrum	ACENIG	native	4	3
sugar maple	Acer saccharum	ACESAU	native	5	3
swamp agrimony	Agrimonia parviflora	AGRPAR	native	4	0
juneberry	Amelanchier arborea	AMEARB	native	4	3
false nettle	Boehmeria cylindrica	BOECYL	native	5	-5
sedge	Carex bromoides	CXBROM	native	6	-3
sedge	Carex gracilescens	CXGRAS	native	5	3
sedge	Carex intumescens	CXINTU	native	3	-3
sedge	Carex lacustris	CXLACU	native	6	-5
sedge	Carex muskingumensis	CXMUSK	native	6	-5
sedge	Carex pensylvanica	CXPENS	native	4	5
sedge	Carex woodii	CXWOOD	native	8	3
blue-beech	Carpinus caroliniana	CARCAO	native	6	0
bitternut hickory	Carya cordiformis	CARCOR	native	5	0
shagbark hickory	Carya ovata	CAROVA	native	5	3
wood reedgrass	Cinna arundinacea	CINARU	native	7	-3
silky dogwood	Cornus amomum	CORAMO	native	2	-3
autumn-olive	**Elaeagnus umbellata**	**ELAUMB**	**non-native**	**0**	**3**
bottlebrush grass	Elymus hystrix	ELYHYS	native	5	3
virginia wild-rye	Elymus virginicus	ELYVIR	native	4	-3
running strawberry-bush	Euonymus obovatus	EUOOBO	native	5	3
american beech	Fagus grandifolia	FAGGRA	native	6	3
nodding fescue	Festuca subverticillata	FESSUB	native	5	3
wild strawberry	Fragaria virginiana	FRAVIR	native	2	3
white ash	Fraxinus americana	FRAAME	native	5	3
blue ash	Fraxinus quadrangulata	FRAQUA	native	8	3
white wild licorice	Galium circaezans	GALCIR	native	4	3
white avens	Geum canadense	GEUCAN	native	1	0
witch-hazel	Hamamelis virginiana	HAMVIR	native	5	3
michigan holly	Ilex verticillata	ILEVER	native	5	-3
southern blue flag	Iris virginica	IRIVIR	native	5	-5
spicebush	Lindera benzoin	LINBEN	native	7	-3
partridge-berry	Mitchella repens	MITREP	native	5	3
sensitive fern	Onoclea sensibilis	ONOSEN	native	2	-3
ironwood; hop-hornbeam	Ostrya virginiana	OSTVIR	native	5	3
jumpseed	Persicaria virginiana	PERVIR	native	4	0
canada bluegrass	**Poa compressa**	**POACOM**	**non-native**	**0**	**3**
woodland bluegrass	Poa sylvestris	POASYL	native	8	0
cottonwood	Populus deltoides	POPDEL	native	1	0
quaking aspen	Populus tremuloides	POPTRE	native	1	0
white oak	Quercus alba	QUEALB	native	5	3
swamp white oak	Quercus bicolor	QUEBIC	native	8	-3
bur oak	Quercus macrocarpa	QUEMAC	native	5	3
chinquapin oak	Quercus muehlenbergii	QUEMUE	native	5	3
red oak	Quercus rubra	QUERUB	native	5	3
prickly or wild gooseberry	Ribes cynosbati	RIBCYN	native	4	3
common blackberry	Rubus allegheniensis	RUBALL	native	1	3
black raspberry	Rubus occidentalis	RUBOCC	native	1	5
black snakeroot	Sanicula odorata	SANODO	native	2	0
water-parsnip	Sium suave	SIUSUA	native	5	-5

Appendix 20 (continued). Plant species observed in Wilson Woods Wet-Mesic Flatwoods (EO ID 23184, pg 61) during 2017 surveys.

Common Name	Scientific Name	Acronym	Native?	C	W
bristly greenbrier	Smilax hispida	SMIHIS	native	5	0
lake ontario aster	Symphyotrichum ontarionis	SYMONT	native	6	0
basswood	Tilia americana	TILAME	native	5	3
poison-ivy	Toxicodendron radicans	TOXRAD	native	2	0
american elm	Ulmus americana	ULMAME	native	1	-3
canada violet	Viola canadensis	VIOCAN	native	5	3
long-spurred violet	Viola rostrata	VIOROS	native	6	3
prickly-ash	Zanthoxylum americanum	ZANAME	native	3	3


It was a pleasure to explore and document the unique natural features of Maple River State Game Area. Photo of Wacousta Woods Mesic Southern Forest by Jesse M. Lincoln.