Eastern Massasauga Surveys and Outreach at Waterloo State Recreation Area

Prepared By:

Yu Man Lee
Michigan Natural Features Inventory
Michigan State University Extension
P.O. Box 13036
Lansing, MI 48901-3036

Prepared For:

Michigan Department of Natural Resources
Parks and Recreation Division

December 11, 2018

MNFI Report No. 2018-19

Michigan Natural Features Inventory
Discover. Define. Deliver.

MICHIGAN STATE UNIVERSITY | Extension

DEPARTMENT OF NATURAL RESOURCES DNR MICHIGAN

Suggested Citation:

Lee, Y. 2018. Eastern massasauga surveys and outreach at Waterloo State Recreation Area. Michigan Natural Features Inventory Report No. 2018-19, Lansing, MI. 46 pp.

Cover Photographs:

Center: Prairie fen habitat for Eastern Massasaugas, North Fork Mill Creek, Waterloo State Recreation Area, Chelsea, MI. Photo by Yu Man Lee.

Left Inset: Waterloo State Recreation Area Manager, James O'Brien, and his daughter holding snakes at Eastern Massasauga education and outreach program at Gerald E. Eddy Discovery Center, Waterloo State Recreation Area. Photo by Kathleen McGlashen.

Right Inset: Waterloo State Recreation Area Supervisor, Greg Byce, setting a coverboard to survey for Eastern Massasaugas at select sites in 2018. Photo by Yu Man Lee.

Abstract

The eastern massasauga (*Sistrurus catenatus*) is a federally threatened and state special concern species in Michigan. The species also is currently designated a priority Species of Greatest Conservation Need (SGCN) in Michigan's Wildlife Action Plan (WAP) (Derosier et al. 2015). To sustain the species' viability in Michigan and contribute to conservation and recovery of this species rangewide, the Michigan Department of Natural Resources (MDNR) established a Candidate Conservation Agreement with Assurances (CCAA) for the Eastern Massasauga Rattlesnake (EMR) in Michigan. The goal of the CCAA is to minimize adverse impacts to the species from management activities conducted in areas enrolled as Managed Lands within the CCAA to maintain and protect populations of this species in Michigan.

The MDNR's Parks and Recreation Division (PRD) has constructed a new mountain bike trail, the Winn Loop, and is proposing to construct another new trail, the Sugarloaf Loop, within the Waterloo State Recreation Area (SRA) to expand and complete the DTE Trail System. These trails are located in areas enrolled as Managed Lands under Michigan's EMR CCAA. Although these trails have been or will be constructed in a manner that strives to avoid harm to massasaugas during construction, little information is available on potential effects of various types of trails on massasaugas, and what new trails in Managed Lands may mean for the long-term success of the CCAA and viability of the local populations. Effects to massasaugas from trails could occur during construction or operation of the trail, including fragmenting habitat or increasing the likelihood of human-snake encounters.

To obtain current and additional data on the EMR population (i.e., occupancy and distribution) in Waterloo SRA, particularly near the Winn and Sugarloaf Loop trails, and assess potential impacts of these trails on the EMR population, PRD staff conducted coverboard surveys for EMRs at nine locations in Waterloo SRA from April 30 through August 27, 2018. PRD staff also reached out to neighboring property owners to request information on their knowledge of the presence of EMRs on or near their property and in the Waterloo SRA. The Parks and Recreation Division also contracted with Michigan Natural Features Inventory (MNFI) to assist with this project by identifying areas with suitable habitat for EMRs, helping with placement of coverboards, conducting limited visual encounter surveys for EMRs, working with PRD staff to organize and present two EMR education and outreach programs, and reviewing and responding to EMR reports from neighboring landowners and general public.

Although coverboard and visual encounter surveys in 2018 were not able to reconfirm massasaugas in the Waterloo SRA project area, two reliable reports of the species from 2007 and 2017 were obtained from the general public as a result of this project's education and outreach efforts. These reports confirm the continued persistence of EMRs near one of the previously documented sites for the species. Surveys documented the presence of suitable wetland habitat for EMRs at seven of the nine sites surveyed, although habitat quality or suitability varied among sites. The wetlands around Winnewana Lake west of the Winn Loop do not appear to be suitable or likely habitat for EMRs based on the dominance of tall dense vegetation, woody vegetation/shrub encroachment, and hydrology of the site (i.e., persistent standing water). Woody vegetation/shrub encroachment appeared to be a threat at all sites surveyed. Continued surveys are needed to determine the current status and distribution within the Waterloo SRA, particularly on/near CCAA EMR Managed Lands. This information is critical to inform and guide trail planning, construction, and operation efforts and other efforts to manage and conserve the eastern massasauga in the Waterloo State Recreation Area.

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

The eastern massasauga (*Sistrurus catenatus*) (EMR) is a small, thick-bodied rattlesnake that is historically known from shallow wetlands and adjacent uplands in portions of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Wisconsin, and Ontario (Harding 1997, Szymanski 1998, Szymanski et al. 2016). The species was once considered common throughout its range but its populations have severely declined. Most states or provinces within the species' range have lost over 50% of their historical populations, and one third or less of extant populations across the species' range are presumed to be secure or demographically, genetically, and physiologically robust (Szymanski 1998, Szymanski et al. 2016). As a result, the eastern massasauga was listed as a federally threatened species by the U.S. Fish and Wildlife Service in 2016 (USFWS 2016).

The primary factors that have led to the decline of this species are habitat loss and fragmentation, hydrological alteration resulting in drought or flooding, road mortality, persecution, collection, and mortality of individual snakes during habitat management including post-emergent prescribed fire and mowing (Szymanski 1998, Szymanski et al. 2016). Conversion to agricultural land, development and associated infrastructure (e.g., roads, bridges), vegetative succession, invasive species, fire suppression, manipulation of ground water levels, and incompatible habitat management or land use have resulted in the loss and degradation of this species' wetland and upland habitats (Szymanski 1998, Szymanski et al. 2016, USFWS 2016). Fear and dislike of snakes and concern for safety regarding potential snake bites have resulted in people killing massasaugas (Szymanski 1998). Climate change and disease are additional emerging threats to this species (Szymanski et al. 2016).

Michigan is considered to be the last stronghold for this species with more historical and extant massasauga populations than any other state or province in the species' range (Szymanski 1998). Therefore, the long-term viability and persistence of this species in Michigan has important implications for conservation of this species across its range. However, eastern massasauga populations in Michigan also have declined due to similar threats that have impacted populations in other states. As a result, the eastern massasauga has been designated a species of special concern and a priority Species of Greatest Conservation Need (SGCN) in Michigan's Wildlife Action Plan (WAP) (Derosier et al. 2015).

To sustain the species' viability in Michigan and contribute to conservation and recovery of this species rangewide, the Michigan Department of Natural Resources (MDNR) established a Candidate Conservation Agreement with Assurances (CCAA) for the Eastern Massasauga Rattlesnake (EMR) in Michigan (MDNR 2016). The goal of the CCAA is to minimize adverse impacts to the species from management activities conducted in areas enrolled as Managed Lands within the CCAA to maintain and protect populations of this species in Michigan. The MDNR's Parks and Recreation Division (PRD) has constructed a new mountain bike trail, the Winn Loop, and is proposing to construct another new trail, the Sugarloaf Loop, within the Waterloo State Recreation Area (SRA) to expand and complete the DTE Trail System. These

trails are located in areas enrolled as Managed Lands under Michigan's EMR CCAA. Although these trails have been or will be constructed in a manner that strives to avoid harm to massasaugas during construction and is consistent with the CCAA, little information is available on potential effects of various types of trails on massasaugas, and what new trails in Managed Lands may mean for the long-term success of the CCAA and viability of the local populations. Effects to massasaugas from trails could occur during construction or operation of the trail, including fragmenting habitat or increasing the likelihood of human-snake encounters.

To obtain additional data on the EMR population (i.e., occupancy and distribution) in Waterloo SRA, particularly near the Winn and Sugarloaf Loop trails, and assess potential impacts of these trails on the EMR population, PRD staff conducted a coverboard survey for EMRs at several locations in Waterloo SRA from April through October 2018. PRD staff also reached out to neighboring property owners to request information on their knowledge of the presence of EMRs on or near their property and in the Waterloo SRA. The MDNR Parks and Recreation Division also contracted with Michigan Natural Features Inventory (MNFI) to assist with this project. MNFI provided assistance by identifying areas with suitable habitat for EMRs within the project area in Waterloo SRA, helping with placement of coverboards, conducting limited visual encounter or meander surveys for EMRs, working with PRD staff to organize and present two EMR education and outreach programs, reviewing and responding to EMR reports in the Waterloo SRA from neighboring landowners and general public, and providing a summary of project results. PRD and MNFI's survey and outreach efforts for the eastern massasauga at Waterloo SRA will help inform current and future trail planning, construction, operation, and maintenance efforts and efforts to manage and conserve the eastern massasauga.

Methods

Project Objectives

This project addressed the following specific objectives:

1) To provide the Parks and Recreation Division (PRD) with critical information for making well-informed decisions on the construction and management of trails and management and conservation of eastern massasaugas within Waterloo SRA.

2) To provide PRD assistance with identification of suitable habitat and assistance with coverboard surveys for the eastern massasauga on the east side of the Waterloo SRA in areas enrolled as Managed Lands under Michigan's EMR CCAA, particularly in areas near the Winn Loop Trail and proposed Sugarloaf Loop Trails.

3) To conduct limited visual encounter/meander surveys for the eastern massasauga on the east side of the Waterloo SRA in areas enrolled as Managed Lands under Michigan's EMR CCAA, particularly in areas near the Winn and Sugarloaf Trails.

4) To provide a brief report summarizing survey results and findings.

Project Area

The project area was located in the eastern portion of the Waterloo State Recreation Area located about three to seven miles northwest of Chelsea in northwestern Washtenaw County and northeastern Jackson County in southeast Michigan (Figure 1). Most of the project area has been enrolled as Managed Lands in Michigan's EMR CCAA, totaling 6,929 acres (Figure 2, MDNR 2016). Areas identified as Managed Lands in the CCAA are important to the long-term sustainability of eastern massasaugas in Michigan (MDNR 2016). These areas will be managed according to management strategies identified in the CCAA to reduce and/or eliminate threats to massasaugas (MDNR 2016). The project area also has been identified as Tier 1 habitat by the USFWS because massasaugas have been documented and/or are likely to occur in this area (USFWS 2017, MNFI 2018). The recently constructed Winn Loop mountain bike trail and proposed Sugarloaf Loop trail are both located within the project area. The Winn Loop is located east of the Winnewana Lake/Impoundment and west of Cassidy Road (Figure 1). The Sugarloaf Loop will be located east of Sugarloaf Lake and Sugarloaf Road. Identification of areas with suitable habitat for EMRs, coverboard and visual surveys for EMRs, and education and outreach efforts were conducted within the project area, particularly in the vicinity of the Winn and Sugarloaf Loops.

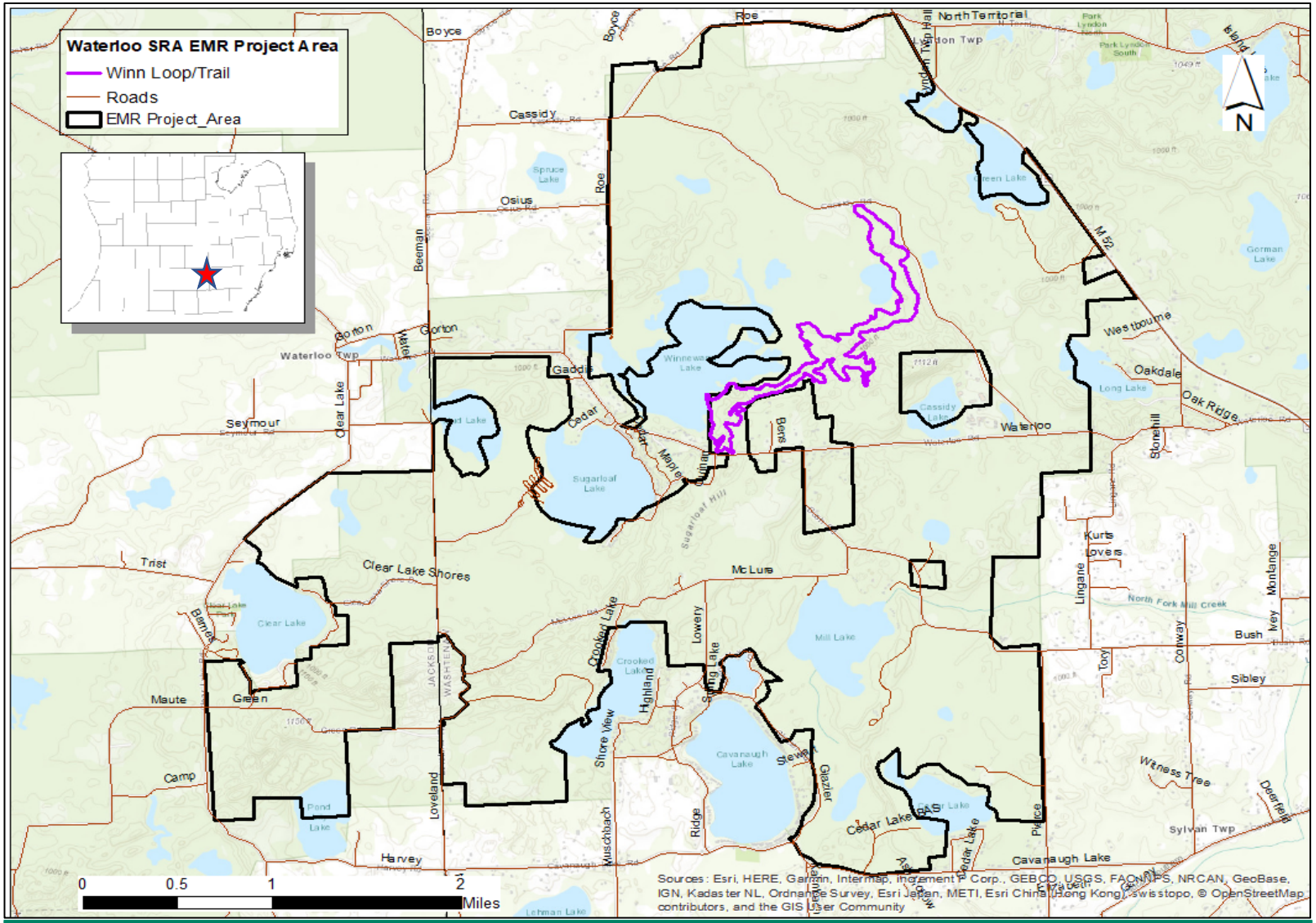


Figure 1. Map of the eastern massasauga project area within the Waterloo State Recreation Area, Chelsea, MI.

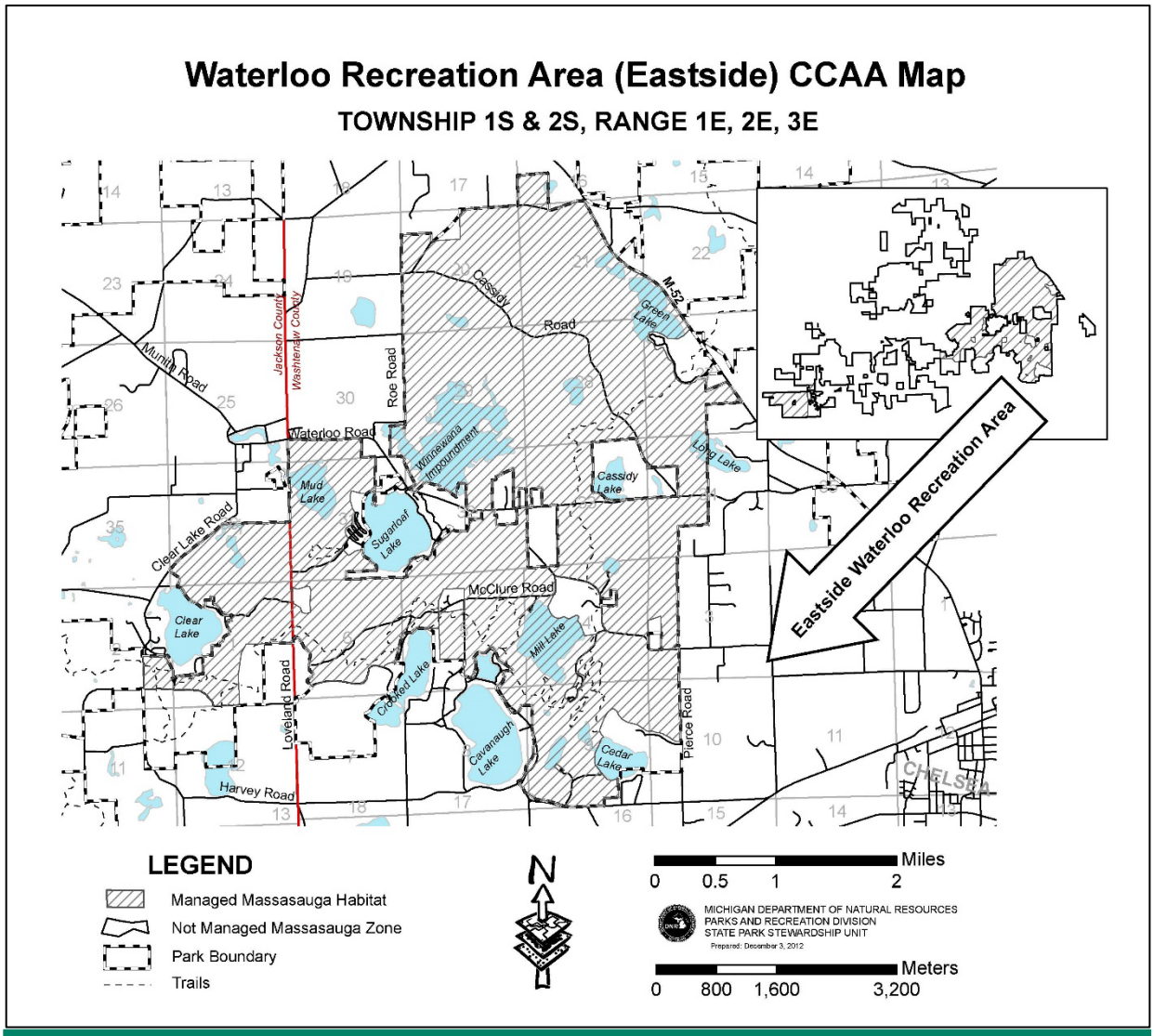


Figure 2. Map showing area enrolled as Managed Lands within the eastern portion of the Waterloo State Recreation Area, Chelsea MI.

Identification of Suitable EMR Habitat

Suitable habitat for eastern massasaugas is generally characterized by limited canopy cover and early successional vegetation in wetland and upland habitat types in southern Michigan and across the species' range (e.g., Reinert and Kodrich 1982, Johnson 1995, Sage 2005, Bissell 2006, Moore and Gillingham 2006, Durbian et al. 2008, McCluskey et al. 2018). Eastern massasaugas in Michigan are primarily associated with wetlands, utilizing a variety of open or early successional wetland types including bogs, fens, peatlands, shrub carr/thickets, wet meadows, emergent marshes, moist grasslands, and wet prairies as well as forested wetlands such as floodplain forests and forested swamps (Reinert and Kodrich 1982, Hallock 1991, Weatherhead and Prior 1992, Johnson 1995, Harding 1997, Johnson et al. 2000, Ernst and Ernst 2003, Harvey and Weatherhead 2006, Marshall et al. 2006, Moore and Gillingham 2006). Although highly varied, predominant plant species in EMR habitats include sedges (*Carex* spp.), dogwoods *Cornus* spp.), rushes (*Juncus* spp.), and cattails (*Typha* spp.; Marshall et al. 2006, Moore and Gillingham 2006, Durbian et al. 2008). Additionally, Moore and Gillingham (2006) reported that massasaugas in a population in southeastern Michigan avoided shrubs >5 m (16 ft) in height and primarily used areas with an open canopy and high amounts of groundcover vegetation ranging from 0.5–1.5 m (1.6–4.9 ft) in height during the active season. Similarly, for a southwestern Michigan population, Bissell (2006) and Bailey (2010) identified optimally suitable ranges of specific habitat components for the massasauga including live herbaceous cover (optimal values ranging from 60-100% cover), dead herbaceous cover (51.5-96% cover), stem density of trees and shrubs ≥3 m (10 ft) in height (0-60 stems/ha), and basal area of trees and shrubs ≥3 m (10 ft) in height (0-0.116 m^2/ha).

To identify areas with suitable habitat for eastern massasaugas within the project area, MNFI staff consulted with PRD Stewardship and Waterloo SRA staff, reviewed remote sensing data and other available information on land cover or habitat types within the project area, identified areas with potential habitat for EMRs, and conducted surveys to assess habitat suitability for massasaugas in the field. MNFI staff reviewed available aerial imagery, land cover data such as the NOAA C-CAP 2016 land cover data layer (NOAA 2018), 2006 National Land Cover Database (NLDC; MRLC 2015), National Wetlands Inventory (NWI) data layer (USFWS 2015), Michigan Forest Inventory (MiFI) stand data (MDNR 2017), natural community element occurrence data from the Michigan Natural Heritage Database (NHD) (MNFI 2018), and circa 1800 presettlement vegetation data layer (Figures 3, 4, 5; Appendix 1). We also reviewed eastern massasauga element occurrences in the NHD within the project area (MNFI 2018) and areas predicted to be suitable habitat for massasaugas based on an EMR habitat distribution model developed by McCluskey (2016) (Figures 4 and 6). In addition to available GIS data layers, we consulted MNFI reports that contained information on natural communities and potential habitat for massasaugas within the project area (e.g., Cooper et al. 2000, Cohen et al. 2012).

Given that eastern massasaugas in Michigan require wetlands for their survival, we focused on identifying wetlands within the project area that may provide suitable habitat for massasaugas. We used available land cover GIS data layers (i.e., C-CAP 2016, NWI 2015, MiFI 2017, and

MNFI natural community element occurrence data) to identify areas with wetlands (Figures 3, 4, 5). Because massasaugas are generally associated with open or early successional wetland habitats, we primarily considered areas with palustrine emergent and palustrine scrub-shrub wetlands in the C-CAP data layer and freshwater emergent wetlands in the NWI data layer as potential areas with suitable habitat for EMRs although some of the palustrine forested wetlands and freshwater forested/shrub wetlands in the C-CAP and NWI data layers, respectively, also may provide suitable habitat for EMRs (Figures 3 and 4). In the MiFI data layer, we initially considered wetland stands classified as fen, emergent wetland, mixed emergent wetland, cattail, wet meadow, shrub-carr, lowland shrub, mixed lowland shrub, mixed non-forested wetland, and tamarack as potential areas with suitable habitat for EMRs (Figure 5). Based on the habitat suitability model developed by Bissell (2006) and Bailey (2010), optimally suitable ranges for certain habitat components in the model (i.e., live herbaceous cover and stem density), and available data in MiFI (MDNR 2017), we used data on canopy closure, percent cover of grasses/sedges, and low shrub cover to further refine our assessment of potential habitat suitability and identify potential areas with suitable EMR habitat (Figure 7). Stands with <50% canopy closure, <40% shrub cover, and at least 10% and ideally >40% grass/sedge cover were identified as priority wetlands with potential for suitable EMR habitat (Figure 7). We also overlaid the EMR predicted habitat layer developed by McCluskey (2016) to provide additional data to identify potential areas with suitable EMR habitat (Figures 4. 6, 7).

Based on available aerial imagery, land cover data, other habitat information, and massasauga occurrence data, we identified nine sites for field reconnaissance (Figure 8). Field visits to assess and determine habitat suitability for massasaugas were conducted at these sites on April 10, April 20, and/or during September 12-21 in 2018 (Figure 8, Appendices 2-9). Habitat suitability was assessed in the field qualitatively based on wetland type, general vegetative composition and structure, hydrology (e.g., how wet the site is, duration and amount of standing water), and threats to the habitat. Sites with suitable habitat for massasaugas were identified as potential sites for coverboard and/or visual encounter surveys.

Coverboard Surveys

Coverboard surveys were conducted by Waterloo SRA staff at sites that appeared to have suitable habitat for eastern massasaugas from April through August 2018. A total of 87 coverboards were set at nine locations or sites associated with Long Lake, Sugarloaf Lake, Mud Lake, Mill Lake, Green Lake, and Hankard Lake (Table 1, Figure 8, Appendices 2-4, 6-8). Waterloo SRA and MNFI staff visited and inspected potential sites for coverboard surveys in the field on April 10, and coverboards were set between April 20-27 prior to or during massasauga emergence. Coverboards primarily consisted of recycled aluminum corrugated siding panels that were approximately 1 x 1 m (3.3 x 3.3 ft) in size (Figure 9). Carpet remnants of approximately the same size also were used as coverboards at a few sites (Figure 9). The initial plan was to place 10–20 coverboards approximately 40–50 m (130-160 ft) apart along 2–3 transects within each location/site, dependent upon the size of the site. However, due to habitat conditions in the field (e.g., some areas were very wet or were too hummocky to set coverboards), coverboards were placed approximately 10-25 m (33-82 ft) apart.

Waterloo SRA staff checked coverboards primarily every two weeks over an 18-week period from April 30 through August 27, with occasional visits separated by only one week or three weeks (Table 1). This resulted in a total of eight coverboard checks for all locations/coverboards in 2018. Additionally, some coverboards were checked opportunistically in September by MNFI during visual encounter surveys. A few coverboards could not be located and checked during the coverboard surveys (e.g., due to tall, dense vegetation), or were removed by park visitors and had to be replaced.

A coverboard survey data sheet was completed for each visit. All amphibians and reptiles found under or near coverboards or en route to coverboards were recorded and photographed for documentation when possible. Other animals encountered during coverboard surveys also were noted and/or photographed.

Table 1. Summary of survey sites, number of coverboards set, and dates coverboards were checked during coverboard surveys for eastern massasaugas within the Waterloo State Recreation Area project area in 2018.

Survey Sites	Number of Coverboards	Survey Dates
Long Lake Fen North	21	4/30, 5/14, 6/4, 6/21, 7/6, 7/18, 8/7, 8/27
Long Lake Fen South	4	5/10, 5/14, 6/4, 6/21, 7/6, 7/18, 8/7, 8/27
Long Lake Fen Uplands	10	4/30, 5/14, 5/30, 6/13, 6/25, 7/9, 7/30, 8/16
Green Lake	10	5/10, 5/17, 5/30, 6/20, 7/3, 7/11, 8/3, 8/17
Hankard Lake	5	5/8, 5/14, 5/30, 6/13, 6/26, 7/9, 7/30, 8/15
Sugarloaf Lake	16	5/1, 5/17, 5/29, 6/12, 6/28, 7/16, 8/2, 8/21
Mud Lake Northwest	4	5/9, 5/29, 6/12, 6/26, 7/9, 7/30, 8/14, 8/27
Mud Lake South	12	5/1, 5/17, 6/1, 6/12, 6/29, 7/16, 8/6, 8/22
Mill Lake	5	5/8, 5/17, 5/29, 6/12, 6/26, 7/9, 7/30, 8/15
TOTAL	**87**	**4/30, 5/1, 5/8, 5/9, 5/10, 5/14, 5/17, 5/29, 5/30, 6/1, 6/4, 6/12, 6/13, 6/20, 6/21, 6/25, 6/26, 6/28, 6/29, 7/3, 7/6, 7/9, 7/11, 7/16, 7/18, 7/30, 8/2, 8/3, 8/6, 8/7, 8/14, 8/15, 8/16, 8/17, 8/21, 8/22, 8/27**

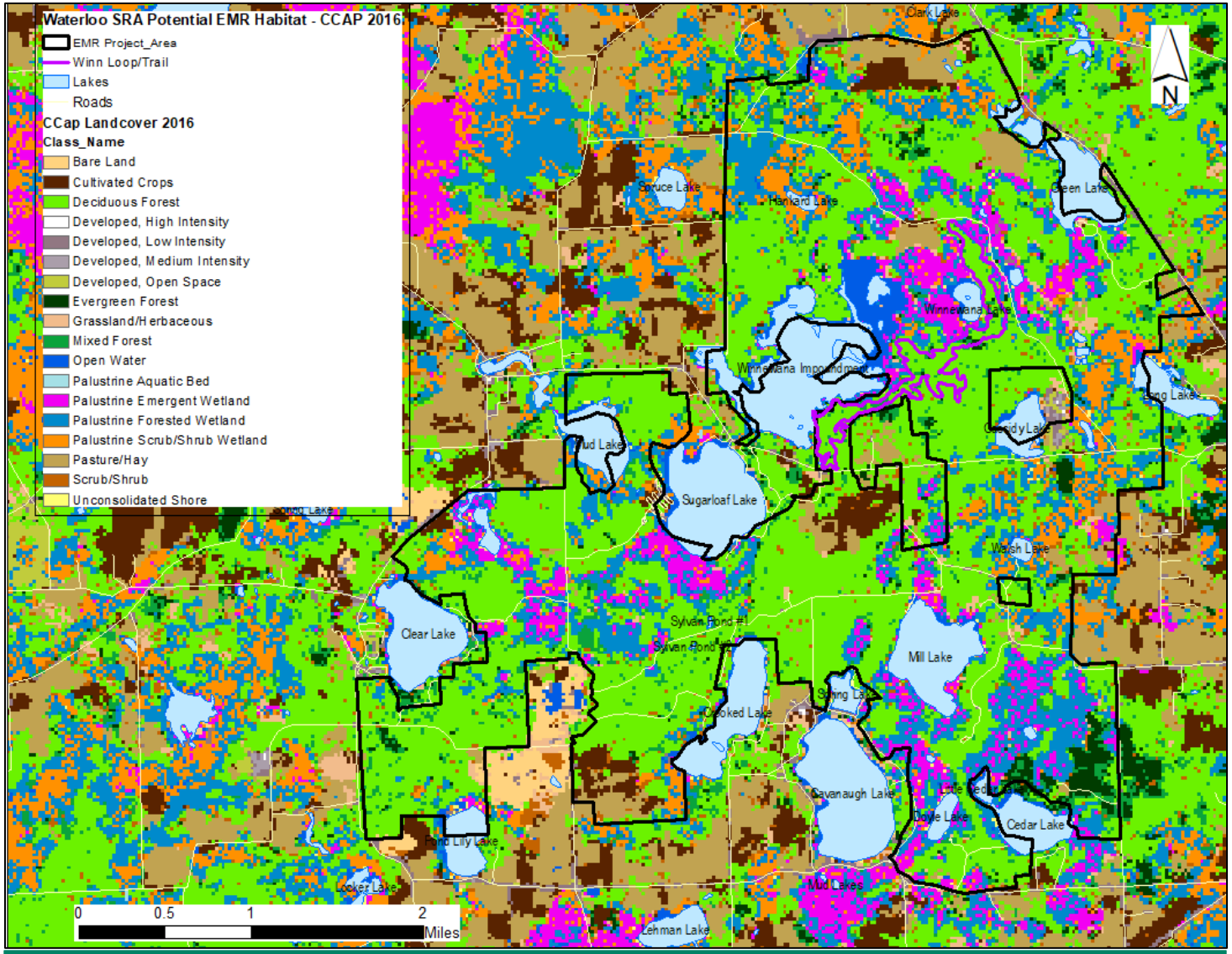


Figure 3. Potential eastern massasauga habitat in Waterloo SRA project area based on NOAA C-CAP 2016 land cover data (NOAA 2018). Palustrine emergent wetlands and palustrine scrub-shrub wetlands were considered priority areas with potential for suitable habitat for massasaugas. Palustrine forested wetlands also may provide suitable habitat for massasaugas.

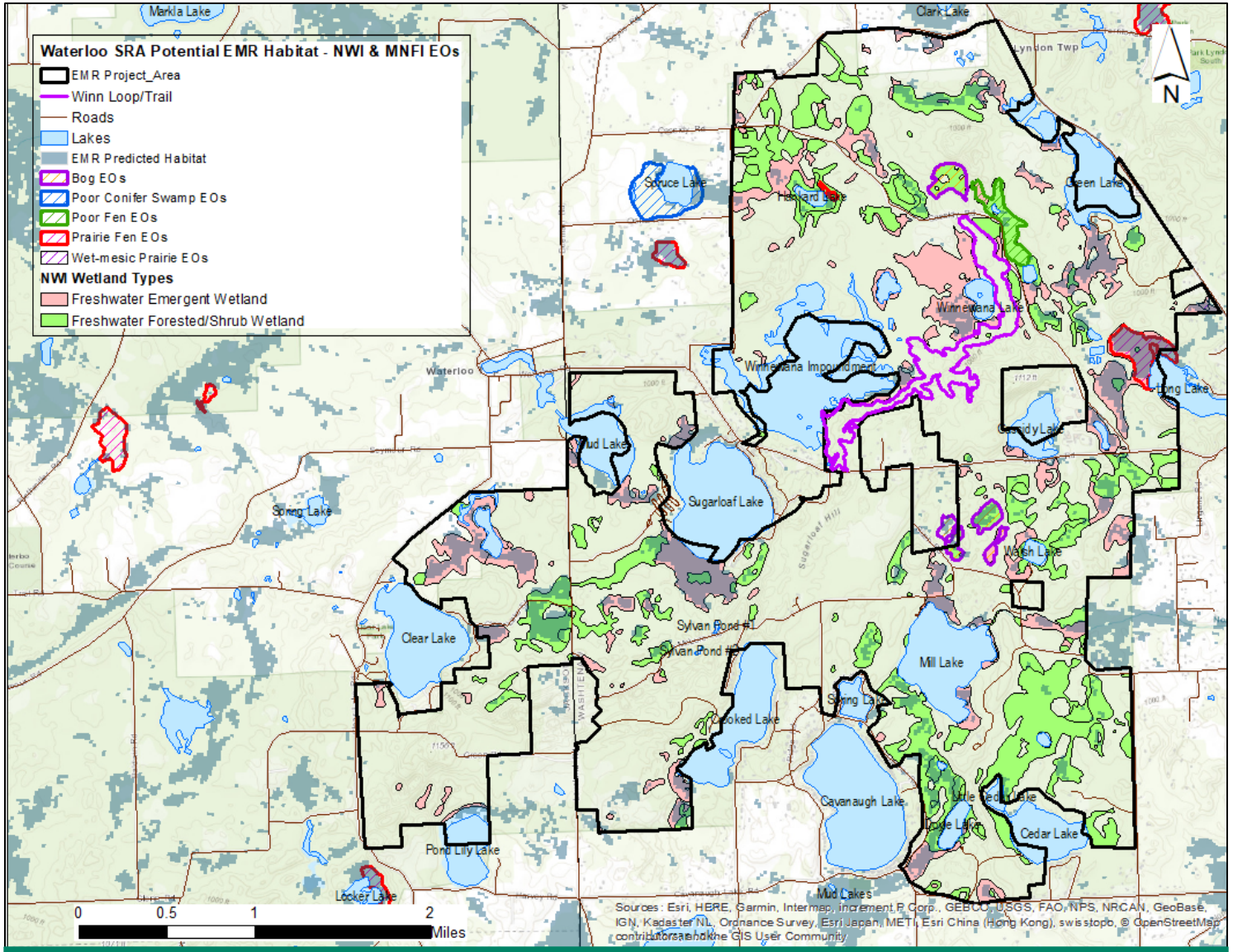


Figure 4. Potential eastern massasauga habitat in Waterloo SRA project area based on National Wetlands Inventory (NWI) data, MNFI natural community element occurrences (EOs), and EMR predicted habitat based on model developed by McCluskey (2016).

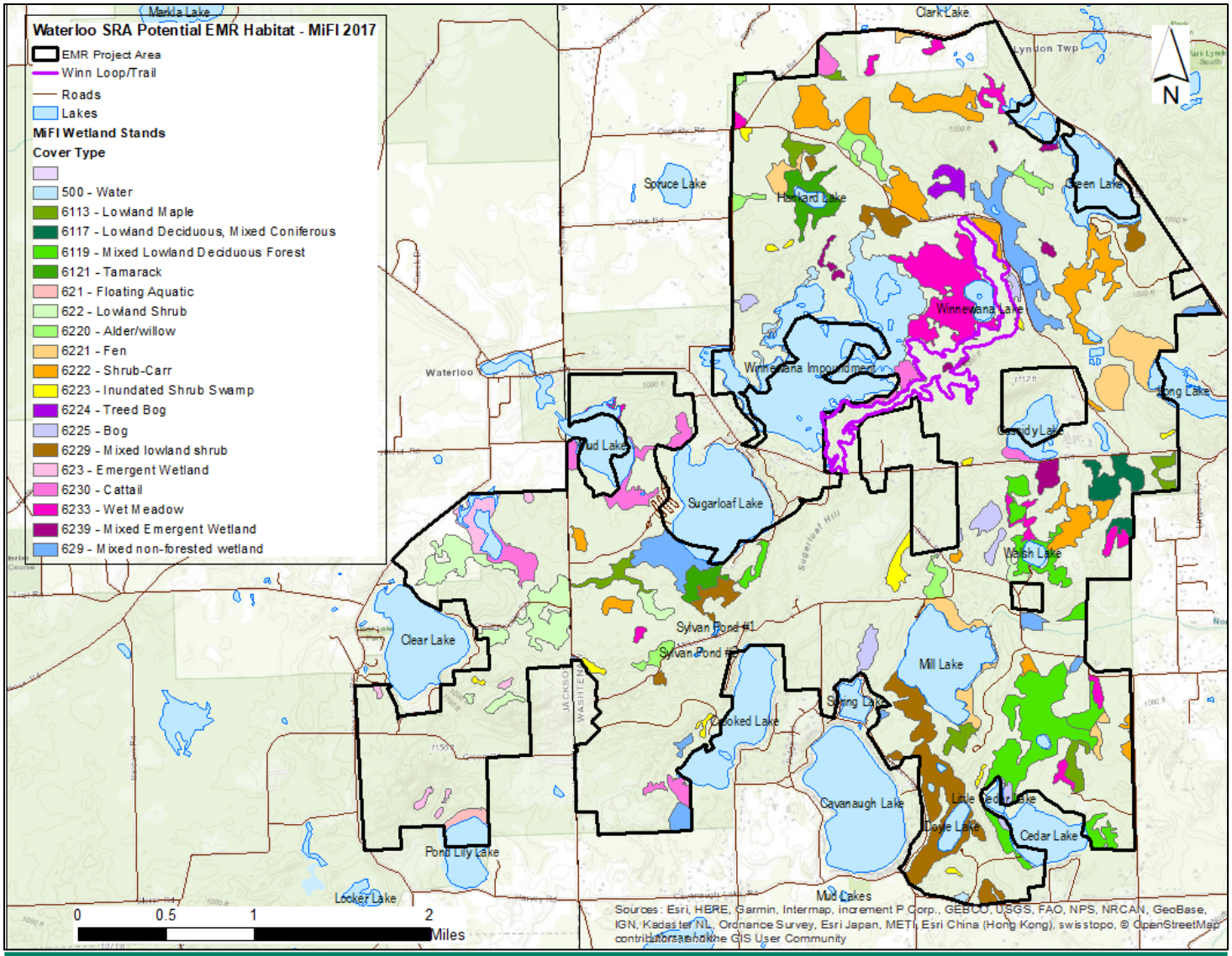


Figure 5. Potential eastern massasauga habitat in Waterloo SRA project area based on MiFI stand inventory data (MDNR 2017).

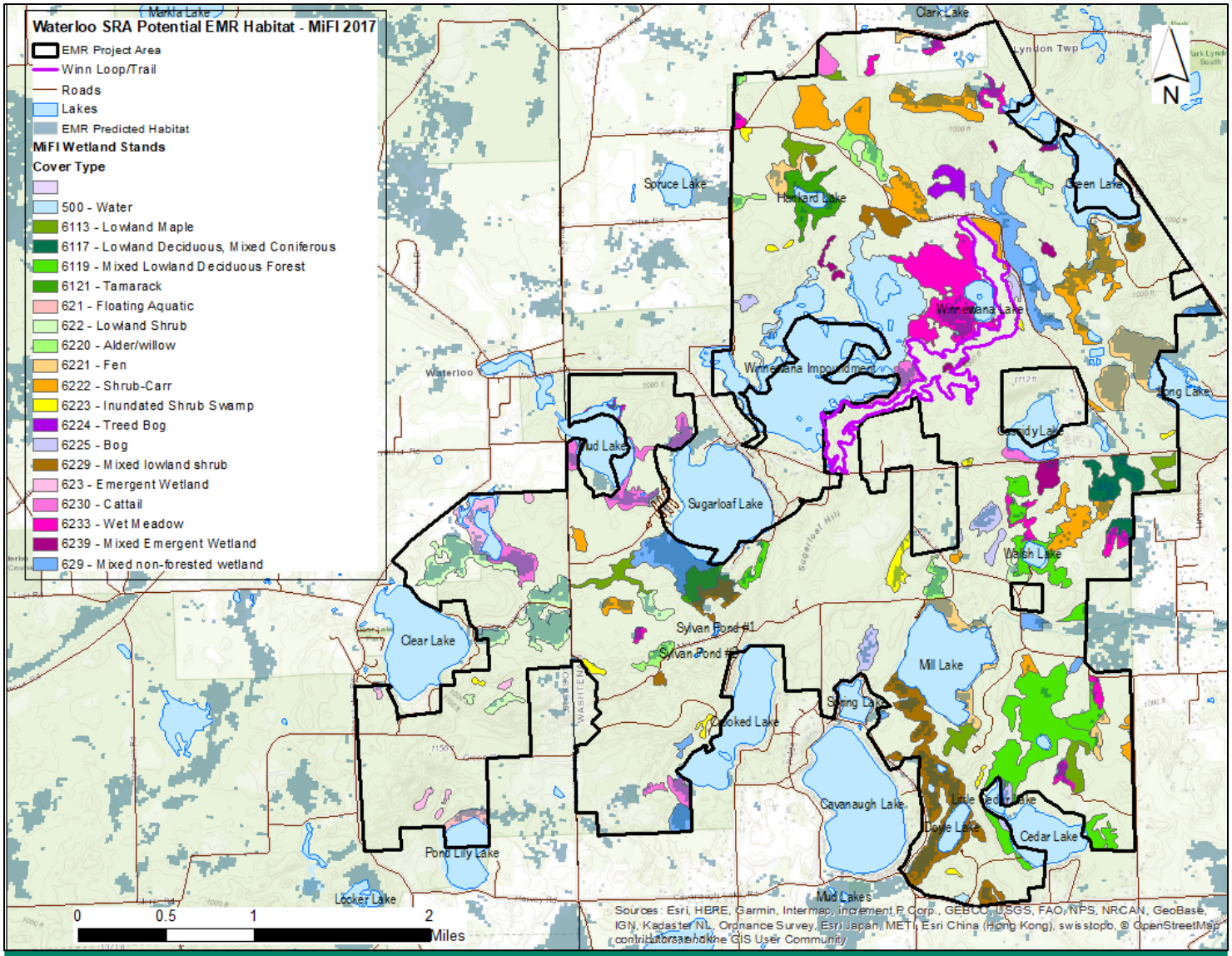


Figure 6. Potential eastern massasauga habitat in Waterloo SRA project area based on MiFI stand inventory data (MDNR 2017) and predicted massasauga habitat based on model developed by McCluskey (2016).

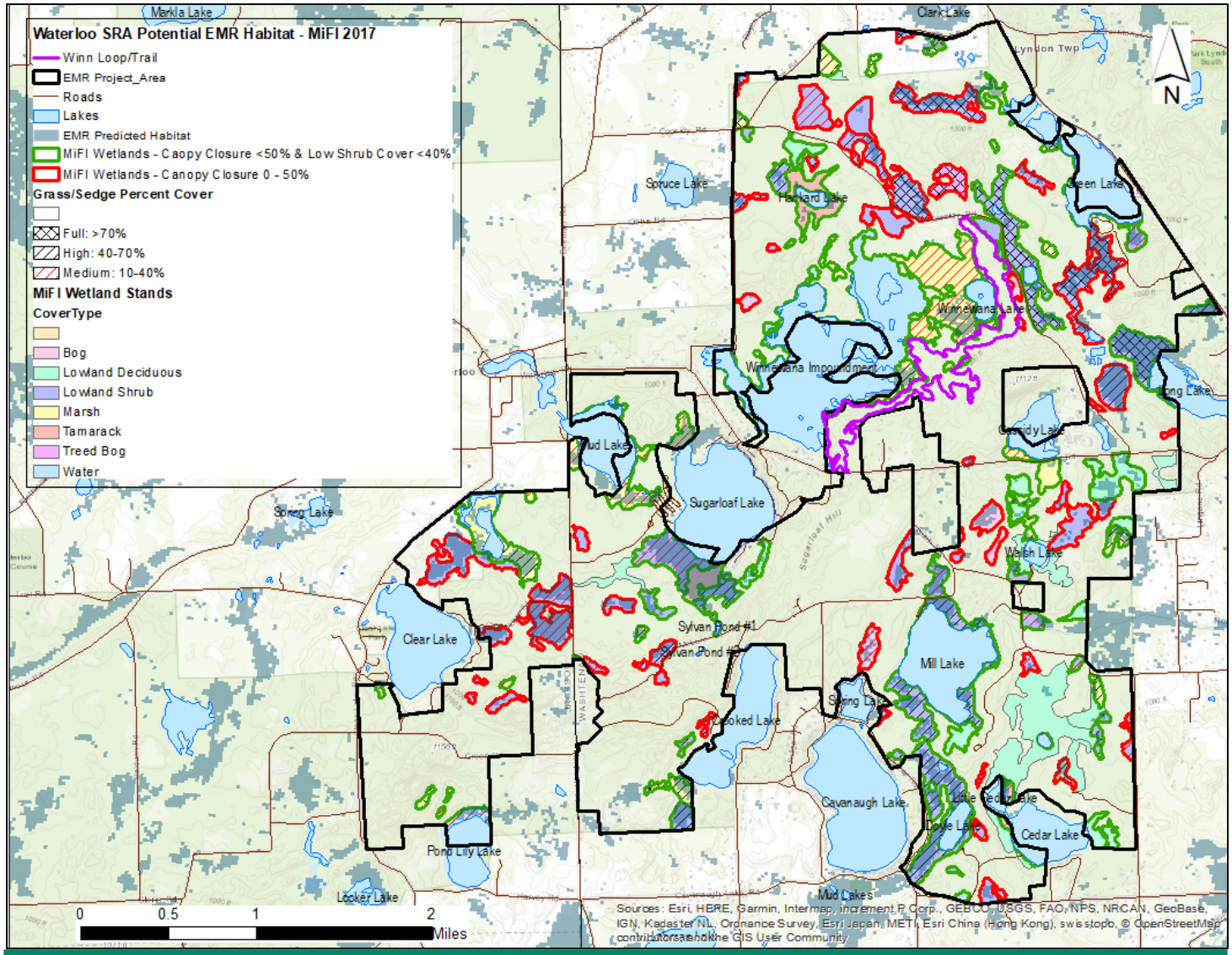
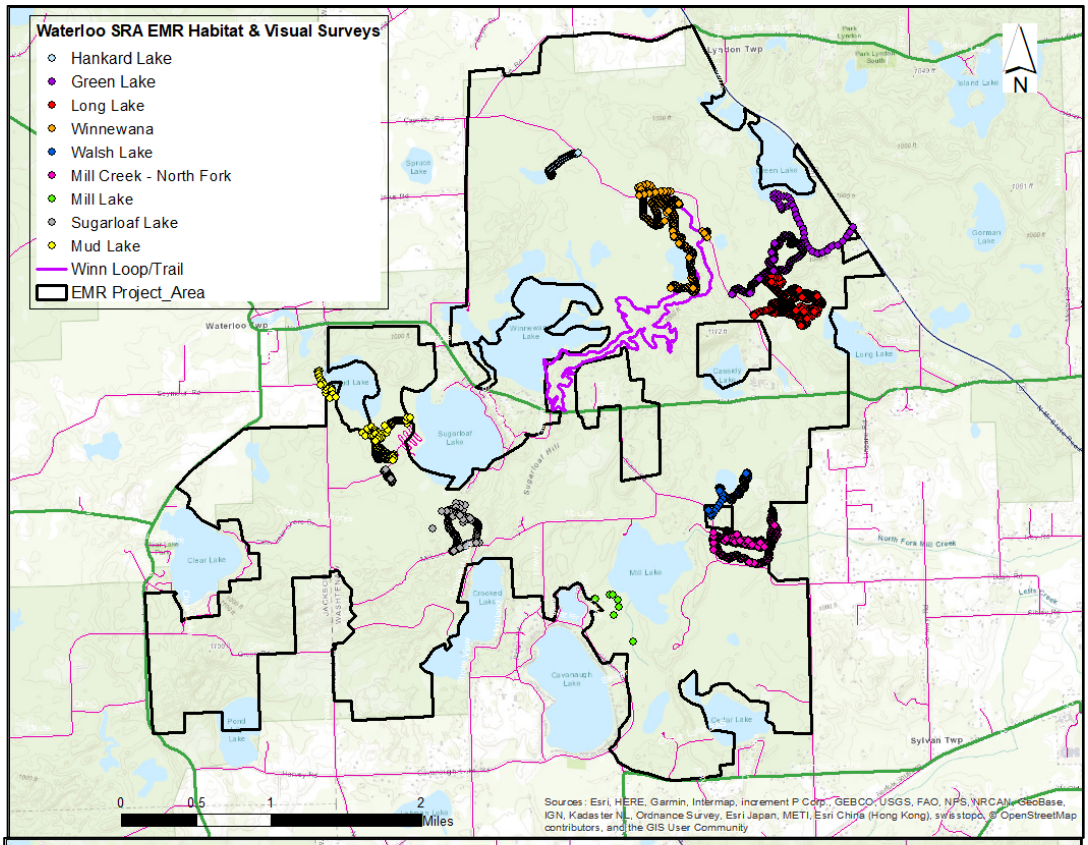


Figure 7. Potential eastern massasauga habitat in Waterloo SRA project area based on MiFI stand inventory data (MDNR 2017), vegetative structure data, and predicted massasauga habitat based on model developed by McCluskey (2016). Areas outlined in green or red with >10% grass/sedge cover overlain with predicted EMR habitat were considered priority areas with potential habitat for massasaugas.



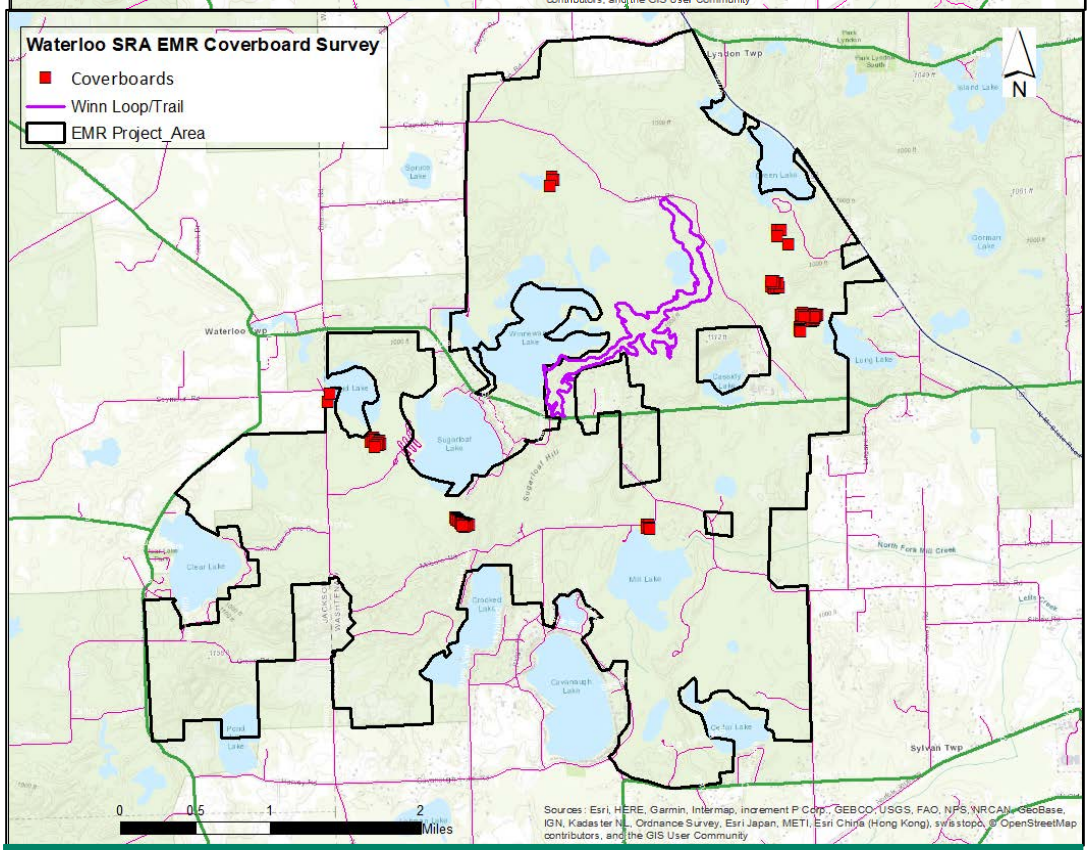


Figure 8. Maps of habitat, visual encounter and coverboard surveys in Waterloo State Recreation Area project area in 2018.

Figure 9. Examples of corrugated aluminum and carpet coverboards set at various sites and the habitats in which they were placed to survey for eastern massasaugas within the Waterloo State Recreation Area project area in 2018. (Photos by Yu Man Lee and James O'Brien.)

Visual Encounter Surveys

Visual encounter surveys were conducted by MNFI staff at nine sites with suitable or potential habitat for massasaugas primarily from September 12-21, 2018, using standard methods for surveying amphibians and reptiles (Figure 8, Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994). Visual surveys for massasaugas also were conducted by MNFI staff on April 20 while setting coverboards and by Waterloo SRA staff during coverboard surveys in 2018. Visual encounter surveys consisted of one to three surveyors walking slowly through areas with suitable habitat, looking for individuals on the surface, under cover, or in retreats (e.g., crayfish burrows). Surveys were conducted during daylight hours under appropriate weather conditions when massasaugas were expected to be active and/or visible (i.e., between 50/55-80°F [10/12.8-27°C], wind less than 15 mph, no or light precipitation) (Casper et al. 2001, Shaffer 2018). Sites were surveyed one to three times during the survey period. This resulted in a total of 31 person hours of visual surveys during September 12-21 and an additional 15 person hours of visual surveys on April 20 while setting coverboards. Survey routes and locations of observations of amphibian and reptile species were recorded using the Backcountry Navigator application on a Samsung tablet. Survey and habitat conditions and amphibian and reptile species observed during surveys were documented on field data forms, and species were photographed for documentation when possible.

Education and Outreach

Waterloo SRA staff and MNFI hosted two education and outreach programs on the eastern massasauga in 2018. Both programs were held on July 14 at the Gerald E. Eddy Discovery Center in the Waterloo SRA. One program primarily targeted the general public. This program was promoted through a statewide press release and a local event calendar for the Waterloo SRA (Appendices 10 and 11). The second program targeted neighboring residents of the recreation area. Waterloo SRA staff compiled the names and addresses of 248 neighboring residents living near the eastern boundary of the Waterloo SRA and area enrolled as Managed Lands in the EMR CCAA and sent invitation letters to these residents. The invitation letter included basic information about the eastern massasauga and a request for information about massasauga sightings within the recreation area or on adjacent lands (Appendix 12). The Waterloo SRA park manager also reached out to three lake associations (Clear Lake, Crooked Lake, Sugarloaf Lake). The Clear Lake and Crooked Lake Association representatives advised they shared the letter with their association members through an e-mail blast. The Sugarloaf Lake Association representative advised their association is informal but would share it with as many property owners as possible.

The objectives for the programs were to increase their awareness and knowledge about the status, life history and ecology of the EMR in Michigan, how to identify a massasauga and snake species that look like it, and what to do when massasauga is encountered in the wild or on their property. Information on how they can help conserve EMRs also was presented including how to report EMR sightings to the MDNR and/or MNFI. The programs also provided an opportunity for participants to see live snakes and share information about EMR sightings.

Results

Identification of Suitable EMR Habitat

Based on rapid, qualitative, visual field assessments of vegetative composition and structure, hydrology and threats, suitable or potential habitat for eastern massasaugas was found at seven of the nine sites that were surveyed in 2018 (Table 2, Figure 10). However, habitat quality or suitability for EMRs varied among sites, and in some cases, varied within different parts of the site as well (Table 2, Figures 10 and 11). Most of the sites were characterized by low canopy cover, with all but three of the sites having 0-25% canopy closure (MDNR 2017). The tamarack swamps around Hankard Lake and in the center of the wetland complex south of Sugarloaf Lake were characterized by 25-50% canopy closure, and the mixed lowland forest around Walsh Lake had 50-75% canopy closure (MDNR 2017). Four of the sites surveyed (i.e., Long Lake, east end of wetland complex south of Sugarloaf Lake, north and west/southwest of Mill Lake) were characterized by high grass/sedge cover (>40%) and low to medium amounts of low shrub cover (<40%) (MDNR 2017), which would be considered optimal to good quality or suitable habitat for massasaugas. The wetlands west/southwest of Mill Lake seemed to be very shrubby which resulted in lower habitat quality or suitability compared to wetland on north side of Mill Lake. The southern wet meadows south of Mud Lake and in the western half of the wetland complex south of Sugarloaf Lake and prairie fen along North Fork Mill Creek were characterized by medium amounts of grass/sedge cover (10-40%) and low shrub cover (10-40%) (MDNR 2017), resulting in good to marginal habitat quality or suitability. The southern wet meadows south of Mud Lake and Sugarloaf Lakes also seemed to be quite wet with standing water throughout the active season, which also may impact and reduce habitat suitability for EMRs. The southern shrub-carr located south of Green Lake had high grass/sedge cover (>70%) and high low shrub cover (40-70%, MDNR 2017), which has resulted in low to medium or marginal habitat quality or suitability. However, some areas within the Green Lake shrub-carr are more open and look like suitable habitat for EMRs. Almost all the sites surveyed are threatened by woody/shrub encroachment and invasive plant species, primarily glossy buckthorn (*Frangula alnus*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), and/or hybrid cat-tail (*Typha xglauca*).

Although the vegetative structure and composition in parts of the wetland around the Winnewana Lake/ Impoundment west of the Winn Loop may be suitable for EMRs, the wetland is densely vegetated, may be too wet, and does not appear to be suitable or likely habitat for EMRs. The overall wetland is characterized by low canopy cover (0-25%), medium grass/sedge cover (10-40%) and medium low shrub cover (10-40%) (MDNR 2017). However, the herbaceous vegetation in this wetland is very tall and dense, and parts of the wetland are very shrubby (Figure 11). Standing water was present in the wetland during surveys in the spring and fall, and common arrowhead (*Sagittaria latifolia*), a plant generally found in shallow water and shores of lakes, ponds, ditches, streams, rivers, swamps, marshes, and bogs, was observed in the wetland.

Table 2. Summary of sites that were surveyed to identify suitable habitat for eastern massasaugas (EMRs) within the Waterloo State Recreation Area project area in 2018.

Survey Sites	Presence of Suitable Habitat & Habitat Quality/Suitability	Habitat Type & Brief Description / Notes[1]	Threats
Long Lake – North side	Yes - High-Medium / Optimal-Good	Prairie fen - MNFI natural community EO, high quality habitat in parts of the site	ATV use, woody/shrub encroachment, esp. in south/west half, invasive species, hydrological alteration
North Fork Mill Creek – East of Bush Rd	Yes - High-Medium / Good	Prairie fen - transitioning to rich tamarack swamp; very diverse, high quality prairie fen to east on private property	Woody/shrub encroachment, invasive species
Hankard Lake – East side	Yes / Medium / Good	Small pockets of prairie fen within rich tamarack swamp complex; diverse	Woody/shrub encroachment, invasive species
Sugarloaf Lake – South side	Yes - Medium / Good	Southern wet meadow transitioning to shrub carr, part of tamarack swamp complex; dense poison sumac E. end	Woody/shrub encroachment; invasive species
Mud Lake – South & NW sides	Yes - Medium / Good-Marginal	Southern wet meadow – high quality; good vegetative structure but very wet in parts	Woody/shrub encroachment, invasive species
Mill Lake – North side & SW side (N.half)	Yes - North – High-Med/Good; SW – Med-Low/ Good-Marginal	Rich tamarack swamp complex with emergent, wet meadow, shrub carr and fen zones; W. side very shrubby	Woody/shrub encroachment, invasive species, likely hydrological alteration
Green Lake	Yes - Low-Med / Marginal	Southern shrub-carr; prairie fen historically; very shrubby	Woody/shrub encroachment
Walsh Lake	No / Not likely - Low / Poor	Rich tamarack swamp & shrub carr; very thick & tall	Shrub encroachment, invasive species
Winnewana Lake / Impoundment	No / Not likely - Low / Poor	Southern wet meadow & shrub-carr; seems too wet	Hydrological alteration (flooding), shrub encroachment

[1]Habitat types, descriptions, and threats are based on field surveys in 2018 and notes in MiFI database (MDNR 2017) and Cohen et al. (2012).

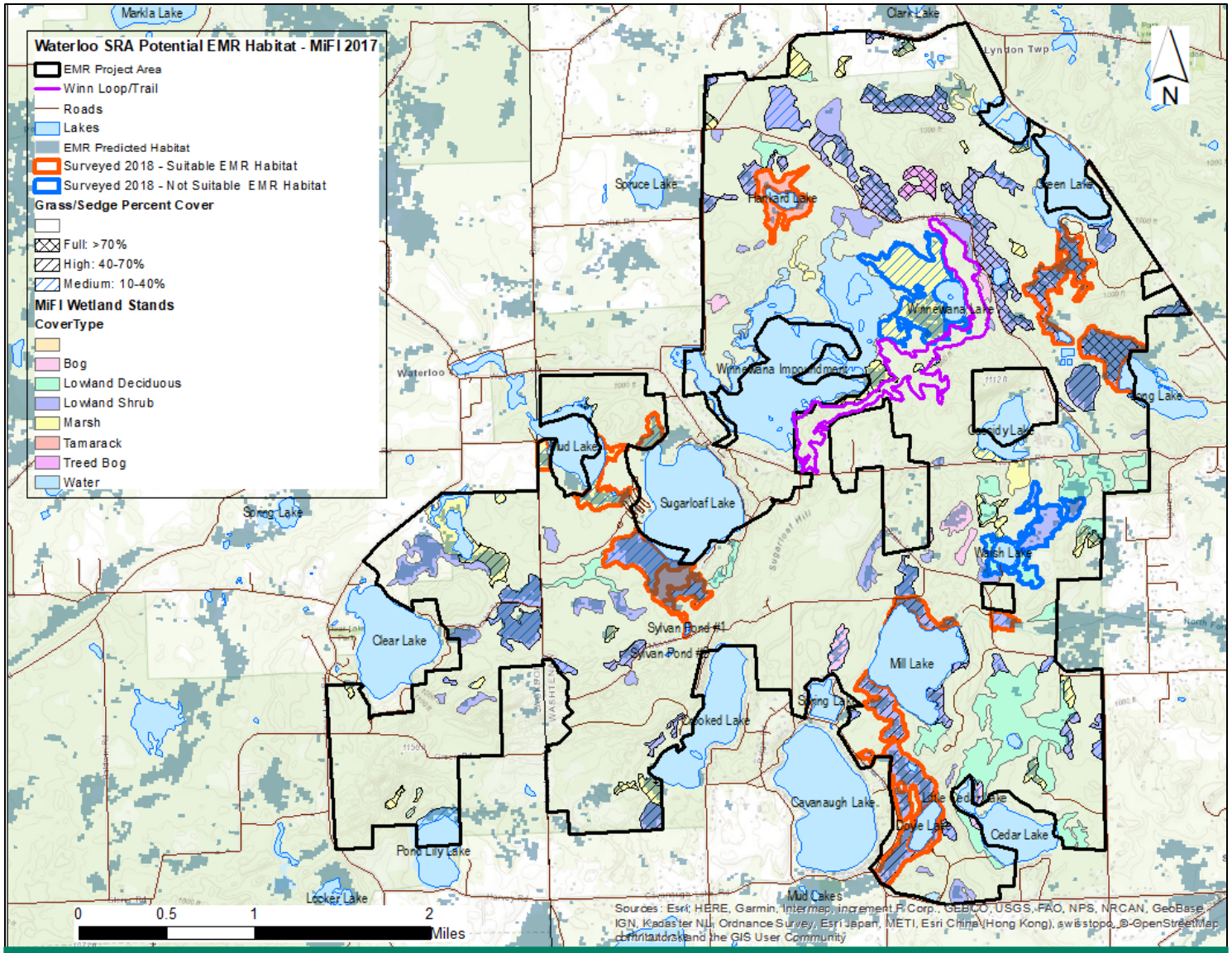


Figure 10. Map showing results of surveys to identify suitable habitat for eastern massasaugas within the Waterloo State Recreation Area project area in 2018 based on wetland stands identified in MiFI (2017) and predicted EMR habitat based on model developed by McCluskey (2016).

Figure 11. Photos of examples of suitable EMR habitat at Long Lake (top left) and North Fork Mill Creek (top right) and not suitable/not likely EMR habitat at Winnewana Lake/Impoundment (bottom photos). (Photos by Yu Man Lee.)

Coverboard Surveys

No eastern massasaugas or other rare herp species were documented during coverboard surveys in Waterloo SRA in 2018. Surveys were able to document six DeKay's brown snakes (*Storeria dekayi*), four northern ribbon snakes (*Thamnophis saurita septentrionalis*), and ten eastern garter snakes (*Thamnophis sirtalis sirtalis*) under coverboards (Table 3, Figure 12). Four snake sheds or skins, including two that were likely from a garter snake and a northern water snake (*Nerodia sipedon sipedon*), a blue-spotted salamander (*Ambystoma laterale*), and a northern leopard frog (*Lithobates pipiens*) also were found under coverboards (Table 3). Additionally, while conducting coverboard surveys, three northern water snakes and a brown snake were encountered incidentally crossing roads, and a blue racer (*Coluber constrictor foxii*) was found dead on a road.

Table 3. Summary of survey sites, number of coverboards set, and amphibians and reptiles found during coverboard surveys for eastern massasaugas within the Waterloo State Recreation Area project area in 2018.

Survey Sites	Number of Coverboards	Species and Number of Amphibians and Reptiles Found
Long Lake Fen North	21	DeKay's brown snake – 1 Northern ribbon snake – 1 Eastern garter snake – 1 Snake shed - 1
Long Lake Fen South	4	None found
Long Lake Fen Uplands	10	Eastern garter snake – 1 Blue-spotted salamander - 1
Green Lake	10	Northern ribbon snake - 1
Hankard Lake	5	DeKay's brown snake – 2 Northern ribbon snake – 2 Eastern garter snake – 4 Snake sheds – 2 (likely from a northern water snake and a garter snake)
Sugarloaf Lake	16	Unidentified snake - 1
Mud Lake Northwest	4	None found
Mud Lake South	12	DeKay's brown snake – 3 Eastern garter snake – 4 Snake shed – 1 Northern leopard frog - 1
Mill Lake	5	None found
TOTAL	**87**	DeKay's brown snake – 6 Northern ribbon snake – 4 Eastern garter snake – 10 Snake sheds – 4 Blue-spotted salamander – 1 Northern leopard frog - 1

Figure 12. Photos of eastern garter snake and DeKay's brown snake found under coverboards during coverboard surveys for eastern massasaugas at Waterloo State Recreation Area in 2018. (Photos by James O'Brien.)

Visual Encounter Surveys

No eastern massasaugas or other rare amphibians or reptiles were observed during visual encounter surveys in the Waterloo SRA project area in 2018. Surveys did document two eastern garter snakes, a spring peeper (*Pseudacris crucifer*), and blue-spotted salamander under a coverboard incidentally. Visual surveys also documented suitable habitat for massasaugas at a number of survey sites (Table 2, Figure 10).

Education and Outreach

The massasauga education and outreach programs had varied results in terms of attendance but were able to generate additional information on massasauga sightings within and adjacent to Waterloo SRA and in other areas as well. The massasauga program primarily targeting the general public had 37 participants, including adults and youth, and was very well-received by those who attended (Figure 13). Only nine people, however, attended the program for neighboring residents, of which only two were neighboring property owners. The other participants were visitors to the Eddy Discovery Center. The two property owners were interested in learning more about the EMR but did not have sighting information to share.

Two reliable reports of eastern massasaugas within the Waterloo SRA project area were obtained due to the EMR education and outreach programs in 2018 and subsequent publicity. One report came from Tom Hodgson, a former interpreter or naturalist at the Eddy Geology Center from 1965 to 1980, who attended the EMR program for the general public. He provided great information on EMRs at Waterloo SRA. He advised he used to see them near the Mill Lake Outdoor Center while providing presentations in the spring. He also reported he would be called upon to move them out of Sugarloaf's Campground and relocate them within Waterloo SRA where Moeckel Road intersects with Mt. Hope Road. He indicated his last sighting of an EMR in the area was in 2007 when he found a dead juvenile in the road at the entrance of the Eddy Center on Bush Road. He turned the snake over to the Eddy Center staff. However, this sighting was either not reported to MNFI or was not entered into Michigan's Natural Heritage Database (NHD) prior to this project. This sighting has now been mapped and entered into the NHD.

A second reliable report of an EMR in the Waterloo SRA project area came from a neighboring resident to the recreation area who did not attend one of the EMR programs but heard about MDNR's interest in obtaining EMR reports from the invitation letter and/or news article in a local newspaper that was published after the education and outreach programs (Appendix 13). This report was of an eastern massasauga road mortality from 2017 on Lingane Road near North Fork Mill Creek and included photo documentation. This report was mapped and entered into the NHD.

As a result of two articles on the EMR that were published in a local newspaper (i.e., The Sun Times News) this summer, three additional verified reports of EMRs in other locations outside of Waterloo SRA were emailed to the Waterloo SRA park manager and MNFI. One news article

was about the eastern massasauga and the education and outreach program at the Eddy Center (Appendix 13). The second article was about an eastern massasauga that was found along a trail in Dexter, which was reported to and verified by Waterloo SRA and MNFI staff. The three verified eastern massasauga sightings were from Pinckney, Dexter and Tecumseh. These reports have been or will be entered into the NHD. The newspaper articles also generated at least 12 additional reports of eastern massasaugas that were submitted to the Waterloo SRA park manager and MNFI staff. These reports were of snakes that came from places outside of Waterloo SRA and were not verified with photos or were other look-alike snake species and not massasaugas.

Figure 13. Photos from the eastern massasauga education and outreach program for the general public organized and presented by Waterloo SRA and MNFI staff at the Eddy Discovery Center in Waterloo SRA on July 14, 2018. (Photos by James O'Brien/Kathleen McGlashen.)

Discussion

The goal of this project was to get a better understanding of the current status and distribution of eastern massasaugas (EMRs) within the Waterloo SRA project area to inform management and conservation of this species. This information is critical given most of the project area's designation as Managed Lands in Michigan's EMR CCAA. This information would be used to evaluate potential impacts of projects and activities on EMRs and plan and implement them to minimize the potential for adverse impacts on the species. Results and findings from this project will be used to assess potential impacts of mountain bike trails, such as the recently constructed Winn Loop and proposed Sugarloaf Loop, on EMRs in the project area and plan construction and maintenance of these trails to minimize adverse impacts on the species.

Although surveys in 2018 were not able to reconfirm EMRs in the Waterloo SRA project area, education and outreach efforts conducted as part of this project resulted in verified massasauga reports from the public reconfirming the species' presence within the project area. Prior to this project, massasaugas had been documented from three sites or areas within the project area (MNFI 2018). Massasaugas were last documented at two of these areas in the late 1950s and at one area in 1996 (MNFI 2018). The EMR reports obtained during this project documented observations of this species in 2007 and 2017 in the vicinity of the area in which EMRs had been last documented in 1996 (i.e., Mill Lake area). Surveys in 2018 documented suitable and high to moderate quality habitat in the vicinity of these sightings (i.e., Mill Lake North and West, North Fork Mill Creek). Surveys should continue to determine the distribution and extent of EMRs in this area.

Surveys conducted in 2018 at or in the vicinity of the other two areas at which EMRs have been documented in the past were not able to reconfirm the species' presence but did document the presence of suitable habitat and potential for EMRs to still occur at these sites. These include wetlands north of Long Lake, south and west of Mud Lake, and south of Sugarloaf Lake. The quantity and/or quality of EMR habitat at these sites have been reduced due to shrub encroachment, invasive species and/or hydrological alterations. Runoff (e.g., nutrients) from adjacent agricultural lands and residential areas also may be contributing to or exacerbating these threats. However, massasaugas have been found in habitats or sites that have been degraded or classified as marginal or poor habitat suitability (e.g., due to high woody stem density) based on a habitat suitability index developed for EMRs in southern Michigan (Bissell 2006, Bailey 2010, Shaffer 2018). Shaffer (2018) found that massasaugas are able to continue to persist in degraded or lower quality sites by finding and utilizing patches of suitable habitat within the degraded sites.

Potential exists for eastern massasaugas to occur at additional sites within the Waterloo SRA project area. Suitable but degraded habitat for EMRs was found in 2018 at other sites within the project area at which EMRs have not been documented in the past according to the NHD (MNFI 2018). These include wetlands south of Green Lake and around Hankard Lake. Additional sites within the project area also may have suitable habitat for EMRs and potential for the species to

occur at these sites. Based on wetland/land cover data, stand information in MiFI (MDNR 2017) and predicted EMR habitat based on McCluskey's massasauga habitat model (McCluskey 2016), additional sites with potential habitat for EMRs include the northwest side of Sugarloaf Lake, northeast side of Mud Lake, southeast corner of Mill Lake, south end of Crooked Lake, west of Doyle Lake, wetlands east of Cassidy Road between Cassidy Lake and Green Lake/Long Lake, wetlands along the north side of Cassidy Road east of Hankard Lake, and wetlands north of the DTE Trail north of Cassidy Road and south of North Territorial Road (see Figure 8). Surveys should be conducted in these areas in the future to determine if EMRs occur at these sites and assess the presence and condition of suitable habitat for EMRs.

The wetland at the northeast end of Winnewana Lake/Impoundment west of the Winn Loop Trail and south of Sugarloaf Lake west of the proposed Sugarloaf Loop Trail were surveyed in 2018 to assess and determine if EMRs and/or suitable habitat for the species occur in these areas. This wetland did not seem to be suitable or likely habitat for EMRs based on the presence of tall, thick vegetation, minimal thatch or dead herbaceous vegetation layer, and wetness of the site (i.e., site seemed to be wet based on presence of standing water year-round and certain plant species associated with very wet conditions). Additionally, the adjacent upland habitat in which the Winn Loop is located consists of fairly mature, closed canopy mesic southern forest. Massasaugas in Michigan generally only use this type of habitat for overwintering, typically along or near the forest-wetland edge (on average, within 300-500 m [0.2-0.3 mi] of wetland edge, Sage 2005, Smith 2009), or briefly in the spring and/or fall when moving between hibernacula and summer activity areas. The wetlands east of the north end of the Winn Loop and west of Cassidy Road were not surveyed in 2018 but they may not be suitable habitat for EMRs based on aerial imagery, information on these wetlands in MiFI (MDNR 2017), and the EMR predicted habitat model (McCluskey 2016). However, other wetlands in the vicinity of the Winn Loop and the DTE Energy Foundation Trail north of Cassidy Road may provide suitable habitat for EMRs and should be surveyed in the future.

Additional surveys of the wetlands on the south side of Sugarloaf Lake and north side of Mill Lake also should be conducted to determine if massasaugas occur in these areas. Suitable habitat for massasaugas were found in these areas during surveys in 2018 but coverboard and limited visual encounter surveys did not detect EMRs in these areas. This information could help inform construction and/or maintenance of the proposed Sugarloaf Trail. However, activities that occur on the surface or above ground in upland areas with unsuitable habitat (e.g., active agricultural lands, row crops) or in upland areas located greater than 800 m – 1 km (0.5-0.6 mi) from suitable wetland habitat for EMRs should have minimal impact on or low potential for impacting massasaugas in southern Michigan.

Given the cryptic nature of EMRs and limited surveys for EMRs in 2018, additional surveys should be conducted to further investigate and determine the species' current status and distribution within the Waterloo SRA project area. Casper et al. (2001) recommends a minimum accumulation of forty person hours at a site distributed over a standard (April-October) field season before any evaluations are made regarding the presence/absence of massasaugas. The majority of these hours should be spent in two time windows reflecting presumed

maximum activity levels of the massasauga: 1) spring emergence, 2) mid- to late summer basking and birthing period (Casper et al. 2001). If massasaugas are not found, Casper et al. (2001) recommend continuing this minimum survey effort at a site for ten years before evaluating the likelihood of population extirpation. Continuing negative results after ten survey years should be interpreted to mean that the population can be considered "extirpated for management purposes," and that no management response is recommended (Casper et al. 2001). Casper et al. (2001) also recommend that a determination of permanent population extirpation should require either a minimum of fifteen years of negative survey data, or unequivocal evidence and consensus that habitat losses (complete habitat destruction/ development) at the site have been so great that a population could not persist. Shaffer (2018) also recommends dividing sites into 2-ha (5 ac) survey units or subsites, surveying these 2-ha units using transects for at least 90 minutes per survey, and surveying when air temperatures are between 13 and 21°C (55-70°F) to maximize detection of EMRs.

Future surveys for eastern massasaugas in the Waterloo SRA project area should incorporate coverboard and visual encounter surveys if possible. As mentioned earlier, eastern massasaugas are very cryptic and can be difficult to detect in the field, particularly in areas with small population sizes or densities and/or dense vegetation. In the past, surveys using artificial cover objects or coverboards have been reported as less effective for detecting EMRs in Michigan compared to other states (e.g., Ohio) or other methods such as visual encounter surveys (Casper et al. 2001). But recent studies in Michigan have found that surveys using artificial cover objects or coverboard surveys can be effective at finding EMRs in certain habitats and/or under certain conditions (Hileman pers. comm.) and more effective than visual encounter surveys at detecting certain groups of EMRs (i.e., females, Bartman et al. 2016). Additional investigation of the use and effectiveness of artificial cover objects or coverboards for finding EMRs is warranted. Coverboard surveys can supplement visual surveys and increase chances detecting EMRs at a site (Bartman et al. 2016). Increasing the number and density of coverboards at a site and checking coverboards more frequently would likely increase the probability of detecting massasaugas at individual sites. Given limited time and resources, focusing coverboard surveys on a smaller number of sites may be beneficial.

Finally, management to reduce encroachment of shrubs, trees and invasive species and maintain open vegetative structure with some cover (e.g., thatch/dead herbaceous vegetation, live herbaceous vegetation, shrubs, trees and/or downed woody debris) and retreats (e.g., crayfish/small mammal burrows) for thermoregulation and refugia would increase habitat quality and quantity for EMRs in the project area. Habitat management can increase habitat use by massasaugas (e.g., Dovčiak et al. 2013) and individual fitness (Johnson et al. 2016) if implemented appropriately (e.g., properly timing prescribed burns or mowing; Durbian 2006, Bailey et al. 2012). For example, Johnson et al. (2016) observed increased use of basking areas that had been managed (i.e., shrub removal) compared to unmanaged areas in a New York population of massasaugas, which could contribute to increased detectability of the species. Furthermore, reducing stem density can directly affect basal area and indirectly affect live and dead herbaceous cover, resulting from a decrease in canopy cover, and improve habitat suitability for massasaugas (Shaffer 2018).

Acknowledgements

This project was funded by the Michigan Department of Natural Resources (MDNR), Parks and Recreation Division (PRD). We would like to thank Glenn Palmgren and James O'Brien with MDNR PRD for initiating, sponsoring, and administering the project. We also would like to sincerely thank and recognize James O'Brien for all his hard work conducting the coverboard survey portion of this project and assistance with identifying areas with potential habitat for eastern massasaugas for the coverboard and visual surveys. James also was instrumental in implementing the education and outreach portions of this project by helping to organize and host the outreach programs, identifying and inviting neighboring residents and lake associations, and responding to massasauga reports that resulted from the education and outreach efforts. We also would like to recognize and thank additional Waterloo SRA staff who assisted with the coverboard surveys and/or education and outreach portions of this project including Greg Byce, Kathleen McGlashen, and Katlyn Naughton. AmeriCorps members with MNFI, Dan Earl and Kailyn Atkinson, provided assistance with setting coverboards and conducting visual encounter surveys. MNFI staff, Kraig Korroch, Ashley Adkins, Nancy Toben, Brian Klatt, provided administrative and computer support. We also sincerely thank Lynne Beauchamps with The Sun Times News for assisting with outreach efforts by writing two articles on the eastern massasauga and this project which resulted in a number of massasauga and other snake reports from local residents and the public. Finally, we thank all the people who attended the massasauga education programs at the Eddy Discovery Center or submitted massasauga reports to assist with this project.

Literature Cited

Bailey, R.L. 2010. Modeling habitat suitability and population demographics of the eastern massasauga rattlesnake in managed lands in southwestern Michigan. M.S. Thesis, Michigan State University. 12 pp.

Bartman, J.F., N. Kudla, D.R. Bradke, S. Otieno, and J.A. Moore. 2016. Work smarter, not harder: Comparison of visual and trap survey methods for the Eastern Massasauga Rattlesnake (*Sistrurus catenatus*). Herpetological Conservation and Biology 11:451–458.

Bissell, K.M. 2006. Modeling habitat ecology and population viability of the eastern massasauga rattlesnake in southwestern Lower Michigan. M.S. Thesis, Michigan State University. 124 pp

Campbell, H.W. and S.P. Christman. 1982. Field techniques for herpetofaunal community analyses. Pages 193-200 in N.J. Scott, Jr., ed. Herpetological Communities, USDI Fish and Wildlife Service, Wildlife Research Report 13, Washington, D.C. 239 pp.

Casper, G.S., T.G. Anton, R.W. Hay, A.T. Holycross, R.S. King, B.A. Kingsbury, D. Mauger, C. Parent, C.A. Phillips, A. Resetar, R.A. Seigel, T.P. Wilson. 2001. Recommended standard survey protocol for the eastern massasauga, Sistrurus catenatus catenatus. Report for the Milwaukee Public Museum, Milwaukee, Wisconsin, USA.

Cohen, J.G., B.S. Slaughter, and M. A. Kost. 2012. Natural Community Surveys of Known Element Occurrences on State Park and Recreation Area Lands. Michigan Natural Features Inventory, Report Number 2012-1, Lansing, MI. 109 pp.

Cooper, J.L., P.J. Higman, J. Spieles, M.R. Penskar, D.L. Cuthrell, Y. Lee, D.A. Albert, and L. Peltz-Lewis. 2000. Inventory and Management Recommendations for Pinckney and Waterloo State Recreation Areas' Natural Communities, Rare Plants, and Rare Wildlife. Michigan Natural Features Inventory, Report Number 2000-07, Lansing, MI. 98 pp.

Corn, P.S. and R.B. Bury. 1990. Sampling methods for terrestrial amphibians and reptiles. USDA Forest Service, Gen. Tech. Rep. PNW-GTR-256. 34 pp.

Crump, M.L. and N.J. Scott. 1994. Visual encounter surveys. Pages 84-92 in W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster, eds. Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. Smithsonian Institution Press, Washington, D.C.

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

Dovčiak, M., P.A. Osborne, D.A. Patrick, J.P. Gibbs. 2013. Conservation potential of prescribed fire for maintaining habitats and populations of an endangered rattlesnake Sistrurus c. catenatus. Endangered Species Research 22:51-60.

Durbian, F. E., R. S. King, T. Crabill, H. Lambert-Doherty, and R. A. Seigel. 2008. Massasauga home range patterns in the Midwest. Journal of Wildlife Management 72(3):754-759.

Ernst, C.H. and E.M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Institution, Washington, D.C. 668 pp

Hallock, L.A. 1991. Habitat utilization, diet and behavior of the eastern massasauga (*S. c. catenatus*) in southern Michigan. M.S. Thesis, Michigan State University. 31 pp.

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

Harvey, D.S. and P.J. Weatherhead. 2006. Hibernation site selection by eastern Massasauga Rattlesnakes (*Sistrurus catenatus catenatus*) near their northern range limit. Journal of Herpetology 40: 66-73.

Johnson, G. 1995. Spatial ecology, habitat preference, and habitat management of the eastern massasauga, *Sistrurus c. catenatus*, in a New York weakly-minerotrophic peatland. Dissertation. SUNY, College of Environmental Science and Forestry, Syracuse, NY. 222 pp.

Johnson, G. 2000. Spatial ecology of the eastern massasauga (*Sistrurus c. catenatus*) in a New York peatland. Journal of Herpetology 34:186−92.

Johnson, G., B. Kingsbury, R. King, C. Parent, R.A. Seigel, and J. Szymanski. 2000. The Eastern Massasauga Rattlesnake: A Handbook for Land Managers. U.S. Fish & Wildlife Service, Fort Snelling, MN, vi, 52 pp., plus 6 appendices.

Marshall, J.C., Jr., J.M. Manning, and B.A. Kingsbury. 2006. Movement and macrohabitat selection of the Eastern Massasauga in a fen habitat. Herpetologica 62:141-150.

McCluskey, E.M. 2016. Landscape ecology approaches to Eastern Massasauga Rattlesnake conservation. PhD dissertation, Ohio State University. 128 pp.

McCluskey, E.M., S.N. Matthews, I.Y. Ligocki, M.L. Holding, G.J. Lipps, Jr., and T.E. Hetherington. 2018. The importance of historical land use in the maintenance of early successional habitat for a threatened rattlesnake. Global Ecology and Conservation 13:1-11.

Michigan Department of Natural Resources [MDNR]. 2016. Candidate Conservation Agreement Assurances for the Eastern Massasauga Rattlesnake in Michigan, Lansing, MI. 58 pp.

Michigan Department of Natural Resources [MDNR]. 2017. Michigan Forest Inventory (MiFI) data. Lansing, MI.

Michigan Natural Features Inventory. 2018. Michigan Natural Heritage Database, Lansing, MI.

Moore, J. A. and J. C. Gillingham. 2006. Spatial ecology and multi-scale habitat selection by a threatened rattlesnake: The eastern massasauga (Sistrurus catenatus catenatus). Copiea 2006(4):742-751.

MRLC. 2015. National Land Cover Database 2006; Multi-Resolution Land Characteristics Consortium. Available at: http://www.mrlc.gov/index.php.

National Oceanic and Atmospheric Administration [NOAA], Office for Coastal Management. 2018. NOAA's Coastal Change Analysis Program (C-CAP) 2016 Regional Land Cover Data - Coastal United States from 2010-06-15 to 2010-08-15. NOAA National Centers for Environmental Information, https://inport.nmfs.noaa.gov/inport/item/48336.

Reinert, H.K. and W.R. Kodrich. 1982. Movements and habitat utilization by the massasauga, *S. c. catenatus.* Journal of Herpetology 16: 162-171.

Sage, J. R. 2005. Spatial ecology, habitat utilization, and hibernation ecology of the Eastern Massasauga Rattlesnake (Sistrurus catenatus catenatus). M.S. Thesis, Indiana-Purdue University, Ft. Wayne. 54 pp.

Shaffer, S.A. 2018. Eastern Massasauga Rattlesnake population and habitat ecology in southern Michigan. PhD Dissertation, Michigan State University, Lansing, MI. 189 pp.

Smith, C.S. 2009. Hibernation of the Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*) in Northern Michigan. M.S. Thesis, Purdue University, Ft. Wayne, IN. 44 pp.

Szymanski, J.A. 1998. Status assessment for the eastern massasauga (*Sistrurus c. catenatus*). U.S. Fish and Wildlife Service, Fort Snelling, MN. 19 pp + apps.

Szymanski, J. A., C. Pollack, L. Ragan, M. Redmer, L. Clemency, K. Voorhies, and J. JaKa. 2016. Species Status Assessment for the Eastern Massasauga Rattlesnake (*Sistrurus catenatus*). SSA Report Version 2 July 2016. 103 pp.

United States Fish and Wildlife Service [USFWS]. 2015. National Wetlands Inventory (NWI) website. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. http://www.fws.gov/wetlands/

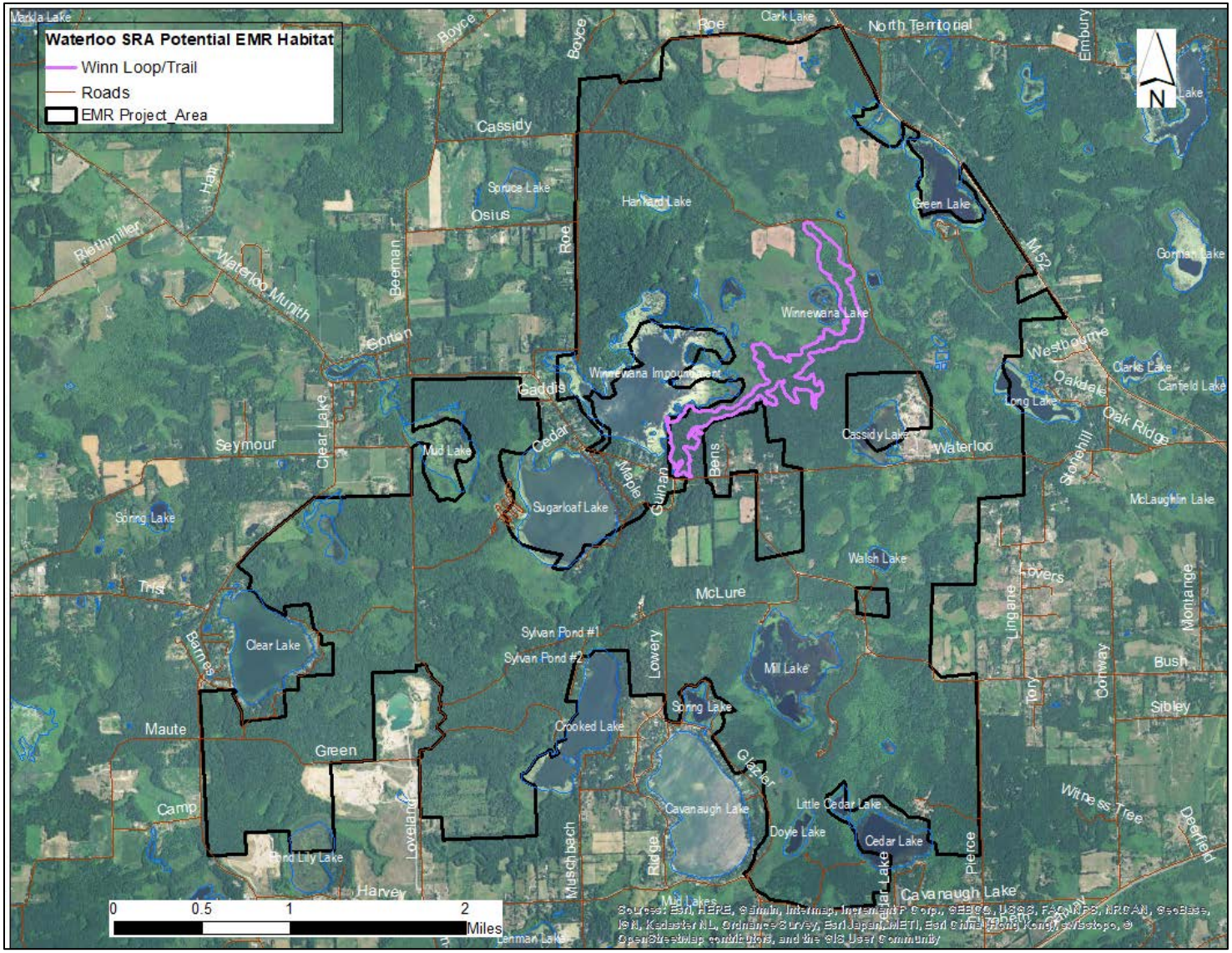
United States Fish and Wildlife Service [USFWS]. 2016. Endangered and Threatened Wildlife and Plants; Threatened Species Status for the Eastern Massasauga Rattlesnake. Federal Register 81(190):67193-67214. September 30, 2016.

United States Fish and Wildlife Service [USFWS]. 2017.Environmental screening for eastern massasauga rattlesnake in Michigan. March 14, 2017. 13 pp.

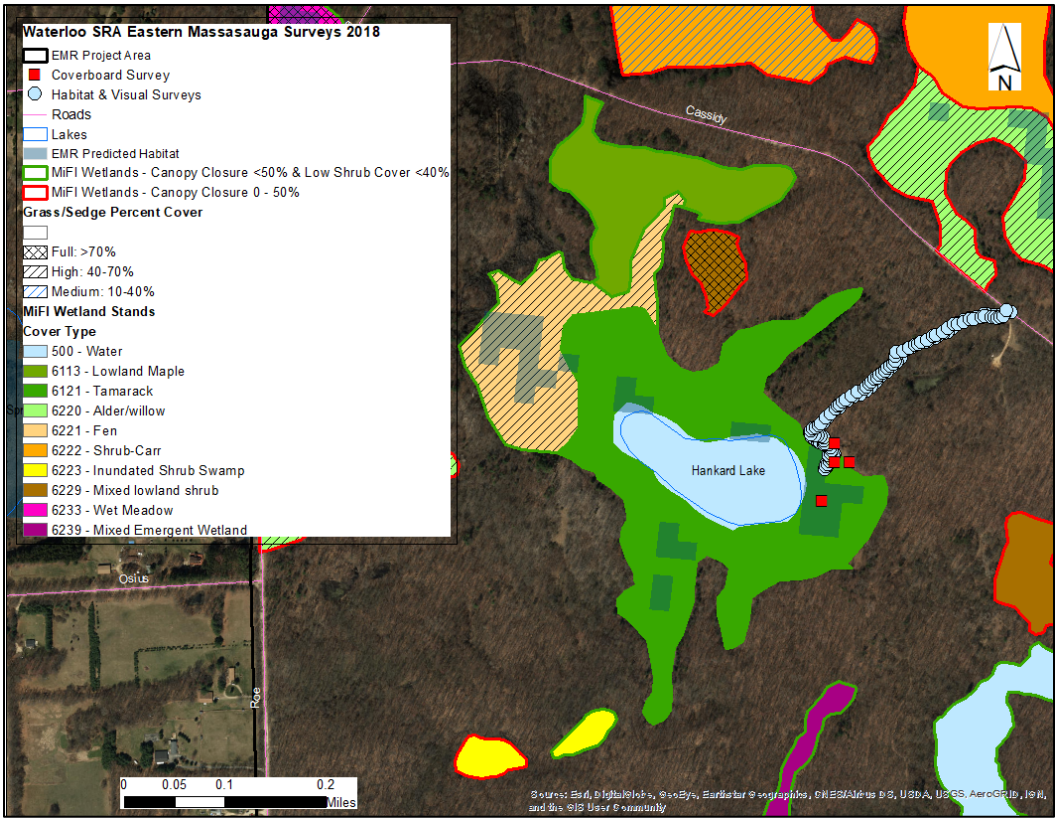
Weatherhead, P.J. and K.A. Prior. 1992. Preliminary observations of habitat use and movements of the Eastern Massasauga Rattlesnake (*Sistrurus catenatus catenatus*). Journal of Herpetology 26(4): 447-452.

Appendices

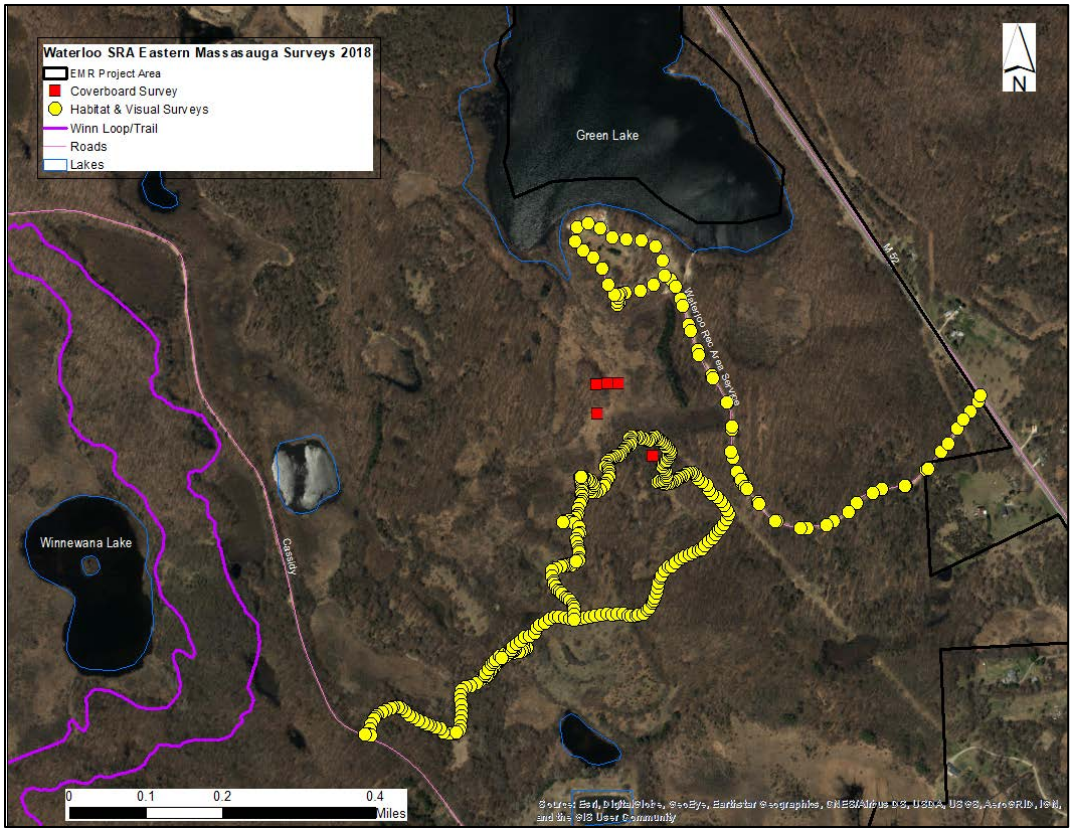
Appendix 1. Aerial imagery of Eastern Massasauga Surveys and Outreach Project Area in the Waterloo State Recreation Area, Chelsea, MI.

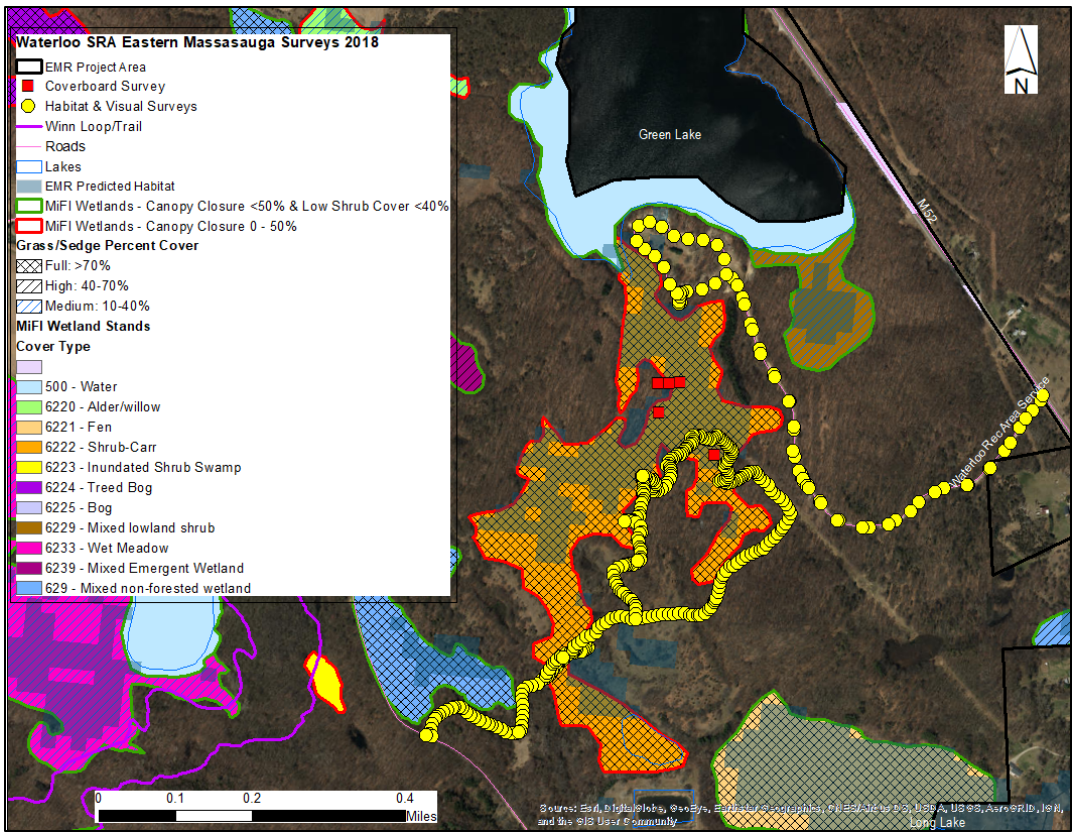


Appendix 2. Maps showing locations of visual encounter and coverboard surveys for EMRs at Hankard Lake in the Waterloo SRA Project Area.

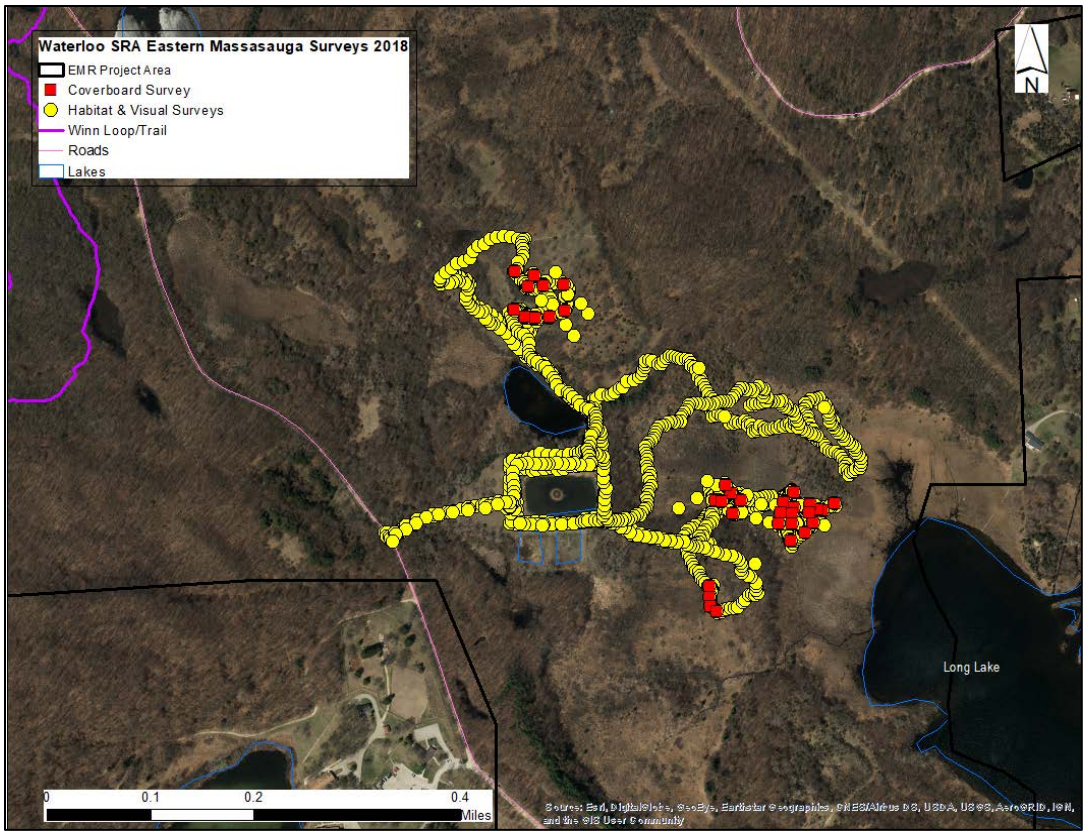


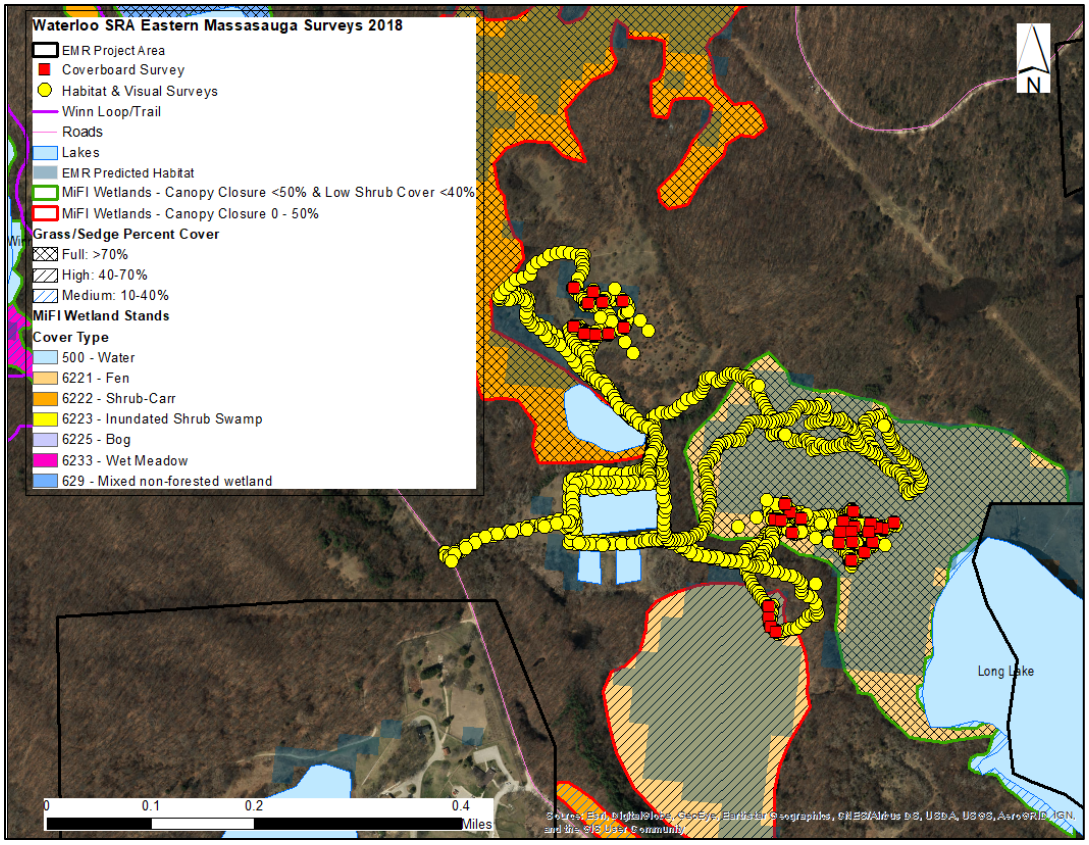
Appendix 3. Maps showing locations of visual encounter and coverboard surveys for EMRs at Green Lake in the Waterloo SRA Project Area.



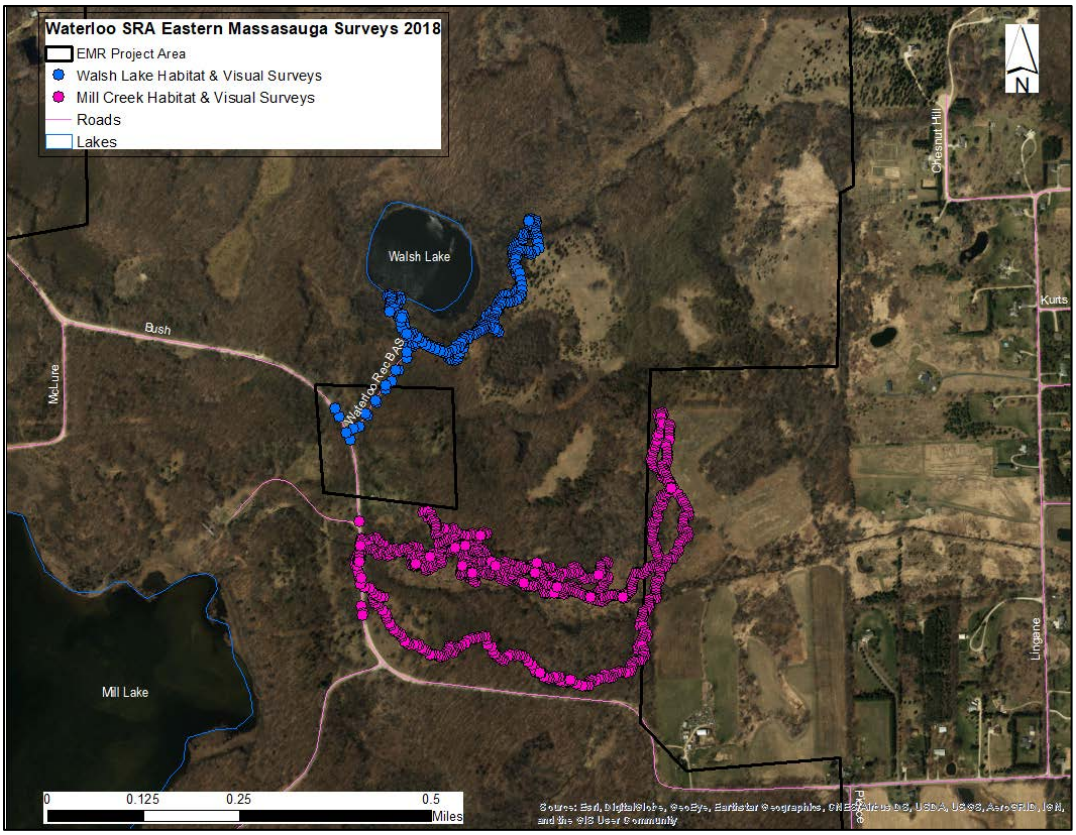


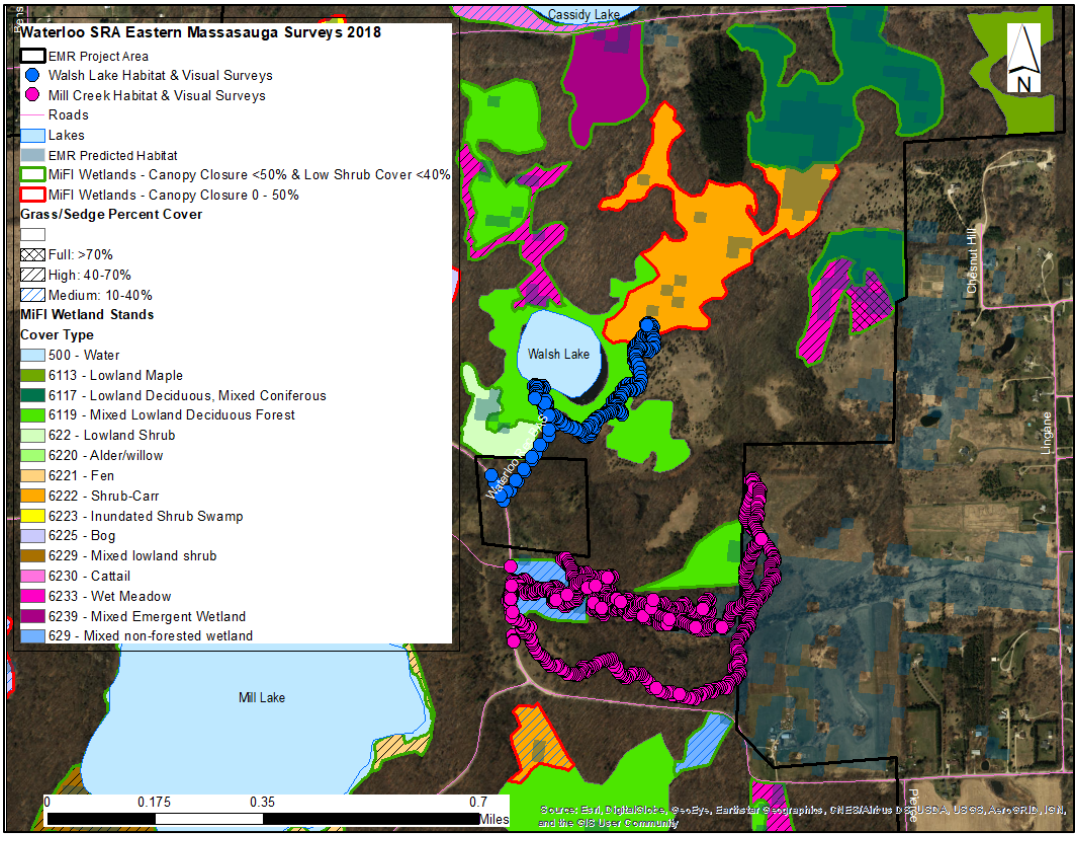
Appendix 4. Maps showing locations of visual encounter and coverboard surveys for EMRs at Long Lake in the Waterloo SRA Project Area.



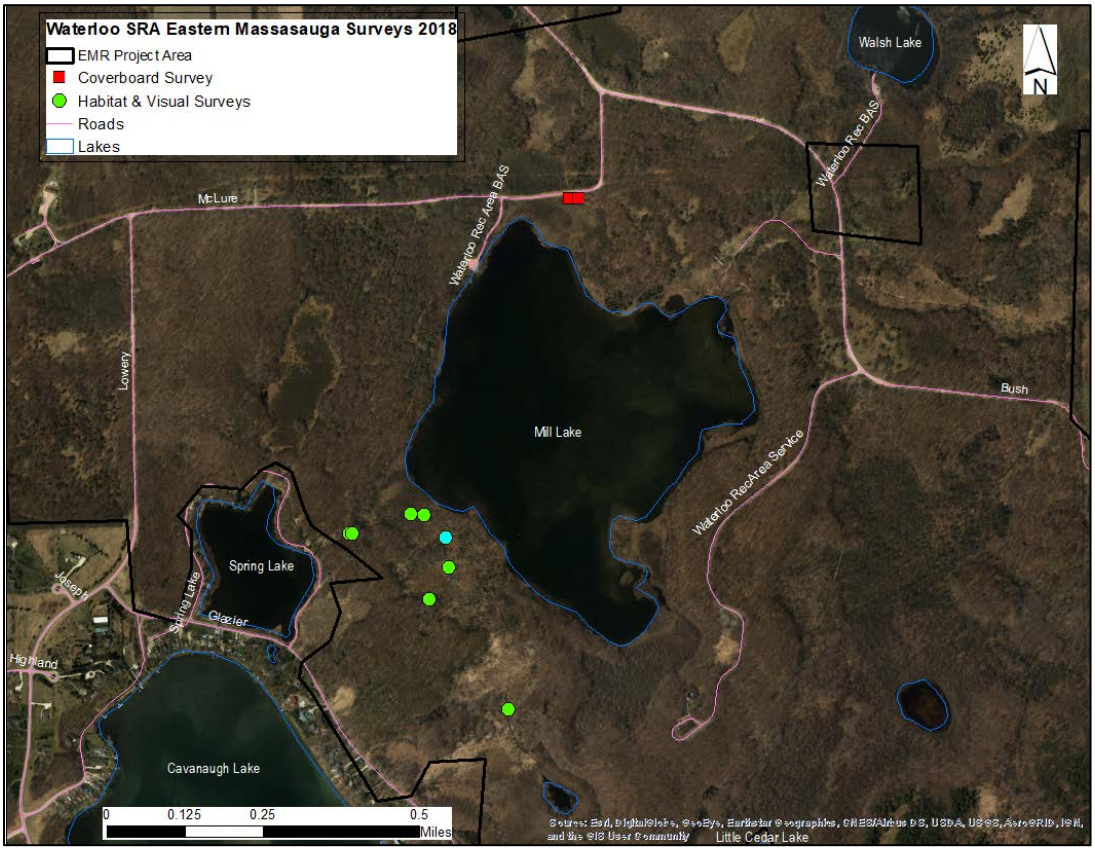


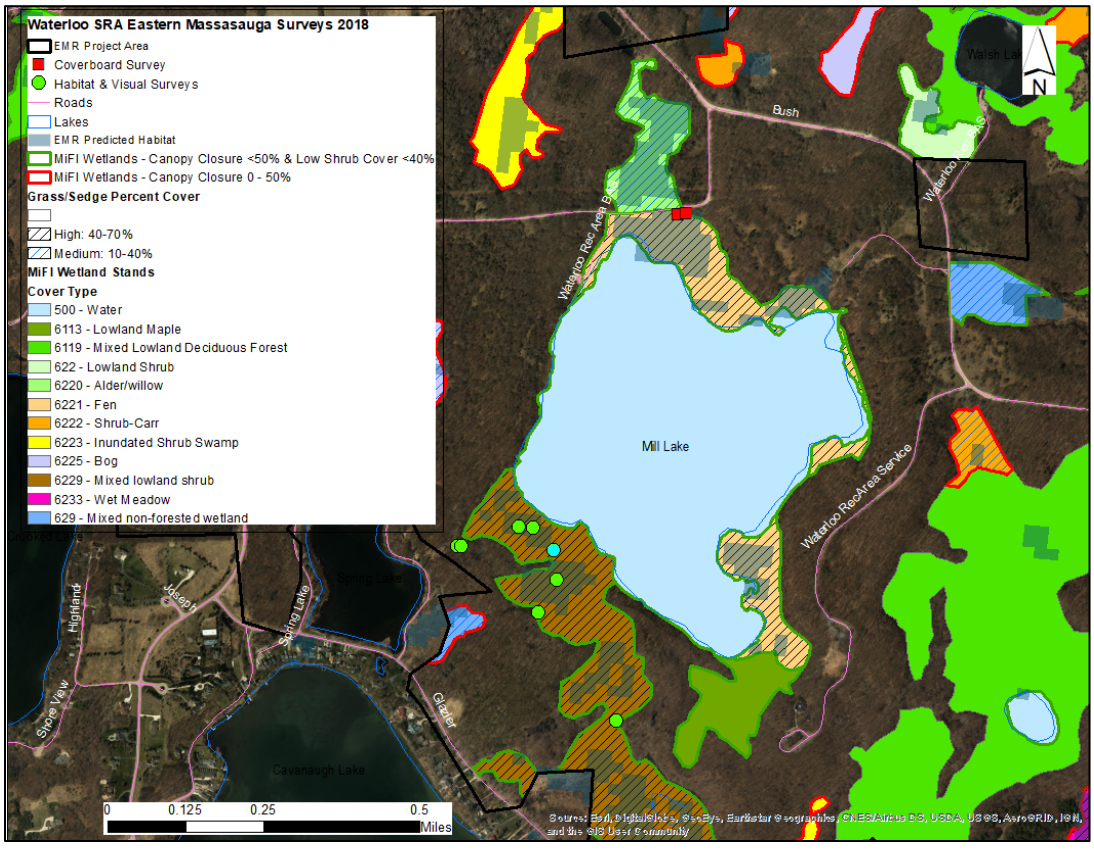
Appendix 5. Maps showing locations of visual encounter and coverboard surveys for EMRs at Walsh Lake & Mill Creek in the Waterloo SRA Project Area.



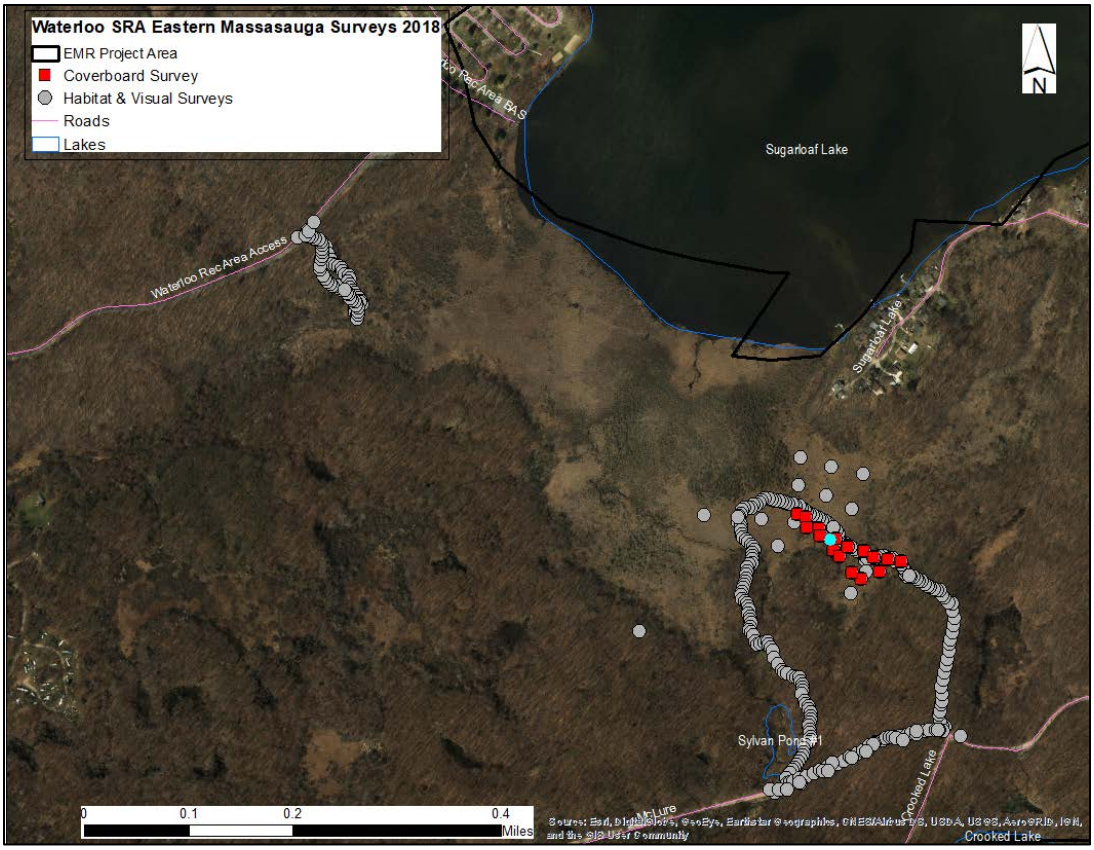


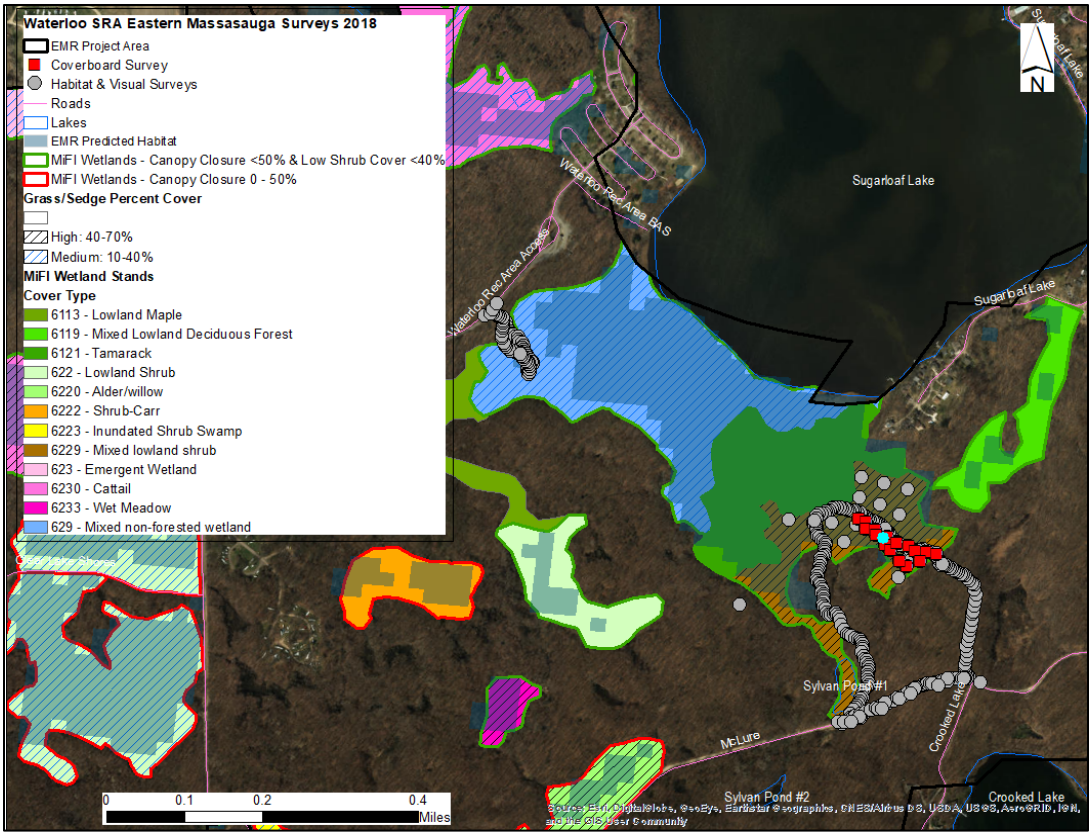
Appendix 6. Maps showing locations of visual encounter and coverboard surveys for EMRs at Mill Lake in the Waterloo SRA Project Area.



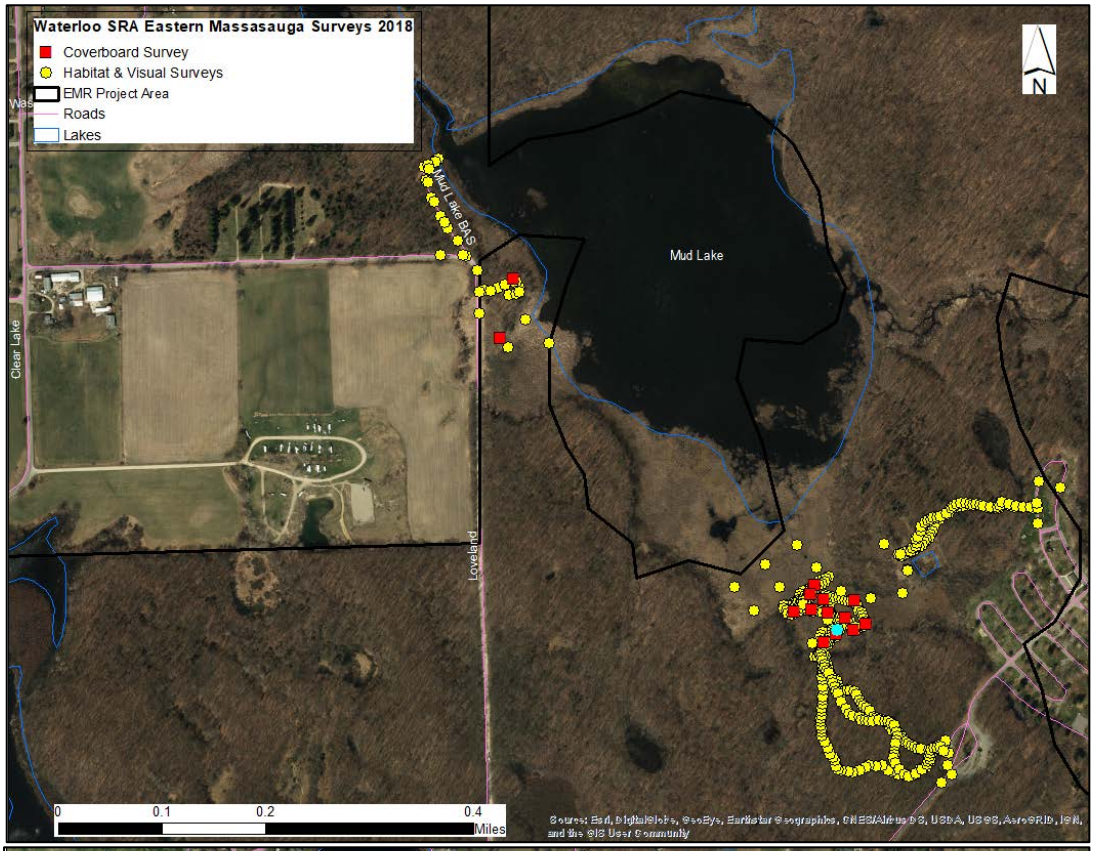


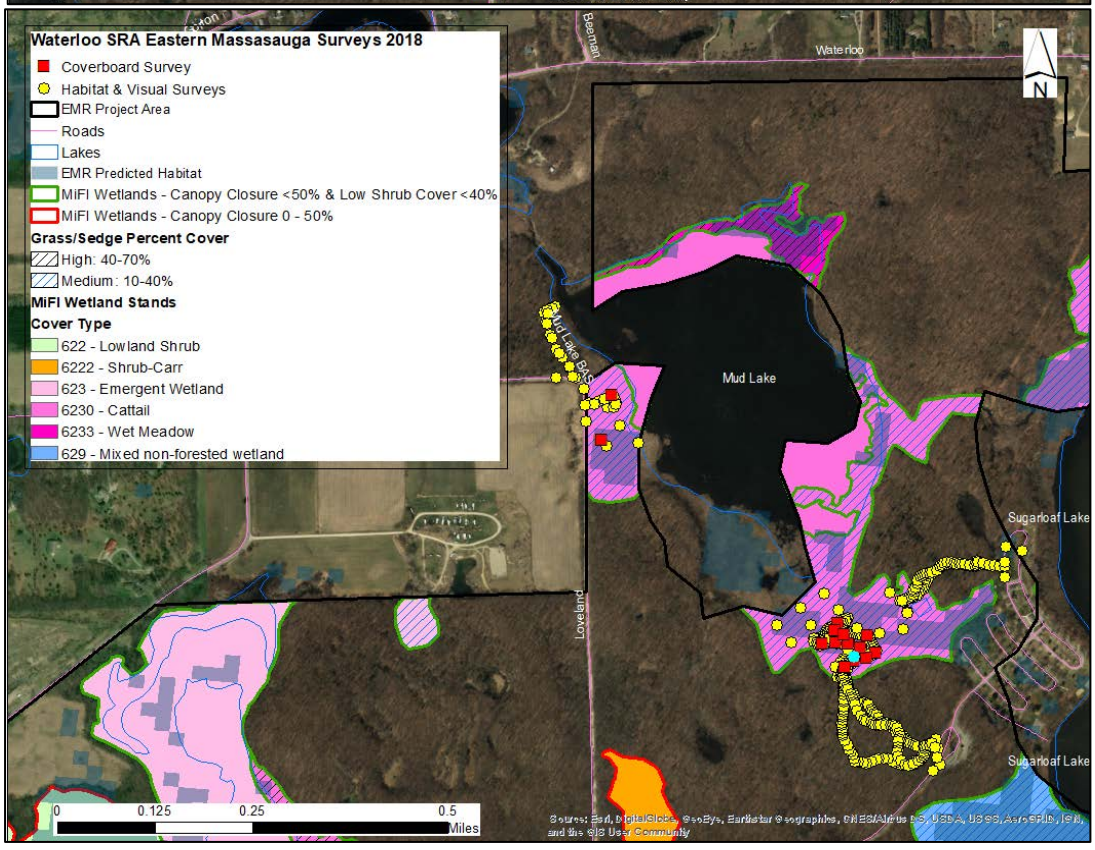
Appendix 7. Maps showing locations of visual encounter and coverboard surveys for EMRs at Sugarloaf Lake in the Waterloo SRA Project Area.



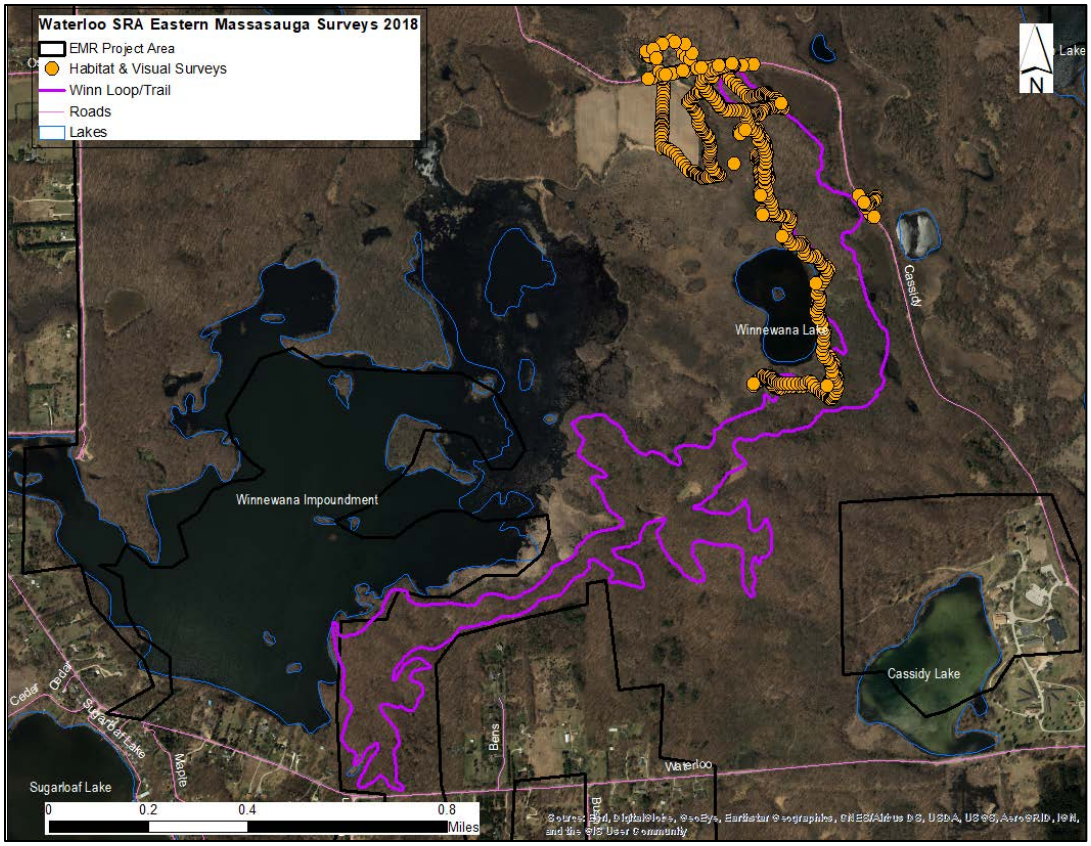


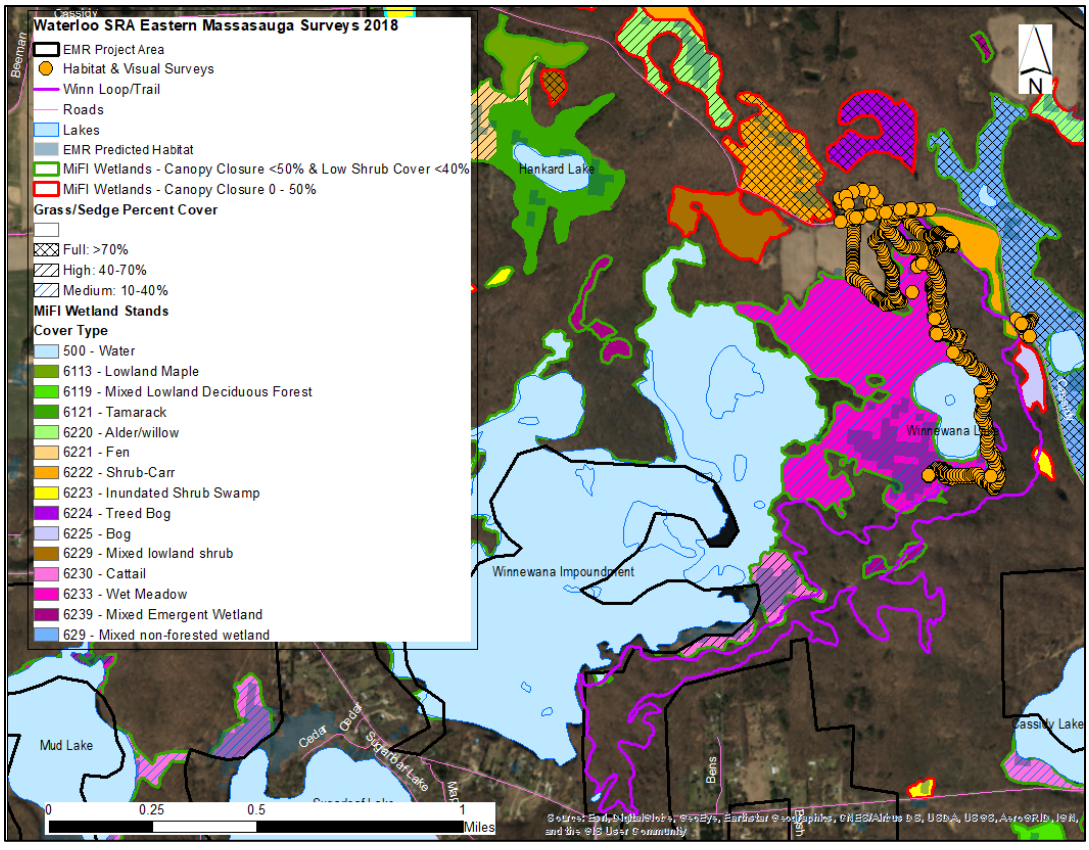
Appendix 8. Maps showing locations of visual encounter and coverboard surveys for EMRs at Mud Lake in the Waterloo SRA Project Area.





Appendix 9. Maps showing locations of visual encounter and coverboard surveys for EMRs at Winnawana Lake/Impoundment in the Waterloo SRA Project Area.





Appendix 10. Statewide press release for EMR education and outreach program at the Eddy Discovery Center in Waterloo SRA on July 14, 2018.

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
LANSING

RICK SNYDER
GOVERNOR

KEITH CREAGH
DIRECTOR

FOR IMMEDIATE RELEASE
June 15, 2018

Contact: Katie McGlashen, 734-475-3170, for event information or Yu Man Lee, LeeY@michigan.gov, to report sightings.

Eastern Massasauga Rattlesnake Public Education Program

Saturday, July 14, 10:00 a.m.
The Michigan Department of Natural Resources will hold a public education program about the Eastern Massasauga Rattlesnake Saturday, July 14, at 10:00 a.m. It will be held at the Eddy Discovery Center located in Waterloo Recreation Area at 17030 Bush Rd., Chelsea, MI 48118. This one-hour session will be an opportunity for you to see a live Eastern Massasauga Rattlesnake and some of the look-alike species found in the area. It is also an chance for you to share any information on Massasauga sightings you've had in Waterloo Recreation Area. This event is free to attend, but a Recreation Passport is required for vehicle entry to Waterloo Recreation Area and the Discovery Center. This event is posted on the Eddy Discovery Center webpage.

The Michigan Department of Natural Resources is working with the United States Fish and Wildlife Service on a Candidate Conservation Agreement with Assurance (CCAA) for the Eastern Massasauga Rattlesnake (EMR) in Michigan due to its recent listing as a "Threatened Species." Michigan is still known to have a greater population of EMR than any other state and the CCAA program helps ensure we are working towards improving population numbers. The Eastern Massasauga Rattlesnake is the only venomous snake in Michigan but are shy creatures that will avoid humans whenever possible. They spend the vast majority of their time in year-round wetlands.

Waterloo Recreation Area is enrolled in the CCAA program. Presently, staff are performing surveys and habitat mapping with the assistance of the Michigan Natural Features Inventory to establish a better understanding of the presence of the EMR within and adjacent to Waterloo Recreation Area. Because the EMR is such a cryptic snake species it can be difficult to detect their presence. It is also an opportunity for you to share any information on EMR sightings you've had in the area.

If you are unable to attend on July 14th but still have information you would like to share on EMR sightings then you can send us an e-mail at obrienj4@michigan.gov or LeeY@michigan.gov.

CONSTITUTION HALL • 525 WEST ALLEGAN STREET • P.O. BOX 30028 • LANSING, MICHIGAN 48909-7528
www.michigan.gov/dnr • (517) 284-MDNR(6367)

Appendix 11. Local program and event calendar to promote EMR education and outreach program at the Eddy Discovery Center in Waterloo SRA on July 14, 2018.

Waterloo Recreation Area & Eddy Discovery Center

Programs & Events
July 10– July 16 , 2018

www.michigan.gov/natureprograms

Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday
MICHIGAN MAMMALS WEEK! **Discovery Center Hours** **Monday - Saturday 10 am to 5 pm** **Sunday 12 pm to 5 pm** Earn your ***WATERLOO JUNIOR RANGER BADGE!!*** Attend 3 programs this summer and have a guide punch your card to get certified as a Junior Ranger!	**W.R.A.P. Camp** Discovery Center staff with be assisting with the Waterloo Recreation Area Program Camp today! 	 **W.R.A.P. Camp** Discovery Center staff with be assisting with the Waterloo Recreation Area Program Camp today!	**Skull Science** 2 pm Compare and contrast the skulls of predator and prey species of Michigan. Location: Discovery Center **Mammal Myths and Superstitions** 8 pm Get set straight with the real facts about our unique mammals. Location: Portage Lake Camp Host Site **Mammal Myths and Superstitions** 9:30 pm Get set straight with the real facts about our unique mammals. Location: Sugarloaf Beach Area	***SPECIAL PROGRAM*** **Live! Eastern Massasauga Rattlesnake** 10 am An up close look at Michigan's only venomous snake! Location: Discovery Center  **Arrows Away** 6 pm to 7:30 pm Learn Archery through fun, safe instruction. Equipment provided. Must be at least age 7 years old. Location: Portage Lake Day Use Beach Area	**Make a Hand Drum** 9 am Rhythm music for your campfire! Location: Portage Lake Camp Host Site  **Make a Hand Drum** 10:30 am Rhythm music for your campfire! Location: Sugarloaf Camp Host Site	**Call of the WILD!** Learn how animals communicate and practice your communication skills with various animals calls! Location: Discovery Center 

www.michigan.gov/eddycenter - (734) 475 - 3170

All programs are free unless otherwise noted; however, a Recreation Passport is required for entry to the park.

PARK HERE

Appendix 12. Invitation letter to neighboring residents to EMR education and outreach program at the Eddy Discovery Center in Waterloo SRA on July 14, 2018.

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
LANSING

RICK SNYDER
GOVERNOR

KEITH CREAGH
DIRECTOR

June 19th, 2018

Dear Neighboring Resident,

The Michigan Department of Natural Resources is working with the United States Fish and Wildlife Service to help conserve the Eastern Massasauga Rattlesnake (EMR) in Michigan due to its recent listing as a federally threatened species. Michigan has the largest remaining population of EMRs than any other state/province in the species' range. As a result, conservation of EMRs in Michigan is critical for recovery of this species. The EMR is the only venomous snake in Michigan. They are shy creatures that will avoid humans whenever possible and spend most of their time in year-round wetlands and adjacent upland habitats.

In the past, Eastern Massasauga Rattlesnakes have been documented in the Waterloo Recreation Area. Presently, we are performing surveys and habitat mapping with the assistance of the Michigan Natural Features Inventory to better understand the current presence and distribution of the EMR within and adjacent to Waterloo Recreation Area. Because the EMR is such an elusive snake, it can be difficult to establish their presence. Therefore, we are seeking information and assistance from neighboring residents to help us document any occurrences of EMRs in the area. We would like to invite you to a program on the EMR at the Eddy Discovery Center on July 14th, 2018 at 1:00 p.m. to learn more about the snake, including how to identify it, its life history and ecology, and safety tips. This one-hour session will be an opportunity for you to see a live EMR and some of the look-alike snake species found in the area. It is also an opportunity for you to ask questions and share any information on EMR sightings you may have had in the area.

If you are unable to attend on July 14th but still have information you would like to share on EMR sightings, please send us an e-mail at obrienj4@michigan.gov or leey@michigan.gov. We hope that you will be able to attend the program and thank you for your interest and assistance in helping us better understand and conserve this species!

Sincerely,

Jim O'Brien/Park Manager
Waterloo Recreation Area
16345 McClure Road
Chelsea, MI 48118
(734) 475-8307

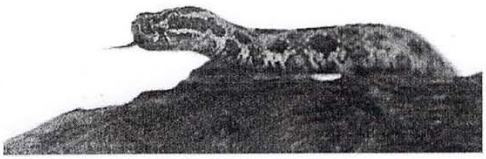
CONSTITUTION HALL • 525 WEST ALLEGAN STREET • P.O. BOX 30028 • LANSING, MICHIGAN 48909-7528
www.michigan.gov/dnr • (517) 284-MDNR(6367)

Appendix 13. Sun Times News article about EMR education and outreach program at the Eddy Discovery Center in Waterloo SRA on July 14, 2018.

MDNR Educates The Public On Eastern Massasauga Rattlesnake

By Lynne Beauchamp, lbeauchamp@thesuntimesnews.com

Michigan's only venomous snake, the Eastern Massasauga Rattlesnake is declining in numbers. This information comes from Yu Man Lee, Conservation Scientist with Michigan Natural Features Inventory (MFNI) of the Michigan State University Extension. Lee, along with Katie McGlashen, Park Interpreter at Waterloo Recreation Area and Jim O'Brien, Park Manager with Waterloo Recreation Area educated the public on these snakes at the Eddy Discovery Center at Waterloo Recreation Center in Chelsea on July 14.



The presentation provided information on what the rattlesnake looks like, which snakes resemble it, its habitat, its life cycle and what one should do if bitten.

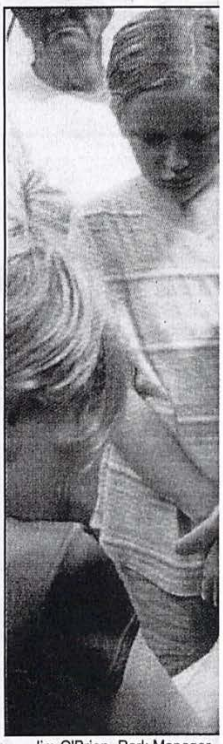
The Eastern Massasauga Rattlesnake is a thick-bodied snake and measures between 18-24 inches. It is gray or light brown with large, light-edged, chocolate brown, often saddle-shaped blotches on the back and smaller dark spots along the sides of its body. The tail is blunt-tipped with a segmented rattle on the end. It has heat sensing pits between its eyes and nostrils. The rattlesnake can be found in the Lower Peninsula of Michigan. Its habitat range is often in wetlands but also in uplands like meadows and prairies.

There are many snakes that resemble the Eastern Massasauga in appearance and include the Milk Snake, Fox Snake, Hognose Snake and Northern Water Snake.

The Eastern Massasauga is venomous, its venom contains toxic proteins and digestive enzymes that kill its prey and break down the tissue for easy digestion. It is generally non-aggressive, usually only biting if feeling threatened. While Eastern Massasauga bites are uncommon (according to Michigan Poison Control, an average of 1/year), one should seek medical attention if bitten. Often the snake does not inject venom, however remain calm, remove jewelry, do not apply ice or tourniquets or try to suck out the venom, in the meantime.

In Michigan, the Eastern Massasauga Rattlesnake is listed as a species of special concern and is protected under a special Director of Natural Resources' Order. It is unlawful to kill, harm or take these snakes from the wild.

MFNI and the Waterloo Recreation Area are interested in those who may have seen the Eastern Massasauga and share a photograph (if safely possible) including its location. . To share information of sightings near the Waterloo Recreation Area, contact Jim O'Brien at obrienj4@michigan.gov. For sightings throughout Michigan, contact Yu Man Lee at LeeY@michigan.gov.



Jim O'Brien, Park Manager, venomous snake. P

Appendix 14. Map showing predicted habitat for EMRs in the Waterloo SRA project area based on EMR habitat model developed by McCluskey (2016).