Natural Features Inventory and Management Recommendations for Muskegon State Game Area

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Michigan Natural Features Inventory
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A bur oak in the Muskegon Floodplain forest. Photo By Jesse Lincoln.

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Cover Photo: The Muskegon Floodplain Forest, Muskegon State Game Area. Photo By Jesse Lincoln.

EXECUTIVE SUMMARY

The Muskegon State Game Area (SGA) is a large block of semi-continuous public land in western Lower Michigan, consisting of 15,691 acres in Muskegon and Newaygo Counties. Muskegon SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports 7,285 acres of forest and 9,726 acres of wetlands. The river and its floodplain are prominent features of Muskegon SGA and the numerous and diverse wetlands, vernal pools, and lakes within the game area support a diversity of insect, herptile, avian, mammalian, plant, and aquatic species.

Because the landscape surrounding Muskegon 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. Michigan Natural Features Inventory (MNFI) conducted Stage 1 Michigan Forest Inventory (MiFI) in 2011 and 2012. Surveys for high-quality natural communities were conducted in Muskegon SGA in 2016 and for vernal pools and rare animals in 2018 as part of the Integrated Inventory Project: a long-term effort by the Michigan DNR Wildlife Division to document and sustainably manage areas of high conservation significance on state lands.

Throughout this report, high-quality natural communities and state and federally listed rare species are referred to as elements and their documented occurrence at a specific location is referred to as an element occurrence or "EO." During the Integrated Inventory Project at Muskegon SGA, MNFI scientists documented 10 new natural community EOs, 4 new rare animal EOs, 8 new rare plant EOs, and provided information for updating 35 existing EOs. In all, 24 species of greatest conservation need (SGCN) and 24 rare animal species have been recorded in Muskegon SGA. In total, 54 EOs have been documented in Muskegon SGA including 29 animal EOs, 13 plant EOs, and 12 natural community EOs.

During the project, MNFI ecologists documented 10 new natural community EOs. Nine different natural community types are represented in the twelve EOs surveyed including coastal plain marsh, dry sand prairie, floodplain forest, hardwood-conifer swamp, intermittent wetland, oak-pine barrens, poor fen, southern hardwood swamp, and wet-mesic sand prairie. We assessed the current ranking, classification, and delineation of these occurrences and detailed the vegetative structure and composition, ecological boundaries, landscape and abiotic context, threats, management needs, and restoration opportunities. This report provides detailed descriptions of each site as well as a comprehensive discussion of site-specific threats and stewardship needs and opportunities.

Prior to the MiFI surveys there were five existing rare plant EOs and eight additional rare plants were opportunistically documented. Wild rice (*Zizania aquatica*, state threatened) was documented along Cedar Creek and the Maple River. Climbing hempweed (*Mikania scandens*, state threatened) was known from the Muskegon River area from one vague collection taken in the late 1800s but relocation efforts were unsuccessful and the species was presumed extirpated from Michigan until the MiFI surveys relocated the population in 2012. The remainder of the species are associated with the prairies and coastal plain systems in the Eastern Unit of the Game Area.

A total of 63 potential vernal pools (PVPs) were identified and mapped in Muskegon SGA. Of these, 57 were identified and mapped through aerial imagery interpretation and an additional 6 that had not been mapped from aerial imagery interpretation were encountered during field surveys. A total of 29 potential vernal pools were surveyed, resulting in 17 field-verified vernal pools. These survey and mapping results provide baseline information on vernal pool status, distribution, and ecology in the game area, which will help natural resource planners and managers develop and implement appropriate management of these wetlands.

Surveys for rare avian species included point-counts for forest songbirds, raptors, and marsh birds. We conducted morning surveys for rare songbirds at 97 point-count locations within forest. A new EO for Louisiana waterthrush was documented in the western portion of the game area along the Muskegon River. Rare raptor surveys were completed at 97 points within the game area. Red-shouldered hawks were detected at 20 (21%) of the points visited. Two potential red-shouldered hawk nests were seen but no birds were seen on or near these nests. Twenty-three points were surveyed for marsh birds at Muskegon SGA in 2018. Prior to these surveys, EOs had been documented within the game area for least bittern, black tern, and marsh wren. The presence of least bittern was reconfirmed at one of the occurrences and marsh wren at both occurrences, but black terns were not observed during the 2018 surveys.

MNFI scientists conducted visual encounter or meander surveys, basking surveys, dipnetting, aquatic funnel trapping, and breeding frog call surveys for rare amphibians and reptiles. Amphibian and reptile surveys in the Muskegon SGA in 2018 documented two rare reptile species and twelve common amphibian and reptile species. Records for Blanding's turtle and eastern box turtle were updated for the game area.

Aquatic surveys were performed at nine sites within Muskegon State Game Area. A total of seven unionid mussel species were found including one federally endangered and one state endangered species. One slightly chalky female half shell of the federally endangered snuffbox (*Epioblasma triquetra*) was found in the main stem of the Muskegon River. The occurrence is only the second record of snuffbox in the Muskegon River watershed. One shell of the state endangered black sandshell (*Ligumia recta*) was also found near the boat ramp. Both species are also considered SGCN and these findings represent new EOs. No live individuals were found at any of the aquatic survey sites. All species were represented by shells only. Although a large amount of area in the lower Muskegon River was visually surveyed by boat in order to try to locate any sign of mussels, no shells or live individuals were found.

Muskegon SGA supports 9,726 acres of wetlands, including the large floodplain forest along the river. These wetlands are critical for maintaining water quality of the Muskegon River and Muskegon Lake. Floodplain forests provide a variety of ecosystem services, including habitat 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, water temperature regulation with cooler water temperatures occurring along floodplains due to shading of the river and tributaries. These services provide water quality protection of the Muskegon River, Muskegon Lake, and Lake Michigan and by extension, benefit the local economies surrounding tourism, recreation, and fisheries that rely on the health of those bodies of water.

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. Land management in an area as ecologically significant as Muskegon SGA requires the careful prioritization of stewardship efforts in the most critical habitats and these recommendations are intended to protect native biodiversity and ecosystem integrity. The primary management needs in order of importance are to: 1) prevent alterations to hydrology within the floodplain forest and other high-quality wetlands throughout the game area; 2) prevent fragmentation and maintain the canopy closure of high-quality forests, particularly floodplain forest along the Muskegon River; 3) continue to implement landscape-scale prescribed fire; 4) control invasive species in high-quality natural communities; and 5) monitor these management activities to facilitate adaptive management.

ACKNOWLEDGEMENTS

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DNR employee Hunter Pulling provided critical navigational support of during the surveys of the Muskegon Floodplain forest. Photo by Jesse Lincoln.

INTRODUCTION

The Muskegon State Game Area (SGA) is a large block of semi-continuous public land in western Lower Michigan, consisting of 15,691 acres in Muskegon and Newaygo Counties (Figure 1). Muskegon SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports 7,285 acres of forest and 9,726 acres of wetlands. The river and its floodplain are prominent features of Muskegon SGA. The Muskegon River flows from the third largest watershed in Michigan, draining over 2,350 square miles. Michigan Natural Features Inventory (MNFI) conducted Stage 1 Michigan Forest Inventory (MiFI) in 2011 and 2012. Surveys for high-quality natural communities were conducted in Muskegon SGA in 2016 and for vernal pools and rare animals in 2018 as part of the Integrated Inventory Project. This project is part of a long-term effort by the Michigan DNR Wildlife Division to document and sustainably manage areas of high conservation significance on state lands. 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. This baseline information is critical for facilitating site-level decisions about biodiversity stewardship; prioritizing protection, management and restoration; monitoring the success of management and restoration; and informing landscape-level biodiversity planning efforts.

Natural land cover within Muskegon SGA plays an important role in sustaining the riparian ecosystem, including rare and economically and culturally important species. This report provides an overview of the landscape and historical context of Muskegon SGA, summarizes the findings of MNFI's surveys for high-quality natural communities and rare animal species, and identifies stewardship priorities within the game area. Because the landscape surrounding Muskegon 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. Muskegon SGA supports several rare reptile, avian, mussel, insect, and plant species. During the natural features inventory of this

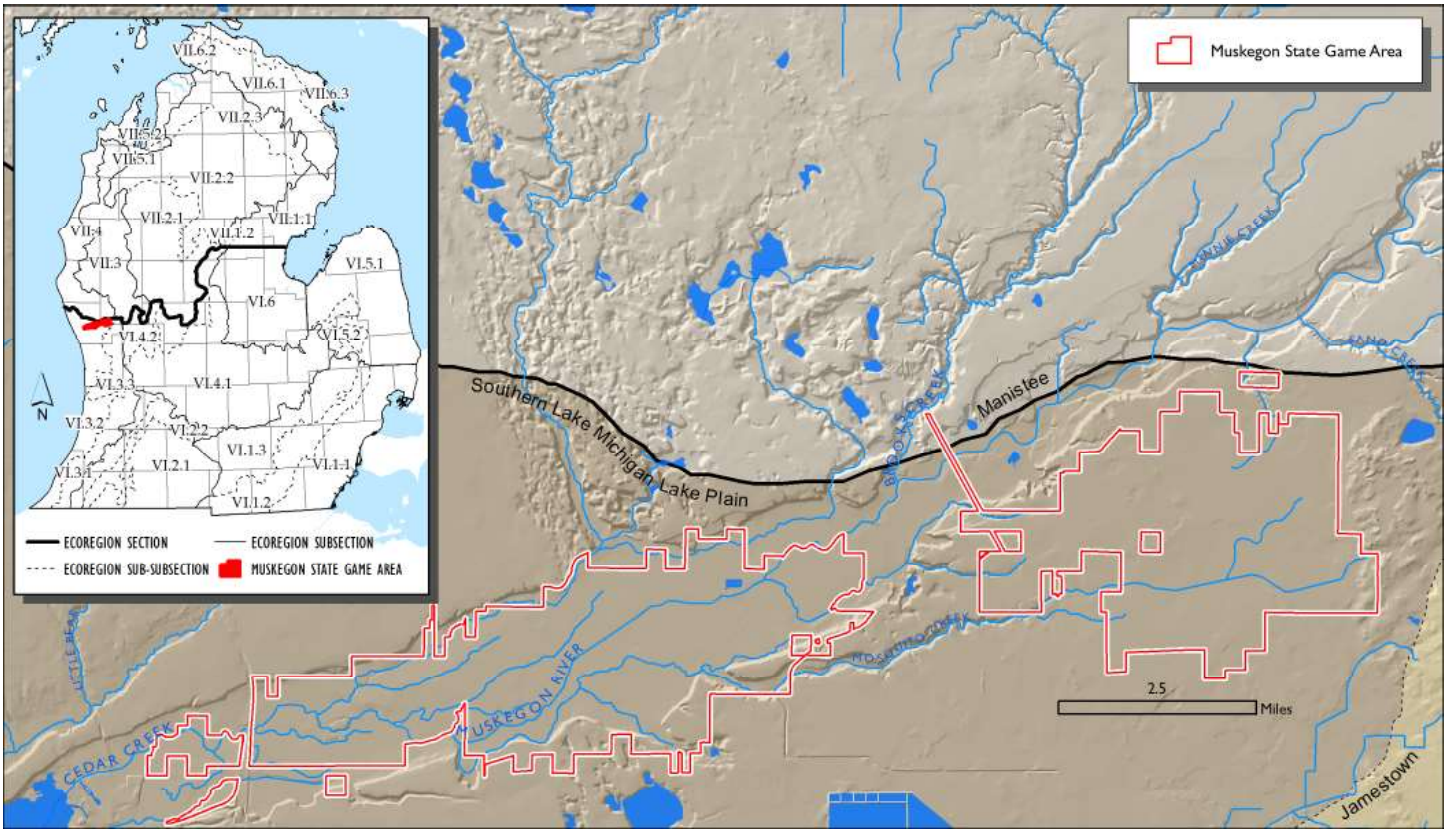


Figure 1. Ecoregions and topographic relief of Muskegon State Game Area (Albert 1995).

game area, MNFI scientists documented 4 occurrences of rare animals, 8 occurrences of rare plants, 17 vernal pools, and 10 high-quality natural communities. Management recommendations are provided for rare species, specific natural communities, vernal pools, and the game area in general.

Throughout this report, high-quality natural communities and state and federally listed rare species are referred to as elements and their documented occurrence at a specific location is referred to as an element occurrence or "EO." A natural community is defined as 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. 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.

Survey Area and Landscape Context

The regional landscape ecosystems of Michigan have been classified and mapped based on an integration of climate, physiography, soils, and natural vegetation (Albert 1995; Figure 1). 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. Muskegon SGA lies within Southern Lake Michigan Lakeplain Sub-subsection (VI.3.2) of the Allegan Subsection (Subsection VI.3; Figure 1). The Allegan Subsection (VI.3) is bounded by Lake Michigan to the west and the typical land forms are flat lakeplain, coastal sand dunes, gently rolling till plain, and rolling to steep end moraines. Several of the state's major rivers cross the Subsection, including the Kalamazoo, St. Joseph, Grand, and Muskegon rivers. Within the Allegan Subsection, the Southern Lake Michigan Lakeplain Sub-subsection is characterized by extensive lakeplain features associated with historic levels of Lake Michigan that were much higher during periods of glacial recession. Sand dunes

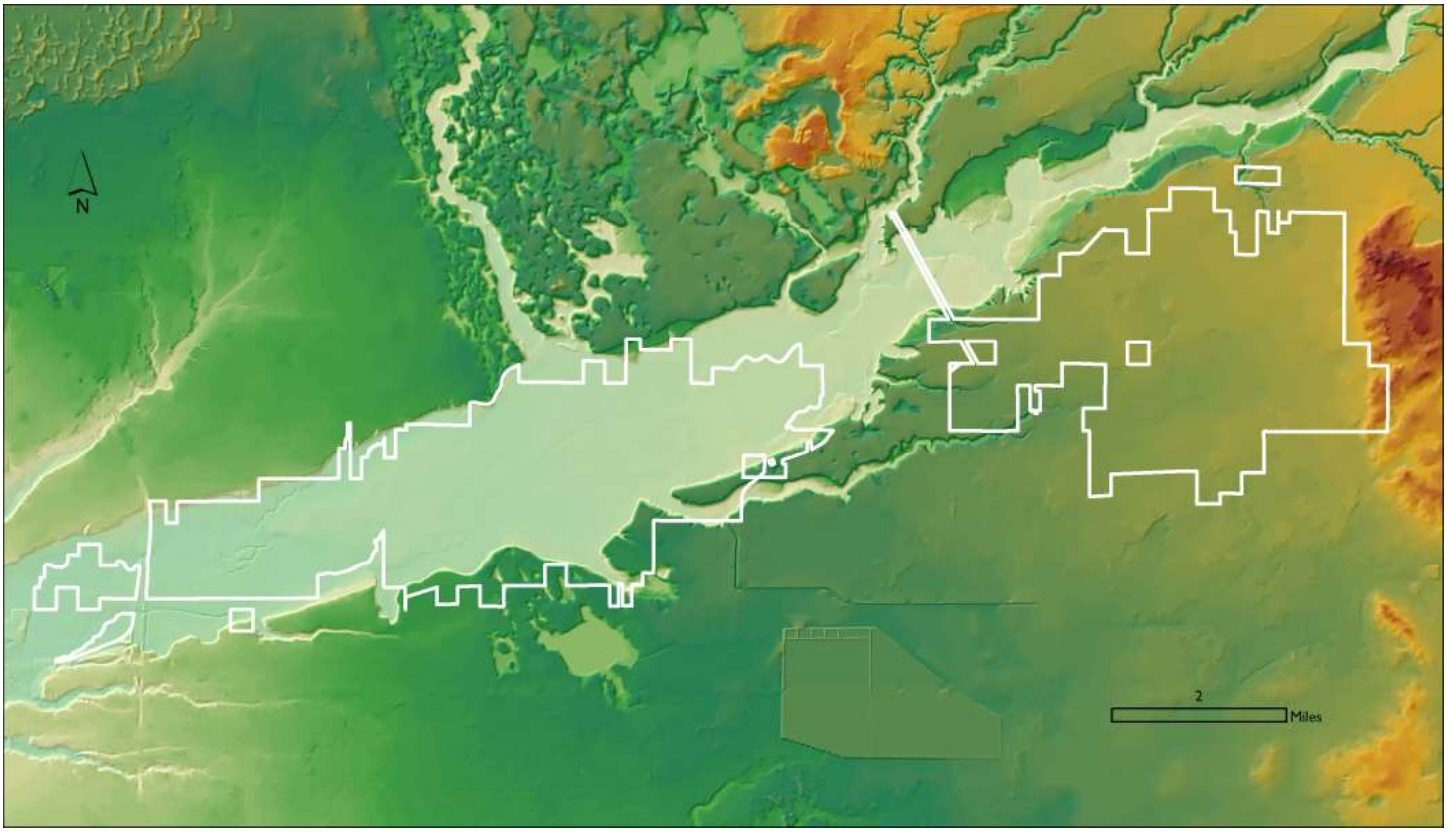


Figure 2. A digital elevation map of Muskegon State Game Area. This map highlights the Muskegon River outwash channel that bisects the surrounding outwash plain. The lower elevation of the outwash channel is depicted with light green and higher elevations are shown in orange.

inland from the present-day Lake Michigan shoreline are associated with those historic shorelines. Deep sands were deposited over the lakeplain during outwash events that formed the major river channels (Figure 2). Throughout the sub-subsection are small kettle depressions left by fragments of the receding glacier (Albert 1995).

Circa-1800 Vegetation

General Land Office (GLO) surveyor notes were interpreted by MNFI ecologists and indicate that several distinct vegetation assemblages occurred in the region around 1800 (Comer et al. 1995; Figure 3). Surveyors for the GLO recorded information on tree species composition, tree size, and general condition of the lands within and surrounding Muskegon SGA. Circa 1800, the game area was predominantly forested with an estimated 94% of the game area supporting forested ecosystems including Mixed Hardwood Swamp (41%), Hemlock-White Pine Forest (26%), Mixed Conifer Swamp (17%), and White Pine-White Oak Forest (6%).

Historically, wetlands were a prominent feature within the game area, most notably within the Muskegon River outwash channel where original surveyors described "impossible bottoms." Additional wetlands occurred sporadically in the eastern unit of the game area along the margins of small streams, within kettle depressions, and in poorly drained portions of outwash plain (Figure 3). Mixed Hardwood Swamp was the most abundant cover type and corresponds to the forested wetlands along the river. Where the surveyors noted canopy composition of these swamps, American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), and sycamore (*Platanus occidentalis*) were prevalent canopy dominants with conifers more abundant in the Mixed Conifer Swamps at the margins of the outwash channel and in forested wetlands of the eastern unit of the game area. Within these forested swamps, recorded diameters of canopy trees ranged from 17 to 122 cm (7 to 48 in) with an average of 45 cm (18 in; N = 68).

Upland forests occurred on the slopes along the Muskegon River outwash channel and on the surrounding outwash plain. White pine (*Pinus strobus*) was by far the most prevalent tree species recorded by GLO surveyors in this area. Other common species frequently mentioned in the

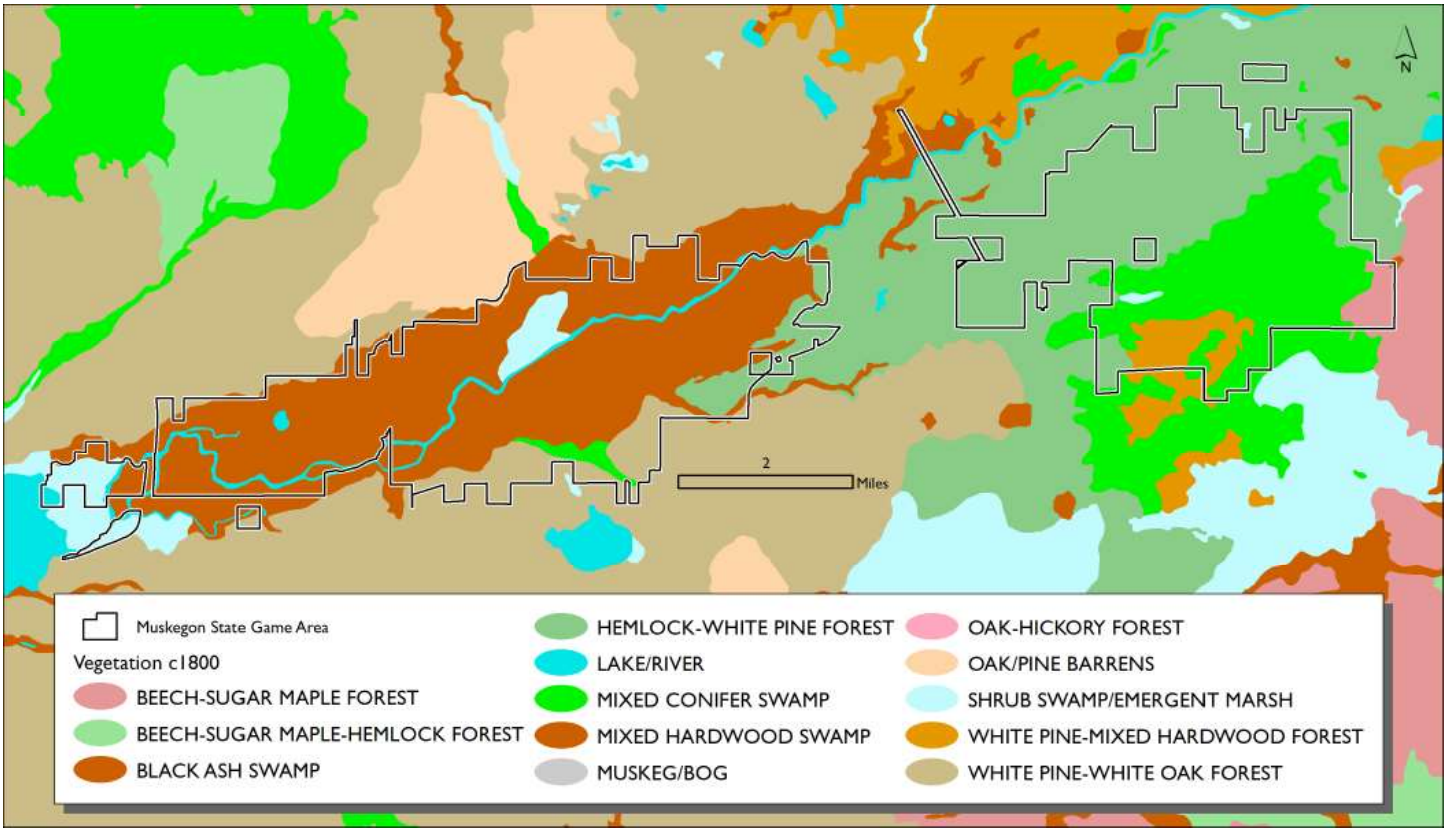


Figure 3. Circa-1800 vegetation of Muskegon State Game Area (Comer et al. 1995).

original survey notes were beech (*Fagus grandifolia*), hemlock (*Tsuga canadensis*), white oak (*Quercus alba*), and black oak (*Q. velutina*). Within the areas classified as upland forest, recorded diameters of trees ranged widely from 17 to 101 cm (7 to 40 in) with an average of 45 cm (18 in; N = 66).

Despite no mention of oak-pine barrens or prairies in the GLO notes, MNFI ecologists identified many areas supporting species characteristic of those rare community types and they were doubtlessly historically present throughout the landscape. These community types were relatively small and occasionally missed in the GLO surveys as a result of the coarse scale of the historic mapping efforts. Open ecosystems would have occurred within a shifting mosaic of oak-pine forest and oak-pine barrens, depending on the frequency and intensity of fire. These sites were likely a significant component of the vegetation cover on the sandiest areas of outwash plain surrounding the Muskegon River basin.

Current Land Cover

The landcover within Muskegon SGA (Figures 4 and 5) has changed significantly since the early 1800s due to logging, hydrologic alteration, tree disease, non-native insect outbreak, agriculture, fire suppression, and deer herbivory. The GLO notes documented elm as the most prevalent tree in the floodplain and pine as the most common tree in the uplands. Neither of these species are dominant on the landscape today. Likewise, ash and hemlock, also prevalent in the GLO notes, have become only minor components of the forest canopy. Such changes in canopy dominance are due to logging, tree disease, and insect outbreak. Aerial photographs from 1938 (Figure 4) show how logging,

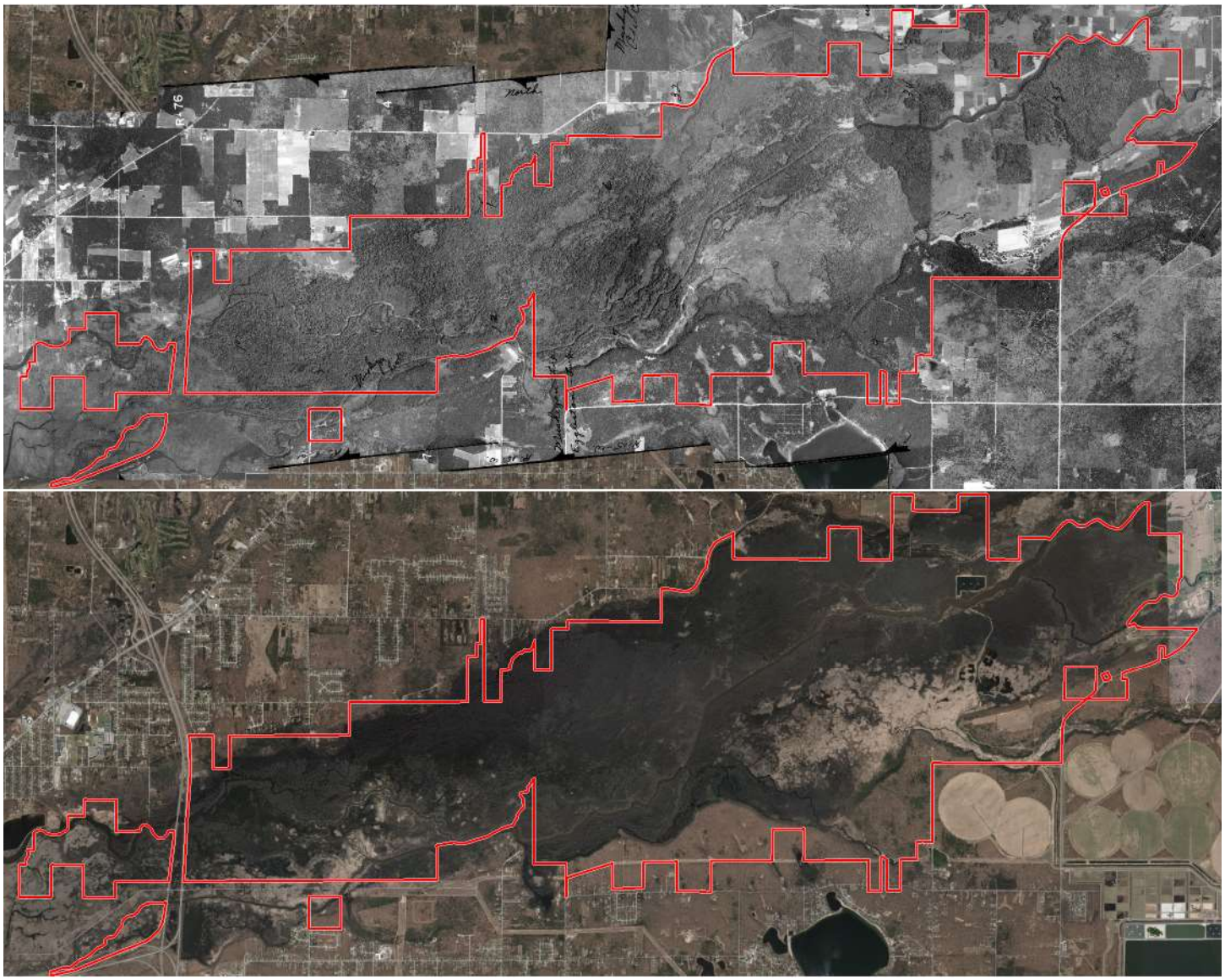


Figure 4. Mosaic of 1938 aerial photographs of the western management unit of Muskegon State Game Area (top) contrasted with imagery from 2014 (bottom).

hydrologic changes in the floodplain complex, and the expansion of agriculture led to habitat fragmentation, increased dominance of invasive species, more extensive herbivory, and protracted fire suppression throughout the Muskegon SGA and the surrounding area.

Currently, non-forested wetland is the most predominant land cover type in Muskegon SGA (39% of the game area; 6,042 ac). Upland forest and forested wetlands are the next two most common cover types at 28% (4,446 ac) and 18% (2,839 ac), respectively. This is a dramatic shift in composition over the past 200 years as the historic composition was 58% (9,081 ac) forested wetland and only 3% (513 ac) non-forested wetland. Much of this conversion is due to hydrologic alterations. Significant changes occurred along US Highway 31 where the flow from east to west was impeded and the forest transitioned to open wetlands on the east side of the highway. The drainage along Mosquito Creek has been impacted by discharge from the wastewater treatment facility that has increased output and nutrient content of the creek, drowning the forest and creating an extensive open wetland dominated by narrow-leaved cat-tail (*Typha angustifolia*). Agricultural and logging operations throughout the floodplain have converted extensive areas of forest to non-forested cover through clearing and ditching within portions of the wetland complex. Despite the dramatic shifts in composition as a result of anthropogenic disturbance, abundant natural cover remains within Muskegon SGA with 24% (3,768 ac) of the game area identified as high-quality natural community, including the largest floodplain forest documented within the state.

The floodplain along the Muskegon River contains 3,752 acres of lowland forest and wetland openings and is the largest documented example of that community type within the state. It is a large system with areas of varying community structure and composition and a long and complex history of anthropogenic use and disturbance. Photo by Jesse Lincoln.

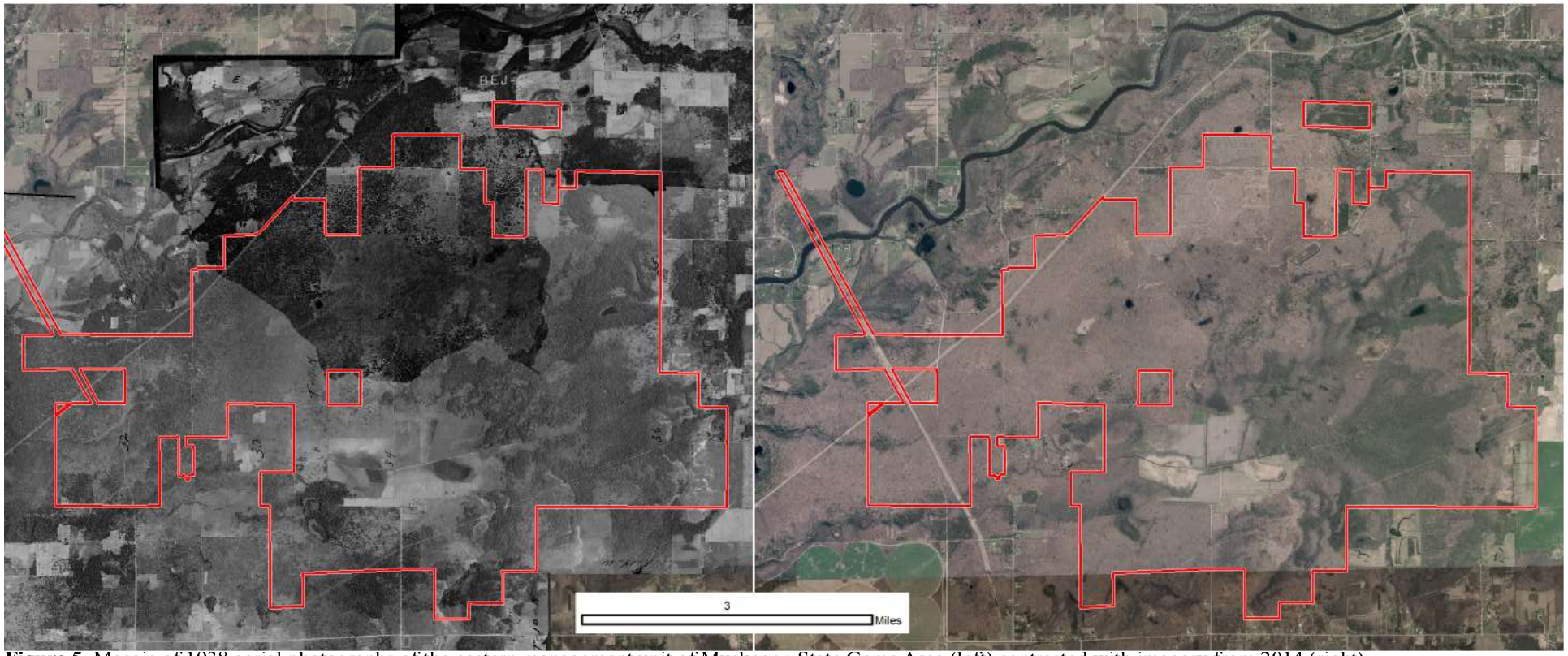


Figure 5. Mosaic of 1938 aerial photographs of the eastern management unit of Muskegon State Game Area (left) contrasted with imagery from 2014 (right).

METHODS

Natural Communities

Natural community surveys detailed the vegetative structure and composition, ecological boundaries, and landscape and abiotic context of exemplary natural communities. These surveys also assessed the current ranking, classification, and delineation of these occurrences. Each natural community was evaluated employing 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, Faber-Langendoen et al. 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 and entered into MNFI's database as an element occurrence (EO). Ecological field surveys to evaluate the condition and classification of the sites were conducted from June to October of 2016.

The ecological field surveys involved:

a) compiling comprehensive plant species lists and noting dominant and representative species
b) describing site-specific structural attributes and ecological processes
c) measuring tree diameter at breast height (DBH) of representative canopy trees and aging canopy dominants (where appropriate)
d) analyzing soils and hydrology
e) noting current and historical anthropogenic disturbances
f) evaluating potential threats to ecological integrity
g) ground-truthing aerial photographic interpretation using GPS
h) taking digital photos and GPS points at significant locations
i) surveying adjacent lands when possible to assess landscape context
j) evaluating the natural community classification and mapped ecological boundaries
k) assigning or updating element occurrence ranks
l) 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 2018a). 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. 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). Information from these surveys was used to produce site descriptions, threat assessments, restoration opportunities, and management recommendations for each natural community occurrence, which appear within the following Natural Community Surveys Results section.

Vernal Pools

Potential vernal pools (PVPs) and verified vernal pools were identified and mapped in Muskegon SGA using aerial imagery interpretation and field sampling (Figure 13, pg 47). To map PVPs, we examined color infrared, leaf-off aerial imagery from the spring of 1998, and natural color aerial imagery from the summer of 2005, 2010, and/or 2012 (i.e., NAIP 2005, NAIP 2010, and NAIP 2012 True Color). Topographic maps of the game area also were examined. Potential vernal pools were digitized and mapped as polygons using ESRI ArcGIS software. A subset of the mapped PVPs in Muskegon SGA was surveyed in late March and July 2018 to verify, map, and collect data on vernal pools. Surveyors verified if PVPs represented actual vernal pools or other types of wetlands or ecosystems. Vernal pools or potential vernal pools that were encountered during field sampling and had not been remotely mapped as PVPs also were recorded and mapped. Basic information about the physical characteristics, general condition, surrounding cover, vegetative structure, and presence of vernal pool indicator species and other animals were recorded in the field using a standardized vernal pool monitoring data form (Appendix 2). Vernal pools were classified into the following six general types based on vegetation within the pools: open pools; sparsely vegetated pools; shrubby pools; forested pools; marsh pools; and other (e.g., half open and half shrubby). Definitions of vernal pool types are provided in Appendix 3. Vernal pools and other ecosystems identified

Table 1. Rare insect EOs at Muskegon State Game Area. State status abbreviation of "T" signifies state threatened. Federal status abbreviation of "LE" signifies federally endangered. EO rank abbreviations are as follows: B, good viability; BC, good to fair viability; H, historic record; and E, verified extant but with insufficient information to rank viability at this time.

Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Rank	Year First Observed	Year Last Observed	Location
Persius dusky wing	*Erynnis persius persius*	T		20748	BC	2016	2018	Fitzgerald Road ITC Transmission Line
Karner blue	*Lycaeides melissa samuelis*	T	LE	10	B	2002	2018	Fitzgerald Road ITC Transmission Line
Karner blue	*Lycaeides melissa samuelis*	T	LE	13509	E	2003	2003	Wolf Lake Powerline
Karner blue	*Lycaeides melissa samuelis*	T	LE	2529	H	1950	1953	Becker Road

in the field were photographed for documentation and verification. Potential vernal pools and field sampling data were incorporated into the Michigan Vernal Pool Database (MNFI 2018), a statewide geodatabase containing locational and ecological data about potential and field-verified vernal pools.

Rare Animals

Target species for rare animal surveys were identified using historical distribution within Michigan, past occurrences in or near Muskegon SGA, and the presence of potential habitat. A variety of data sources were used to determine if potential habitat occurs within the game area, including natural community EOs, MiFI cover types and descriptions, aerial photography, and on-the-ground observations. Based on these criteria, rare animal surveys focused on woodland raptors, forest interior songbirds, secretive marsh birds, herptiles, and unionid mussels. 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.

Four insect EOs of two different rare insect species have been documented from Muskegon SGA including three EOs for Karner blue (*Lycaeides melissa samuelis*, federally endangered and state threatened) and one EO for persius dusky wing (*Erynnis persius*, state threatened) (Table 1, Figure 6). Karner blue and persius dusky wing are currently listed as SGCN and Karner blue is a focal species of the DNR's Wildlife Action Plan. We did not choose to survey for these rare insects for this project because a concurrent survey project addressed this survey need for Karner blue (Monfils and Cuthrell 2015) and persius dusky wing has been recently been documented within the game area (Table 1).

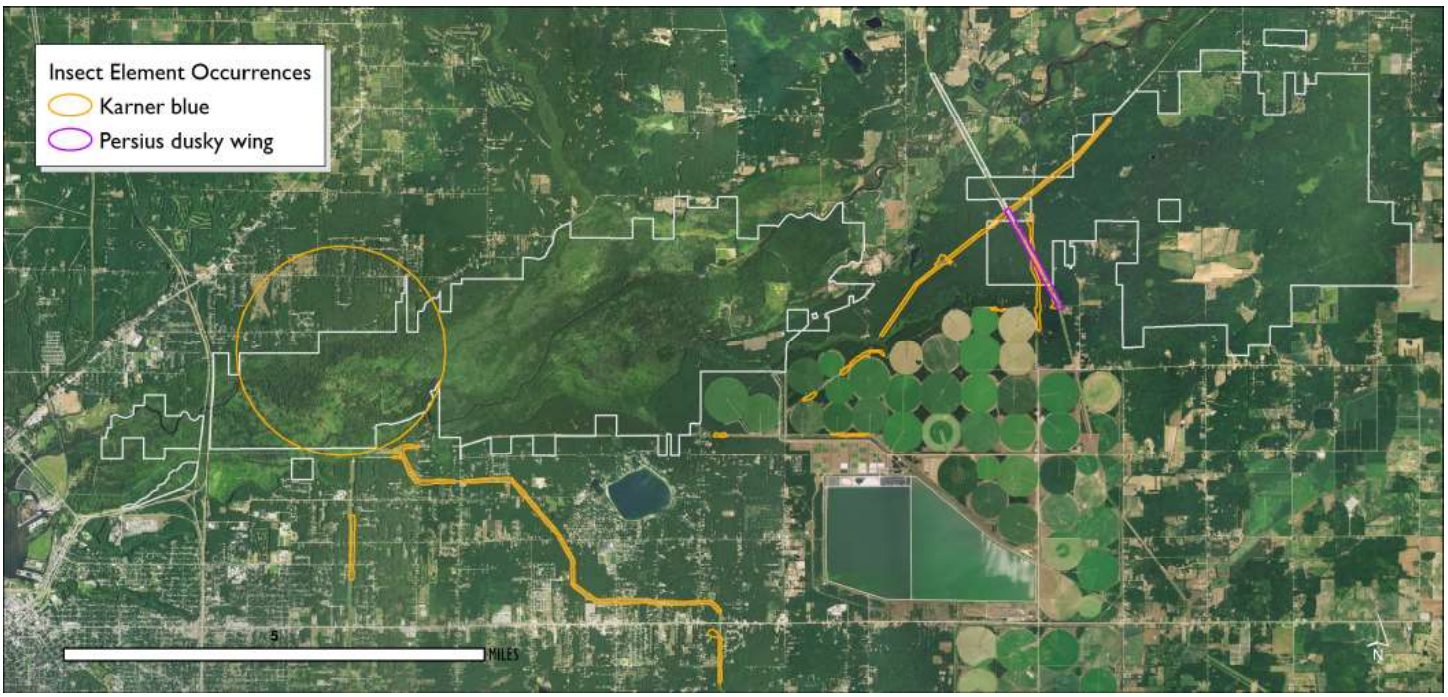


Figure 6. Location of rare insect element occurrences in Muskegon State Game Area.

Birds

Given the presence of tracts of mature forest and results of previous surveys, bird surveys targeted rare songbirds, raptors, and marsh birds. Raptor surveys focused on red-shouldered hawk (*Buteo lineatus*, state threatened) and northern goshawk (*Accipiter gentilis*, state special concern), both DNR featured species. Contiguous forested stands of at least 4 ha (10 ac) were considered potential habitat for target species. A 250 m X 250 m grid of possible survey points was generated and overlaid on potential survey stands. Those points within potential survey stands were locations for conducting raptor and songbird surveys. Because of the high number of potential survey points identified for surveys in 2018, potential points were prioritized based on stand type, age, and density. Points falling within pine plantations were not surveyed. Remaining points were classified as priority 1, 2, 3, and 4 in order of highest to lowest priority. Priority 1 points fell within stands having an age of at least 80 years (i.e., ≥ 80 years since harvest, year of entry 1936 or earlier) and a stand density of 9 (saw timber, well stocked). Points occurring in stands less than 80 years of age but having a stand density of 9 were assigned Priority 2. Priority 3 points fell within stands of at least 80 years in age but had stand densities of 7 or 8 (saw timber, poor to medium stocking). Points not meeting the criteria for priority 1, 2, or 3 were assigned priority 4; these points were not targeted for surveys but were visited opportunistically. Points were assigned unique identification numbers and uploaded to a GPS unit or 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.

Three-minute raptor surveys were conducted at systematically located point count stations (Figure 14, pg 48; Mosher et al. 1990, Anderson 2007, Bruggeman et al. 2011). Each three-minute point count consisted of two minutes of broadcasts (one minute for red-shouldered hawk and one minute for northern goshawk) and one minute of silent listening. Surveys were conducted between April 26nd and May 10th, 2018. At each station the following data were recorded: whether a red-shouldered hawk or northern goshawk was detected; all other raptor sightings or vocalizations; other bird observations; and other rare animal species detections or potential habitats. If a rare raptor was observed, the vicinity surrounding the point was searched for potential nests. Trees were also visually inspected for stick nests while walking and driving between station locations.

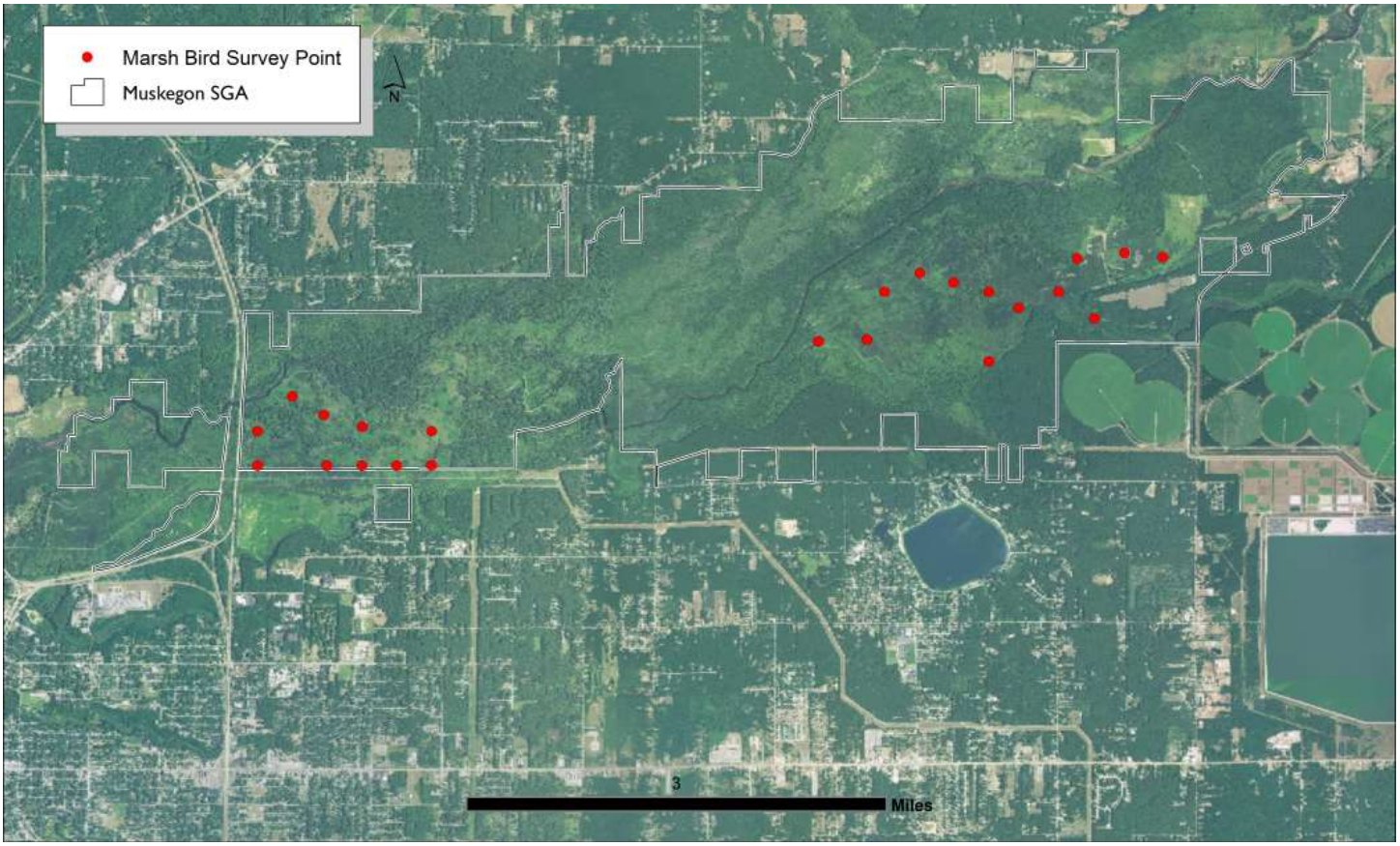


Figure 7. Location of marsh bird surveys conducted in Muskegon State Game Area in 2018.

Forest songbird surveys targeted the detection of 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). Cerulean warbler and prothonotary warbler had been detected in the game area previously. Forest bird point counts were conducted at the same systematically located points used for raptor surveys (Figure 14, pg 48). 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, therefore each point was visited only once. Surveys were conducted during May 31st to June 26th, 2018 from sunrise to 6 hours after sunrise. In addition to documenting observations of the four rare species, data were recorded for all birds observed during each 10-minute point count. The species and number of individuals observed were documented 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) and commonly used 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.

Surveys for marsh birds were conducted in large areas of emergent wetland within the game area. Target species consisted of all species surveyed under the Michigan Marsh Bird Survey (MMBS) protocol (Table 5, 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). Within emergent wetland, 23 points were systematically generated using a 400 x 400 m grid (Figure 6). Point count stations were uploaded to a tablet computer used for navigation in the field. Each point was surveyed once between May 1st and June 15th, 2018 between 0.5 hour before to three hours after sunrise. Ten-min point counts were conducted, each consisting of a five-min passive listening period followed by one-min broadcast periods for American bittern, least bittern, king rail, Virginia rail, and sora. The locations of rare species were recorded using GPS or estimated distances and azimuths from point count stations.

A yellow-billed cuckoo was observed during the bird surveys of 2018. Photo by Aaron Kortenhoven.

Reptiles and Amphibians

Surveys conducted in 2018 for rare amphibian and reptile species (i.e., herptiles or herps) focused on the following species: eastern massasauga (*Sistrurus catenatus*, federally threatened and state special concern), Blanding's turtle (*Emydoidea blandingii*, state special concern), eastern box turtle (*Terrapene carolina carolina*, state special concern), wood turtle (*Glyptemys insculpta*, state special concern), spotted turtle (*Clemmys guttata*, state threatened), Blanchard's cricket frog (*Acris blanchardi*, state threatened), Fowler's toad (*Anaxyrus fowleri*, state special concern), pickerel frog (*Lithobates palustris*, state special concern), queen snake (*Regina septemvittata*, state special concern), and gray ratsnake (*Pantherophis spiloides*, state special concern). These species were also 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 could occur within the game area based on the species' range and presence of potential habitat (Appendix 5). Surveys focused on identifying new occurrences and reconfirming and/or expanding existing occurrences. Surveys in 2018 also had potential for detecting several additional rare amphibian and reptile species or SGCN in Michigan's Wildlife Action Plan (Derosier et al. 2015) (Appendix 5), including blue racer (*Coluber constrictor foxii*), northern ribbonsnake (*Thamnophis sauritus septentrionalis*), northern ring-necked snake (*Diadophis punctatus edwardsii*), smooth green snake (*Opheodrys vernalis*), and eastern musk turtle (*Sternotherus odoratus*).

Visual encounter, nesting turtle, basking, auditory/breeding frog call, and road cruising surveys were conducted in areas with suitable habitat for the target herp species (Figure 8). Surveys were conducted from June 6th through October 9th, 2018 using standard methods for surveying amphibians and reptiles (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Graeter et al. 2013). Visual encounter surveys were conducted within and along the edge of open wetlands and waterbodies, adjacent open uplands, and upland and lowland forest stands. Surveys consisted of one or two surveyors walking slowly through areas with suitable habitat for survey targets, overturning cover (e.g., logs, rocks, etc.), inspecting retreats, and looking for basking, resting, or active individuals on the surface or under cover objects. A subset of these visual surveys was conducted in June in areas with open sandy habitat to look for nesting turtles and active turtle nesting areas. A basking survey was conducted on October 9th and consisted of two surveyors kayaking a section of the Muskegon River while looking for turtles and snakes, especially wood and Blanding's turtles and queen snakes, basking on logs and other structures within and along the river (Figure 8). Auditory surveys to listen for breeding

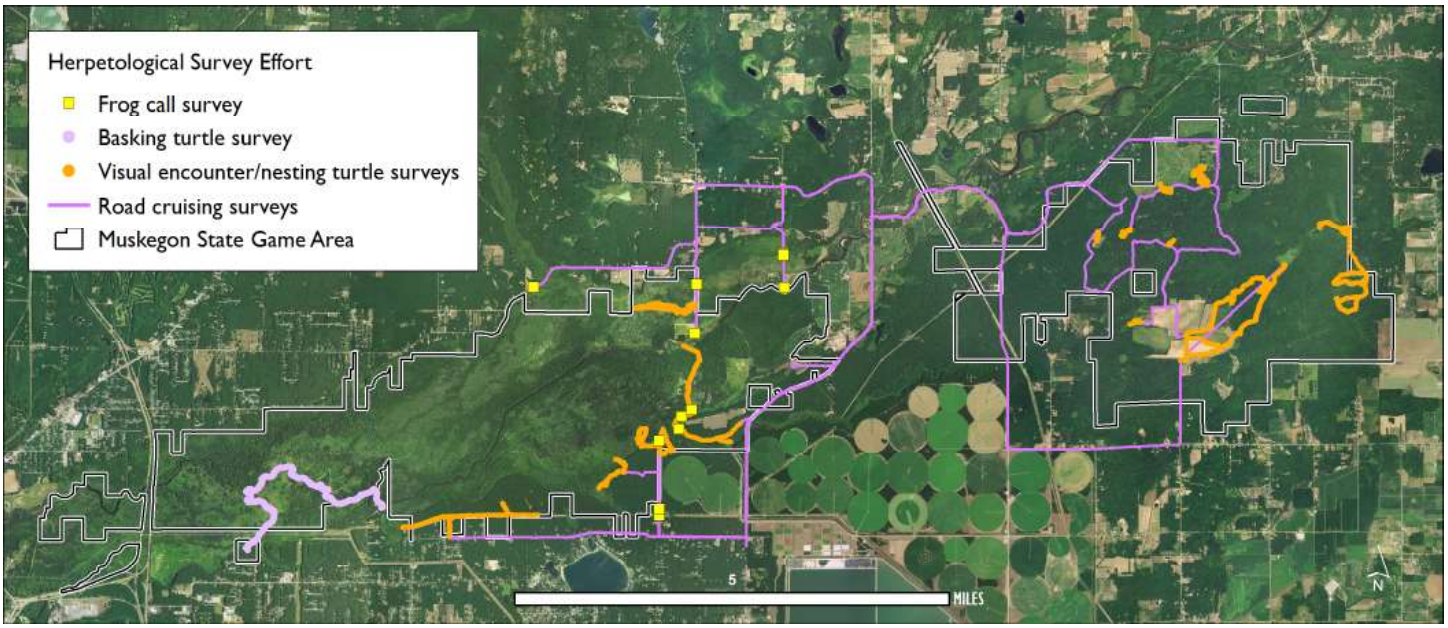


Figure 8. Location of reptile and amphibian surveys conducted in Muskegon State Game Area in 2018.

frog calls were conducted on June 11th to determine if Blanchard's cricket frogs may be breeding in the Muskegon River and/or adjoining streams and wetlands. Road cruising surveys were conducted to supplement the other herp surveys and consisted of driving slowly on roads within and adjacent to the game area to document individuals of target species on or along the edge of roads. Visual encounter surveys and basking surveys were conducted during the day, whereas nesting turtle and auditory surveys were conducted during the evening and night, respectively. Road cruising surveys were completed during the day and evening (Graeter et al. 2013). All surveys were conducted under appropriate weather conditions when target species were expected to be active or visible (i.e., between 60-80°F [16-27°C], wind less than 15 mph, no or light precipitation). Survey sites were visited one to four times during the field season.

Survey data forms were completed for all herptile surveys and MNFI special animal survey forms were completed when rare herptiles were observed. Survey locations and locations of rare herp species were recorded using the Backcountry Navigator application on a Samsung tablet. We documented all reptiles and amphibians and other animals encountered during surveys. The species, number of individuals, age class, location, general habitat, behavior, and time of observation were noted. Weather conditions and survey times also were recorded. Whenever possible, we took photos of observed species for supporting documentation.

Several reptiles were observed during the surveys in Muskegon SGA, including this eastern hognose snake pretending to be dead. Photo by Yu Man Lee.

Mussels

Unionid mussels were chosen as survey targets because of the presence of potential habitat for listed mussel species. Several occurrences of rare and listed mussel species have been documented within the lower Muskegon River below Croton Dam Pond, including snuffbox (*Epioblasma triquetra*, federally and state endangered), black sandshell (*Ligumia recta*, state endangered), slippershell (*Alasmidonta viridis*, state threatened), elktoe (*Alasmidonta marginata*, special concern), round pigtoe (*Pleurobema sintoxia*, special concern), and fluted-shell (*Lasmigona costata*, special concern). Aquatic surveys were performed to determine the presence/absence and abundance of unionid mussels at each site, as well as document stream water chemistry and physical habitat characteristics. Additional taxa including aquatic snails, fish, crayfish, and fingernail clams were recorded as incidental finds. Presence/absence was documented for non-native gastropods and bivalves as well (i.e., zebra mussel [*Dreissena polymorpha*] and Asian clam [*Corbicula fluminea*]).

Surveys took place in wadable habitats (less than approximately 70 cm deep). Three survey methodologies were used, glass bottom bucket (GBB) surveys, snorkel surveys, and a visual boat survey. For GBB surveys the search area was measured to standardize sampling effort among sites and allow unionid mussel density estimates to be made. The search area typically extended from bank to bank to include the widest range of microhabitats. Glass bottom buckets were used to facilitate visual detection. Snorkel gear was used at survey site 6a-6b (Figure 9) to efficiently cover a large amount of habitat with very low mussel density. Surveyors hiked upstream along the banks then entered the river and drifted with the current. Each surveyor covered a one meter wide transect for approximately 394 meters. An additional 128-m^2 area at the downstream end of the transect was also surveyed. For both GBB and snorkel surveys, mussels were located with a combination of visual and tactile means. Tactile searches through the substrate were made to help ensure that buried individuals were being detected, including smaller sized unionid mussels like the slippershell. At Site 8a-8b (Figure 9), very shallow and clear water allowed for a visual survey of the river bottom as surveyors slowly motored upstream in a boat from Business-31 to US Highway 31, the location of site 8b (approximately 2.94 km). Mussels were identified to species and returned to where they were found. The number of individuals was determined for each unionid mussel species at each site. Gastropod shells were collected by hand and small dip net and were either brought back

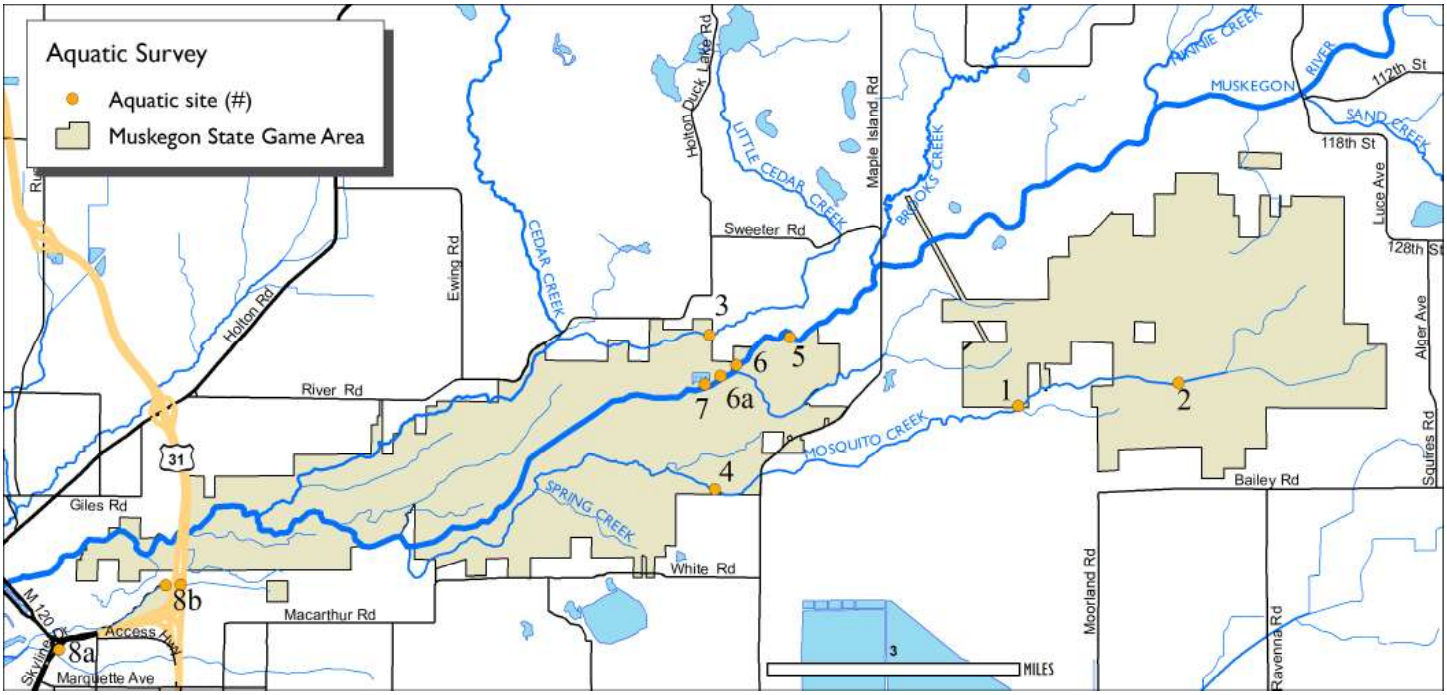


Figure 9. Location of aquatic surveys conducted in Muskegon State Game Area in 2018.

Table 2. Locations of mussel survey sites within Muskegon State Game Area, Summer 2018.

Site #	Waterbody	Access	Latitude (N)	Longitude (W)
1	Mosquito Creek	Powerline off Fitzgerald Ave.	43.2936	-86.0066
2	Mosquito Creek	2-track N. of Bossett Rd.	43.29757	-85.96878
3	Little Cedar Creek	Holton Duck Lake Rd.	43.30577	-86.07949
4	Mosquito Creek	2-track	43.27923	-86.07813
5	Muskegon River	Boat	43.30539	-86.0606
6a	Muskegon River	Snorkel start	43.30057	-86.07315
6b		Snorkel end - Snuffbox shell found	43.29872	-86.07684
7	Muskegon River	Boat	43.29728	-86.08047
8a	Muskegon River	Visual search from boat start	43.25140	-86.23270
8b		Visual search from boat end	43.26254	-86.20754
9	Muskegon River	Boat	43.26254	-86.20754

to the lab for identification or identified on site. Latitude and longitude of survey sites were recorded with handheld Garmin GPS units (Table 2).

Habitat data were recorded to document stream conditions at the time of the surveys. The substrate within each search area was characterized by visually 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). 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 was estimated visually, and a characterization of current speed was made by timing floating debris over a measured distance. Conductivity and pH were recorded with an Oakton handheld meter. Alkalinity and hardness were measured with LaMotte kits (models 4491-DR-01 and 4824-DR-LT-01).

Riparian habitat at aquatic survey Site 6b. Photo by Peter J. Badra.

RESULTS

Before 2018, 26 element occurrences (EOs) were documented within Muskegon SGA composed of 23 rare species occurrences and 3 high-quality natural communities. Of those rare species occurrences, 2 were birds, 11 were rare herptiles, 3 were mussels, 2 were insects, and 5 were plant EOs. During surveys completed for the Integrated Inventory Project at Muskegon SGA, MNFI scientists documented 8 new rare plant EOs (Table 3, Figures 10 and 11), 10 new natural community EOs (Table 4, Figure 12), 4 new rare animal EOs (Tables 5, 6, and 10; Figures 14, 15, 16, 17, and 18), and provided information for updating 21 existing EOs. Data compiled on these EOs were entered into MNFI's Natural Heritage Database (MNFI 2018). In addition, MNFI scientists mapped 17 vernal pools within the game area (Figure 13, pg 47).

Prior to the MiFI surveys there were 5 existing rare plant EOs. During this project, 8 additional rare plant EOs were opportunistically documented (Table 2, Figures 9 and 10). Wild rice (*Zizania aquatica*, state threatened) was observed along Cedar Creek and the Maple River. Virginia water-horehound (*Lycopus virginicus*, state threatened) had been previously documented in the floodplain complex near the boat launch at Holton-Duck Lake Road. Climbing hempweed (*Mikania scandens*, state threatened) was known from the Muskegon River area from one vague collection taken in the late 1800s but relocation efforts were unsuccessful and the species was presumed extirpated from Michigan until the MiFI surveys relocated the population in 2012. The remainder of the species are associated with the prairies and coastal plain systems in the Eastern Unit of the Game Area: tall green milkweed (*Asclepias hirtella*, state threatened), spike rush (*Eleocharis engelmannii*, state special concern), three-ribbed spike rush (*E. trichostata*, state threatened), short-fruited rush (*Juncus brachycarpus*, state threatened), scirpus-like rush (*J. scirpoides* state threatened), Leggett's pinweed (*Lechea pulchella*, state threatened), tall nut rush (*Scleria triglomerata*, state special concern), and eastern blue-eyed-grass (*Sisyrinchium atlanticum*, state threatened).

Figure 10. Rare plant element occurrence locations in the western management unit of Muskegon State Game Area.

Table 3. Newly documented and previously known rare plant element occurrences at Muskegon State Game Area. State status abbreviation of T signifies state threatened, E signifies state endangered, and SC signifies special concern. EO rank abbreviations are as follows: A, excellent estimated viability; B, good estimated viability; BC, good to fair estimated viability; C, fair estimated viability; and CD, fair to poor estimated viability.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year Last Observed
Tall green milkweed	*Asclepias hirtella*	T	15701	CD	2005
Tall green milkweed	*Asclepias hirtella*	T	15705	C	2017
Spike rush	*Eleocharis engelmannii*	SC	20096	BC	2015
Three-ribbed spike rush	*Eleocharis trichostata*	T	20097	B	2013
Short-fruited rush	*Juncus brachycarpus*	T	20099	BC	2015
Scirpus-like rush	*Juncus scirpoides*	T	20098	BC	2015
Leggett's pinweed	*Lechea pulchella*	T	20431	B	2015
Virginia water-horehound	*Lycopus virginicus*	T	6900	BC	1994
Climbing hempweed	*Mikania scandens*	T	19794	A	2016
Tall nut rush	*Scleria triglomerata*	SC	20430	BC	2015
Eastern blue-eyed-grass	*Sisyrinchium atlanticum*	T	20095	B	2018
Wild rice	*Zizania aquatica*	T	13590	B	2016
Wild rice	*Zizania aquatica*	T	20670	C	2016

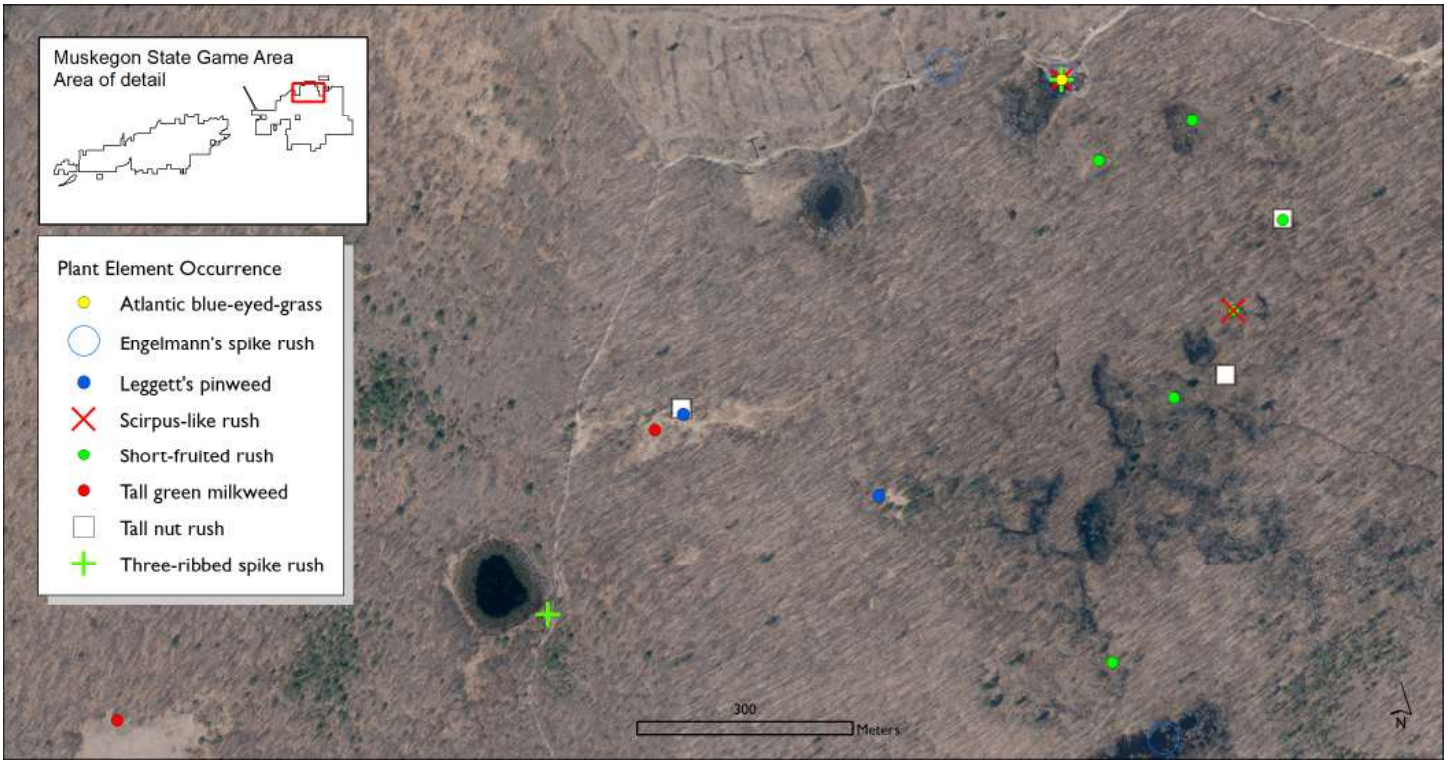


Figure 11. Rare plant element occurrence locations in the eastern management unit of Muskegon State Game Area.

Natural Communities

MNFI ecologists documented 10 new high-quality natural communities in the Muskegon SGA (Table 4, Figure 11). Three previously documented community EOs were also evaluated: a hardwood-conifer swamp, an oak-pine barrens, and a wet-mesic sand prairie. The previously existing oak-pine barrens does not meet the criteria required to qualify as an element occurrence and was removed from the database. The site, which corresponds to Compartment 9, Stand 71, has low floristic diversity and lacks the species composition expected within an exemplary natural community, despite being included in recent prescribed burns. Although the site lacks characteristic barrens vegetation and structure, it has relatively few invasive species and actions to maintain ecological integrity should be considered when developing management plans. The following 9 natural community types are represented in the 12 element occurrences surveyed: coastal plain marsh (1 EO), dry sand prairie (2 EOs), floodplain forest (1 EO), hardwood-conifer swamp (3 EOs), intermittent wetland (1 EO), oak-pine barrens (1 EO), poor fen (1 EO), southern hardwood swamp (1 EO), and wet-mesic sand prairie (1 EO).

The following site summaries contain a detailed discussion for each of the 12 natural community EOs organized alphabetically by community type and EO name. A summary of priority management recommendations is provided in Table 12 (pg 58**)** in the discussion.

Table 4. Newly documented and previously known natural community element occurrences for the Muskegon State Game Area. EO rank abbreviations are as follows: B, good estimated viability; BC, good to fair estimated viability; C, fair estimated viability; and CD, fair or poor estimated viability. An " * " indicates that the EO was newly documented in 2016 and " ** " indicates that the former EO was eliminated from the database following evaluation in 2016.

Site Name	Community Type	EO ID	EO Rank	Year First Observed	Year Last Observed	Global Rank	State Rank
Green Stone Marsh*	Coastal Plain Marsh	21678	CD	2012	2018	G2	S2
Comstock Prairie*	Dry Sand Prairie	20595	C	2012	2018	G3	S2
Wolf Lake Prairie*	Dry Sand Prairie	21724	C	2012	2016	G3	S2
The Muskegon Floodplain*	Floodplain Forest	22025	BC	2012	2016	G3?	S3
Lowe Lake Swamp	Hardwood-Conifer Swamp	15881	C	2006	2016	G4	S3
South Channel Swamp*	Hardwood-Conifer Swamp	21728	C	2012	2016	G4	S3
North Channel Swamp*	Hardwood-Conifer Swamp	21729	C	2012	2016	G4	S3
Green Intermittent Wetland*	Intermittent Wetland	22701	C	2012	2016	G2	S3
Muskegon Barrens**	Oak-Pine Barrens	NA		2006	2016	G3	S2
Fitzgerald Barrens*	Oak-Pine Barrens	20566	BC	2012	2016	G3	S2
Bridgeton Poor Fen*	Poor Fen	21472	BC	2016	2016	G3	S3
Bridgeton Hardwood Swamp*	Southern Hardwood Swamp	21602	C	2012	2016	G3	S3
Muskegon Prairies	Wet-Mesic Sand Prairie	15729	BC	2005	2018	G2	S2

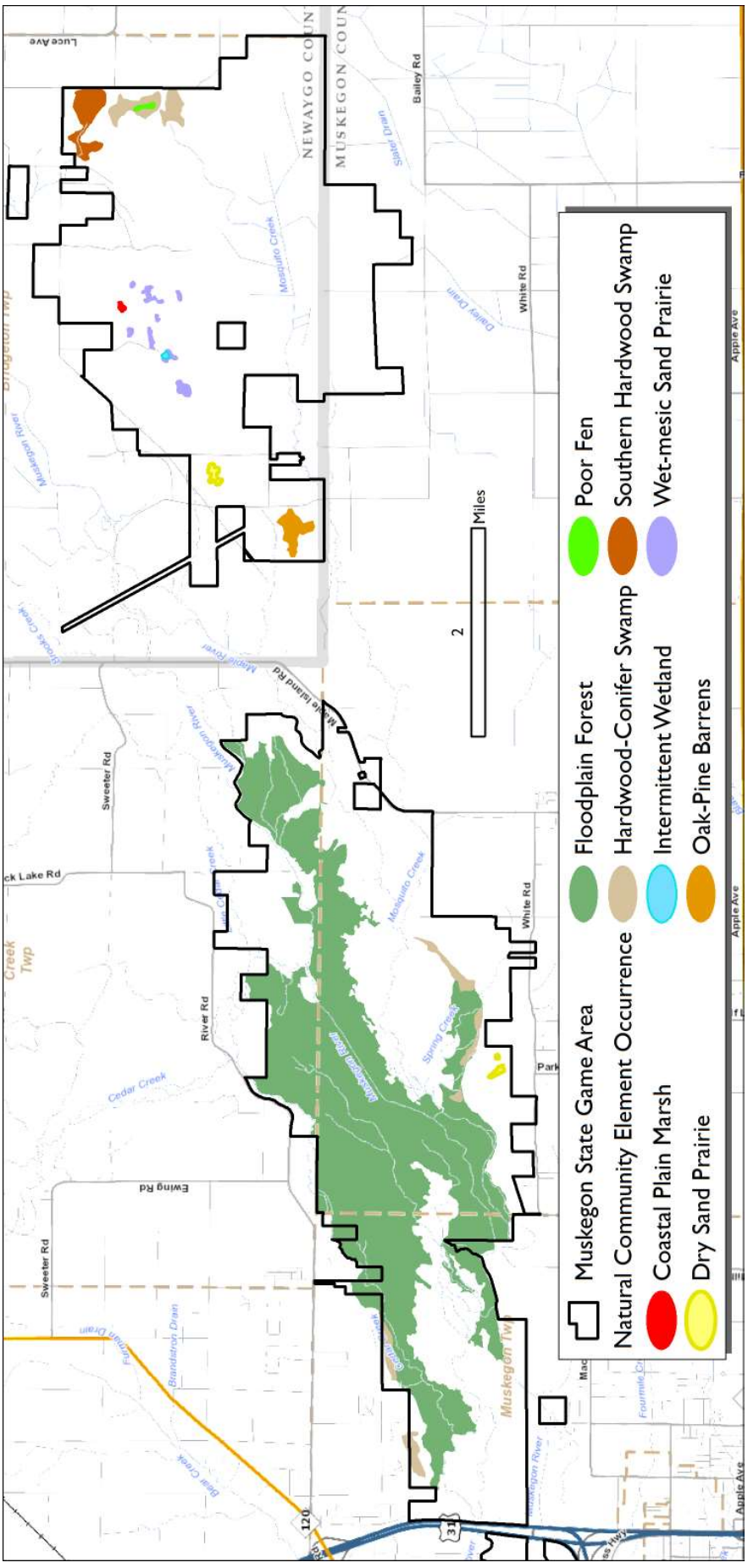


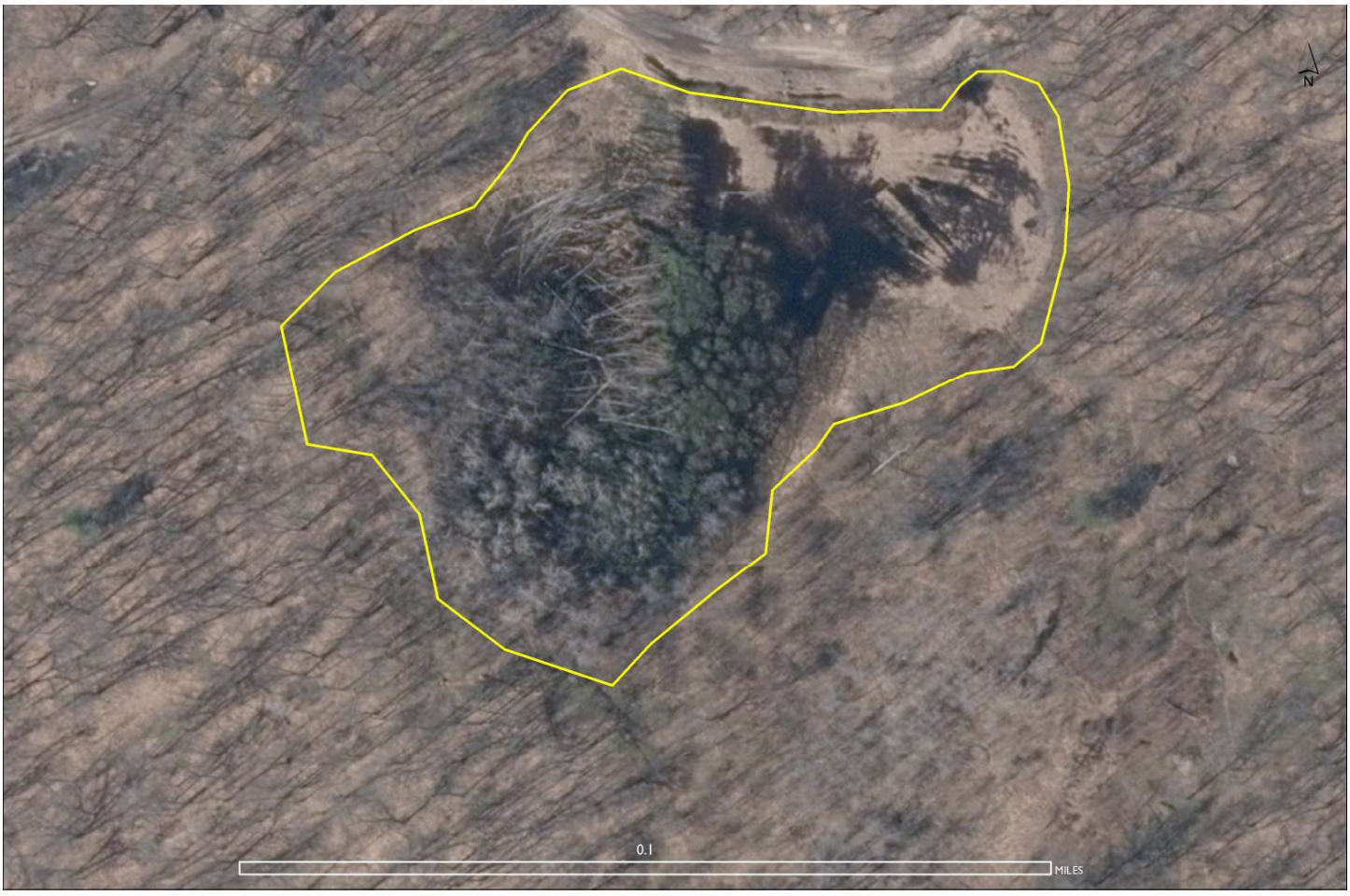
Figure 12. Natural community element occurrences in Muskegon State Game Area.

Coastal Plain Marsh (G2 S2, imperiled throughout range)

Green Stone Marsh

EO ID Number	EO Rank	Size (acres)	Compartment	Stand
21678 (new)	CD	3	9	59

Green Stone Marsh is a small, seasonally-inundated coastal plain marsh within a broad, flat outwash landscape that features fire-adapted natural communities. The marsh is characterized by acidic, sandy soils (pH 5.5-6.0) and dynamic hydrology with zones that have prolonged inundation some years. The system is likely partially inundated in late winter and early spring, though that varies from year to year, with some years experiencing longer durations of inundation and other years with no standing water. Migratory waterfowl may facilitate the transfer of seeds from coastal plain disjuncts that characterize the system. The sandy soils also create droughty conditions and the landscape is one historically shaped by fires ignited by lightning strikes and Native Americans. ORVs have caused extensive damage to the soil and deep ruts persist. Additionally, landscape-level fire suppression is facilitating the encroachment of woody vegetation, particularly aspen, oak, and maple.
The marsh is characterized by diverse graminoids, including rushes (*Juncus* spp.), spike rushes (*Eleocharis* spp.),



2014 aerial imagery of Green Stone Marsh.

sedges (*Carex* spp.), and grasses, such as panic grass (*Dichanthelium* spp.) and Canada blue-joint (*Calamagrostis canadensis*). Several flowering plant species occur throughout, including bushy aster (*Symphyotrichum dumosum*), flat-topped goldenrod (*Euthamia caroliniana*), southern blue flag iris (*Iris virginana*), and St. John's wort (*Hypericum canadense*). The margins have quaking aspen (*Populus tremuloides*), northern pin oak (*Quercus ellipsoidales*), and red maple (*Acer rubrum*) extending into the open wetland. An area prone to prolonged standing water has a dense thicket of willow (*Salix petiolaris*) and meadowsweet (*Spiraea alba*) at the margins. Rare species at this site include spike rush (*Eleocharis engelmannii*, state special concern), three-ribbed spike rush (*E. trichostata*, state threatened), short-fruited rush (*Juncus brachycarpus*, state threatened), scirpus-like rush (*J. scirpoides* state threatened), and eastern blue-eyed-grass (*Sisyrinchium atlanticum*, state threatened).

This site was visited once during the 2016 field season. A total of 61 plant species were documented with no non-native species observed. The total floristic quality index (*FQI*) was 39.8.

Green Stone Marsh is a coastal plain marsh dominated by vegetation characteristic of the Atlantic and Gulf Coast shorelines. Photo by Jesse Lincoln.

Dry Sand Prairie (G3 S2, vulnerable globally and imperiled within state)

Comstock Prairie

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
20595 (new)	C	9	9	13, openings in 11

Comstock Prairie is a small grassy opening within a small depression on deep, flat outwash sands over historic lakeplain. The site occurs within a matrix of oak-pine forest and barrens. Soils in this prairie are characterized by 30 cm of fine to coarse, loamy sands (pH 5.5-5) with organics overlaying coarse loamy sands (pH 6.0-6.5). The forest at the margins is dominated by oaks, which range in diameter from 25 to 83 cm (10 to 33 in). A large white oak (*Quercus alba*) at the margin of the prairie was aged to 132 years old and a 25 cm (10 in) white oak within the prairie was estimated to be 52 years old. Historically, this prairie opening within the adjacent oak-pine forest was likely maintained by frequent fires ignited by Native Americans. Additionally, the prairie exists within a slight depression on a relatively flat landscape. This depression likely functions as a frost pocket that limits tree growth and succession to a closed-canopy forest. Fire and frost, in conjunction with droughty, low-nutrient soils, are predominant factors maintaining the community. Ants also play an important role in these systems, excavating areas, mixing soils, transporting seeds, and mediating interactions between other insects, including the Karner blue butterfly (*Lycaeides melissa samuelis*, federally endangered and state threatened), which were observed here in 2014. Moles are prevalent within this site and may play a role in determining community structure and composition.

2014 aerial imagery of Comstock Prairie.

The areas of the dry sand prairie most exposed to sunlight are overwhelmingly dominated by graminoids, including sedges (*Carex pensylvanica* and *C. tonsa*), poverty grass (*Danthonia spicata*), panic grasses (*Dichanthelium* spp.), and little bluestem (*Schizachyrium scoparium*). Forbs within the opening are generally sparse but include bastard toadflax (*Comandra umbellata*), frostweed (*Crocanthemum canadense*), and Grey's goldenrod (*Solidago nemoralis*). Lichens (e.g., reindeer moss) are locally abundant on exposed soils throughout the prairie, particularly in areas that may have had some anthropogenic disturbance. Areas along the margins are influenced by increased shade and have more forbs, including old-field cinquefoil (*Potentilla simplex*), wild lupine (*Lupinus perennis*), sand coreopsis (*Coreopsis lanceolata*), and goats-rue (*Tephrosia virginiana*). Bracken fern (*Pteridium aquilinum*) is locally dominant and invasives are locally abundant. Oak, black cherry (*Prunus serotina*), and sassafras (*Sassafras albidium*) are sparse throughout but occasionally dense at the transition from forest to prairie where shade facilitates gradual woody encroachment.

This site was visited once during the 2016 field season. A total of 51 plant species were documented with 47 native species and 4 non-native species. The total FQI was 31.

Comstock Prairie is a small, graminoid-dominated prairie with open conditions maintained by drought, growing-season frosts, and historic fires. Photo by Jesse Lincoln.

Wolf Lake Prairie

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
21724 (new)	C	5	5	34, opening in 18

Wolf Lake Prairie consists of two small prairie openings in small kettle depressions within a broad outwash-over-lakeplain landform within a matrix of oak-pine forest and barrens. Soils in this prairie are characterized by 25 cm of coarse, slightly loamy sands (pH 5.5) with fine organics overlying slightly acidic to circumneutral (pH 6.5-7) coarse loamy sands. Though impacted by off-road-vehicles, the system appears to be untilled. As with Comstock Prairie, these openings were historically maintained by frequent, landscape-scale fires, growing-season frosts, and droughty conditions and continue to be influenced by frost and drought

This site was visited once during the 2016 field season. A total of 35 plant species were documented with 30 native species and 5 non-native species. The total FQI is 30.1. Vegetative structure and composition are very similar to Comstock Prairie (described above).

2014 aerial imagery of Wolf Lake Prairie.

Wolf Lake Prairie is dominated by native vegetation, including lupine (top photo), and it may support populations of the federally endangered Karner blue butterfly. The site faces significant threats, including fire suppression, woody encroachment (especially by sassafras), and abuse by off-road vehicles (bottom photo). Photos by Jesse Lincoln.

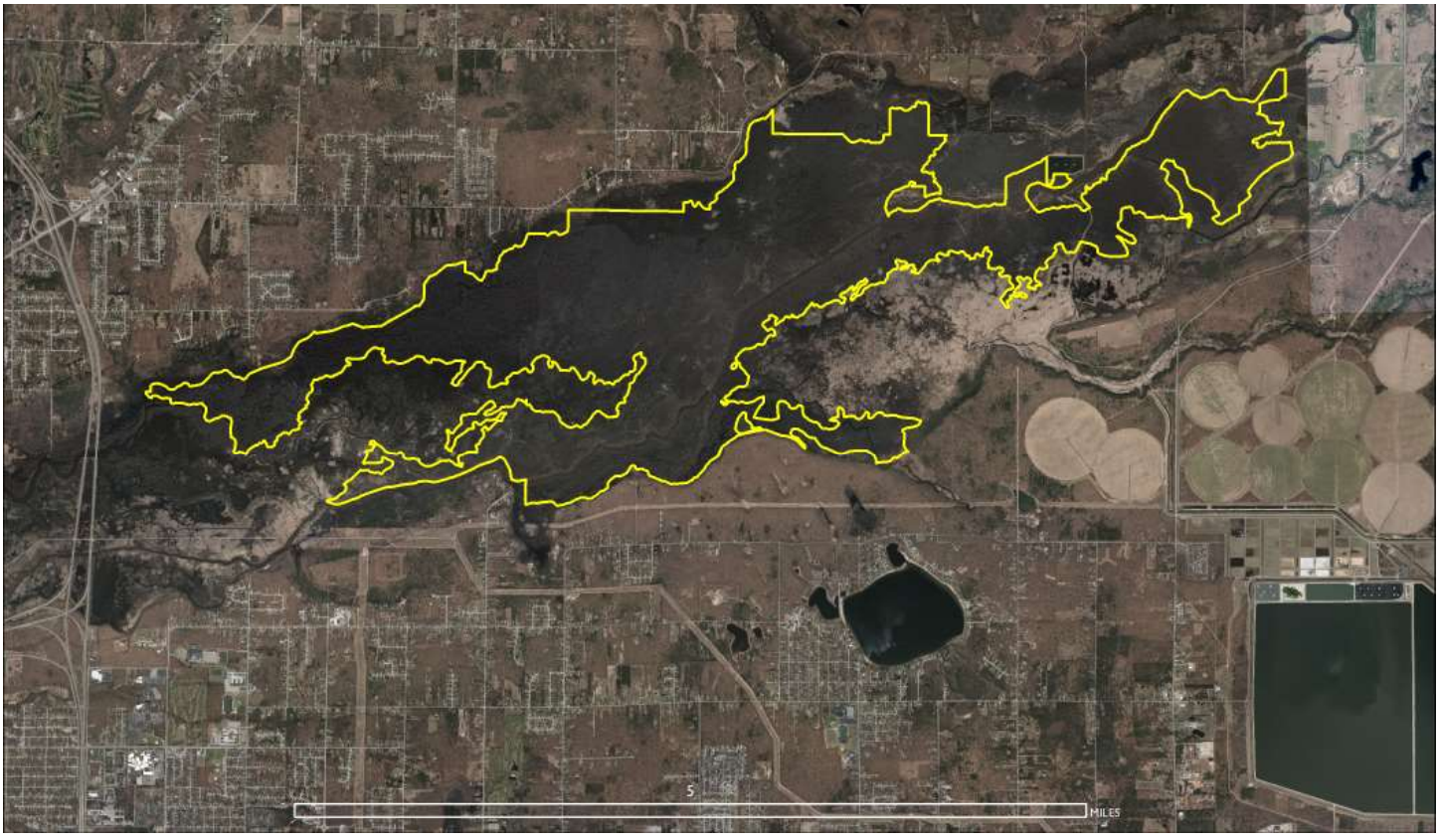
Floodplain Forest (G3? S3, likely vulnerable globally and vulnerable within state)

Muskegon Floodplain

EO ID Number	EO Rank	Size (acres)	Compartments	Stands
22025 (new)	BC	3,752	3, 4, 5, 6, 7, 8	numerous

The Muskegon River watershed is one of the largest in Michigan and this floodplain forest is the largest documented in the state. This floodplain forest occurs within the outwash channel that the Muskegon River carved through a broad outwash feature. The surrounding uplands are a mosaic of fire-adapted oak-pine forest and barrens, which remain relatively intact within the game area. Hardwood-conifer swamps occur locally at the base of the slopes adjacent to the floodplain where there is constant seepage of cold, minerotrophic groundwater and deep organic mucks. Soils within the floodplain forest are complex and variable, changing with proximity to nearby uplands and the main channel of the river. Generally, soils are circumneutral (pH 7.0), saturated sands with bands of loams and clays throughout.

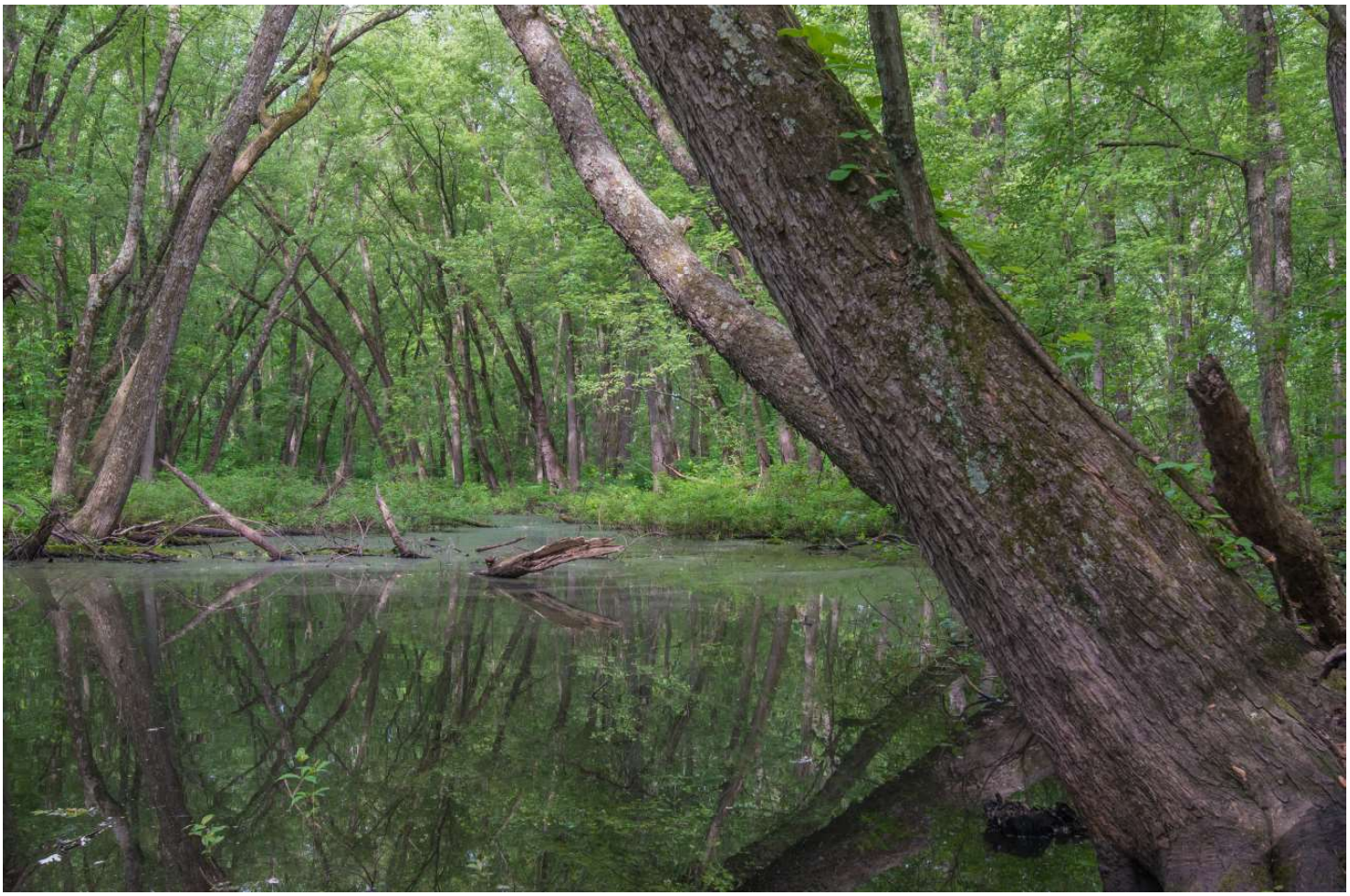
This is a large, mature, second-growth (80 to 120 years old) floodplain forest. Much of the floodplain was logged in the late 1800s and parts of the Muskegon River were channelized with cedar logs that were vertically driven into the river bed along the edges to facilitate moving timber. The system still floods seasonally, primarily in late winter and early spring, though dams upstream cause floods to be less dynamic. Emerald ash borer and Dutch elm disease have nearly eliminated ash (*Fraxinus* spp.) and American elm (*Ulmus americana*) from the canopy, though both species persist in the subcanopy.



2014 aerial imagery of the Muskegon Floodplain Forest.

Despite the influence of the dams upstream and localized channel alterations, the floodplain's hydrology appears to be minimally impacted within the EO and fragmentation and road density are generally low. Historic annual over-the-bank flooding resulted in complex patterns of sediment erosion and deposition. Erosion of the streambed leads to trees falling in 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. Historic floods have shifted the course of the river, leading to numerous oxbows and pools. The floodplain morphology is complex and influenced by confluences of smaller streams and rivers, distance from main channels, and adjacent landform. These factors drive floristic diversity and vegetative structure. The prevalent fluvial landform within this floodplain is first bottom with second bottom occurring locally. Massive buttonbush depressions – locally known as "buttonbush hellholes" – occur in old meander scars and other zones where water collects for prolonged periods, preventing tree encroachment.

There is a long history of Native American presence throughout the area, with known permanent settlements on the adjacent outwash plain south of the Muskegon River floodplain. Wild rice occurs along small-order streams and rivulets within the complex and it seems likely that there was an agrarian Native American culture that was an integral component of the system. The area was doubtless used for farming rice as well as an important trade route from the big lake to the center of the state.



A meander scar in the silver maple-dominated first bottom of the floodplain forest. Photo by Aaron Kortenhoven.

This is a large and variable floodplain forest with the primary component being expansive first bottom forest dominated by large (15 to 43 in) silver maple (*Acer saccharinum*). Green ash (*Fraxinus pennsylvanica*) and American elm were historically canopy co-dominants but have been relegated to the subcanopy and understory. Basswood (*Tilia americana*), cottonwood (*Populus deltoides*), swamp white oak (*Quercus bicolor*), bur oak (*Q. macrocarpa*), black willow (*Salix nigra*), and sycamore (*Platanus occidentalis*) are important but infrequent canopy components. Silver maples range in age from 80 to 120 years old and a 96 cm (38 in) bur oak was aged to 189 years old. The first bottom ranges from 50 to 95% canopy coverage and is more open where green ash was more prevalent or where there is more prolonged standing water. Within the first bottom are extensive meander scars with buttonbush (*Cephalanthus occidentalis*), cut-grass (*Leersia* spp.), and sparse green ash. There are also numerous oxbows, stagnant pools, seasonal rivulets, and old river channels, some which may have been diverted during the logging era. There are localized areas of natural levee along the river channels of the Muskegon and the levee is generally not continuous. Areas of levee are characterized by a slight rise above the adjacent first bottom and have an increased amount of sand and gravelly substrate within the soil profile. Better soil drainage and soil aeration along the levees results in more abundant shrubs and more sycamore in the canopy. Zones of second bottom forest are not flooded every year and have a greater canopy abundance of bur oak as well as hackberry (*Celtis occidentalis*), black maple (*Acer nigrum*), bitternut hickory (*Carya cordiformis*), and beech (*Fagus grandifolia*). A prevalent second bottom occurs on portions of Maple Island (Compartment 8, Stands 3 and 7).

Climbing hempweed was known from only one collection in the late 1800s and believed extirpated from Michigan until it was rediscovered in the Muskegon Floodplain during the MNFI surveys in 2012. Photo by Jesse Lincoln.

The subcanopy and understory of the maple-dominated first bottom forest features silver maple, green ash, elm, and basswood. Understory shrubs include buttonbush, spicebush (*Lindera benzoin*), nannyberry (*Viburnum lentago*), prickly ash (*Zanthoxylem americanum*), musclewood (*Carpinus caroliniana*), and hawthorn (*Crataegus* spp.).

The herbaceous components of the forested areas are complex and variable. There are extensive areas characterized by native vegetation and other areas with significant impacts by non-native species, particularly reed canary grass (*Phalaris arundinacea*) and money wort (*Lysimachia nummularia*). Dominant native species include sensitive fern (*Onoclea sensibilis*), wood nettle (*Laportia canadensis*), lizards-tail (*Saururus cernuus*), Virginia wild-rye (*Elymus virginanicus*), sedges (*Carex* spp.), northern bugle weed (*Lycopus uniflorus*), fringed loosestrife (*Lysimachia ciliata*), arrow-arum (*Peltandra virginica*), and smartweed (*Persicaria* spp.). Additionally, input from streams, such as Cedar Creek, locally causes over-the-bank flooding and deposition of sands within the Muskegon River outwash channel. Where such deposition occurs, bur and swamp white oak occur and locally create a supercanopy and occasionally a savanna structure where they are open-grown within extensive stands of native reed (*Phragmites australis* subs. *americanus*), buttonbush, and river bulrush (*Bolboschoenus fluviatilis*).

This site was visited five times during the 2016 field season. A total of 103 plant species were documented with 97 native species and 6 non-native species. The total FQI is 43.3.

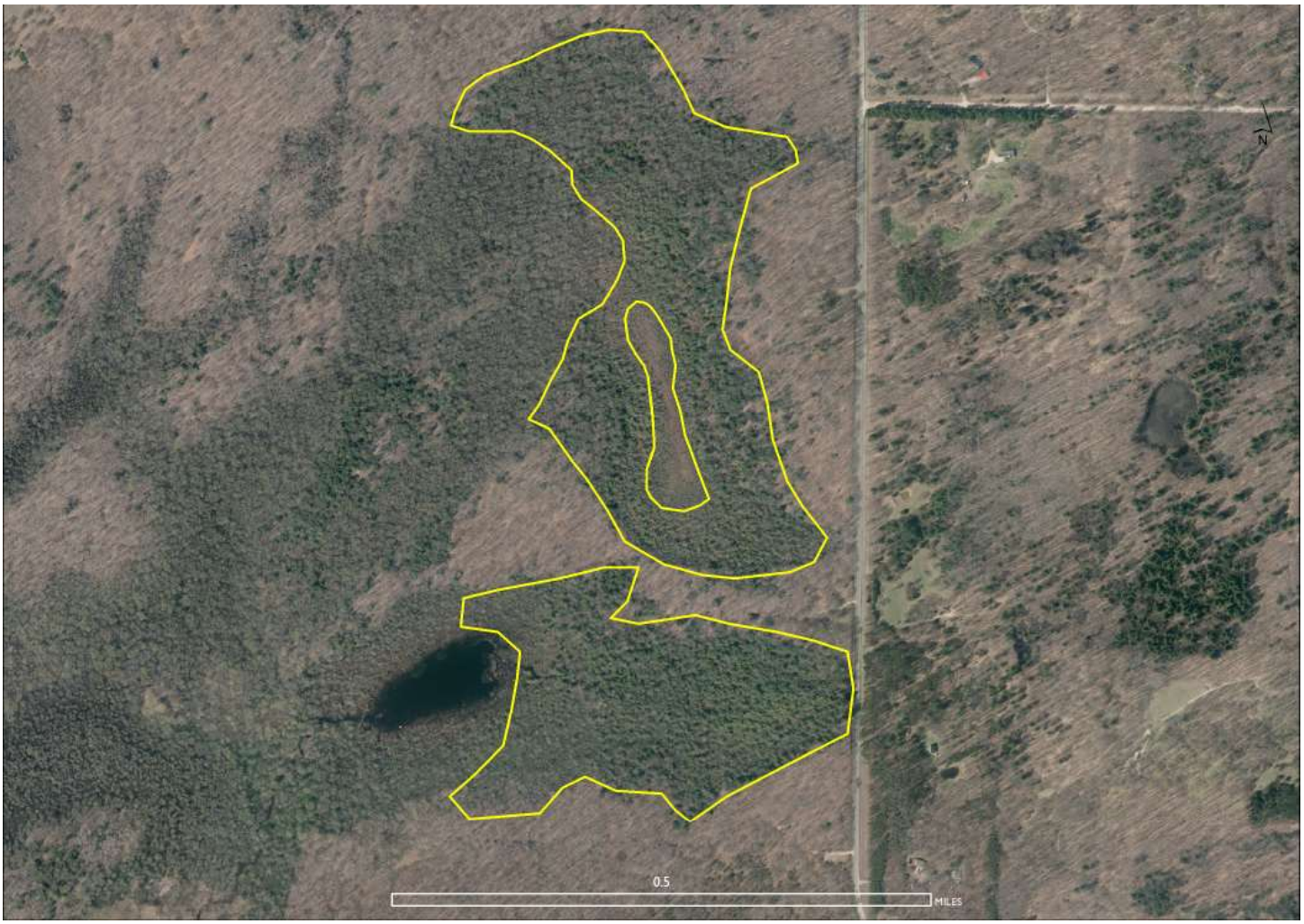
The Muskegon Floodplain forest is extensive and highly variable. Photo by Jesse Lincoln.

Hardwood-conifer Swamp (G4 S3, apparently secure globally and vulnerable within state)

Lowe Lake Swamp

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
15881 (update)	C	85	11	29, 38

This is a conifer-dominated, forested wetland characterized by mature, large-diameter trees occurring in a flat, outwash landscape context. This was an existing EO and was originally one polygon but a second polygon was added after this survey as the system was very close and of similar composition. Many nearby wetlands have been altered by channelization and recent logging but the hydrology of this forested wetland is relatively intact. This forest is likely mature second growth and the oldest trees were cored and estimated to be between 75 and 120 years old and ranged in diameter from 25 to 76 cm (10 to 30 in). Canopy coverage ranges from 60 to 95%. Soils are variable in composition, depth of organics, and pH with circumneutral peats (pH 7.0-7.5) overlying saturated, slightly acidic loamy sand (pH 6.5). Hummock-hollow development drives structural variability of the forest floor. Windthrow and disease outbreak contribute to the pit-and-mound topography and accumulation of coarse woody debris with both influencing vegetative composition and distribution.



2014 aerial imagery of Lowe Lake Swamp.

In the wetter areas, hummock-hollow microtopography is associated with tree buttresses, tree root mats, abundant coarse woody debris, and tip-up mounds. Hollows are sparsely vegetated due to prolonged standing water in spring and early summer. Hummocks support a greater diversity of species. Coarse woody debris is common and supports fungus, bryophytes, and a variety of vegetation, depending on the stage of decay. There is an abundance of dead ash and the presence of elm has likely also been reduced due to insect and disease outbreak. Deer herbivory was noted throughout the swamp and many species may not be reproducing as a result: hemlock was conspicuously absent from lower forest strata.

Species and structural diversity are associated with subtle fluctuations in elevation, resulting in diverse matrix of small upland inclusions with sparse vegetation within a broader area of saturated soils and zones of inundation. This swamp is variable but is generally dominated in the canopy by eastern hemlock (*Tsuga canadensis*), red maple (*Acer rubrum*), and yellow birch (*Betula alleghaniensis*) with supercanopy white pine (*Pinus strobus*). Red maple, black ash (*Fraxinus nigra*), spicebush, and witch-hazel (*Hamamelis virginiana*) are prevalent within the understory. Common plants in the ground layer include cinnamon fern (*Osmunda cinnamomeum*), New York fern (*Thelypteris noveboracensis*), Canada mayflower (*Maianthemum canadense*), spotted touch-me-not (*Impatiens capensis*), and false nettle (*Boehmeria cylindrica*).

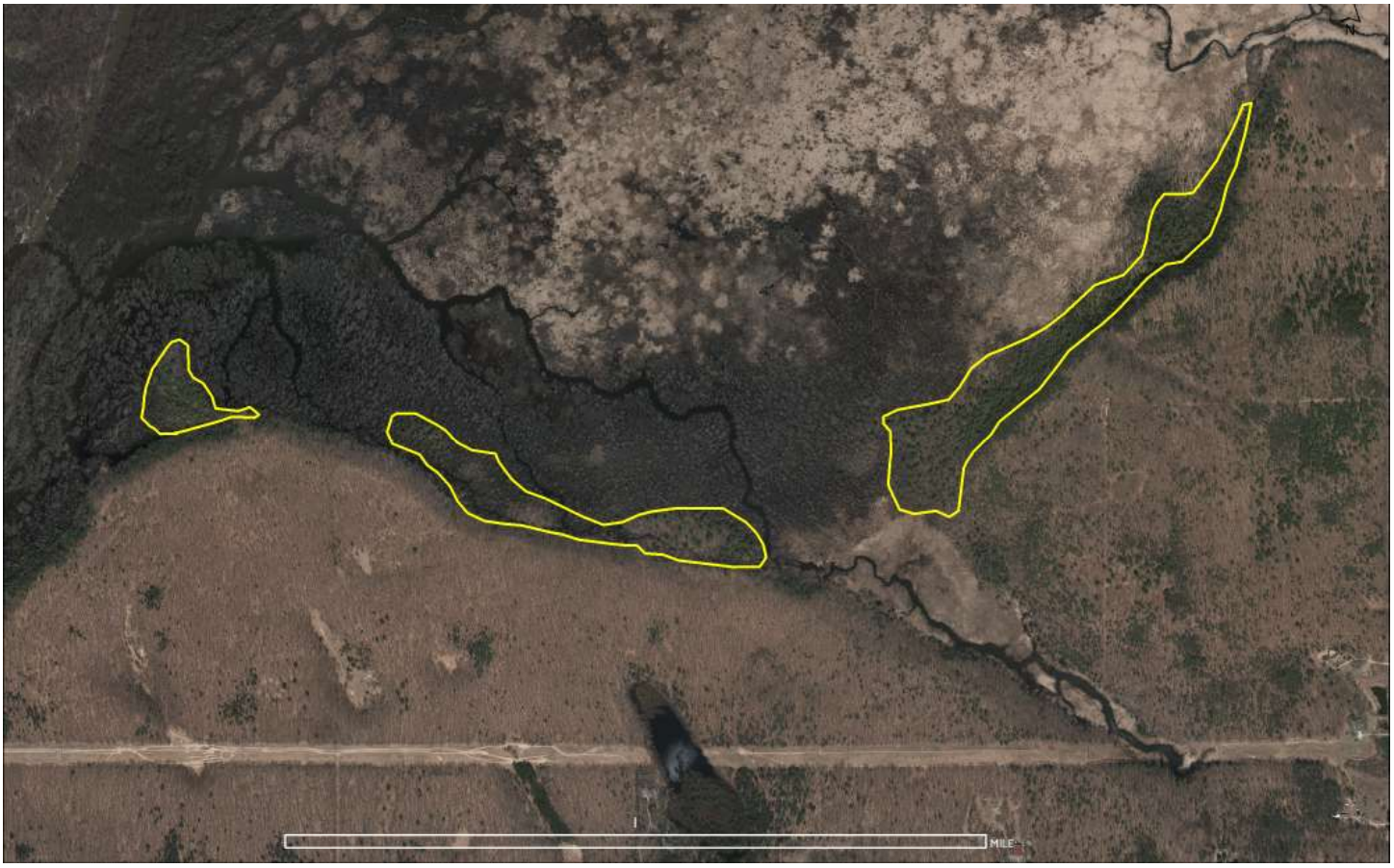
This site was visited once during the 2016 field season. A total of 113 plant species were documented with 111 native species and 2 non-native species. The total FQI is 46.1.

Hemlock is locally dominant within Lowe Lake Swamp. Vegetation patterns are strongly influenced by the presence of rotting wood and pools of deep, saturated muck. Photo by Jesse Lincoln.

South Channel Hardwood-Conifer Swamp

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
21728 (new)	C	58	5	10, 32, 46

This EO is comprised of three polygons of hardwood-conifer swamp on the southern portion of the Muskegon River outwash channel near the base of steep slopes. This is a second-growth swamp with a relatively closed-canopy (60 to 90%), featuring large-diameter (10 to 30 in), mature trees. The swamp is characterized by high species and structural diversity associated with subtle micro-topographic gradients and variability of depth of organic substrate over mineral soils. These small-scale gradients result in a mosaic of saturated and inundated areas supporting wetland species with small upland inclusions. Minerotrophic water discharged from adjacent uplands is colder than water in the adjacent floodplain. The depth and duration of saturation from this groundwater influences accumulation of organic material and drives floristic composition of the swamp. There are several areas where groundwater seeps into to the floodplain along small streams, creating zones of shallow water over muck soils. A top mat of fibric peats is partially saturated, acidic (pH 4.5-5.0), and filled with roots. Below this layer are saturated circumneutral (pH 7.0-7.5), sapric peats to two feet with loose, wet muck below. Windthrow, tree disease, and groundwater seepage are all factors impacting structure and composition of the swamp.



2014 aerial imagery of South Channel Hardwood-Conifer Swamp.

White pine, red maple, hemlock, red oak (*Quercus rubra*), and tamarack (*Larix laricina*) occur in the saturated soils along the base of the slope. The canopy cohort is roughly 100 years in age, although some hemlocks appear to be older but were rotten in the center and unable to be aged. Where deeper muck soils have accumulated to depth greater than 3 ft, the canopy of the swamp is sparser (40 to 70 %) and is characterized by a greater component of tamarack, elm, and historically ash. In these areas of deep organics and sparse canopy, there are dense wetland shrubs, including speckled alder (*Alnus incana*), Michigan holly (*Ilex verticilata*), dogwoods (*Cornus* spp.), and spicebush. Herbaceous species of both of these saturated zones include numerous ferns, especially cinnamon and royal fern. Additional species include tussock sedge (*Carex stricta*), joe-pye weed (*Eutrochium maculatum*), fowl manna grass (*Glyceria striata*), wood reed (*Cinna arundinacea*), calico aster (*Symphyotrichum lateriflorum*), and bishop's-cap (*Mitella diphylla*). Areas where hemlock is dominant are characterized by a sparse herbaceous layer with lady fern (*Athyrium filix-femina*), partridge berry (*Mitchella repens*), goldthread (*Coptis trifolia*), and wintergreen (*Gaultheria procumbens*).

This site was visited once during the 2016 field season. A total of 75 plant species were documented with 72 native species and 3 non-native species. The total FQI is 39.0.

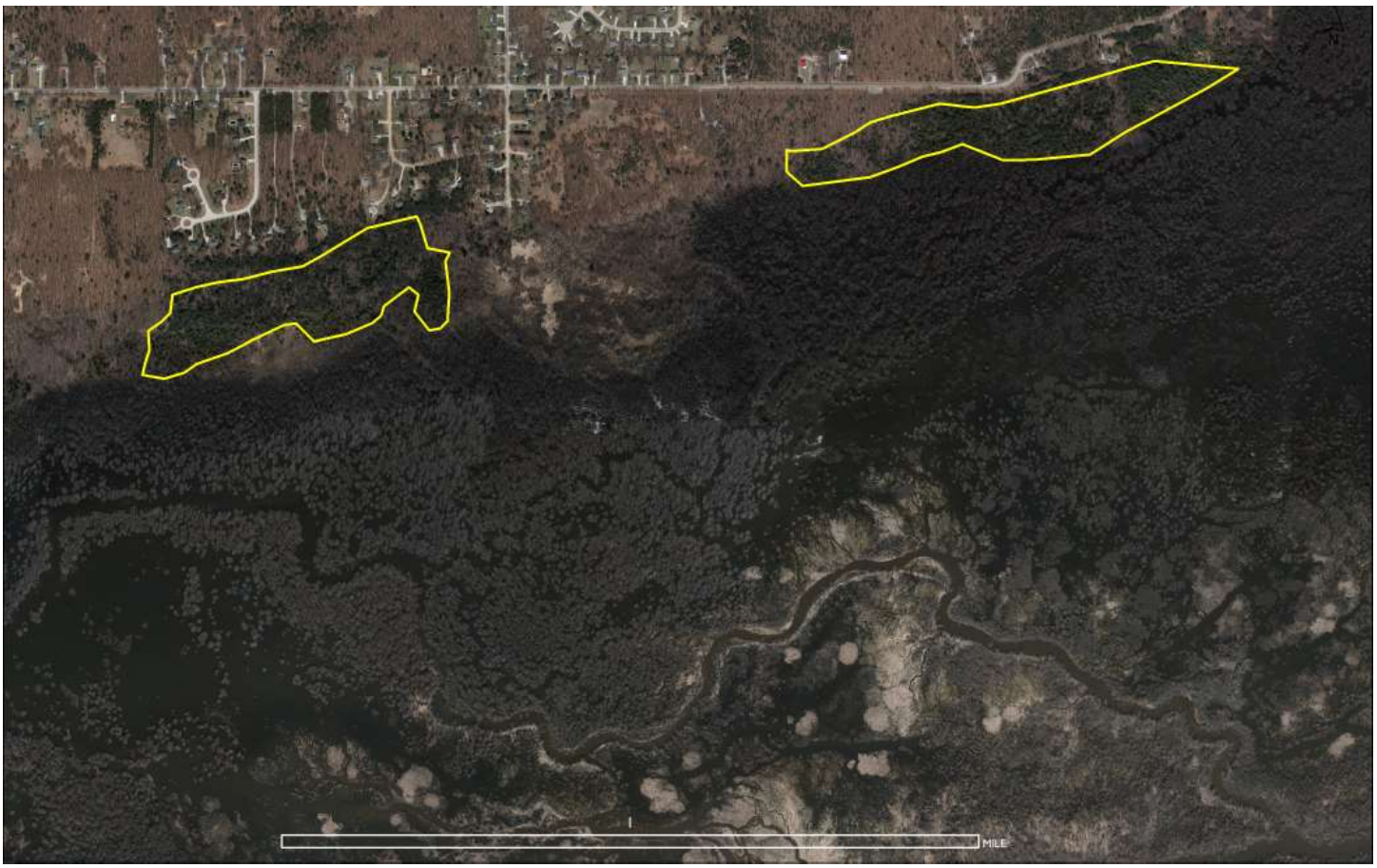
South Channel Swamp occurs at the base of the steep slopes bounding the broad outwash channel of the Muskegon River. Photo by Jesse Lincoln.

North Channel Hardwood-Conifer Swamp

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
21729 (new)	C	59	3	12, 38, northwest portion of 20

This EO consists of two zones of hardwood-conifer swamp along the northern portion of the Muskegon River outwash channel. Saturated soils at the base of slopes support a relatively closed-canopy swamp (60 to 90% canopy coverage) dominated by tall, large-diameter (8 to 36 in) trees. This swamp features mature, second-growth trees and high species and structural diversity associated with subtle micro-topographic gradients and variability of depth of organic substrate over mineral soils. These small-scale gradients result in a mosaic of saturated/ inundated areas supporting wetland species with small upland inclusions. The depth and duration of saturation from this groundwater drives floristic composition of the swamp. Areas with mineral soils near the surface are generally much more acidic (pH 4.5-5.0) and feature red oak, sugar maple (*Acer saccharum*), and beech, with hemlock, white pine, and red maple as canopy co-dominants. Areas with saturated, deep organics (pH 6.5) feature red maple, yellow birch, white cedar (*Thuja occidentalis*), and occasionally tamarack. There are several areas where groundwater seeps into the floodplain along small streams, creating zones of shallow water over muck soils. Windthrow, tree disease, hydrology, are all factors impacting canopy structure and composition.

Generally, the system is very similar in structure and composition of the South Channel Swamp described above. This site was visited once during the 2016 field season. A total of 79 plant species were documented with 77 native species and 2 non-native species. The total FQI is 37.1.



2014 aerial imagery of North Channel Hardwood-Conifer Swamp.

Conifers dominate North Channel Swamp where cold, minerotrophic ground water seeps from the uplands (left, top photo). Silver maple dominates where the dynamic hydrology of the floodplain causes extended periods of inundation and deposition of sediments. Hemlock is locally dominant (bottom photo) and the herbaceous layer is locally sparse as a result of the dense shade. Photos by Jesse Lincoln.

Intermittent Wetland (G2 S3, imperiled globally and vulnerable within state)

Green Intermittent Wetland

EO ID Number	EO Rank	Size (acres)	Compartment	Stand
22701 (new)	C	3	9	38

This is a small graminoid-dominated wetland occupying a shallow depression within a matrix of oak-pine forest and wet-mesic sand prairie. This wetland is characterized by coarse, acidic sands (pH 4.5-5.0) with organics over pure sand (pH 6.0). This wetland is maintained by a fluctuating water table with observed water depths up to 2ft during August surveys in 2016. The intermittently fluctuating water table prevents woody encroachment within this wetland. Periods of inundation are typically in the spring but can occur throughout the year. The fluctuating water table leads to variable zonation and dramatic water level shifts temporally and spatially from season to season, and year to year.

During wet years, the intermittent wetland is inundated year-round and characterized by clumps of emergent vegetation, including blue-joint (*Calamagrostis canadensis*), sedges, (*Carex stricta* and *C. utricularia*) southern blue flag, northern bugleweed, and wool-grass (*Scirpus cyperinus*). Water smartweed (*Persicaria amphibia*) is the dominant floating vegetation in submergent zones. In drier years, blue-joint, tussock sedge, and wool-grass are dominant. The entire wetland is ringed with shrubs, including slender willow (*Salix petiolaris*), Michigan holly, and meadowsweet (*Spiraea alba*). A small patch of reed canary grass was observed at the edge of the wetland along the road.

This site was visited once during the 2016 field season. The site was totally inundated at the time of survey and a total of 11 plant species were documented, all native. The total FQI is 11.9.

2014 aerial imagery of Green Intermittent Wetland.

Green Intermittent Wetland (top photo) occurs in a matrix of fire-adapted oak-pine forest (bottom photo) and wet-mesic sand prairies and should be included in prescribed burns. Photos by Jesse Lincoln.

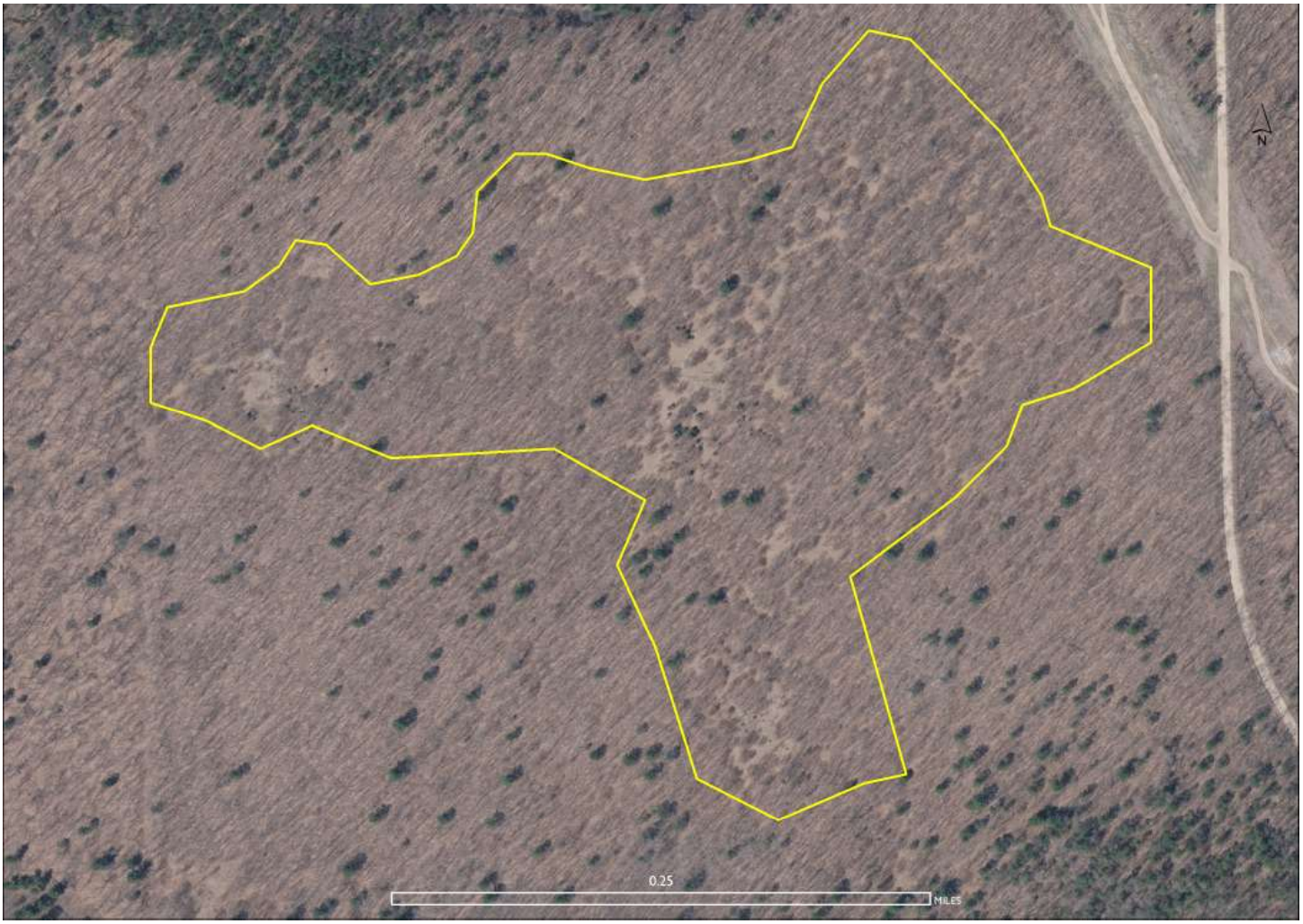
Oak-pine Barrens (G3 S2, vulnerable globally and imperiled within state)

Fitzgerald Barrens

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
20566 (new)	BC	46	9	34, 35

This barrens is a mosaic of grassy openings within oak-pine forest featuring a sparse canopy. The area was historically a matrix of oak-pine forest and barrens, though GLO surveys were coarse and the notes omit a barrens/savanna component in this location. This savanna system occurs on deep outwash sands over lakeplain. The area is flat and soils are coarse, loamy sands (pH 5.5). The forested portions of the site are dominated by small, young oaks with tree diameters typically less than 15 in and ages ranging from 30 to 70 years old. Oak, cherry (*Prunus serotina*), and sassafras are thick in the subcanopy and are suppressing characteristic herbaceous vegetation. The openings support the abundance of barrens vegetation.

The landscape has been impacted by timber management, roads, rural residences, agriculture, and utility corridors. Imagery from the 1938 indicates that there were logging operations within and around this site. These logging operations may have been a disturbance factor that promoted barrens species, as these species are generally concentrated in openings where there appears to have been localized soil disturbance. Historically, the savanna/ barrens openings would have likely been much more extensive as a result of frequent, low-intensity wildfires ignited by Native Americans or lightning.



2014 aerial imagery of Fitzgerald Barren.

Fitzgerald Barrens is characterized by a sparse canopy of oaks and pines with several openings dominated by prairie species, including big bluestem, little bluestem, and lupine (bottom photo). Lupine is the host plant of the federally endangered Karner blue butterfly, which has been documented in nearby powerline corridors. The return of fire to the site is likely beneficial to populations of the butterfly. Photos by Jesse Lincoln.

Forested areas of the savanna are dominated by oaks (*Quercus ellipsoidales*, *Q. alba*, and *Q. velutina*) with occasional black cherry and supercanopy white pine. Tree diameters are typically small (ranging from 25 to 46 cm [10 to 18 in]) with a few supercnaopy white pines measuring over 60 cm (2 ft) in diameter. Within these forested areas the canopy is often sparse (50 to 80%). The subcanopy is characterized by the same species found in the canopy and often dense thickets of sassafras. Shrubs in the forested areas include witch-hazel, choke cherry (*Prunus virgiana*), serviceberry (*Amelanchier* spp.), flowering dogwood (*Cornus florida*), pasture rose (*Rosa carolina*), and maple-leaved viburnum (*Viburnum acerifolium*). The herbaceous layer consists primarily of *Carex pensylvanica* and black oatgrass (*Piptochaetium avenaceum*) and abundant bracken fern (*Pteridium aquilinum*).

The openings are characterized by a significantly sparser canopy (25 to 50%). Shrubs include sand cherry (*Prunus pumula*), New Jersey tea (*Ceanothus americanus*), and prairie willow (*Salix humilis*). There is also a greater diversity of herbaceous species, including lupine (*Lupinus perennis*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), showy goldenrod (*Solidago speciosa*), birdfoot violet (*Viola pedata*), June grass (*Koeleria macrantha*), western sunflower (*Helianthus occidentalis*), and rough blazing-star (*Liatris aspera*). Invasives are ubiquitous but not dominant and include Canada bluegrass (*Poa compressa*), common St. John's-wort (*Hypericum perforatum*), hawkweeds (*Hieracium* spp.), and sheep sorrel (*Rumex acetosella*).

This site was visited twice during the 2016 field season. A total of 98 plant species were documented with 83 native species and 15 non-native species. The total FQI is 40.6.

Recent prescribed burns at Fitzgerald Barrens have temporarily reduced the understory of cherry and sassafras, increased the abundance of characteristic prairie vegetation, and potentially expressed species dormant in the seedbank. This progress can be swiftly reversed without continual application of prescribed fire to reduce the vigorous subcanopy growth. Photo by Jesse Lincoln.

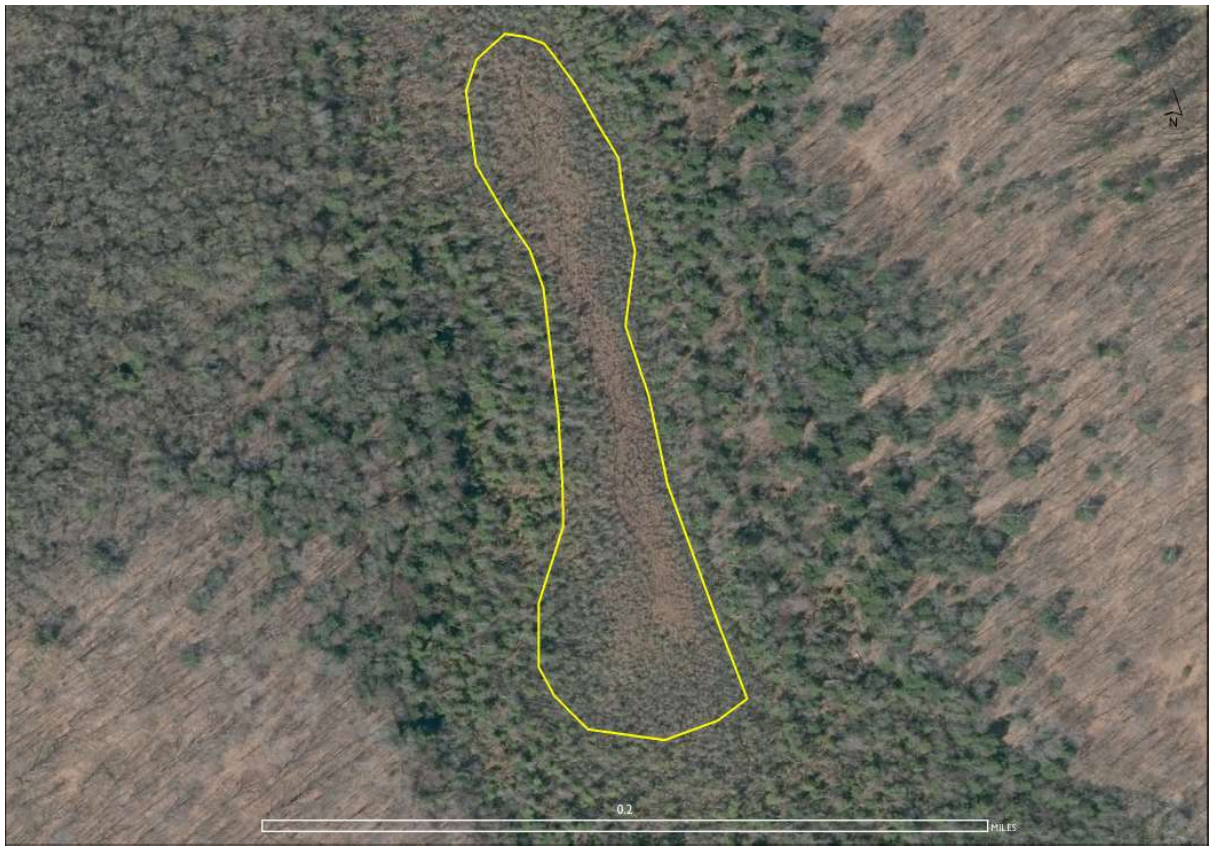
As a result of protracted fire suppression, many of the grassy openings have been dramatically reduced by woody encroachment (top photo). Despite habitat loss to woody encroachment, many openings with characteristic savanna vegetation persist (bottom photo). Photos by Jesse Lincoln.

Poor Fen (G3 S3, vulnerable throughout range)

Bridgeton Poor Fen

EO ID Number	EO Rank	Size (acres)	Compartment	Stand
21472 (new)	B	4	11	Center of 29

This is a small, narrow poor fen surrounded by a high-quality hardwood-conifer swamp from which cold groundwater constantly wells up, creating saturated, weakly-minerotrophic soils. The cold groundwater and permanently saturated soils allow for the accumulation of sphagnum which slows decay of organic matter. The system is influenced by seasonal and long-term fluctuations in the level of the water table. The canopy trees of the surrounding swamp are stunted at the margins of the fen. Within the fen, trees are sparse to absent and are less than 5 m tall. Tall shrubs become sparser towards the center of the fen, which is characterized by irregularly shaped mounds of sphagnum that rise to two feet out of the water. The sphagnum mounds are characterized by fine-scale gradients in soil moisture and chemistry with fibric peats on the mounds being strongly acidic (pH 4.5) and sapric peats in the nearby hollows being slightly acidic (pH 6.5). This variability in pH, moisture, and structure of the substrate likely drives species diversity. Acidophiles grow on top of the acidic moss mounds. A diversity of graminoids occur between the mounds, where groundwater moderates the pH. Throughout the fen, ants have formed mounds composed of very fine organics. Grasses growing on these ant mounds likely were rejected from the ant's seed stores due to low nutritional value. The fen appears to be in excellent condition with no obvious past alterations to hydrology, no invasive species, and excellent plant diversity.



2014 aerial imagery of Bridgeton Poor Fen.

The margins of the fen transition from hardwood-conifer swamp to open fen and these zones are characterized by increasingly-stunted constituents of the swamp's canopy, including tamarack, red maple, white pine, and American elm. These forested margins have a dense shrub layer with swamp rose (*Rosa palustris*), poison sumac (*Toxicodendron vernix*), speckled alder, and mountain holly (*Ilex mucronata*). The open zone of more typical fen structure is characterized by mounds of sphagnum that supports the majority of the vegetation. Particularly striking is the dense "canopy" of royal fern (*Osmunda regalis*) interspersed with an unusual abundance of native common reed (*Phragmites australis* subs. *americanus*). At the core of the fen on the sphagnum mounds are dense rosettes of pitcher-plants (*Sarracenia purpurea*) as well as small cranberry (*Vaccinium oxycoccos*), marsh fern (*Thelypteris palustris*), round-leaved sundew (*Drosera rotundifolia*), and dragon's mouth orchid (*Arethusa bulbosa*). Between the mounds is open water where broad-leaved cat-tail (*Typha latifolia*) and sedges are abundant. Native bluegrass (*Poa alsodes*) and marsh wild-timothy (*Muhlenbergia glomerata*) are locally dominant on the numerous ant mounds in the fen.

This site was visited twice during the 2016 field season. A total of 38 plant species were documented with no non-native species. The adjusted FQI is 53.

The open conditions of the poor fen are maintained by a constant flow of cold, minerotrophic groundwater. The system is completely ringed by high-quality hardwood-conifer swamp. Photo by Jesse Lincoln.

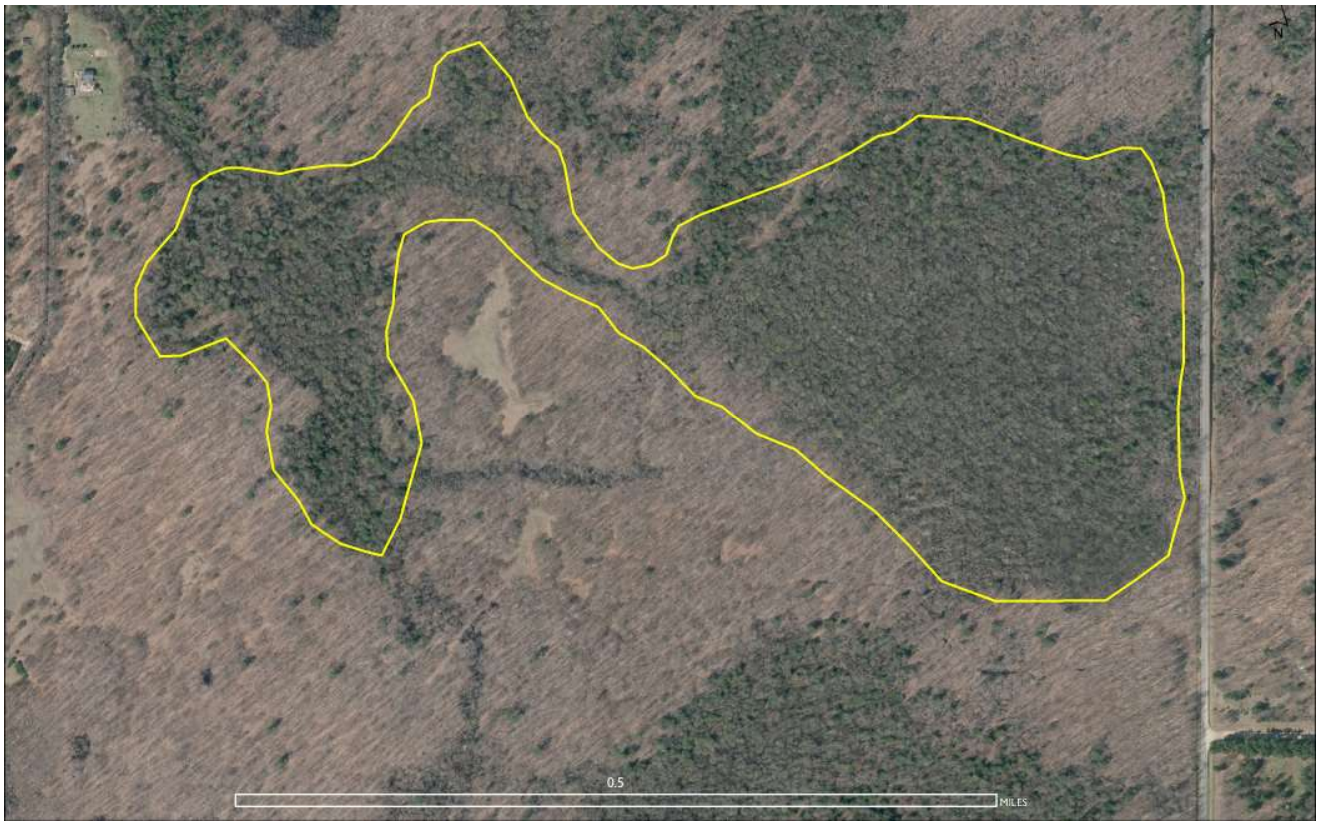
Southern Hardwood Swamp (G3 S3, vulnerable throughout range)

Bridgeton Hardwood Swamp

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
21602 (new)	C	79	11	8, 23

This is a closed-canopy, forested wetland characterized by maturing (~100 yrs old), large-diameter (38 to 81 cm [15 to 32 in]) deciduous trees occurring in a flat, outwash landscape context. Soils are variable in composition, depth of organics, and pH with alkaline (pH 8.0) sandy soils predominant throughout and acidic (pH 5.0-5.5), semi-saturated sands occurring along the swamp margin where conifers occur locally. Species and structural diversity are associated with subtle fluctuations in elevation, resulting in a diverse matrix of small, sparsely vegetated upland inclusions within a broader area of swamp. Windthrow and disease outbreak contribute to pit-and-mound topography and the accumulation of coarse woody debris with both influencing vegetative composition and distribution. In the wetter areas, hummock-hollow microtopography is associated with tree buttresses, tree root mats, abundant coarse woody debris, and tip-up mounds. Hollows are sparsely vegetated due to prolonged standing water in the spring and early summer. Hummocks support a greater diversity of species. Coarse woody debris is common and supports bryophytes and a variety of vegetation, depending on stage decay. The majority of the system is southern hardwood swamp but transitions towards hardwood-conifer swamp at the margins, presumably where groundwater seeps are colder and more constant and where sands become more prevalent in the soil. Small areas of mesic northern forest occur at the edges and in small rises within the swamp.

There is an abundance of dead ash due to emerald ash borer and Dutch elm disease likely reduced the canopy presence of elm as well. Deer herbivory was noted throughout and many species may not be reproducing as a



2014 aerial imagery of Bridgeton Hardwood Swamp.

result. Saplings of canopy species that are favored browse of deer were conspicuously absent. A large (27 in) eastern hemlock was aged to 180 years old and evaluation of the spacing of the tree rings suggest that a logging event occurred around 1910.

This is a highly-variable, closed-canopy deciduous swamp with areas of saturated soils and some zones inundated year-round. The majority of the swamp is characterized by inundated zones which are dominated by large silver and red maple, with cottonwood, basswood, and swamp white oak as typical codominants. The margins trend towards hardwood-conifer swamp with a dominance of eastern hemlock and historically white pine. Other areas trend towards mesic northern forest with zones of hemlock, red maple, beech, red oak, and white oak. These mesic zones don't have areas with inundation but are characterized by periodically saturated soils, pit-and-mound topography, and feature a mosaic of saturated depressions. Historically American elm and green ash would have been important canopy constituents throughout. Elm and green ash persist in the subcanopy along with maple species, yellow birch, basswood. The understory and shrub layers are sparse with spicebush and musclewood as the dominant shrubs. The herbaceous layer is diverse and complex with inundated areas featuring sedges (*Carex intumescens*, *C. stricta*, *C. crinita*), fowl manna grass, southern blue flag, fringed loosestrife, sensitive fern, and royal fern. Hummocks or areas with less prolonged inundation are characterized by bluegrass, rough bedstraw (*Galium asprellum*), rough goldenrod (*Solidago patula*), sedges (*C. leptalia* and *C. bromoides*), and wild geranium (*Geranium maculatum*).

This site was visited once during the 2016 field season. A total of 120 plant species were documented with 116 native species and 4 non-native species. The total FQI is 49.3.

Vegetation patterns within Bridgeton Swamp are strongly influenced by the presence of hummock-hollow topography. Photo by Jesse Lincoln.

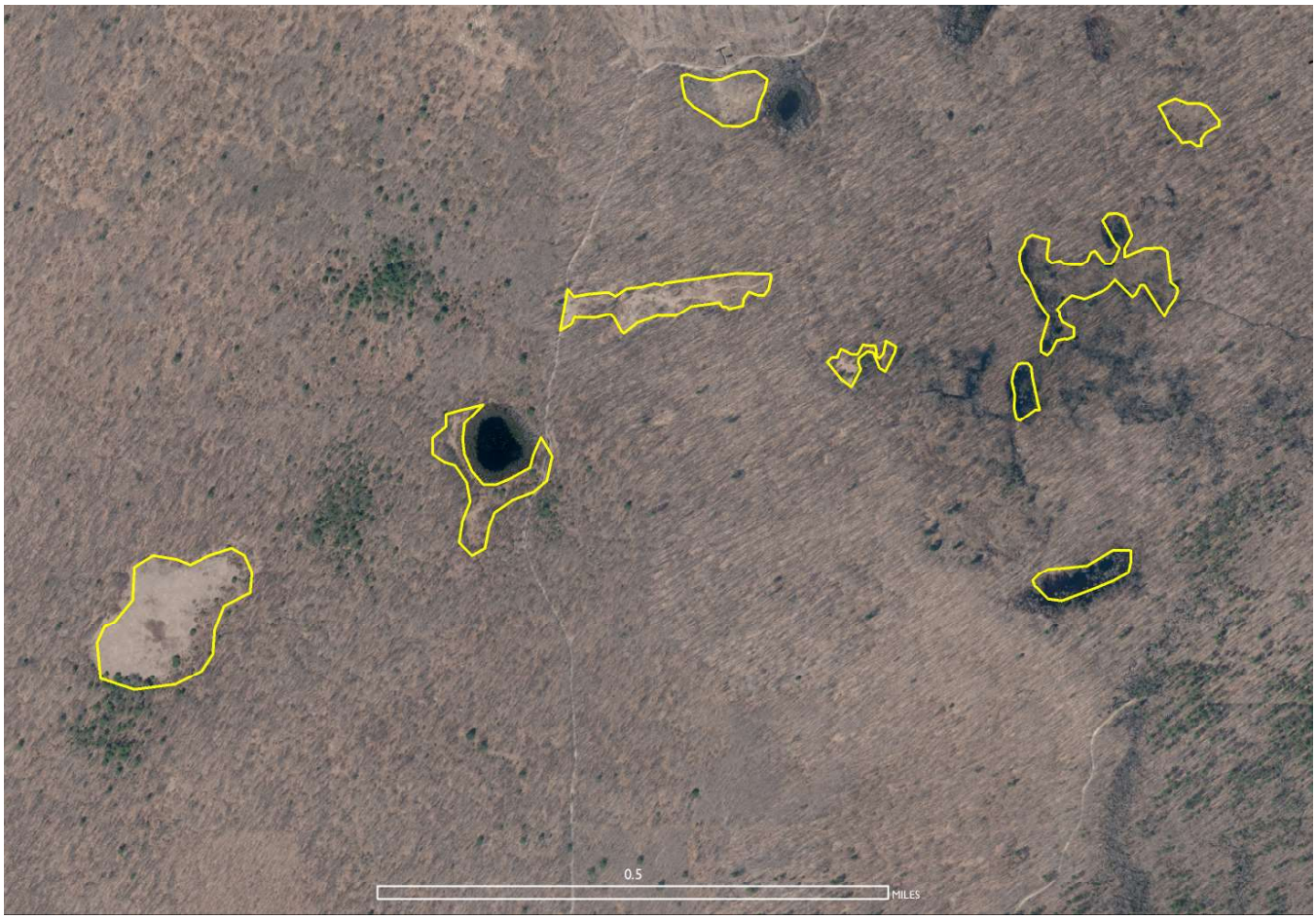
Wet-mesic Sand Prairie (G2 S2, imperiled throughout range)

Muskegon Prairies

EO ID Number	EO Rank	Size (acres)	Compartment	Stands
15729 (new)	BC	26	9	28, 39, 45, 46, openings in 64

These wetlands are characterized by sandy, acidic (pH 4.5-5.0) soils with organics over pure sand (pH 6.0). These open wetlands are maintained by a fluctuating water table that is occasionally near the surface. The fluctuating water table limits woody encroachment. Drought also likely prevents woody encroachment and helps maintain the open nature of the prairie. Historically, adjacent landcover included barrens/savanna systems that have transitioned to closed-canopy, oak-pine forest as a result of protracted fire suppression. The variability of the water table leads to highly variable zonation spatially and temporally between the prairie openings from season to season, and year to year. Some years this wet-mesic sand prairie trends more towards a dry-mesic prairie and other years some openings trend towards a coastal plain marsh.

These prairie wetlands are generally dominated by some combination of big bluestem, blue-joint, switch grass (*Panicum virgatum*), and prairie cord grass (*Spartina pectinata*). Associated shrubs include prairie willow, meadow willow, and meadowsweet. Quaking aspen (*Populus tremuloides*) clones occur locally.



2014 aerial imagery of the Muskegon Prairies.

Characteristic herbaceous species include bushy aster (*Symphyotrichum dumosum*), marsh blazing-star (*Liatris spicata*), grass-leaved goldenrod (*Euthamia graminifolia*), and lance-leaved violet (*Viola lanceolata*). The flora is a blend of barrens species and wetland species. The wet-mesic sand prairie supports several rare species and elements of the coastal plain flora including tall green milkweed (*Asclepias hirtella*, state threatened), short-fruited rush (*Juncus brachycarpus*, state threatened), scirpus-like rush (*J. scirpoides* state threatened), Leggett's pinweed (*Lechea pulchella*, state threatened), tall nut rush (*Scleria triglomerata*, state special concern), and eastern blue-eyed-grass (*Sisyrinchium atlanticum*, state threatened).

This site was visited once during the 2016 field season. A total of 53 plant species were documented with no observed non-native species. The total FQI is 32.8.

The westernmost opening of Muskegon Prairies appears to be unimpacted by alterations to hydrology or past agricultural activities. There were no observed invasive species and this is the best example of the community type in Michigan. Photo by Jesse Lincoln.

Vernal Pools

A total of 63 potential vernal pools (PVPs) were identified and mapped in Muskegon SGA. Of these, 57 were identified and mapped through aerial imagery interpretation and 6 were encountered during field surveys and had not been mapped from aerial imagery interpretation (Figure 13). All the potential vernal pools are located in the East Unit of the Muskegon SGA. Potential vernal pools were identified and mapped within upland and lowland deciduous forest stands (e.g., northern hardwoods, lowland maple, lowland aspen, and maple stands).

A total of 29 potential vernal pools were surveyed in the field, which resulted in 17 field verified vernal pools, 8 potential vernal pools that need additional information to confirm their status (i.e., whether they are vernal pools or not), and 4 that were determined to not be vernal pools (i.e., 3 were other wetland types, and 1 was not a wetland) (Figure 13). Of the 17 vernal pools verified in the field, 13 were classified as forested vernal pools, 8 were open or sparsely vegetated vernal pools, and one was a shrubby vernal pool type. Unfortunately, because most of the vernal pools were dry when they were surveyed, we were not able to detect evidence of vernal pool indicator species (i.e., wood frog, blue-spotted salamander, spotted salamander, fairy shrimp) breeding or using any of the vernal pools that were verified. Fingernail clams (Veneroida: Sphaeriidae), which are commonly found in vernal pools, were found under the leaf litter in 9 of the 17 verified dry vernal pools though, providing further evidence that these were vernal pools.

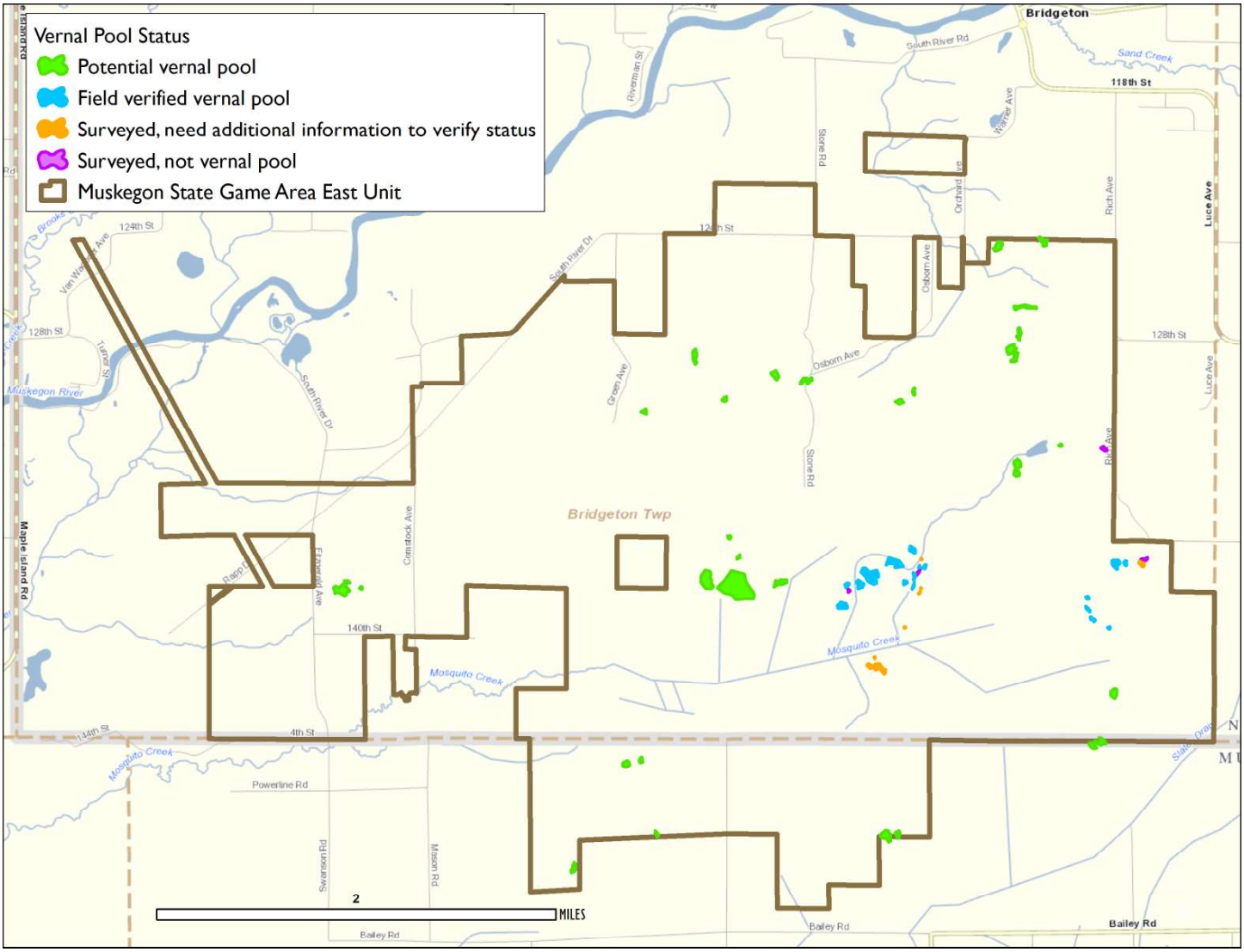


Figure 13. Location of vernal pools and potential vernal pools in Muskegon State Game Area.

Rare Animals

Birds

Rare raptor surveys were completed at 97 points within the game area (Figure 14). Red-shouldered hawks were detected at 20 (21%) of the points visited. Two potential red-shouldered hawk nests were seen but no birds were seen on or near these nests. It is possible that snow storms in April 2018 may have impacted nesting activity and account for the lack of active nests despite the presence of red-shouldered hawks within the game area. Though northern goshawk was not detected during surveys, the game area does appear to have abundant suitable habitat for goshawk and there is potential for this species to nest in the game area.

Forest songbird surveys were conducted at 103 points within forest stands (Figure 14). Prothonotary warbler and cerulean warbler had been documented in the game area prior to 2018 surveys. A new element occurrence for Louisiana waterthrush was documented (Figure 14, Table 5). Two singing male Louisiana waterthrush were detected in the western portion of the game area along the Muskegon River, representing a new occurrence (EO ID 22765). Fifty-one singing male prothonotary warblers were observed at 23 different points within the Muskegon River floodplain between Maple Island Road and US Highway 31. These prothonotary warbler observations were considered part of an existing element occurrence (EO ID 13322) for this species. Twenty-five singing male cerulean warblers were documented at 23 points within the Muskegon River floodplain between Maple Island Road and US Highway 31 (Figure 14). These cerulean warbler observations were included with the existing element occurrence (EO ID 13319). Though hooded warblers were not detected during surveys, the game area does appear to have abundant suitable habitat for this species and there is good potential for hooded warblers to nest in the game area.

A total of 75 bird species were documented during point counts within Muskegon SGA. The seven most commonly detected species were red-eyed vireo (*Vireo olivaceus*; 94% of points), American redstart (74%; *Setophaga ruticilla*), eastern wood-pewee (*Contopus virens*; 70% of points), ovenbird (*Seiurus aurocapilla*; 47%), song sparrow (*Melospiza melodia*; 46%), common yellowthroat (*Geothlypis trichas*; 41%), and American crow (*Corvus brachyrhynchos*; 40% of points). The following twelve species were regularly observed (20-39% of points surveyed): yellow-throated vireo (*Vireo flavifrons*), red-bellied woodpecker (*Melanerpes carolinus*), acadian flycatcher (*Empidonax virescens*), great-crested fly-catcher (*Myiarchus crinitus*), wood thrush (*Hylocichla mustelina*), prothonotary warbler, downy woodpecker (*Dryobates pubescens*), cerulean warbler, blue-grey gnatcatcher (*Polioptila caerulea*), scarlet tanager (*Piranga olivacea*), rose-breasted grosbeak (*Pheucticus ludovicianus*), and

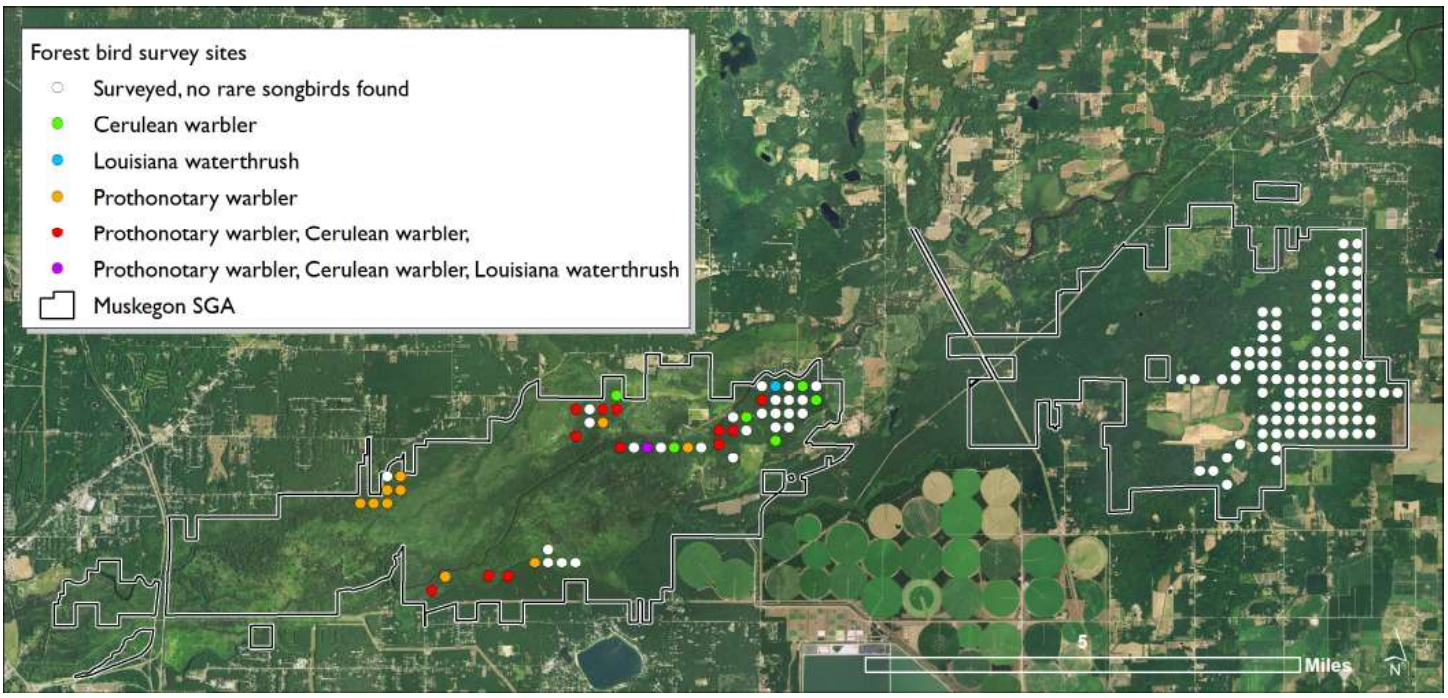


Figure 14. Location of forest songbird and raptor point counts conducted in Muskegon State Game Area in 2018.

Table 5. Rare bird EOs and birds of special conservation status found within Muskegon SGA. State status abbreviation of "SC" signifies state special concern, "T" signifies state threatened. Rank abbreviations are as follows: BC, good to fair viability; C, fair viability; D, poor estimated viability; D?, possibly poor estimated viability; and E, verified extant. An "*" indicates the EO was updated in 2018 with information obtained during this project.

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*	13432	C	T		X	X	2002	2002
American bittern*	*Botaurus lentiginosus*	22861	D	SC	X	X	X	2018	2018
Red-shouldered hawk	*Buteo lineatus*		NA	T	X	X			2018
Black tern	*Chlidonias niger*	15626	D?	SC		X	X	2005	2005
Marsh wren*	*Cistothorus palustris*	14367	B	SC				1998	2018
Marsh wren*	*Cistothorus palustris*	14368	B	SC				1995	2018
Least bittern	*Ixobrychus exilis*	15619	E	T		X		2005	2005
Least bittern*	*Ixobrychus exilis*	22802	C	T		X		2018	2018
Red-headed woodpecker*	*Melanerpes erythrocephalus*	22766	E	SC		X	X	2018	2018
Louisiana waterthrush*	*Parkesia motacilla*	22765	E	T		X	X	2018	2018
Prothonotary warbler*	*Protonotaria citrea*	13320	E	SC		X	X	1999	2018
Cerulean warbler*	*Setophaga cerulea*	13319	E	T		X	X	1999	2018
Unlisted species									
Wood duck	*Aix sponsa*				X				2018
Mallard	*Anas platyrhynchos*				X				2018
Ruffed grouse	*Bonasa umbellus*				X				2018
Veery	*Catharus fuscescens*						X		2018
Pileated woodpecker	*Dryocopus pileatus*				X				2018
Wood thrush	*Hylocichla mustelina*				X		X		2018
Wild turkey	*Meleagris gallopavo*				X				2018
Sora	*Porzana carolina*						X		2018

Cerulean warblers were observed throughout the western management unit of Muskegon SGA. This state threatened species requires large areas of contiguous, mature forest. Photo by Aaron Kortenhoven.

American robin (*Turdus migratorius*). Thirteen (16%) of the species were detected at 10 to 19% of the survey points and 32 species (39%) were detected at less than 10% of the survey points. On average, 10.4 bird species were documented per point count station.

Twenty-three points were surveyed for marsh birds at Muskegon SGA in 2018 (Figure 15). Prior to these surveys, EOs had been documented within the game area for least bittern (EO IDs 15619 and 22802), black tern (EO ID 15626), and marsh wren (EO IDs 14367 and 14368). The presence of least bittern was reconfirmed at one of the occurrences (EO ID 22802) and marsh wren at both occurrences, but black terns were not observed during the 2018 surveys (Table 5). Least bittern was not detected at the EO located in the western portion of the game areas near the black tern EO (Figure 15). Potential habitat remains near these occurrences, so both species could still occur with the emergent wetlands. A calling American bittern was heard at two of the point count stations, resulting in the first documented occurrence of the species within the game area (EO ID 22861; Figure 15). Marsh wren was observed at 10 of the 23 survey points and at two

additional locations while traveling between points (Table 5). Several other bird species were documented during marsh bird surveys of Muskegon SGA in 2018. Swamp sparrow is a common species in a variety of wetland types and was detected at 87% of the survey points. Sandhill crane and sora were regularly observed during surveys, being recorded at 44% and 22% of the point count stations, respectively. Pied-billed grebe, Virginia rail, sedge wren, mallard, and wood duck were detected at less than 10% of the survey points.

Several of the bird species detected have special conservation status (Table 5). Eight species are considered featured species for habitat management by the Wildlife Division of the MDNR: mallard, wood duck, American bittern, ruffed grouse, wild turkey, red-shouldered hawk, pileated woodpecker, and wood thrush. American bittern and red-shouldered hawk are also considered SGCN (Derosier et al. 2015), as are least bittern, red-headed woodpecker, prothonotary warbler, cerulean warbler, and Louisiana waterthrush. Eight species observed in 2018, American bittern, sora, red-headed woodpecker, veery, wood thrush, prothonotary warbler, cerulean warbler, and Louisiana waterthrush, are also focal species for conservation efforts under conservation strategies (Potter et al. 2007, Soulliere et al. 2018) of the Upper Mississippi River and Great Lakes Region Joint Venture.

An American bittern was observed in the western management unit of Muskegon SGA and requires open wetland habitat. Photo by Mike Monfils.

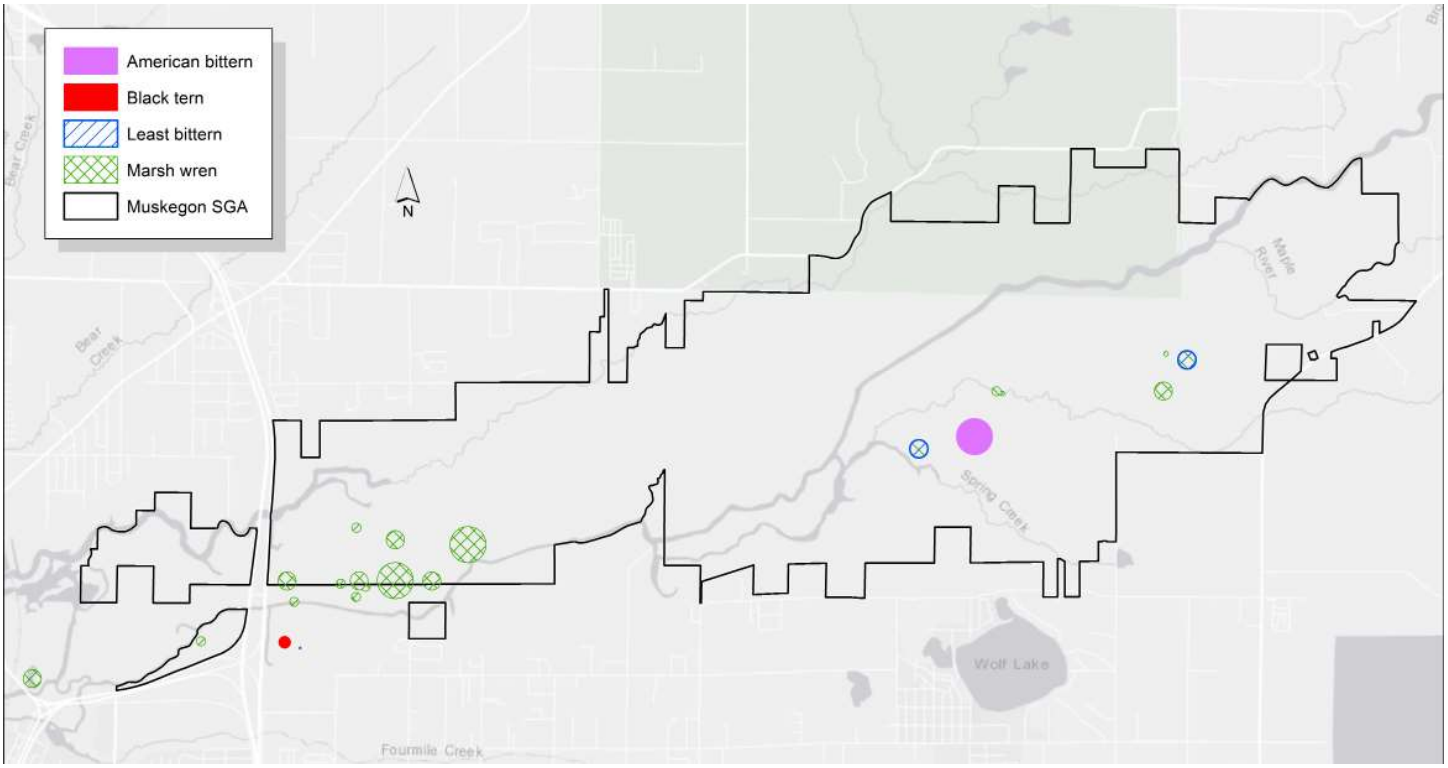


Figure 15. Location of rare marsh birds found in Muskegon State Game Area.

Reptiles and Amphibians

Amphibian and reptile surveys in Muskegon SGA in 2018 documented two rare reptile species and twelve common amphibian and reptile species (Table 6, Figures 16 and 17, Appendix 5). Three adult female Blanding's turtles were observed nesting or walking along an open, sandy powerline corridor south of Spring Creek on June 11th, and three additional adult female Blanding's turtles were observed nesting or walking along a sandy two-track road north of Mosquito Creek on June 20th (Figures 16). These observations updated and expanded the distribution of an existing Blanding's turtle element occurrence (EO ID 8334) that occurs within and outside of the game area, including adding a nesting area sub-element occurrence (EO ID 22658) to this EO (Table 5, MNFI 2019). An adult female eastern box turtle also was observed walking along the same powerline corridor south of Spring Creek on June 11th (Figures 16). This observation updated and expanded the distribution of an existing eastern box turtle element occurrence (EO ID 12138) (Table 6, MNFI 2019). Additional amphibian and reptile species detected during herptile surveys in 2018 included the northern leopard frog (*Lithobates pipiens*), green frog (*Lithobates clamitans*), northern spring peeper (*Pseudacris crucifer crucifer*), gray treefrog (*Hyla versicolor*), eastern American toad (*Anaxyrus americanus americanus*), wood frog (*Lithobates sylvaticus*), eastern gartersnake (*Thamnophis sirtalis sirtalis*), eastern hog-nosed snake (*Heterodon platirhinos*), Dekay's brownsnake (*Storeria dekayi*), eastern snapping turtle (*Chelydra serpentina serpentina*), northern map turtle (*Graptemys geographica*), and painted turtle (*Chrysemys picta*) (Appendix 5). It is particularly noteworthy that, in addition to several northern map turtles that were encountered during nesting turtle surveys, over 30 map turtles of different sizes/age classes were observed on logs and other structures in the Muskegon River during the basking survey.

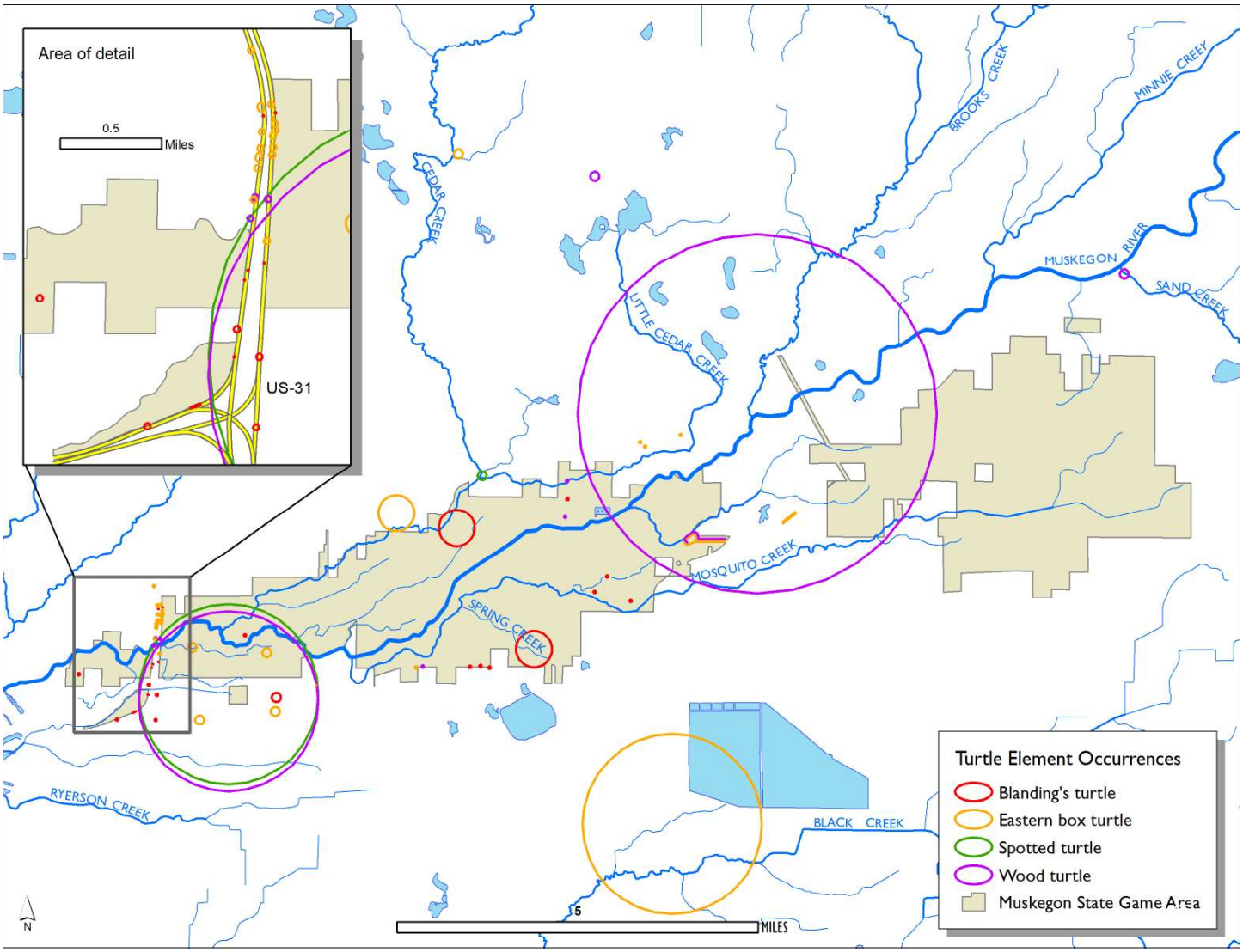


Figure 16. Locations of turtle EOs in Muskegon State Game Area.

Table 6. Rare reptile element occurrences at Muskegon State Game Area. State status abbreviation of "SC" signifies state special concern, "T" signifies state threatened, and "E" signifies state endangered. Federal status of "LT" signifies federally threatened. Element occurrence (EO) rank abbreviations are as follows: A, excellent viability; AB, excellent to good viability; B, good viability; BC, good to fair viability; H, historic record; and E, verified extant but with insufficient information to rank viability. "P" refers to parent EO, and "S" refers to sub-EO.

Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Turtles							
Spotted Turtle[2]	*Clemmys guttata*	T		994	H	1988	1988
Spotted Turtle	*Clemmys guttata*	T		4589	H	1988	1988
Blanding's Turtle (P)	*Emydoidea blandingii*	SC		8334	A	1988	2018
Blanding's Turtle (S)[1]	*Emydoidea blandingii*	SC		22658	E	2018	2018
Wood Turtle (P)	*Glyptemys insculpta*	SC		10284	B	1988	2008
Wood Turtle	*Glyptemys insculpta*	SC		12878	AB	1986	2018
Wood Turtle (S)[1]	*Glyptemys insculpta*	SC		15651	E	2005	2005
Eastern Box Turtle	*Terrapene carolina carolina*	SC		12138	AB	1988	2018
Eastern Box Turtle (S)[1,2]	*Terrapene carolina carolina*	SC		19846	E	2011	2011
Eastern Box Turtle (P)	*Terrapene carolina carolina*	SC		20853	AB	2014	2018
Snakes							
Kirtland's Snake[2]	*Clonophis kirtlandii*	E		447	H	1988	1988
Gray Ratsnake	*Pantherophis spiloides*	SC		9433	BC	1988	2007
Gray Ratsnake	*Pantherophis spiloides*	SC		382	B	1979	2016
Queen Snake	*Regina septemvittata*	SC		20764	AC	2006	2008
Eastern Massasauga	*Sistrurus catenatus*	SC	LT	102	H	1980	1980
Eastern Massasauga	*Sistrurus catenatus*	SC	LT	15932	E	2005	2005

[1]Sub-EO represents turtle nesting area.

[2]EO located just outside Muskegon State Game Area.

Muskegon State Game Area is an important stronghold for box turtle populations and reptiles and amphibians in general. Photo by Aaron Kortenhoven.

Additionally, in 2018, MDNR staff from Muskegon SGA reported recent observations of wood turtle, gray ratsnake, Blanding's turtle, and eastern box turtle in the game area. A wood turtle, an eastern box turtle, and a gray ratsnake were observed in the vicinity of the game area headquarters in 2018 (Figures 15 and 16). An eastern box turtle also was reported from River Road north of Cedar Creek in 2018, and Blanding's turtles were reported from along Cedar Creek east of River Road and along Spring Creek (Figure 15). These observations updated or expanded existing element occurrences of these species (i.e., wood turtle EO ID 12878, Blanding's turtle EO ID 8334, eastern box turtle EO IDs 12138 and 20853, and gray ratsnake EO ID 382) (Table 5, MNFI 2019).

Mussels and Aquatic Species

Aquatic surveys were performed at nine sites within Muskegon SGA **(**Table 2, pg 14; Figure 18)**.** A total of seven unionid mussel species were found including one federally endangered and one state endangered species (Table 9, Figure 18). One slightly chalky female half shell of snuffbox (*Epioblasma triquetra*, federally and state endangered) was found in the main stem of the Muskegon River approximately 200 m upstream from the boat ramp at the end of Holton-Duck Lake Rd. (Site 6b; Figure 18). The occurrence is only the second record of snuffbox in the Muskegon River watershed. One shell of the state endangered black sandshell (*Ligumia recta*) was also found at Site 6 (Figure 18). Both species are also considered SGCN. These findings represent new element occurrences (Table 10). No live individuals were found at any of the aquatic survey sites. All species were represented by shells only. Although a large area (approximately 3,090 m^2) in the lower Muskegon River was visually surveyed by boat to try to locate any sign of mussels, no shells or live individuals were found (Site 8a-8b, Figure 18).

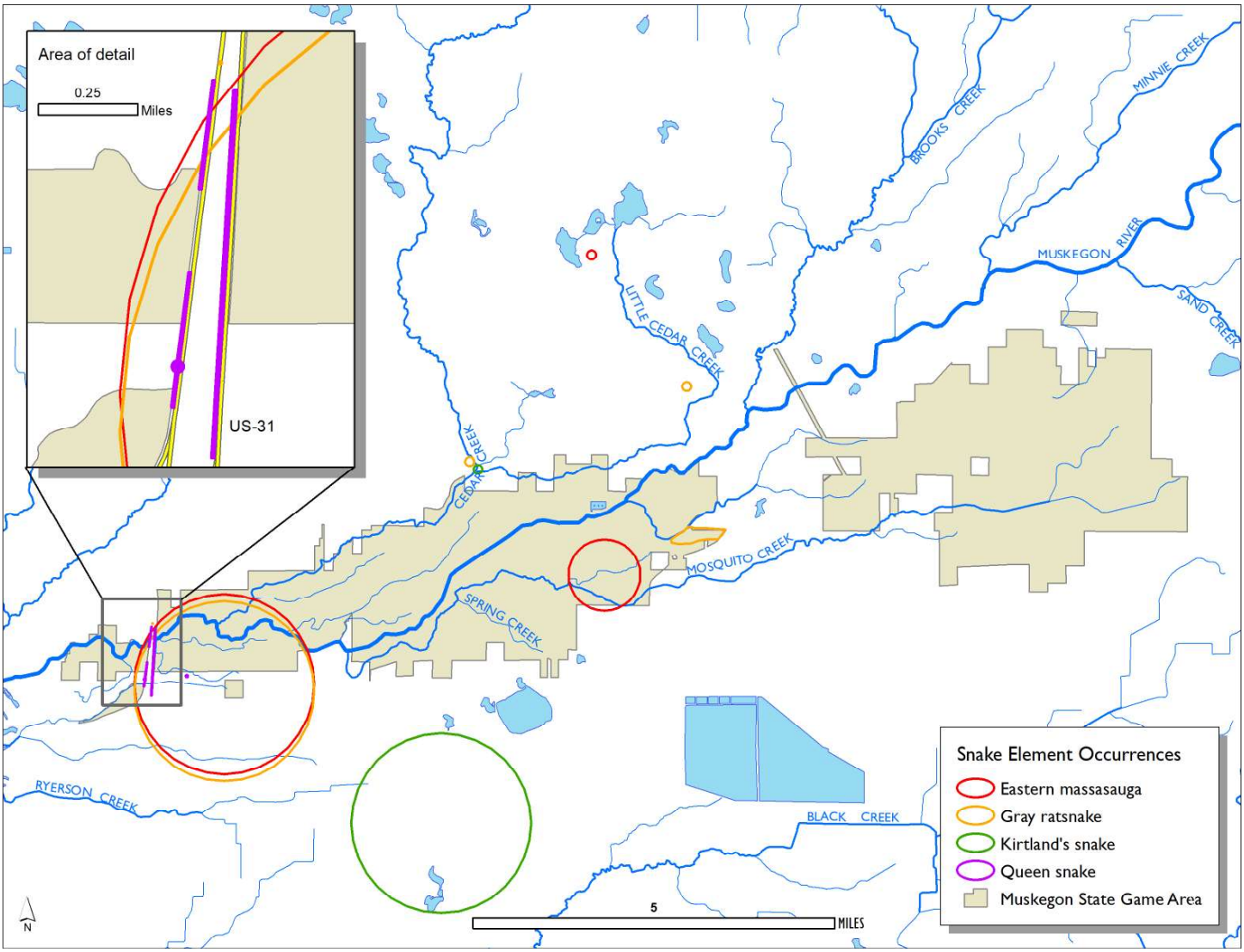


Figure 17. Locations of snake EOs in Muskegon State Game Area.

All seven mussel species documented in the survey were found in the Muskegon River at Site 6 (Figure 18). One species was found in Little Cedar Creek and none were found in Mosquito Creek. Empty zebra mussel (*Dreissena polymorpha*) shells were found at all sites in the Muskegon River, but were absent from Little Cedar Creek and Mosquito Creek. Asian clams (*Corbicula fluminea*) were not observed at any survey sites. Live aquatic snails (Gastropoda) were observed at eight of the nine sites (Table 9). Fingernail clams (Sphaeriidae) were observed at all survey sites except one. Crayfish (Decopoda) were noted only in Mosquito Creek at aquatic survey Sites 1 and 4. The invasive round goby (*Neogobius melanostomus*) was seen in Mosquito Creek (Site 4) and the Muskegon River (Site 8).

Stream substrate at aquatic survey sites was predominantly sand except for the site in Little Cedar Creek, which was predominantly silt. Overall, gravel, pebble, and larger size particles comprised a small component of the habitat sampled during the survey (Table 7). Aquatic vegetation and woody debris were present at most sites, providing cover and habitat structure for fish (Table 8). Erosion of the stream bank was noted at Site 6b in the main stem of the Muskegon River. Water clarity was high, and visibility was very good at all sites at the time of surveys. Water chemistry measures are provided in Table 11.

Table 7. 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			15	25	50	10
2				10	60	30
3					20	80
4					80	20
5				10	70	20
6			10	15	70	5
7					100	
8a					90	10
8b/9					90	10

Table 8. Physical habitat characteristics recorded at aquatic survey sites.

Site #	Current speed (m/second)	Aquatic vegetation?	Woody debris?	Eroded banks?	%Pool	%Riffle	%Run
1	1.00	N	Y	N	30	30	40
2	0.33	N	Y	N	20		80
3	0.14	Y	Y	N			100
4	0.25	Y	Y	N	33		67
5	0.20	Y	Y	N			100
6	0.50	Y	Y	Y			100
7	0.50	Y	Y	N			100
8b/9	0.3	Y	Y	N			100

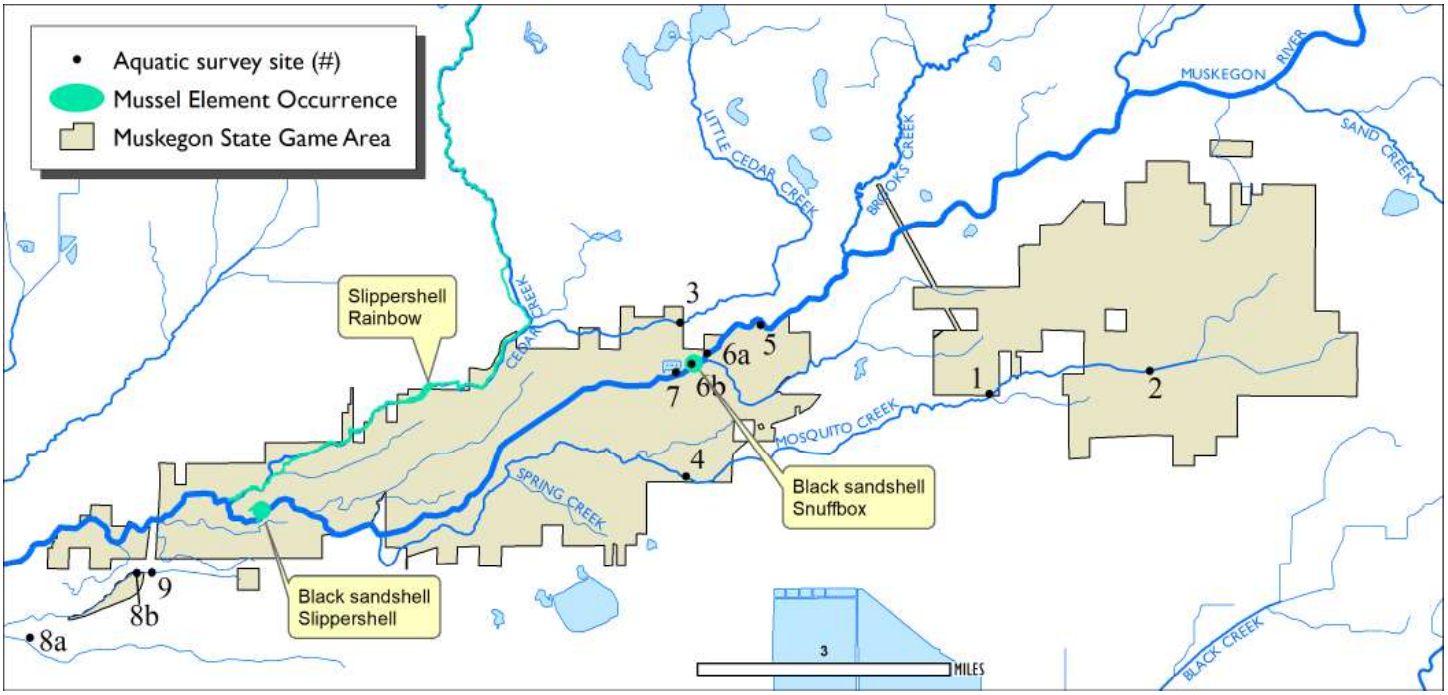


Figure 18. Map of aquatic survey sites and rare mussel occurrences.

Table 9. Numbers of native unionid mussel shells (#) recorded at each aquatic survey site. No live individuals were found. Presence/absence of non-native bivalves is noted. Status abbreviations are as follows: LE, federally endangered; and E, state endangered.

		1	2	3	4	5	6a-6b	7	8a-8b	9
Species		#	#	#	#	#	#	#	#	#
Mucket	*Actinonaias ligamentina*						S(2)			
Snuffbox	*Epioblasma triquetra* (LE)						S(1)[B]			
Spike	*Eurynia dilatata*			S(1)[A]			S(4)			
Wabash pigtoe	*Fusconaia flava*						S(4)			
Plain pocketbook	*Lampsilis cardium*					S(1)	S(10)			
Fatmucket	*Lampsilis siliquoidea*						S(3)			
Black sandshell	*Ligumia recta* (E)						S(1)			
	Total # individuals and density	0	0	0	0	0	0	0	0	0
	# species live	0	0	0	0	0	0	0	0	0
	# species live or shell	0	0	1	0	1	7	0	0	0
	Area searched (m^2)	128	128	77	128	117	1310[C]	200	~3090[D]	127
Asian clam	*Corbicula fluminea*									
Zebra mussel	*Dreissena polymorpha*					S	S	S	S	S

[A] Found outside measured search area

[B] One half shell, slightly chalky, female, found at downstream end of transect

[C] Three meter wide by approx. 394m long snorkel transect, plus 128m^2 area at downstream end of transect

Mussel shells found at aquatic survey Site 6b in the Muskegon SGA. Photo by Peter J. Badra.

Table 10. New and past rare mussel element occurrences within Muskegon SGA. Status abbreviations are as follows: E, endangered; T, threatened; SC, species of special concern; and LE, federally endangered. Element occurrence (EO) rank abbreviations are as follows: E, verified extant; and H, historical.

Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Rank	Year First Observed	Year Last Observed	Survey Site #
Slippershell	*Alasmidonta viridis*	T		13285	H	pre-1936	pre-1936	
Snuffbox	*Epioblasma triquetra*	E	LE	22778	E	2018	2018	6b
Black sandshell	*Ligumia recta*	E		22779	E	2018	2018	6b
Black sandshell	*Ligumia recta*	E		17660	H	pre-1936	pre-1936	
Rainbow	*Villosa iris*	SC		13286	H	pre-1936	pre-1936	

Table 11. Water chemistry measures taken at aquatic survey sites. Water samples were collected June 21, July 10, July 30-31, and September 28, 2018.

Site #	pH	Conductivity (µS)	Alkalinity (mg/l CaCO3)	Hardness (mg/l)	Water temp. (C)
1	8.37	290	104	112	14.7
2	8.15	353	156	128	17.6
3	8.14	341	152	152	21.0
4	8.40	1023	240	236	21.5
5	8.62	374	144	148	24.9
6	8.69	373	136	148	23.2
7	…	…	…	…	…
8b/9	8.02	443	190	184	17.0

Riparian habitat at aquatic survey Site 6b. Photo by Peter J. Badra.

DISCUSSION

Natural Communities

Prioritization of 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 they are not yet well established and their local population size is small. Within Muskegon SGA, we recommend that management efforts to maintain ecological integrity be focused in natural communities that provide potential habitat for numerous rare plant and animal species. We also recommend the prioritization of stewardship in sites located along riparian corridors and in forests that include vernal pools and other wetland inclusions. Priority natural communities meeting these criteria include the Muskegon Floodplain (Floodplain Forest, EO ID 3752), Muskegon Prairies (Wet-Mesic Sand Prairies, EO ID 15729), Fitzgerald Barrens (Oak-Pine Barrens, EO ID 20566), and Comstock Prairie (Dry Sand Prairie, EO ID 20595) (Table 11).

We provide the following general management recommendations for your consideration below and specific recommendations in Table 12. Land management in an area as ecologically significant as Muskegon SGA requires careful prioritization of stewardship efforts in the most critical ecosystems to protect native biodiversity and ecosystem functioning. We believe the primary management needs in order of importance are to: 1) prevent alterations to hydrology within the floodplain forest and other high-quality wetlands throughout the game area; 2) prevent fragmentation and maintain the canopy closure of high-quality forests, particularly floodplain forest along the Muskegon River; 3) continue to implement landscape-scale prescribed fire; 4) control invasive species in high-quality natural communities; and 5) monitor these activities to facilitate adaptive management.

Muskegon State Game Area is an area of extensive natural cover and contains many unique natural communities. It is a reservoir of biodiversity and regionally significant for wildlife, especially reptiles, amphibians, and migratory birds. Pictured is the largest opening of the Muskegon Prairies, one of the most significant remaining wet-mesic sand prairie in Michigan. This is part of a large restoration project on state lands in southern Michigan. DNR biologists are surveying the wetland after a prescribed burn. This is being managed with prescribed fire to improve habitat for game species and to promote and expand imperiled prairie habitat. Photo by Jesse Lincoln.

Table 12. Summary of management recommendations for natural community element occurrences in Muskegon State Game Area.

Habitat Type	Community Types	Management Recommendations
Forested Wetlands	Floodplain Forest Hardwood-Conifer Swamp Southern Hardwood Swamp	• Avoid fragmentation and maintain an intact buffer of natural cover surrounding forested wetlands • Protect hydrology in and around wetlands by avoiding damming, ditching, and diking • Avoid heavy equipment on saturated soils, especially in wetlands adjacent to high-quality areas • Estabilish forested buffer between logging activities and high-quality natural communities • Allow trees to continue maturing in high-quality forests • Monitor for invasives and treat new or isolated populations when practical
Non-Forested Wetlands	Coastal Plain Marsh Intermittent Wetland Wet-Mesic Sand Prairie	• Prevent ORV access • Retain intact buffer of natural cover surrounding wetlands • Apply prescribed fire to reduce woody encroachment • Vary seasonality of burns • Treat invasive species when practical • Monitor for fire effects, invasive species, and deer herbivory
Fire-Adapted Uplands	Dry Sand Prairie Oak-Pine Barrens Forested Uplands	• Prevent ORV access • Retain intact buffer of natural cover surrounding high-quality sites • Apply prescribed fire to reduce woody encroachment • Vary seasonality of burns • Mechanically reduce canopy of prairie and barrens • Treat invasive species when practical • Prevent supplementing with additional plant species to maintain status as valuable reference areas • Mow subcanopy in the winter to reduce sassafras and cherry • Monitor for fire effects, invasive species, and deer herbivory

Table 13. Stewardship priorities for Muskegon State Game Area.

Site Name	Community Type	EO ID	EO Rank	Year First Observed	Year Last Observed	Global Rank	State Rank
Comstock Prairie	Dry Sand Prairie	20595	C	2012	2018	G3	S2
The Muskegon Floodplain	Floodplain Forest	22025	BC	2012	2016	G3?	S3
Fitzgerald Barrens	Oak-Pine Barrens	20566	BC	2012	2016	G3	S2
Muskegon Prairies	Wet-Mesic Sand Prairie	15729	BC	2005	2018	G2	S2

Wetland Values

Muskegon SGA supports 9,726 acres of wetlands, including the large floodplain forest along the river. These wetlands are critical for maintaining water quality of the Muskegon River and Muskegon Lake (Figure 19). Floodplain forests provide a variety of ecosystem services, including habitat 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, water temperature regulation with cooler water temperatures occurring along floodplains due to shading of the river and tributaries. These services provide water quality protection of the Muskegon River, Muskegon Lake, and Lake Michigan and by extension, benefit the local economies surrounding tourism, recreation, and fisheries that rely on the health of those bodies of water (Sather and Smith 1984, Russi et al. 2013, Klatt et al. 2018).

Though small compared to the extensive floodplain complex, vernal pools also contribute important ecosystem services including nutrient cycling, water storage and infiltration, groundwater recharge, and flood control (Colburn 2004, Calhoun and deMaynadier 2008). Vernal pools are small, generally isolated, temporary pools of water or wetlands that form in shallow depressions primarily in forested areas throughout Michigan (Thomas et al. 2010, Appendix 1). These wetlands fill with water from rainfall, snowmelt, and/or groundwater between late fall and spring, and usually dry up by mid to late summer. The periodic drying of vernal pools prevents fish from establishing populations in these wetlands. Because vernal pools lack predatory fish, these wetlands provide critical breeding habitats for a host of amphibians and invertebrates, including some species that are specialized for life in vernal pools and depend on these unique habitats for their survival. Vernal pools also provide habitat for over 550 animal species in the northeastern U.S. (Colburn 2004). Several endangered, threatened, or rare species in Michigan use vernal pools extensively, such as the Blanding's turtle (*Emydoidea blandingii*, state special concern), spotted turtle (*Clemmys guttata*, state threatened), copperbelly water snake (*Nerodia erythrogaster neglecta*, federally threatened and state endangered), and red-shouldered hawk (*Buteo lineatus*, state threatened).

These systems are incredibly diverse and productive wetlands and are important for maintaining healthy forest ecosystems. Identifying and mapping vernal pools and understanding their ecological values are critical for effective planning, management, and conservation of

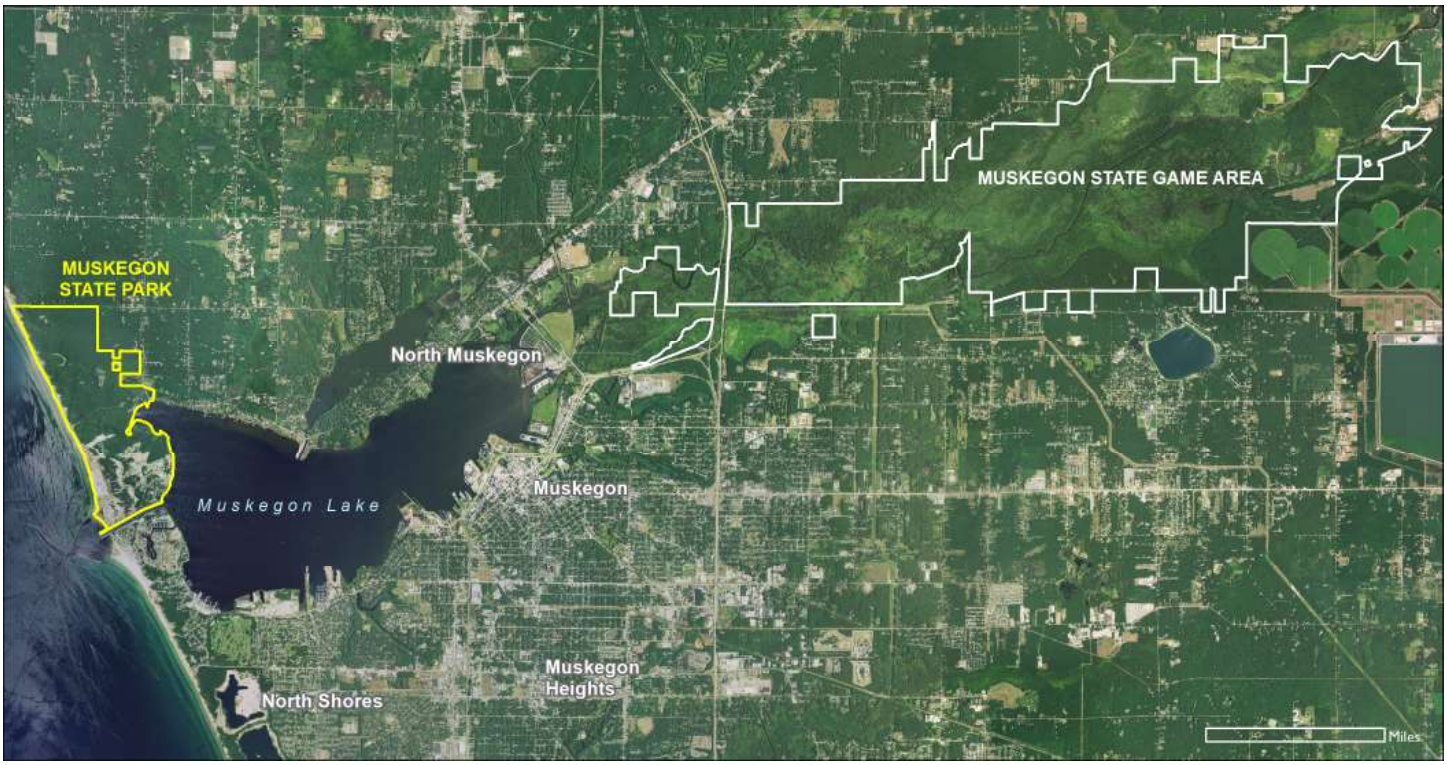


Figure 19. Regional context of the Muskegon State Game Area. The Muskegon State Game Area is adjacent to the city of Muskegon. The floodplain forest in the game area intercepts flood waters and agricultural runoff from the watershed. The natural cover in the game area is integral to protecting water quality in Muskegon Lake and the beaches of nearby Lake Michigan.

these important wetlands not only in the Muskegon SGA but statewide. Management of vernal pools should focus on protecting the vernal pool's physical basin and water quality, and the integrity of the surrounding forest 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 or minimized, particularly during critical time periods for most amphibians (i.e., March/April through July/August) (Thomas et al. 2010). Rutting and scarification of the forest floor also may create barriers and prevent salamanders from travelling to breeding pools (Means et al. 1996). 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 or minimize creating deep ruts (Michigan DNR and Michigan DEQ 2018). Construction of roads and landings and applications of chemicals (e.g., herbicides and/or pesticides) should be avoided within the 30-meter (100 ft) buffer around a vernal pool and minimized within the adjacent landscape (Calhoun and deMaynadier 2008).

The extensive forested wetlands throughout Muskegon SGA provide valuable nesting habitat for red-shouldered hawk, Louisiana waterthrush, prothonotary warbler, cerulean warbler, and other neotropical migrant songbirds. Prothonotary warbler and Louisiana waterthrush are riparian zone obligate species. Although Michigan represents the northern edge of the breeding range for these rare songbirds, both species regularly breed within the game area, highlighting the value of the large, contiguous floodplain forest to rare birds.

The marsh bird surveys conducted in 2018 indicate the game area is providing habitat for a variety of rare and common marsh bird species, several of which are species

The Muskegon River is a vital part of the region, in terms of ecosystem services, benefits to the regional economy, and opportunities for recreating in nature. Photo by Jesse Lincoln.

of conservation concern (i.e., state listed, DNR featured species, SGCN, and Joint Venture focal species). Muskegon SGA supports species requiring large home ranges (e.g., American bittern), while also providing habitat for those species with smaller territories (e.g., rails and songbirds). Three species documented in the game area, American bittern, sora, and black tern, are focal species of the Upper Mississippi River and Great Lakes Region Joint Venture. Detailed information about habitat requirements, limiting factors, and recommended habitat actions are provided in the focal species accounts of the Waterbird Habitat Conservation Strategy (Soulliere et al. 2018). Black tern is also a focal species for the conservation of Great Lakes and inland emergent wetlands in Michigan's Wildlife Action Plan (Derosier et al. 2015), which highlights habitat and management recommendations for black tern conservation. We recommend conducting marsh bird surveys at Muskegon SGA periodically to track the status of rare and common marsh birds over time.

Management to limit the degradation caused by invasive species, such as invasive reed (*Phragmites australis* subs. *australis*), narrow-leaved cattail, and reed canary grass would benefit the marsh birds using the game area. A framework for managing common reed was developed by experienced practitioners and presented in *A Guide to the Control and Management of Invasive Phragmites* (Michigan Department of Environmental Quality 2014). Follow-up monitoring to assess the success of management efforts is critical, and the Great Lakes Phragmites Collaborative (https://www.greatlakesphragmites.net/) has been developing the Phragmites Adaptive Management Framework (PAMF) to create management approaches that maximize effectiveness and efficiency. Partners managing invasive reed are encouraged to participate in the PAMF and use its monitoring protocol and centralized database to facilitate the adaptive management process. Minimizing the encroachment of shrubs and trees within open wetlands through prescribed fire or mechanical treatment could also help maintain habitat for marsh birds.

It is critical to maintain suitable wetland and upland habitats that meet the needs of all the life history stages of the diverse amphibian and reptile species that occur at Muskegon SGA. Twenty-seven (48%) of 56 amphibian and reptile species found in Michigan have been documented within or adjacent to the game area, including eight rare species and four additional SGCN (Table 5, Appendix H1, Lee 2005, Lee 2006, Lee 2007, Lee and Monfils 2008, MNFI 2019). Rare herp species and SGCN that

The diverse wetlands in Muskegon SGA provide critical habitat for a range of species, including several species of rare marsh birds. Photo by Mike Monfils.

were documented within or adjacent to Muskegon SGA prior to surveys in 2018 include the eastern massasauga, queen snake, Kirtland's snake (*Clonophis kirtlandii*, state endangered), spotted turtle, eastern musk turtle, northern ribbonsnake, northern ring-necked snake, and blue racer (Table 6, pg 52; Appendix 5; Lee 2005, Lee 2006, Lee 2007, Lee and Monfils 2008, MNFI 2019). These species likely still occur within the game area based on available suitable habitat. Muskegon SGA is particularly important for turtle conservation as all four rare turtle species (i.e., Blanding's, eastern box, wood, and spotted turtles) and the eastern musk turtle (Appendix 5) have been documented within the game area. The populations of all four rare turtles have excellent or good estimated viability, bolstering the significance of Muskegon SGA in conservation of these species. However, alterations to vegetative structure and hydrology can significantly impact habitat quality and suitability for amphibians and reptiles. Many of the emergent wetlands within Muskegon SGA are dominated by dense cat-tails (*Typha* spp.). Preventing alterations to hydrology is critical for limiting expansion of non-native cat-tail and maintaining plant and structural diversity which benefits the eastern massasauga, spotted turtle, Kirtland's snake, and other amphibian and reptile species in the game area as well. Controlling woody encroachment and maintaining early-successional conditions within open wetlands, particularly the east unit, would also sustain suitable habitat for these species in the game area. Maintaining good water quality in wetland habitats is critical to the area's populations of reptiles and amphibians.

Upland management should also carefully consider impacts to herptiles. Reptiles and amphibians utilize upland habitats for foraging, mating, thermoregulating, nesting, gestating, giving birth to young, aestivating and/or overwintering (Harding and Mifsud 2017, NatureServe 2019). Blanding's turtles, eastern box turtles, wood turtles, spotted turtles, and other turtle species generally nest in open, sunny, unvegetated or sparsely vegetated areas with moist but well-drained, sandy or loamy soil, but will also use plowed fields, and road edges if suitable natural nesting habitat is not available (Harding and Mifsud 2017, NatureServe 2019). Several turtle species, including Blanding's turtles, box turtles, wood turtles, snapping turtles, painted turtles, and map turtles, have been found nesting along powerline/utility corridors, sandy two-track roads, and road shoulders

Turtle nests predated by raccoons were regularly observed. Photo by Yu Man Lee.

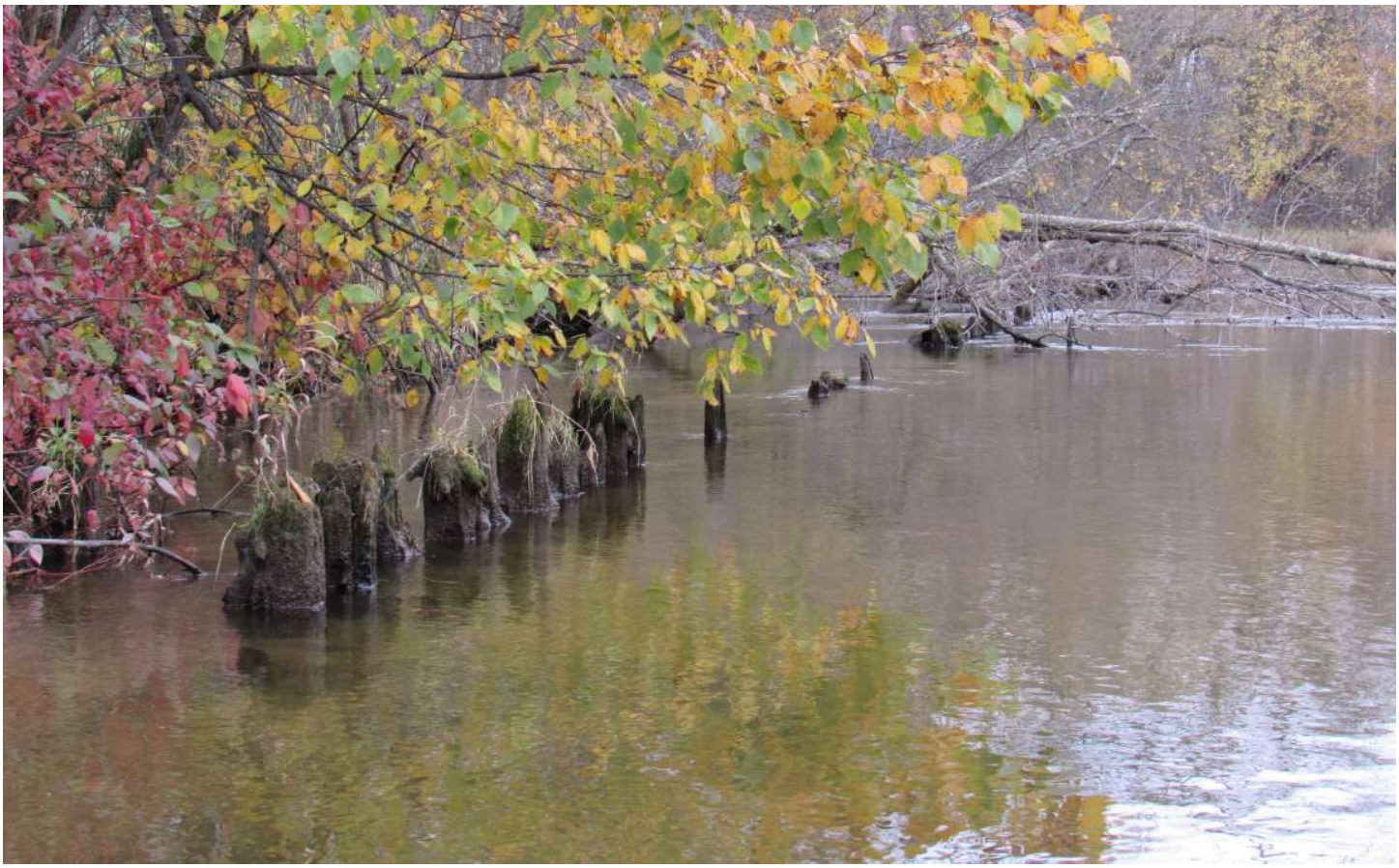
along US Highway 31 (Lee 2005, Lee 2006, Lee 2007, Lee and Monfils 2008, MNFI 2019). Turtle nest depredation rates in these areas are very high. Suitable nesting habitats that are safe from nest predators may be limited in the Muskegon SGA. Maintaining, restoring, and/or creating open, sandy areas near 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. Maintaining or providing downed woody debris (e.g., hollow logs, rotting stumps, rootwads), brush piles, decaying leaf litter/piles, compost piles, and/or sawdust or wood chip piles would provide microhabitats in which snakes could deposit their eggs or give birth to their young (Ernst and Ernst 2003, Harding and Mifsud 2017, NatureServe 2019).

The lack of live mussels found during these surveys very likely reflects a history of impact from historical use of river to transport logs, altered water and sediment flow regime by dams/impoundments, and zebra mussels. The Muskegon River was a logging river during the 1880s and 1890s. Logs floated down the river degraded mussel habitat by physically altering stream substrate and river flow especially during log jams. A historical dam on the Muskegon River in Newaygo, MI failed suddenly in the late 1960s. The sand and other sediment that had accumulated for decades behind the dam was released. This slug of sand and sediments is thought to still be working its way through the river system and is likely a big contributor to the high proportion of unstable sand substrate observed during mussel surveys. Though no live zebra mussels were found in 2018 surveys, a 2002 mussel survey recorded live zebra mussels at multiple sites (Carman and Goforth 2002). Unusually high conductivity at mussel survey site 4 in Mosquito Creek could be a sign of a problem point or non-point source discharge into the stream such as excessive input of fertilizer or sewage overflows. Investigating and addressing potential sources of discharge above this site could help improve habitat (water quality) for mussels within Muskegon SGA.

The wastewater treatment plant has caused hydrologic changes in Mosquito Creek and the southern portion of the outwash channel, leading to the conversion of closed-canopy, floodplain forest to an extensive colony of non-native cat-tail. Photo by Jesse Lincoln.

The snuffbox shell found in this survey is only the second record of this federally endangered species in the watershed, though two large-scale mussel surveys of the Muskegon River watershed have been done in the past (van der Schalie 1941, Carman and Goforth 2002). Unionid mussels rely on fish hosts to reproduce. Their larvae, called glochidia, are released and must attach to the gills or fins of a fish host to develop into the adult mussel form (Haag 2012). The fish host provides a stable environment for the glochidia to grow. Without the proper species of fish, glochidia do not survive. Barriers to the movement of fish hosts, such as dams and impoundments also prevent migration and gene flow in native mussels (Watters 1996). Rivers that support higher numbers of fish species tend to support higher numbers of mussel species as well (Watters 1992). Three fish species known to act as hosts for snuffbox have been reported from the Muskegon River (O'Neal 1997). These are logperch (*Percina caprodes*), blackside darter (*Percina maculata*), and mottled sculpin (*Cottus bairdi*) (Watters et al. 2009). Snuffbox is thought to prefer substrate composed of sand, coarse gravel, and cobble. The heavily sand dominated substrate found during these surveys is likely a limiting factor to snuffbox and possibly its host fish species.

The forests along the margins of the river and tributaries provide water temperature regulation due to shading, input of coarse woody debris for fish habitat, and nutrients that support a healthy river ecosystem, thereby promoting greater diversity of fish and mussel species. Low water levels were observed on the Muskegon River in July 2018 and this may have been detrimental to aquatic species. More closely mimicking natural flow regimes with the dam release schedule would benefit fish and mussels relying on the system. A 2003 management plan for the Muskegon River watershed by MDNR Fisheries Division identified 28 management actions to address problems and opportunities related to the health of its aquatic resources and fisheries. The plan includes short (i.e., 5 years) and long-term objectives focusing on a range of topics from dams and barriers, to water quality, to the decline of biological communities over the past 150 years. Evaluating present and historical flow patterns and channel characteristics and protecting lands through land-use planning and zoning are two examples of proposed actions (O'Neal 2003). Actions identified in this management plan would help address a long history of impacts to the river and improve mussel and fish habitat quality within Muskegon SGA.



Evidence of historic logging events is still visible along the edges of the river where cedar logs were vertically driven into the sediment to facilitate moving logs down the river by preventing timber from being lodged in the banks. Photo by Jesse Lincoln.

Forest Fragmentation

Muskegon SGA supports over 4,446 acres of upland forest and 2,839 acres of lowland forest, including the largest documented floodplain forest in the state. Because the landscape surrounding Muskegon SGA is impacted by agriculture and rural development, the large area of natural cover within the game area serves as an important reservoir of biodiversity for the local region. 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 75 bird species during point-count surveys, of which ten are SGCN and eight are DNR featured species (Table 5, pg 49; and Appendix 6).

Although Muskegon 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). Forestry and wildlife management practices that focus on species- and stand-based management have directly and indirectly promoted landscape fragmentation and exacerbated edge effects through prescriptions that generate and maintain small discrete patches of vegetation or stand types (Bresse et al. 2004). The small, insular nature of forest fragments may make them too small to support the full array of species formerly found in the landscape (Rooney and Dress 1997). 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).

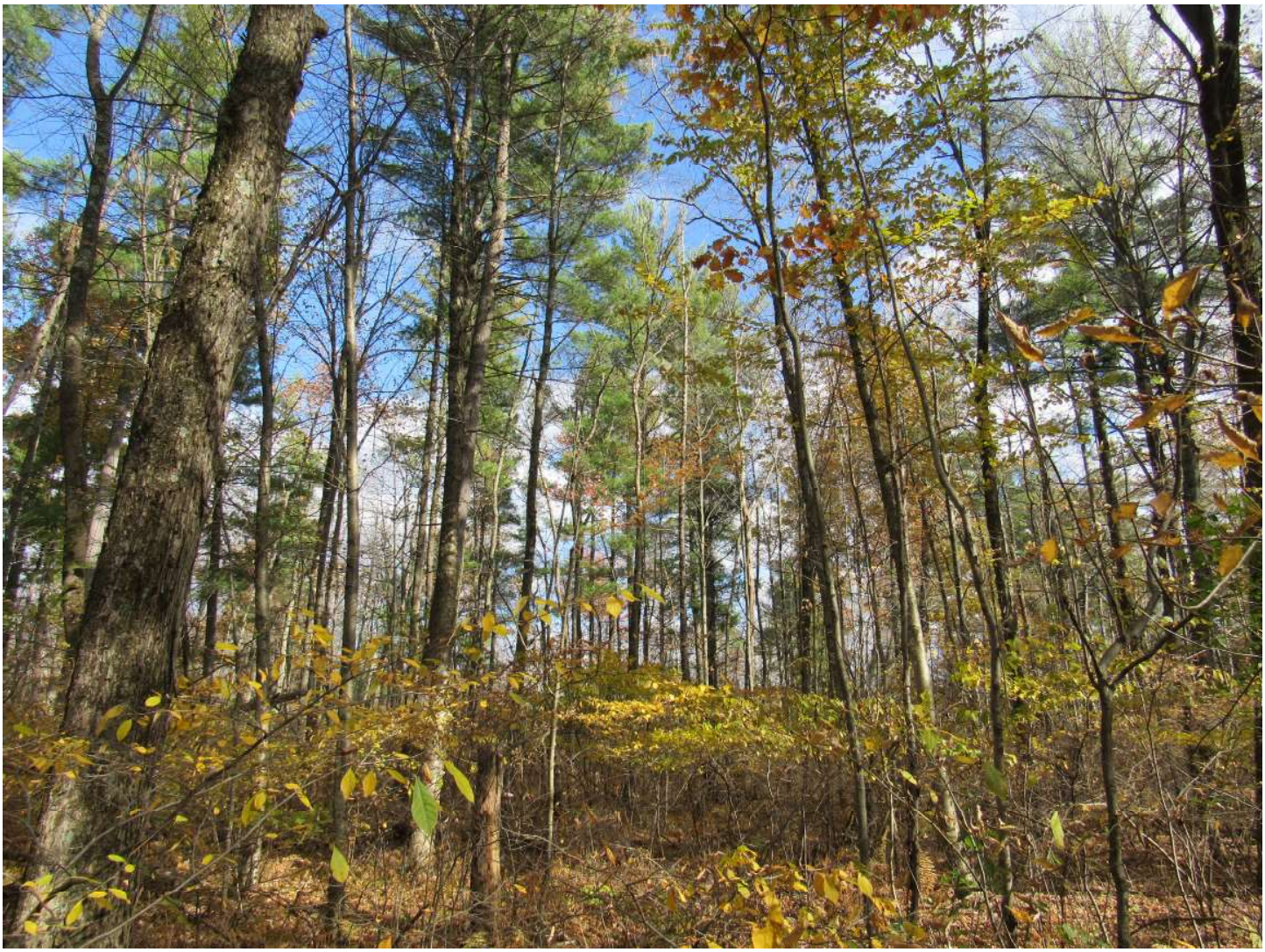
Within fragmented forests, avian diversity is reduced by nest predation and nest parasitism, and herptile diversity is reduced by the prevalence of mesopredators (e.g., raccoons, skunks, and opossums).

Prothonotary warblers are a neotropical migrant that requires large blocks of mature forested wetlands like those along the Muskegon River. We found this special concern species throughout the western portion of Muskegon SGA, reflecting the area's importance as a reservoir for biodiversity. Photo by Aaron Kortenhoven.

The extensive forested wetlands also provide critical habitat for cerulean warbler (above). Hunter Pulling expertly measures the diameter of a large silver maple during ecological surveys of the floodplain forest. Above photo by Aaron Kortenhoven and below photo by Jesse Lincoln.

Numerous neotropical migrant songbirds are dependent on interior forest habitat and are highly susceptible to nest parasitism and predation (Robinson et al. 1995, Heske et al. 2001, Heilman et al. 2002). The maintenance and expansion of mature blocks of forest within the game area, especially within the floodplain, benefits the populations of documented rare species and other forest-interior species, such as Acadian flycatcher and wood thrush. Activities that reduce the cover of mature forest or increase fragmentation will reduce the value of Muskegon SGA to forest-interior nesting songbirds. Furthermore, brown-headed cowbirds (*Molothrus ater*) were observed at 16% of the point-count stations surveyed in the game area. Cowbirds thrive in fragmented landscapes and reduce the reproductive success of forest-breeding songbirds through nest parasitism (Robinson et al. 1995). Efforts to reduce forest fragmentation 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.

In general, dampening the effects of forest fragmentation can be realized by targeting large blocks of mature, contiguous forest and preventing timber harvest in those and adjacent stands. We recommend that efforts to reduce fragmentation and promote connectivity be concentrated in the vicinity of existing wetlands, riparian corridors, and especially around the high-quality natural communities described in this report.



Muskegon State Game Area has extensive areas of unique high-quality, closed canopy forest. Photo of South Channel Hardwood-Conifer Swamp by Jesse Lincoln.

Fire as an Ecological Process

Most of the uplands within Muskegon SGA support fire-dependent ecosystems. Prairie and barrens systems occur locally within the matrix of dry-mesic northern forest or oak-pine forest. Historically, lightning- and human-set fires frequently spread over large areas of the region. With the absence of fire and the expansion of agriculture in southern Michigan over the past two centuries, prairies and barrens systems have become imperiled throughout their range, making the stewardship of these community types in Muskegon SGA a regional and global conservation priority.

Fire is the single most significant factor in preserving barrens and prairie ecosystems. The ongoing landscape-scale fire-management program being implemented in Muskegon SGA is helping to maintain fire-dependent ecosystems that provide important habitat for wildlife, such as nesting reptiles and Karner blue butterfly (*Lycaeides melissa samuelis*, federally endangered and state threatened). It is critical to continue burning the prairie and barrens systems in Muskegon SGA – particularly those natural communities documented in Compartment 9 – to maintain these systems on the landscape. In addition to prescribed fire, selective cutting or girdling is a valuable management step in the restoration of savanna and barrens physiognomy. Savanna/barrens restoration efforts that combine repeated prescribed fire application in conjunction with mechanical thinning are most likely to succeed where populations of relict savanna/barrens plants persist (Lettow et al. 2014). Where canopy closure has degraded the savanna/barrens character, resource managers can selectively cut or girdle the majority of trees (White 1986), leaving between 10 and 60% canopy closure. Once open-canopy conditions have been re-established, the regular use of fire is essential for the maintenance of floristic composition and structure.

Prescribed fire benefits plant communities in several ways. Depending on the season and intensity of a burn, prescribed fire may be used to decrease the cover of invasive woody species and increase the cover of native grasses and forbs (White 1983, Abrams and Hulbert 1987, Tester 1989, Collins and Gibson 1990, Glenn-Lewin et al. 1990, Anderson and Schwegman 1991). Prescribed fire can also help express and rejuvenate seed banks, which may

Repeated fire is critical for maintaining open prairie habitat, which is rapidly colonized by species such as sassafras. Implementing growing season burns can be especially effective in reversing the successional process. Historically, areas such as this wet-mesic sand prairie likely burned every 3 to 5 years. Photo by Jesse Lincoln.

be especially important for maintaining species diversity (Leach and Givnish 1996, Kost and De Steven 2000). Many host plants for rare insect species are fire-dependent plant species. Fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs (White 1983, Tester 1989, Abella et al. 2001). Once the structure has been securely established, burning at longer time intervals can be employed to allow for seedling establishment and the persistence of desirable woody plants. Apfelbaum and Haney (1991) recommend gaps of five to ten years to allow for canopy cohort recruitment.

When implementing prescribed fire, we recommend that the seasonality of burns be varied across the game area. Prescribed fire is often seasonally restricted to spring. When woody species are top-killed by early spring fires, they are able to resprout vigorously using large energy stores (Cohen et al. 2009). However, if burns are conducted later in the spring after leafout, or during the growing season, energy reserves are already partially depleted, and resprouting vigor is lower, particularly for clonal species like sassafras (Axelrod and Irving 1978, Reich et al. 1990, Sparks et al. 1998). Fires have the greatest impact on those plants that are actively growing at the time of the burn. Repeated fires at the same time of year impact the same species year after year, and over time, can lower floristic diversity (Howe 1994, Copeland et al. 2002). For example, forbs that flower in early spring often overwinter as a green rosette or may have buds very close to the soil surface and in the litter layer. Repeated burns in early spring can be detrimental to these species. Historically, fires burned in a variety of seasons, including spring, during the growing season, and fall (Howe 1994, Copeland et al. 2002, Petersen and Drewa 2006). Varying the seasonality and intensity of prescribed burns to match the full range of historical variability better mimics the natural disturbance regime and leads to higher biodiversity (Howe 1994, Copeland et al. 2002). In other words, pyrodiversity leads to biodiversity.

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. Larger, more mobile, and subterranean animals can temporarily move out of an area being burned. Smaller and

The dynamic nature of the area's hydrology means that fire-adapted systems like wet-mesic sand prairies can be inundated some seasons and completely dry for years at a time. Photo by Jesse Lincoln.

less mobile species can die in fires; this includes some rare insects (Panzer 1998) and reptiles. Where rare invertebrates and herptiles are a management concern, burning strategies should allow for ample refugia to facilitate effective post-burn recolonization (Siemann et al. 1997). Insects and herptiles, characterized by fluctuating population densities, poor dispersal ability, and patchy distribution, rely heavily on unburned sanctuaries from which they can reinvade burned areas (Panzer 1988). Dividing large contiguous areas into two or more separate burn units or non-fire refugia that can be burned in alternate years or seasons can protect populations of many species. This allows unburned units to serve as refugia for immobile invertebrates and slow-moving herptile species, such as eastern box turtle. When burning relatively large areas, it may be desirable to strive 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. In addition, burning under overcast skies and when air temperatures are cool (<13 °C or 55 °F) can help protect reptiles, because they are less likely to be found basking above the surface when conditions are cloudy and cool.

Conducting management activities, such as prescribed burning, in open uplands in early spring or late summer prior to or after the turtle nesting season (late May –June) and before turtle hatchlings emerge (late August – early October) would minimize the potential for harming turtles. If prescribed burning needs to occur during the active season, burning later in the spring when herp species are more active may reduce the potential for adverse impacts.

We recommend continuing the implementation of prescribed fire at a landscape-scale and the creation of large burn units (e.g., several hundred acres in size). If resources for burning are limited, we recommend that prescribed fire be prioritized for high-quality and/or underrepresented, fire-dependent natural communities (e.g., high-quality prairies and areas of barrens restoration) and areas immediately adjacent to these systems. Fire-suppressed sites should be burned using an initially aggressive fire-return interval of one to three years. We recommend implementing prescribed fire in areas of high-quality prairie and barrens in Compartment 9 as these sites represent the rarest natural community types and already comprise some of the most significant prairie and savanna restoration projects in the region.

The Karner blue butterfly is a federally endangered species and its obligate host plant is lupine, which grows in open, fire-adapted natural communities such as oak-pine barrens and dry sand prairie. The inclusion of prescribed fire in these habitats is critical for this species' long-term survival. Photo by Aaron Kortenhoven.

Invasive Species Control

Invasive species pose a major threat to species diversity and habitat heterogeneity within Muskegon SGA. Invasive plants affect ecosystem processes through their patterns of resource acquisition and growth and degrade native biodiversity by altering the fundamental structure and function of ecosystems and even triggering trophic cascades (Ehrenfield 2010). 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). Non-native invasive species often have no natural predators and can therefore spread aggressively while contributing little available biomass to the local food web. Invasive infestations are projected to increase as the landscape continues to be fragmented (Vila and Ibanez 2011) and the climate changes.

Within Muskegon SGA, the most pronounced impact from invasive species occurs within wetlands where reed canary grass, narrow-leaved cat-tail, and invasive reed (*Phragmites australis* subs. *australis*) threaten the long-term health of the floodplain forest and populations of rare plants. There is a large infestation of narrow-leaved cat-tail where Mosquito Creek enters the floodplain. Unusually high conductivity at site 4 in Mosquito Creek could be a sign of point and/or non-point source discharge into the stream (e.g., excessive input of fertilizer or sewage overflows). This points to the link between altered hydrology and invasive species and clearly shows how an intact system like a floodplain forest can be impacted by such changes. Preventing additional alterations to hydrology is paramount to preventing new outbreaks of invasive species, especially within the floodplain complex. Managers can also mitigate inputs of pollution and agricultural runoff through wetland restoration, reduced fertilizer application, development of buffer strips in agricultural plantings, etc., and can thereby reduce the potential for invasive species to take over areas of native vegetation. Invasive species management at Muskegon SGA should focus on prevention and then the

DNR Employee, Gregory Hochstetler shows MNFI ecologist, Clay Wilton, the finer points of operating machinery. This piece of equipment was integral for developing permanent burn breaks around restoration project areas. Photo by Jesse Lincoln.

control of populations of pernicious invasive species within high-quality natural communities and the immediately surrounding areas. 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

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 seed source for these invaders. Prescribed fire can be employed as the primary mechanism for reducing invasive species at the landscape scale in upland forests and targeted prescribed fire and spot treatment through cutting and/or herbicide application can be employed locally within priority high-quality natural community EOs. Additionally, evaluating forests for risk of invasive species should occur before logging operations proceed. Logging in southern Michigan has been found to locally increase invasive species populations with areas of recent logging being associated with local dominance of garlic mustard (*Alliaria petiolata*) (Michele Richards, personal communication, July 2010). Restricting future logging operations to winter months when the soils are frozen may limit the establishment and expansion of invasives, such as garlic mustard that benefit from soil disturbance, and can also reduce detrimental impacts to plant and animal species.

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 Muskegon SGA. We recommend that monitoring be implemented at Muskegon SGA and that it be concentrated within the high-quality natural communities but also throughout actively managed areas. Monitoring can help inform adaptive management by evaluating the success of restoration at meeting the goals of reducing invasive species populations, limiting woody encroachment in understories of fire-prone systems, and fostering regeneration in fire-dependent ecosystems. Assessing the impacts of prescribed fire on herptile and rare insect populations should also be a component of the burning program, especially following potential burns in the summer and fall, and can help direct adaptive management. As management continues to expand and restore prairie and barrens habitat within the game area, we recommend continued surveys for rare plants, herptiles, and insects. In addition, monitoring deer densities and deer herbivory will allow for the assessment of the extent that deer browsing threatens floristic structure and composition and whether active measures to reduce local deer populations are needed.

The occurrence of red-headed woodpecker (state special concern) was documented during the rare bird surveys in Muskegon SGA. Photo by Aaron Kortenhoven.

CONCLUSIONS

Muskegon State Game Area was established with lands acquired through tax reversion and secured with hunters' monies from hunting licenses. The area is largely managed to promote habitat for game species, but this extensive block of public land also supports significant high-quality natural communities, provides myriad benefits to non-game species, and offers critical ecosystem services. These services include flood mitigation, maintenance of water quality for Muskegon Lake, and the protection of the economically-significant fisheries that rely on the health of the river. By supporting such extensive natural cover and maintaining high-quality ecosystems therein, the game area protects and maintains the services provided by those ecosystems.

Scientists from Michigan Natural Features Inventory documented numerous high-quality natural communities and several species of rare plants and animals during surveys in Muskegon SGA. The area is regionally significant for biodiversity, hunting, and ecosystem services. But there are threats to the natural communities, rare species, and the area's capacity to provide ecosystem services. These threats include altered hydrology in wetlands, reduced water quality, further fragmentation of forests, protracted fire suppression, and invasive species. Therefore, we recommend that managers prioritize actions around sustaining the unique natural communities and populations of rare animals and plants by preventing alterations to hydrology, implementing practices to protect water quality, reducing forest fragmentation around the high-quality natural communities, continuing to implement prescribed fire, and treating invasive species.

The managers of the game area are currently implementing actions to protect imperiled natural communities while managing large areas for game species habitat. There is considerable overlap between managing for game species and managing for ecosystem integrity, especially in the application of prescribed fire and the preservation of forested wetlands. The extensive savanna and prairie restoration efforts in the east unit represent some of the most significant stewardship activity in the region and are aimed at improving habitat for game species and protecting imperiled ecosystems. The work being done in this game area is a critical component of local conservation efforts and essential for protecting the natural heritage that characterizes the region.

A prothonotary warbler. Photo by Aaron Kortenhoven.

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A jumping spider observed in Muskegon State Game Area. Photo by Aaron Kortenhoven.

APPENDICIES

Appendix 1. Vernal Pool Working Definition

Developing an Approach for Identifying, Mapping and Assessing Vernal Pools in MI

Initial Working Draft April 2014; Revised September 2018; Approved by MVPP Steering Committee October 25, 2018

Vernal Pool Working Definition/Description:

Vernal pools are naturally occurring, small (typically less than 1 ha/2.5 acres), temporarily-flooded wetlands found in depressions primarily in forested settings throughout Michigan. Vernal pools also can occur in grasslands, thickets, and other natural communities (e.g., sand dunes). As confined-basin depressions, they lack continuously flowing inlets or outlets, and they have no continuous surface-water connection with permanently flooded water bodies. Vernal pools may be surrounded by uplands or may be connected to other wetlands or part of larger wetland complexes as long as those wetlands are also confined and not continuously connected to permanent water bodies. In most years, vernal pools are filled with water in the spring, and dry up or significantly draw down by summer or early fall, exposing all or most (i.e., >50%) of the pool bottom and retaining only a fraction of the peak volume. Vernal pools typically fill with water in the spring but also can fill in the fall or winter, and generally contain water for a minimum of two months in the spring in most years. Because vernal pools dry out every year or on a regular basis, vernal pools lack permanent fish populations.

Vernal pools are generally shallow ponds during the wet season that later become exposed basins during dry periods. Vegetation in vernal pools may vary seasonally and/or annually and may be dominated by woody species (trees and shrubs), marsh or wet meadow species, aquatic species, or may be devoid of vegetation. Substrates are comprised of hydric soils and often covered by leaf litter. Vernal pools are important for wildlife because they provide essential habitat for many animals, including amphibian and invertebrate species that depend on them for part or all of their life cycle.

Vernal Pool Required Attributes:

Origin	Naturally occurring
Size	Small (typically less than 2.5 ac/1 ha)
Geomorphology	Confined basin/depression with no continuously flowing surface water inlet or outlet; no continuous surface water connection with permanently flooded water bodies. Vernal pools can be connected to other wetlands or part of larger wetland complexes as long as those wetlands are also confined and not continuously connected to permanent water bodies.
Hydrology	Temporarily flooded; fluctuating water regime with alternating periods of flooding and drying; typically filling with water in spring and drying down or significantly drawn down in summer in most years; also can fill in the fall or winter but must have water in the spring; typically hold water for minimum of two months in most years. Some vernal pools are semi-permanent, and may only dry in some years (e.g., 3 out of every 5 years).
Substrate	Hydric soil
Biological Community	Fishless or free of a permanent fish population. Evidence of breeding (i.e., egg masses, larvae, breeding/mating adults) by vernal pool indicator species is not required for a vernal pool, but indicates a vernal pool if present. Vernal pool indicator species in Michigan include the Wood Frog, Spotted Salamander, Blue-spotted Salamander, and fairy shrimp.

Appendix 2. Vernal Pool Monitoring Form.

Michigan Natural Features Inventory

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Vernal Pools Project

Volunteer Vernal Pool Monitoring Form

http://mnfi.anr.msu.edu/vernalpools/ - Contact MNFI at (517) 284-6200

QC Date: _____

QC Initials: _____

Date Entered: _____

1a) Observer Information ☐ Visit 1 ☐ Visit 2 ☐ Visit 3 Time: from _____ ☐AM ☐PM to _____ ☐AM ☐PM

Name(s): _____ Date: _____

1b) Property Information Ownership? ☐ Public ☐ Private Landowner/Manager Name: _____

Site name: _____ Address: _____

Plot # _____ City: _____ State: _____ Zip: _____

2a) Vernal Pool Location Was pool mapped as a Potential Vernal Pool (PVP)? ☐ Yes ☐ No

Pool ID #: _____ New Pool ID #: _____

Enter coordinates in Decimal Degrees (e.g. Latitude: 44.764322 Longitude: -72.654222)

Township/Range/Section/1/4 info : _____ Latitude: _____ Longitude: _____

County: _____

For verification of PVP's location please enter names and coordinates for the nearest crossroads. Record as Decimal Degrees as shown above.

Method for locating pool? ☐ In the Field Latitude: _____ Longitude: _____

☐ GPS ☐ Topo Map ☐ Google Earth ☐ Air Photo Crossroad names: _____

2b) Brief Site Directions to Pool **

** **Written site directions to pool** (This should include: (1) description of a logical starting point; (2) the distance from the starting point to pool; (3) the direction of travel; and (4) distinctive landmarks and water bodies.): For example 'Enter Robinhood Park on the trailhead at Jordan Road. Follow the trail west approximately 1/2 mi. This is the first pool on your left, just behind a low stone wall.'

3a) Pool Type Is this a Vernal Pool? ☐ Yes ☐ No ☐ Not Sure Pool Photo Numbers: _____

☐ Open Pool ☐ Sparsely Vegetated Pool ☐ Shrubby Pool

☐ Forested Pool ☐ Marsh Pool ☐ Other (describe): _____

3b) Presence of Inlet or Outlet

Is this pool isolated or connected to a part of another water feature? ☐ culvert ☐ lake ☐ open/emergent/shrubby wetland

☐ Yes, pool is isolated ☐ No, pool is connected to: (check **ALL** that apply) ☐ stream ☐ ditch ☐ forested wetland ☐ vernal pool

If inlet/outlet is present, indicate type: ☐ permanent ☐ temporary ☐ do not know ☐ none

3c) Surrounding Habitat (within 100 feet of pool) (check **ALL** that apply)

☐ Upland Deciduous Forest ☐ Lowland Deciduous Forest **Disturbances:** ☐ Powerline right-of-way ☐ Other: _____

☐ Upland Coniferous Forest ☐ Lowland Coniferous Forest ☐ Agriculture ☐ Light development (<25%) ☐ No disturbances

☐ Upland Mixed Forest ☐ Lowland Mixed Forest ☐ Road/driveway ☐ Intensive development (>25%)

☐ Floodplain ☐ Grassland or open ☐ paved ☐ Minor logging (> or = 70% canopy remaining)

☐ Emergent Wetland (marsh, bog) ☐ dirt/gravel ☐ Major logging (< or = 70% canopy remaining)

4a) Approximate Maximum Pool Depth

☐ Ankle-deep (<6") ☐ Hip-deep (2-3 ft)

☐ Shin-deep (6-12") ☐ Chest-deep (3-4 ft)

☐ Knee-deep (12-24") ☐ Deeper than 4 ft

4b) Water Level at Time of Survey (check one)

☐ Full/Nearly full 75-100% ☐ Less than half 25-49%

☐ Partially full 50-74% ☐ Dry/mostly dry 0-24%

4c) Water temperature (*F): _____

4d) Approximate Size of Pool (at maximum capacity - at widest and longest points)

Width: _____ feet

Length: _____ feet

Size determined by: ☐ Pacing ☐ Measuring ☐ Using GPS

4e) Substrate (when dry - check **ALL** that apply)

☐ Leaf litter ☐ Sand - Gravel ☐ Unknown

☐ Bedrock ☐ Muck - Peat ☐ Other: _____

☐ Loam ☐ Silt - Clay

Funding for this project was provided by the US Environmental Protection Agency along with the Michigan Department of Environmental Quality

Appendix 2 (continued). Vernal Pool Monitoring Form.

4f) Vegetation in Pool

Are trees (trees = or > 4" in diameter) present in the basin? (check one)

☐ No ☐ Yes, within pool basin ☐ Yes, but only at the edge

# of trees only within the pool basin? _____ ☐ live and/or ☐ dead/snags

% Cover within the pool (check one):

Floating vegetation: ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

Emergent vegetation: ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

Shrubs: ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

4h) Cover (Any material in the pool that can provide egg attachment sites and offer concealment to adults and/or larvae; check all that apply):

☐ Shrubs ☐ Submergent vegetation

☐ Branches, twigs ☐ Logs or large woody debris

☐ Sphagnum moss ☐ Emergent vegetation (grasses, cattails)

☐ Algae ☐ Other: _____

☐ Leaf litter

Tree canopy over pool basin (when leaves are fully out): ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

4g) Pool Disturbance (in pool, immediately adjacent or along shore of pool - check all that apply)

☐ Dumping - Refuse ☐ Filling ☐ Invasive Species Present

☐ Ditching - Draining ☐ Sediment ☐ Purple loosestrife ☐ Garlic mustard

☐ Agricultural runoff ☐ Vehicle ruts ☐ Reed canary grass ☐ Other: _____

☐ Cultivation - Livestock ☐ Presence of rock pile or other anthropogenic disturbance ☐ No disturbances

5) Indicator Species and Additional Species (if other species are observed please list below in blank fields under Fingernail Clams)

Provide a photograph of each indicator species (adults, juveniles/larvae, or egg masses) observed. **Photos of species observed are required.**

Species Observed	Adults	Tadpoles/Larvae	Egg Masses			Photo? Yes	Notes/Photo ID#
			Number	Estimated	Counted		
Wood Frog				☐	☐	☐	
Spotted Salamander				☐	☐	☐	
Blue-spotted Salamander				☐	☐	☐	
Fairy Shrimp							
Fingernail Clams							
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	

Were any of the following observed? (check **ALL** that apply)

☐ Fish: (indicate all lengths observed) ☐ ≤ 3" ☐ > 3" ☐ Green frogs: ☐ tadpoles ☐ adults

☐ Bullfrogs: ☐ tadpoles ☐ adults ☐ Other: _____

Comments:

Draw diagram of pool (include landmarks, location of indicated species, north arrow and area surveyed if entire pool was not surveyed)**:**

Funding for this project was provided by the US Environmental Protection Agency along with the Michigan Department of Environmental Quality

Appendix 3. Vernal Pool Types.

VERNAL POOL TYPES

1) **Open Pool** – "Classic" vernal pool with trees, shrubs, and herbaceous (non-woody) plants covering less than 10% of the ground within the pool when the pool is flooded or wet. Herbaceous plants are plants whose stems and leaves die at the end of the growing season and have no woody stems above ground.

2) **Sparsely Vegetated Pool** – Trees, shrubs, and non-woody herbaceous plants covering 10% to less than 30% of the ground within the pool when the pool is flooded or wet.

3) **Shrubby Pool** – Pool is dominated by shrubs, with shrubs covering 30% or more of the ground within the pool when it is flooded or wet, and representing the tallest vegetation layer within the pool.

Appendix 3 (continued). Vernal Pool Types.

4) **Forested Pool –** Pool is dominated by trees with rooted, live trees covering 30% or more of the ground within the pool when it is flooded or wet, and representing the tallest vegetation layer within the pool. For example, a forested swamp pool, pool within a larger forested swamp, and a floodplain pool.

Forested Swamp Pool

Floodplain Forest

5) **Marsh Pool –** Pool dominated by non-woody herbaceous plants, including emergent plants which are plants that grow in water and stick up out of the water. Non-woody herbaceous and emergent plants cover 30% or more of the ground within the pool when it is flooded or wet, and represent the uppermost vegetation layer within the pool. Trees and shrubs may be present but cover less than 30% of the pool.

Appendix 4. Rare Herptile Survey Form.

STATE LANDS INVENTORY SPECIAL ANIMAL SURVEY FORM - HERPS

I. LOCATION INFORMATION

Site Name _____ Stand Number(s)_____ Date_____

Observer(s)_____ Stand classifications_____

Quad_____County_____ Town, Range, Sec_____

Directions/access _____

_____

GPS Unit Type & #: _____ GPS Waypoint(s): _____ GPS Track(s): _____

II. SURVEY INFORMATION

Time Start _____ Time End _____ Weather: Air Temp – Start_____End _____ RH – Start_____ End_____

Sky Code – Start _____ End _____ Wind Code - Start _____ End _____ Precip Code - Start_____ End _____

Target species/group & survey method_____

Target/rare species found? Yes No Comments: _____

Habitat for target species/group found? Yes No Comments: _____

Species found (common or rare)	Number	Location (GPS, landmarks)	Notes (habitat, behavior, condition, etc.)

Survey comments (area surveyed, potential for other rare species, revisit warranted, photos taken? etc.)

_____

_____

_____

III. GENERAL SITE DESCRIPTION (describe in relation to species surveyed for – presence, quantity, and quality of appropriate habitat, crayfish burrows, hostplants/nectar sources, dominant vegetation, natural communities, habitat structure, etc.)

_____

_____

_____

_____

IV. MANAGEMENT CONSIDERATIONS

Threats (e.g., ORV's, excessive mt. bike use, grazing, structures, past logging, plantations, development, erosion, ag, runoff, hydrologic alteration, etc.) _____

_____

Exotic species (plants or animals)_____

_____

Stewardship Comments _____

_____

Appendix 4 (continued). Rare Herptile Survey Form.

V. LISTED ANIMAL OR PLANT SPECIES or COMMUNITY EOS _____

_____

_____

VI. ADDITIONAL ASSOCIATED SPECIES FOUND

Species found (common or rare)	Number	Location (GPS, landmarks)	Notes (habitat, behavior, condition, etc.)

VII. Map/drawing of general area surveyed and approximate locations of suitable habitat and/or rare species found

Wind Codes (Beaufort wind scale):

0 = Calm (< 1 mph) smoke rises vertically

1 = Light air (1-3 mph) smoke drifts, weather vane inactive

2 = Light breeze (4-7 mph) leaves rustle, can feel wind on face

3 = Gentle breeze (8-12 mph) leaves and twigs move, small flag extends

4 = Moderate breeze (13-18 mph) moves small tree branches, twigs & leaves, raises loose paper

5 = Strong breeze (19-24 mph) small trees sway, branches move, dust blows

6 = Windy (> 24 mph) larger tree branches move, whistling

Precipitation Codes:

0 = None

1 = Mist

2 = Light rain or drizzle

3 = Heavy rain

4 = Snow/hail

Sky Codes:

0 = Sunny/clear to few clouds (0-5%)

1 = Mostly sunny (5-25% cloud cover)

2 = Partly cloudy, mixed variable sky (25-50%)

3 = Mostly cloudy (50-75%)

4 = Overcast (75-100%)

5 = Fog or haze

01/05/2016

Appendix 5. List of amphibian and reptile species known to occur or with potential to occur in Muskegon State Game Area. Each species' status at federal and state levels and within the game area is provided along with general habitat associations. State status abbreviation of "T" signifies state threatened and "SC" signifies state special concern. Federal status abbreviation of "LT" signifies federally threatened. An asterisk (*) indicates rare species not targeted for surveys in 2016 due to low likelihood or probability of detecting the species given available methods and resources for surveys. Two asterisks (**) indicates that the species was a SGCN prior to 2015 but was removed as a SGCN by the Michigan DNR in 2015.

Amphibian/ Reptile	Common Name[1,3]	Scientific Name[1]	US Status	State Status	WAP SGCN[2]	Rare Species Targeted for 2018 Surveys	Species Observed in 2018 by MNFI and/or Others	Species Observed Prior to 2018	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	Fowler's Toad	*Anaxyrus [Bufo] fowleri*		SC	X	X			Open woodlands, sand prairies, meadows, dunes, and beaches, also agricultural areas and suburban backyards; closely associated with sandy soils, particularly along lake shorelines and river valleys
Amphibian	Blanchard's Cricket Frog	*Acris blanchardi*		T	X	X			Open, muddy edges of permanent ponds, lakes, bogs, and slow-moving streams or rivers with abundant aquatic vegetation, including fens and wet or sedge meadows
Amphibian	Northern Spring Peeper	*Pseudacris crucifer crucifer*					X		Temporary and permanent ponds, marshes, floodings, and ditches, as well as forests, old fields, shrubby areas
Amphibian	Western Chorus Frog *	*Pseudacris triseriata triseriata*							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		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	American Bullfrog	*Lithobates [Rana] catesbeianus*						X	Permanent waterbodies - river backwaters, sloughs, lakes, farm ponds, impoundments, marshes, shallow Great Lakes bays; abundant emergent and submergent vegetation
Amphibian	Green Frog	*Lithobates [Rana] clamitans*					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		Moist, forested habitats (deciduous, coniferous, and mixed); breeding - vernal ponds, floodings, forested swamps, and quiet stream backwaters
Amphibian	Pickerel Frog	*Lithobates [Rana] palustris*		SC	X	X			Bogs, fens, ponds, streams, springs, sloughs, and lake coves; cool clear waters, grassy stream banks
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	Eastern Musk Turtle	*Sternotherus odoratus*			X	X		X	Permanent waterbodies - ponds, lakes, marshes, sloughs, rivers; highly aquatic
Reptile	Spotted Turtle	*Clemmys guttata*		T	X	X		X	Shallow ponds, wet meadows, tamarack swamps, bogs, fens, marshes, sphagnum seepages, slow streams; require clear shallow water with mud/muck bottom and ample aquatic and emergent vegetation

Amphibian/ Reptile	Common Name[1,3]	Scientific Name[1]	US Status	State Status	WAP SGCN[2]	Rare Species Targeted for 2018 Surveys	Species Observed in 2018 by MNFI and/or Others	Species Observed Prior to 2018	General Habitat Description[3,4]
Reptile	Wood Turtle	*Glyptemys insculpta*		SC	X	X	X		Sand-bottomed streams or rivers, also streams with rocky or silty beds; mostly terrestrial during summer months - forests, alder thickets, swamps, wet meadows, and fields within or near the floodplain, generally within 150 m (500 ft) of moving water; nest in open sandy habitats along or near rivers and streams
Reptile	Eastern Box Turtle	*Terrapene carolina carolina*		SC	X	X	X		Deciduous or mixed forests, esp. with sandy soils, also adjacent old fields, pastures, dunes, marshes, and bog edges
Reptile	Blanding's Turtle	*Emydoidea blandingii*		SC	X	X	X		Shallow, weedy waters - ponds, marshes, forested and shrub swamps, wet meadows, lake inlets and 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	Common Five-lined Skink	*Plestiodon [Eumeces] fasciatus*							Moist but not wet, forested or partially forested habitats with ample cover and basking sites - stumps, logs, rock outcrops, wood or brush piles, sawdust piles, fallen bark; moist not wet habitats
Reptile	Northern Watersnake	*Nerodia sipedon sipedon*						X	wet meadows, impoundments; also utilize shallow, small temporary ponds and wetlands
Reptile	Queen Snake	*Regina septemvittata*		SC	X	X		X	Warm, shallow, rocky-bottomed streams with abundance of crayfish; edges of ponds, lakes, marshes, ditches and canals, open to mostly forested but totally shaded sites are avoided; often bask at water's edge or in overhanging shrubbery or tree branches.
Reptile	Kirtland's Snake	*Clonophis kirtlandii*		E	X				Damp habitats in vicinity of streams, ditches, marshes, or ponds; open grassy habitats such as wet prairies, wet meadows, fens, swales, and pastures are preferred; also forested swamps; also disturbed/developed lands - e.g., cemeteries, old fields, etc.
Reptile	Dekay's Brownsnake	*Storeria dekayi*					X		Variety of habitats from dense forests and shrubby habitats to open prairies, meadows, and marshes; prefer areas with moist soils but also found on dry hillsides, pine forests, and railroad embankments
Reptile	Eastern Gartersnake	*Thamnophis sirtalis sirtalis*					X		Almost any natural habitats - open and forested habitats and moist grassy places - edges of ponds, lakes, streams ditches,
Reptile	Northern Ribbonsnake	*Thamnophis sauritus septentrionalis*			X	X		X	Edges of lakes, ponds, streams, marshes, especially with grasses, sedges and low shrubs, open sunny areas/habitats
Reptile	Northern Ring-necked Snake	*Diadophis punctatus edwardsii*			X	X		X	Moist, shady forests and adjacent open habitats including old fields, grassy dunes; often found under leaf litter or cover or in burrows

Amphibian/ Reptile	Common Name[1,3]	Scientific Name[1]	US Status	State Status	WAP SGCN[2]	Rare Species Targeted for 2018 Surveys	Species Observed in 2018 by MNFI and/or Others	Species Observed Prior to 2018	General Habitat Description[3,4]
Reptile	Eastern Hog-nosed Snake *	*Heterodon platirhinos*					X		All types of terrestrial habitats - from open pine or deciduous forests to old fields, meadows, and pastures. Prefer sandy, well-drained soils.
Reptile	Blue Racer	*Coluber constrictor foxii*			X	X		X	Dry sunny, open habitats with access to cover - old fields, hedgerows, shrub thickets, open forests, forest edges, also grassy lake borders and marshes
Reptile	Gray Ratsnake	*Pantherophis spiloides*		SC	X	X		X	In or near forests, and adjacent open habitats - shrubby fields, pastures, marsh and bog edges
Reptile	Eastern Milksnake	*Lampropeltis triangulum triangulum*						X	Open forests, bogs, swamps, forest edges, marshes, lakeshores, old fields, and pastures
Reptile	Smooth Greensnake	*Opheodrys vernalis*		SC	X	X			Moist grassy places including prairie remnants and savannahs, meadows, old fields, pastures, roadsides, marsh and lake edges, also open deciduous and pine forests
Reptile	Eastern Massasauga	*Sistrurus catenatus*	LT	SC	X	X		X	Open and forested wetlands including shrub swamps, bogs, fens, marshes, wet or sedge meadows, moist prairie, and forested swamps, and adjacent open and forested upland habitats including prairies, old fields, meadows, shrub thickets, and deciduous, coniferous, and mixed forests.

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*). M.S. Thesis, University of Michigan-Flint, Flint, MI. 48 pp.

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 7. List of bird species detected during 97 point counts conducted in forested areas of Muskegon State Game Area during 2018. State status (T = threatened, SC = special concern) and the proportion of points having detections are provided for each species. Bird species considered as Michigan Department of Natural Resources featured species, species of greatest conservation need (SGCN), and focal species of the Upper Mississippi River and Great Lakes Region Joint Venture (JV) are indicated with an "X."

Common Name	Scientific Name	State Status	Featured Species	SGCN	JV Focal Species	Prop. of Points
Acadian flycatcher	Empidonax virescens					0.33
Alder flycatcher	Empidonax alnorum					0.01
American crow	Corvus brachyrhynchos					0.39
American goldfinch	Spinus tristis					0.14
American redstart	Setophaga ruticilla					0.81
American robin	Turdus migratorius					0.20
Baltimore oriole	Icterus galbula					0.03
Barn swallow	Hirundo rustica					0.02
Barred owl	Strix varia					0.02
Belted kingfisher	Megaceryle alcyon					0.01
Black-billed cuckoo	Coccyzus erythropthalmus				X	0.05
Black-capped chickadee	Poecile atricapillus					0.20
Black-throated green warbler	Setophaga virens					0.01
Blue jay	Cyanocitta cristata					0.08
Blue-gray gnatcatcher	Polioptila caerulea					0.21
Blue-headed vireo	Vireo solitarius					0.04
Broad-winged Hawk	Buteo platypterus					0.01
Brown creeper	Certhia americana					0.13
Brown-headed cowbird	Molothrus ater					0.16
Canada goose	Branta canadensis					0.02
Cedar waxwing	Bombycilla cedrorum					0.06
Cerulean warbler	Setophaga cerulea	T		X	X	0.22
Chipping sparrow	Spizella passerina					0.01
Common grackle	Quiscalus quiscula					0.11
Common yellowthroat	Geothlypis trichas					0.40
Downy woodpecker	Picoides pubescens					0.23
Eastern towhee	Pipilo erythrophthalmus					0.07
Eastern wood-pewee	Contopus virens					0.68
Gray catbird	Dumetella carolinensis					0.07
Great Blue Heron	Atlanta herodias				X	0.04
Great crested flycatcher	Myiarchus crinitus					0.29
Great-horned owl	Bubo virginianus					0.01
Green heron	Butorides virescens					0.01
Hairy woodpecker	Picoides villosus					0.09
Hermit thrush	Catharus guttatus					0.01
House wren	Troglodytes aedon					0.02
Indigo bunting	Passerina cyanea					0.12
Least flycatcher	Empidonax minimus					0.11
Louisiana waterthrush	Seiurus motacilla	T		X	X	0.03
Mourning dove	Zenaida macroura					0.09
Northern cardinal	Cardinalis cardinalis					0.10
Northern flicker	Colaptes auratus					0.05
Northern waterthrush	Parkesia noveboracensis					0.02
Ovenbird	Seiurus aurocapilla					0.46
Pileated woodpecker	Dryocopus pileatus		X			0.14
Pine warbler	Setophaga pinus					0.01
Prothonotary warbler	Protonotaria citrea	SC		X	X	0.23
Red-bellied woodpecker	Melanerpes carolinus			X		0.34
Red-breasted nuthatch	Sitta canadensis					0.01
Red-eyed vireo	Vireo olivaceus					0.91
Red-headed woodpecker	Melanerpes erythrocephalus	SC			X	0.04
Red-shouldered hawk	Buteo lineatus	T	X	X		0.04

Appendix 7 (continued). List of bird species detected during 97 point counts conducted in forested areas of Muskegon State Game Area during 2018. State status (T = threatened, SC = special concern) and the proportion of points having detections are provided for each species. Bird species considered as Michigan Department of Natural Resources featured species, species of greatest conservation need (SGCN), and focal species of the Upper Mississippi River and Great Lakes Region Joint Venture (JV) are indicated with an "X."

Common Name	Scientific Name	State Status	Featured Species	SGCN	JV Focal Species	Prop. of Points
Red-tailed hawk	Buteo jamaicensis					0.01
Red-winged blackbird	Agelaius phoeniceus					0.06
Rose-breasted grosbeak	Pheucticus ludovicianus					0.19
Ruby-throated hummingbird	Archilochus colubris					0.01
Ruffed grouse	Bonasa umbellus		X			0.02
Sandhill crane	Antigone canadensis				X	0.05
Scarlet tanager	Piranga olivacea					0.20
Song sparrow	Melospiza melodia					0.45
Swamp sparrow	Melospiza georgiana					0.02
Tree swallow	Tachycineta bicolor					0.02
Tufted titmouse	Baeolophus bicolor					0.12
Warblering vireo	Vireo gilvus					0.01
Veery	Catharus fuscescens			X	X	0.15
White-breasted nuthatch	Sitta carolinensis					0.12
Wild turkey	Meleagris gallopavo		X			0.02
Winter wren	Troglodytes hiemalis					0.01
Wood duck	Aix sponsa		X			0.05
Wood thrush	Hylocichla mustelina		X	X	X	0.28
Yellow warbler	Setophaga petechia					0.15
Yellow-bellied sapsucker	Sphyrapicus varius					0.01
Yellow-billed cuckoo	Coccyzus americanus					0.11

Appendix 8. Number of marsh bird detections at survey points by species at Muskegon State Game Area. The proportion of points having detections for each species is provided.

Survey Station ID	American bittern	Least bittern	Marsh wren	Pied-billed grebe	Sandhill crane	Sedge wren	Sora	Swamp sparrow	Virginia rail	Wood duck	Mallard
MU175	0	0	0	0	4	0	0	5	0	0	0
MU169	0	0	0	0	1	0	0	4	0	0	1
MU168	0	0	0	0	1	0	0	2	0	0	0
MU167	0	0	0	0	2	0	0	5	0	1	0
MU166	0	0	0	0	0	0	0	4	0	0	0
MU165	1	0	6	0	1	0	1	2	3	0	0
MU164	1	0	0	0	1	0	2	4	1	0	0
MU185	0	0	2	0	2	0	0	3	0	0	0
MU183	0	0	3	0	0	0	0	5	0	0	0
MU182	0	0	4	0	0	0	1	4	0	0	0
MU179	0	0	0	0	1	0	1	0	0	0	0
MU181	0	0	0	0	0	0	0	0	0	0	0
MU187	0	0	3	0	0	0	0	1	0	0	0
MU188	0	0	9	0	0	0	1	2	0	0	0
MU189	0	0	1	0	1	1	0	4	0	0	0
MU190	0	0	1	0	4	0	0	2	0	0	0
MU191	0	0	0	0	0	0	0	2	0	0	0
MU170	0	0	0	0	0	0	0	0	0	0	0
MU171	0	1	5	0	0	0	0	3	0	0	0
MU162	0	0	0	0	0	0	0	5	0	1	0
MU161	0	2	5	1	0	0	0	1	0	0	0
MU160	0	0	0	0	0	0	0	4	0	0	0
MU177	0	0	0	0	0	0	0	3	0	0	0
Total	2	3	39	1	18	1	6	65	4	2	1
% of points	8.7	8.7	43.5	4.3	43.5	4.3	21.7	87.0	8.7	8.7	4.3

Appendix 9. List of bird species having special status that were detected at Muskegon State Game Area during 2018` surveys and general habitat requirements.

Species	General Habitat Requirements	State Status[1]	Featured Species[2]	WAP SGCN[3]	JV Focal Species[4]
Mallard	Shallow marshes and ponds, lakes, rivers, and streams. Nests in grasslands, wetlands, hayfields, and shrublands.		X		
Wood duck	Variety of swamps, marshes, streams, beaver ponds, and lakes. Nests in tree cavities of mature forests near wetlands or water bodies.		X		
American bittern	Usually large marshes with dense cover of cattails, sedges, or bulrushes. Also occurs in shrubby marshes, bogs, wet meadows, and sometimes hayfields.	SC	X		X
Least bittern	Occurs in deeper water marshes compared to the American bittern, especially those will dense cattails and/or bulrushes.	T		X	
Sora	Uses shallow wetlands of a variety of types and sizes, including marshes dominated by cattails, sedges, grasses, and bulrushes, and bogs, fens, and wet meadows.				X
Marsh wren	Uses a variety of emergent wetlands with dense vegetation, but typically prefers deeper-water marshes compared to the sedge wren. In Michigan, it most often nests in cattail and bulrushes marshes.	SC			

[1]Michigan listing status (E = endangered; T = threatened; and SC = special concern).
[2]Identified as featured species for habitat management by MDNR Wildlife Division.
[3]Species of greatest conservation need in the Michigan Wildlife Action Plan (Derosier et al. 2015).
[4]Focal species in the Upper Mississippi River and Great Lakes Region Joint Venture Waterbird Habitat Conservation Strategy (Soulliere et al. 2018).

Appendix 10. A checklist of Michigan's unionid mussels with species found previously in the Muskegon River watershed and in the Muskegon SGA in 2018. Also noted is each species state and federal listed status. (L= live individuals; S= shells)

		Documented in Muskegon Watershed, post 1989	Muskegon SGA 2018	State status	Federal status
Actinonaias ligamentina	Mucket	X	S		
Alasmidonta marginata	Elktoe	X		SC	
Alasmidonta viridis	Slippershell	X		T	
Amblema plicata	Threeridge				
Anodontoides ferussacianus	Cylindrical papershell	X			
Cyclonaias pustulosa	Pimpleback				
Cyclonaias tuberculata	Purple wartyback			T	
Elliptio complanata	Eastern elliptio			SC	
Elliptio crassidens	Elephant-ear				
Eurynia dilatata	Spike	X	S		
Epioblasma perobliqua	White catspaw			E	E
Epioblasma rangiana	Northern riffleshell			E	E
Epioblasma triquetra	Snuffbox	X	S	E	E
Fusconaia flava	Wabash pigtoe	X	S		
Lampsilis cardium	Plain pocketbook	X	S		
Lampsilis fasciola	Wavy-rayed lampmussel			T	
Lampsilis siliquoidea	Fatmucket	X	S		
Lasmigona complanata	White heelsplitter	X			
Lasmigona compressa	Creek heelsplitter	X		SC	
Lasmigona costata	Fluted-shell	X		SC	
Leptodea fragilis	Fragile papershell				
Leptodea leptodon	Scaleshell			SC	E
Ligumia nasuta	Eastern pondmussel	X		E	
Ligumia recta	Black sandshell	X	S	E	
Obliquaria reflexa	Three-horned wartyback			E	
Obovaria olivaria	Hickorynut			E	
Obovaria subrotunda	Round hickorynut			E	
Pleurobema clava	Clubshell			E	E
Pleurobema sintoxia	Round pigtoe	X		SC	
Potamilus alatus	Pink heelsplitter			SC	
Potamilus ohiensis	Pink papershell			T	
Ptychobranchus fasciolaris	Kidney-shell			SC	
Pyganodon grandis	Giant floater	X			
Pyganodon lacustris	Lake floater			SC	
Pyganodon subgibbosa	Round Lake floater			T	
Quadrula quadrula	Mapleleaf				
Simpsonaias ambigua	Salamander mussel			E	
Strophitus undulatus	Strange floater	X			
Toxolasma lividum	Purple lilliput			E	
Toxolasma parvum	Lilliput			E	
Truncilla donaciformis	Fawnsfoot			T	
Truncilla truncata	Deertoe			SC	
Utterbackia imbecillis	Paper pondshell			SC	
Venustaconcha ellipsiformis	Ellipse			SC	
Villosa fabalis	Rayed bean			E	E
Villosa iris	Rainbow	X		SC	