Protecting and Reconnecting Alpena's Coastal Wetlands and Rare Species

Final Performance Report: January 2016 – September 2018

Prepared By:

Daria A. Hyde, Yu Man Lee and Phyllis J. Higman
Michigan Natural Features Inventory
Michigan State University Extension
P.O. Box 13036
Lansing, MI 48901

Prepared For:

Huron Pines
National Fish and Wildlife Federation
Grant ID: 0501.15.048859

12/05/2018

MNFI Report No. 2018-18

Michigan Natural Features Inventory
Discover. Define. Deliver.

MICHIGAN STATE UNIVERSITY | Extension

Suggested Citation:

Hyde, D. A., Y. Lee, and P. J. Higman. 2018. *Protecting and Reconnecting Alpena's Coastal Wetlands and Rare Species***.** Final Performance Report, January 1, 2016 – September 30, 2018. Michigan Natural Features Inventory, Report No. 2018-18, Lansing, MI. 57pp.

Cover: Coastal fen at Squaw Bay Nature Preserve – Yu Man Lee
Insets: AmeriCorp members Kathryn Golpund and Christina Hamilton assist Phyllis Higman with surveys at Squaw Bay Nature Preserve – Daria Hyde
Butler's garter snake – Yu Man Lee
Small fringed gentian – Phyllis Higman

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

Project Overview

The coastline of Lake Huron in Northeast Michigan is home to numerous high-quality wetlands that provide habitat for a myriad of species including several that are rare or declining in the state. These wetlands are vulnerable to habitat fragmentation and loss, high nutrient inputs and invasion by non-native species including invasive phragmites and glossy buckthorn.

In close collaboration with Huron Pines, MNFI project staff provided their professional expertise in identifying and monitoring rare species before and after restoration was implemented at several project sites. We crafted management strategies to promote habitat improvement for rare reptiles and to help measure project success. Finally, we helped to train local volunteers in monitoring project sites for rare species as well as invasive plants as part of the community outreach aspect of this project.

Amphibian and Reptile Surveys

MNFI surveys in 2016-2018 focused on monitoring for the eastern massasauga (*Sistrurus catenatus*, federally threatened and state special concern) and Blanding's turtle (*Emydoidea blandingii*, state special concern) in Alpena's coastal wetlands. These species have been identified as Species of Greatest Conservation Need (SGCN) in Michigan's Wildlife Action Plan (Derosier et al. 2015). Eastern massasaugas utilize a variety of wetland habitats, including fens, bogs, peatlands, shrub carr/thickets, wet meadows, emergent marshes, moist grasslands, wet prairies, floodplain forests, and forested swamps (Reinert and Kodrich 1982, Hallock 1991, Weatherhead and Prior 1992, Johnson 1995, Harding 1997, Johnson 2000, Johnson et al. 2000, Lee and Legge 2000, Ernst and Ernst 2003, Harvey and Weatherhead 2006, Marshall et al. 2006, Moore and Gillingham 2006, Harding and Mifsud 2017). Blanding's turtles also inhabit a diversity of shallow wetlands including small ponds, lake shallows, wet meadows and prairies, forested and shrub swamps, bogs, fens, shallow cattail marshes, vernal pools, slow-moving rivers and streams, and even roadside ditches (Ernst et al. 1994, Harding 1997, Lee 1999, Harding and Mifsud 2017). Both the eastern massasauga and Blanding's turtles also utilize adjacent or nearby open upland habitats, ranging from prairies, savannas, barrens, and old fields to upland forests and forest openings, for thermoregulation, gestation, nesting, parturition, foraging, and dispersal (Reinert and Kodrich 1982, Harding 1997, Szymanski 1998, Johnson et al. 2000, Bissell 2006, Bailey 2010, DeGregorio et al. 2011, Harding and Mifsud 2017). Both these species had been documented in the Squaw Bay Nature Preserve prior to the start of this project (Michigan Natural Features Inventory [MNFI] 2018).

Surveys for these species were initiated in 2016 at the Squaw Bay Preserve, Alpena Township Nature Preserve, Partridge Point and the fen south of the Ossineke State Forest Campground. Although these target reptiles were not observed during initial surveys, abundant suitable habitat for the eastern massasauga was noted at the Squaw Bay Preserve and Ossineke State Forest fen with limited habitat noted at the other two sites. Habitat for the Blanding's turtle was present but very limited at the Squaw Bay Preserve due to lack of basking sites and open, sandy areas for nesting, but some potential habitat was noted at the other three sites.

Management Recommendations:

Based on this initial assessment we recommended several management strategies that could be implemented to improve habitat for the Blanding's turtle and eastern massasauga at Squaw Bay Preserve. One recommendation was to increase nesting habitat for turtles adjacent to the fen by depositing sand in several areas along the woodland edge adjacent to the fen. For a variety of reasons, the stewardship coordinator at The Nature Conservancy did not want to implement this recommendation as he felt that the process of transporting the sand to these areas would be disruptive to the ecology of the fen. We decided to identify nesting areas nearby that could be restored or enhanced using a radio telemetry study as well as nesting surveys. Our plan was to locate one or more female Blanding's turtles and equip them with a radio transmitter so that we could track them to their nesting areas and evaluate the condition of these areas as well as identify restoration potential for these sites. Another key recommendation was to remove and control glossy buckthorn in the fen, especially in and around habitat islands, to maintain open habitat conditions within the fen. We also recommended providing additional cover in the fen itself for use by Blanding's turtles, eastern massasaugas, and other amphibians and reptiles. Huron Pines communicated this recommendation to Nature Conservancy staff who created brush piles from the glossy buckthorn they removed. Another recommendation was to provide basking sites for Blanding's turtles in open water areas of the fen. During initial surveys we did not observe any natural or human-made structures in the ditch that runs parallel to US 23 along the eastern edge of the fen on which turtles could climb onto to get out of the water to thermoregulate. Huron Pines AmeriCorps members installed some basking logs in this ditch along the eastern border of the fen in late summer/fall 2017 to provide turtle basking areas. We had hoped that additional basking sites could be created in the small lake at the southern portion of the fen, but landowner permission could not be secured to do this.

We decided to focus surveys in 2017-2018 at the Squaw Bay Nature Preserve to investigate the extent, distribution, and habitat use of eastern massasaugas and Blanding's turtles and assess the impact of planned habitat management activities on these species. Management activities conducted at Squaw Bay focused on controlling invasive species, primarily glossy buckthorn, in 2016-2018 and providing additional basking habitat and cover for turtles and snakes including basking logs in the roadside ditch and brush piles primarily in the northern portion of the Squaw Bay Preserve in 2017-2018. Management areas were surveyed in 2017-2018 to determine if target species use these areas.

In addition to documenting the extent and distribution of Blanding's turtles at Squaw Bay, we also were interested in obtaining additional information on the species' habitat use within and around the site, particularly nesting areas and overwintering areas, through radio-telemetry. Three radio transmitters were obtained in early summer of 2017 for use with adult Blanding's turtles, particularly females. Adult Blanding's turtles captured during surveys would be fitted with a radio transmitter and tracked using a receiver and antenna throughout the active season until fall when turtles return to their overwintering sites. Information on habitat use, nesting areas and overwintering areas would help identify and inform potential additional management needs and opportunities.

Surveys at Squaw Bay Nature Preserve had potential for detecting other rare and/or declining amphibian and reptile species (i.e., herptiles or herps). These included the pickerel frog (*Lithobates palustris*, state special concern), northern ribbon snake (*Thamnophis sauritus septentrionalis*), smooth green snake (*Opheodrys vernalis*, state special concern), Butler's garter snake (*Thamnophis butleri*, state special concern), and northern ring-necked snake (*Diadophis punctatus edwardsii*). These species also have been identified as SGCN in Michigan's Wildlife Action Plan (Derosier et al. 2015). Pickerel frogs and northern ribbon snakes occur in or along aquatic and wetland habitats including bogs, fens, marshes, streams, ponds, impoundments, and ditches (Harding 1997, NatureServe 2018). Smooth green snakes occur in moist, grassy habitats such as remnant prairies and savannas, meadows, old fields, pastures, and marsh and lake edges (Harding 1997). Butler's garter snakes occur in wet, grassy habitats including wet meadows and prairies, fens, marshy edges of ponds and lakes, forested swamps, often near streams, ditches, marshes or ponds, and disturbed habitats such as old fields, railroad embankments, vacant lots, and cemeteries (Harding 1997). Ring-necked snakes are generally found in forested areas, including forest edges and clearings, and areas with shallow soil and surface bedrock, where they are frequently found under rocks, logs or bark (Harding 1997).

Botanical Surveys

In conjunction with up-to-date surveys for these rare species, it is useful to gather baseline data on habitat conditions and assess trends over time in response to treatment of invasive species. Pre- and post-treatment Floristic Quality Assessments (FQAs) were conducted at several sites along with qualitative observations of invasive species targeted for control.

Pre and Post-Treatment Vegetation Monitoring

Pre-treatment surveys were conducted at Squaw Bay, Alpena Township Nature Preserve and Ossineke State Forest Campground in Alpena County in the summer of 2016. Exact treatment areas were not known prior to surveys, thus Floristic Quality Assessments (FQAs) were conducted to establish baseline data for each of the three sites, and general comments were made regarding the presences of invasive phragmites (*Phragmites australis* var. *australis*) and glossy buckthorn (*Frangula alnus*). Treatments were conducted in 2017 by The Nature Conservancy (TNC) and maps of treatment areas were provided in September 2018. Post-treatment follow-up FQAs were conducted at treatment sites on September 9, 16 and 17, 2018, and specific treatment areas were examined for presence of the invasive species treated. Each of the three sites is discussed individually within this report.

Methods

Amphibian and Reptile Surveys

Visual encounter surveys, coverboard surveys, aquatic funnel trapping, basking surveys, and nesting turtle surveys were conducted at Squaw Bay Nature Preserve in 2017 and 2018 to survey for target species. In 2016, only visual encounter surveys were conducted. In 2017 and 2018, surveys also included identifying potential turtle nesting areas near Squaw Bay. Surveys were conducted primarily in the coastal fen west of US-23 and on state land west and south of the fen along Squaw Bay. Surveys were conducted using standard methods for surveying amphibians and reptiles (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994).

Visual encounter surveys were conducted between June 13-15, July 9-11, and on September 26-27 in 2018. In 2016 and 2017, visual encounter surveys were conducted between May and October. Visual encounter surveys were conducted throughout the coastal fen within the preserve, particularly along the forested edges and around the small forested "islands" within the open fen and in areas undergoing active management (e.g., glossy buckthorn removal areas and brush piles, (Figures 1, 2). Limited visual surveys also were conducted in the wooded dune and swale west of the fen (Figures 1, 2). Surveys consisted of one to four surveyors walking slowly through areas with suitable habitat and searching for target species by overturning cover (e.g., logs, rocks, artificial cover boards, etc.), inspecting retreats, and looking for basking, resting, and/or active individuals on the surface or under cover. Visual encounter surveys were conducted during daylight hours and under appropriate weather conditions when target species were expected to be active and/or visible [i.e., between 60-80°F (16-27°C), wind less than 15 mph, no or light precipitation].

Coverboard surveys were conducted from late April through September in 2017 and 2018. Surveys consisted of placing coverboards or artificial cover objects in areas with suitable habitat for target species and near active management areas and checking the coverboards to look for species hiding or resting under or top of them. Coverboards consisted of plywood sheets approximately 1 m long x 1 m wide (3 ft x 3 ft) (Appendix 1). A total of 16 coverboards were set at least 50-100 m apart distributed throughout the survey area (Fig. 3). Coverboards were set in early April and checked approximately every 2-3 weeks for a total of 8-9 times during the survey period. All amphibian and reptile species found under, on top of, or adjacent to the coverboards were recorded.

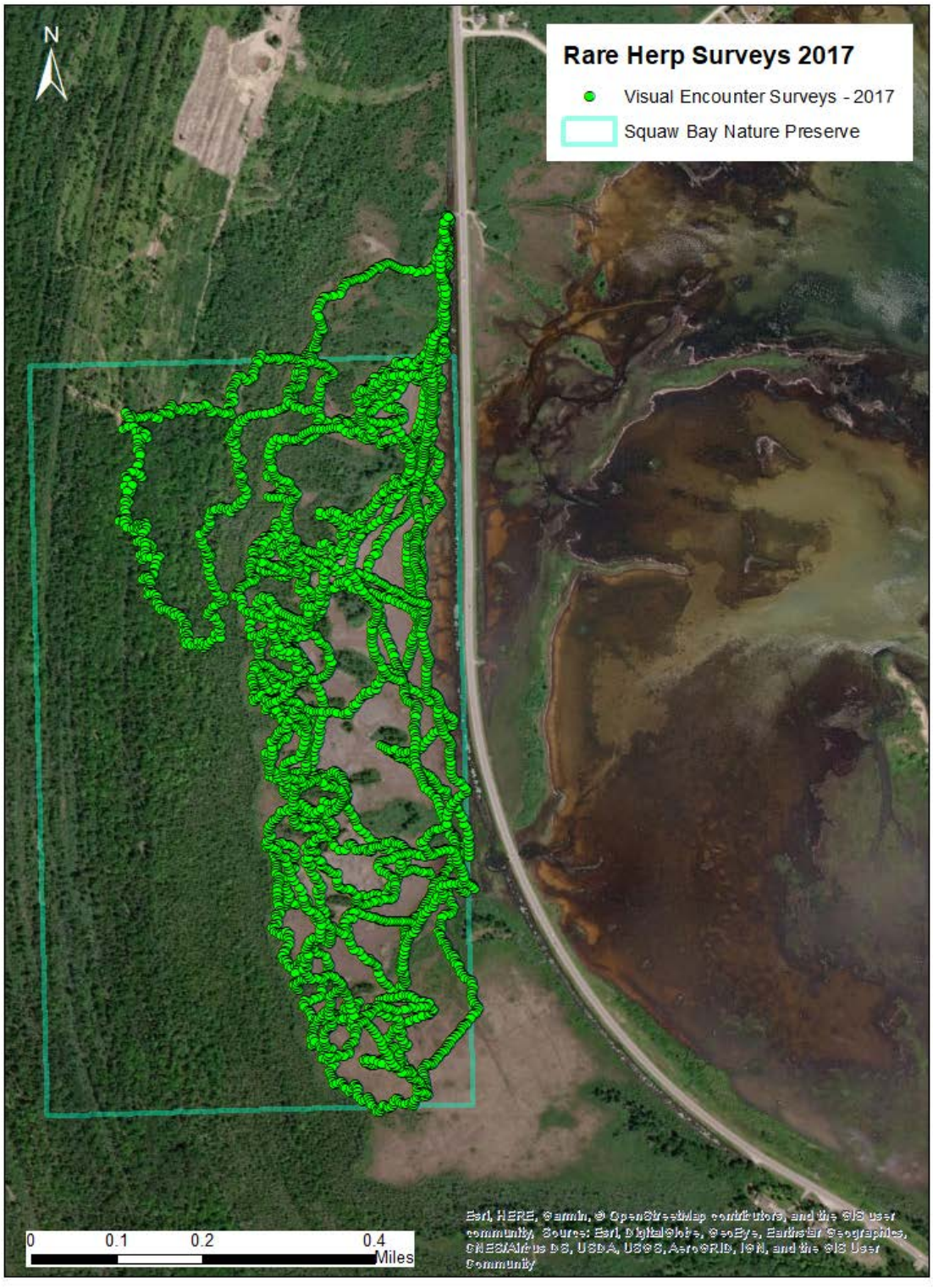


Figure 1. Visual encounter herp surveys in 2017 at Squaw Bay Nature Preserve, Alpena, MI.

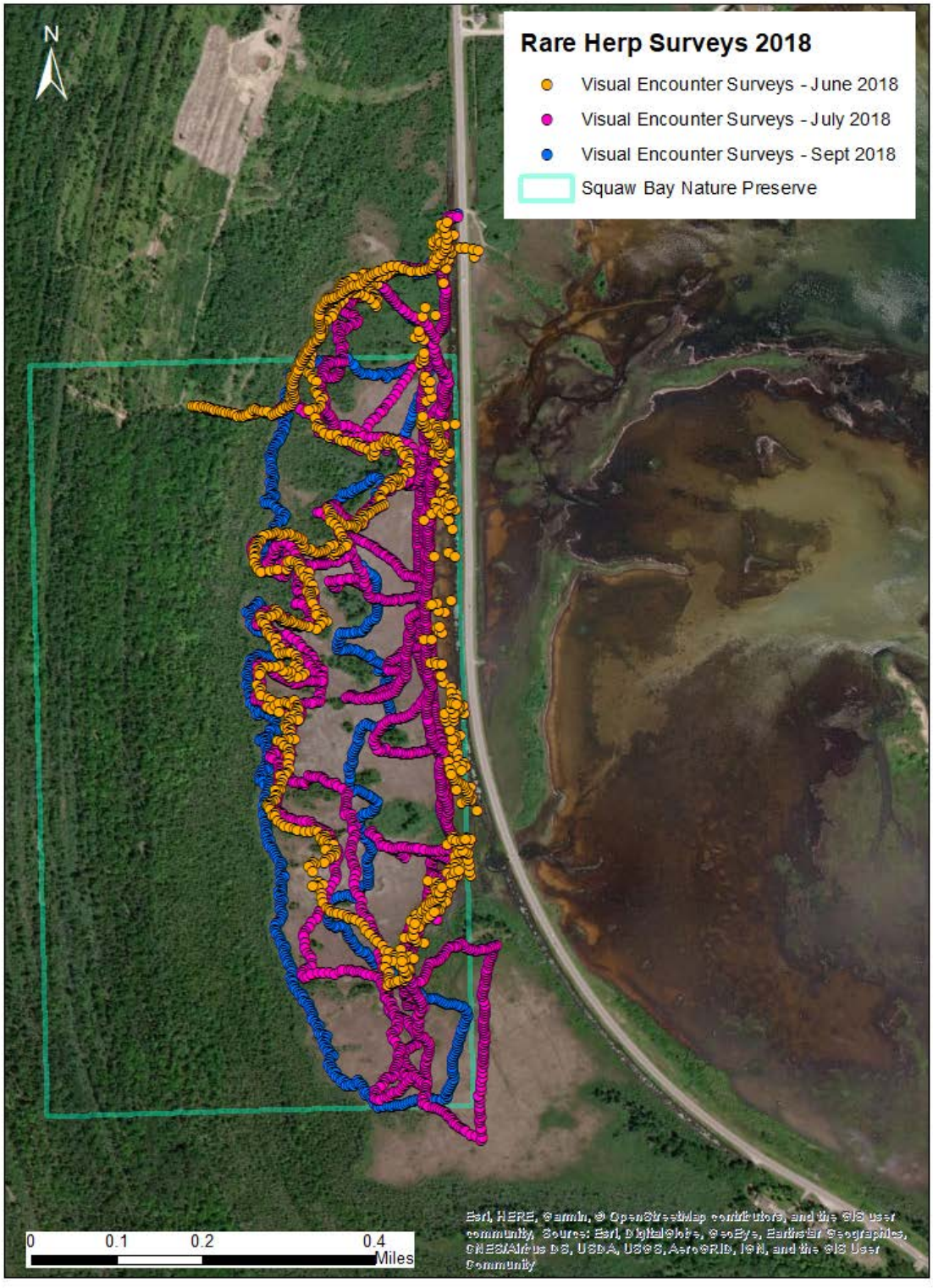


Figure 2. Visual encounter herp surveys in 2018 at Squaw Bay Nature Preserve, Alpena, MI.

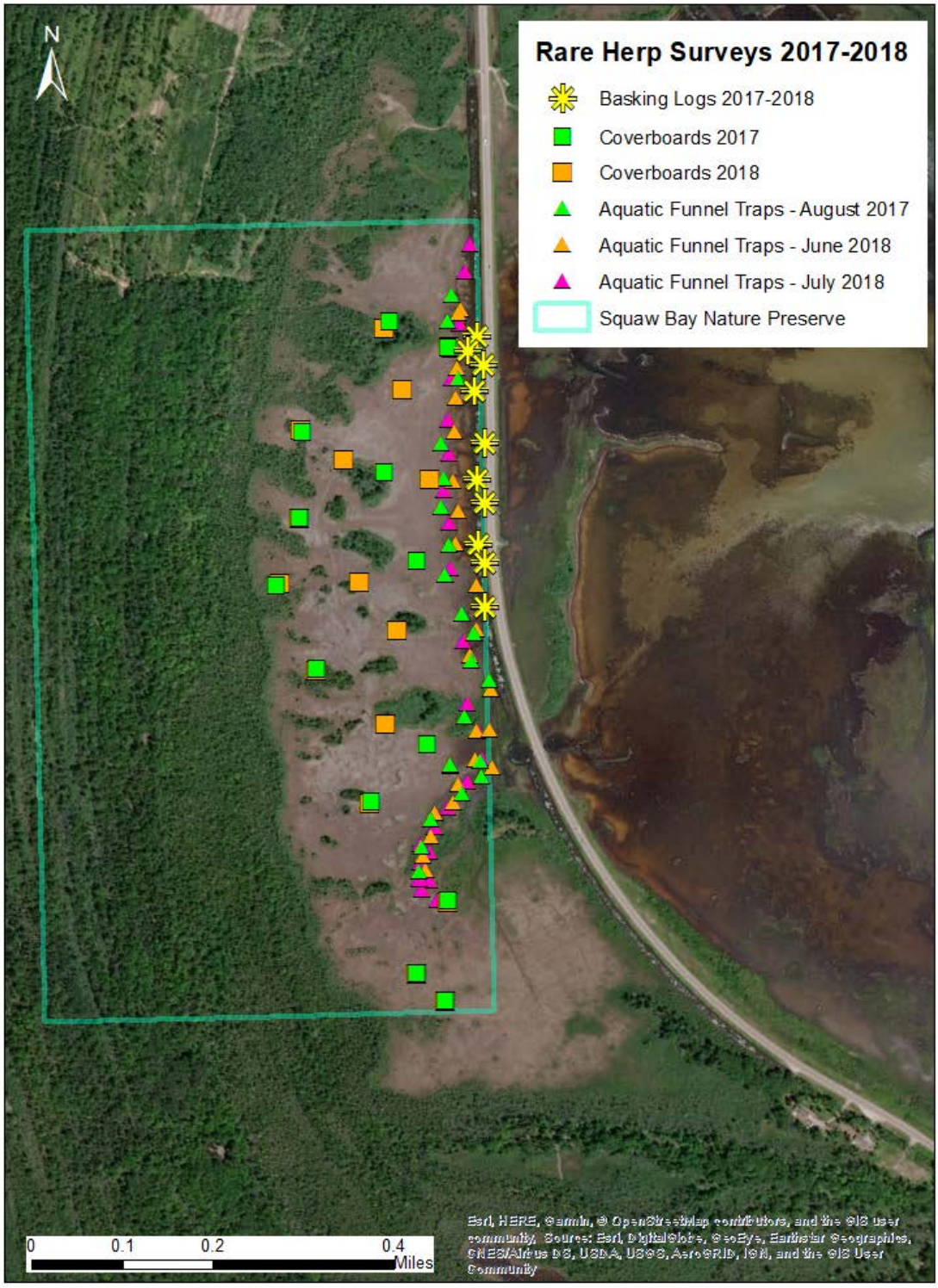


Figure 3. Basking, coverboard and trap surveys – 2017-2018 at Squaw Bay Nature Preserve, Alpena, MI.

Aquatic funnel trapping was conducted during two sampling events in 2018, June 13-15 and July 9-11, to survey for Blanding's turtles at Squaw Bay. Aquatic funnel trapping also was conducted in 2017 from August 21-25. Aquatic funnel traps consisted of large or medium-sized, collapsible mesh minnow traps made by Promar that were 61 cm (24 in) or 91 cm (36 in) long by 30 cm (12 in) wide when open with 13 cm (5 in) dual entrances or openings. Each trap was baited with a can of sardines. A plastic bottle(s) was placed in each trap to maintain an air pocket at the top of the trap above the water level, and each trap was tied to nearby vegetation and staked in the ground to firmly secure the trap (Appendix 1). Traps were placed at least 20 m (66 ft) apart along the edge of the roadside ditch and other areas with standing water along the east half of the fen (Fig. 3). Traps were placed in areas with at least 25 cm (10 in) of standing water, and in channels between vegetation and/or other cover, along the edge of thick vegetation, near turtle basking sites, and/or in areas with good solar exposure. Twenty traps were deployed for two nights in June, and twenty-five traps were deployed for two nights in July, for a total of 90 trap nights in 2018. Traps were checked within 24 hours. Turtles captured in traps were identified, recorded, measured, marked, photographed, and released at the initial capture site after processing.

Basking surveys were conducted between May and September 2018 to investigate the occurrence and distribution of Blanding's turtles and other turtles at Squaw Bay and their use of the basking logs that were placed in the ditch along US-23 and eastern border of the fen in late summer/fall 2017 (Fig. 3). Basking surveys consisted of slowly walking along the edge of the roadside ditch and scanning the habitat with binoculars to look for turtles and snakes partially submerged in the water or basking on the logs that were placed in the ditch. Basking surveys were conducted during visual encounter surveys and/or coverboard surveys, during daylight hours and under appropriate weather conditions when target species were expected to be active and/or visible (i.e., between 60-80°F (16-27oC), wind less than 15 mph, no or light precipitation).

Nesting turtle surveys were conducted from June 13 – 15 in 2018 to document nesting Blanding's turtles and identify turtle nesting areas in the vicinity of Squaw Bay. Several areas with suitable turtle nesting habitat were surveyed along Piper Road and between Piper Road and Devils Lake (Fig. 4). These surveys consisted of one or two surveyors slowing walking through areas with suitable nesting habitat in the evening, looking for turtles that were nesting or preparing to nest or depredated turtle nests.

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

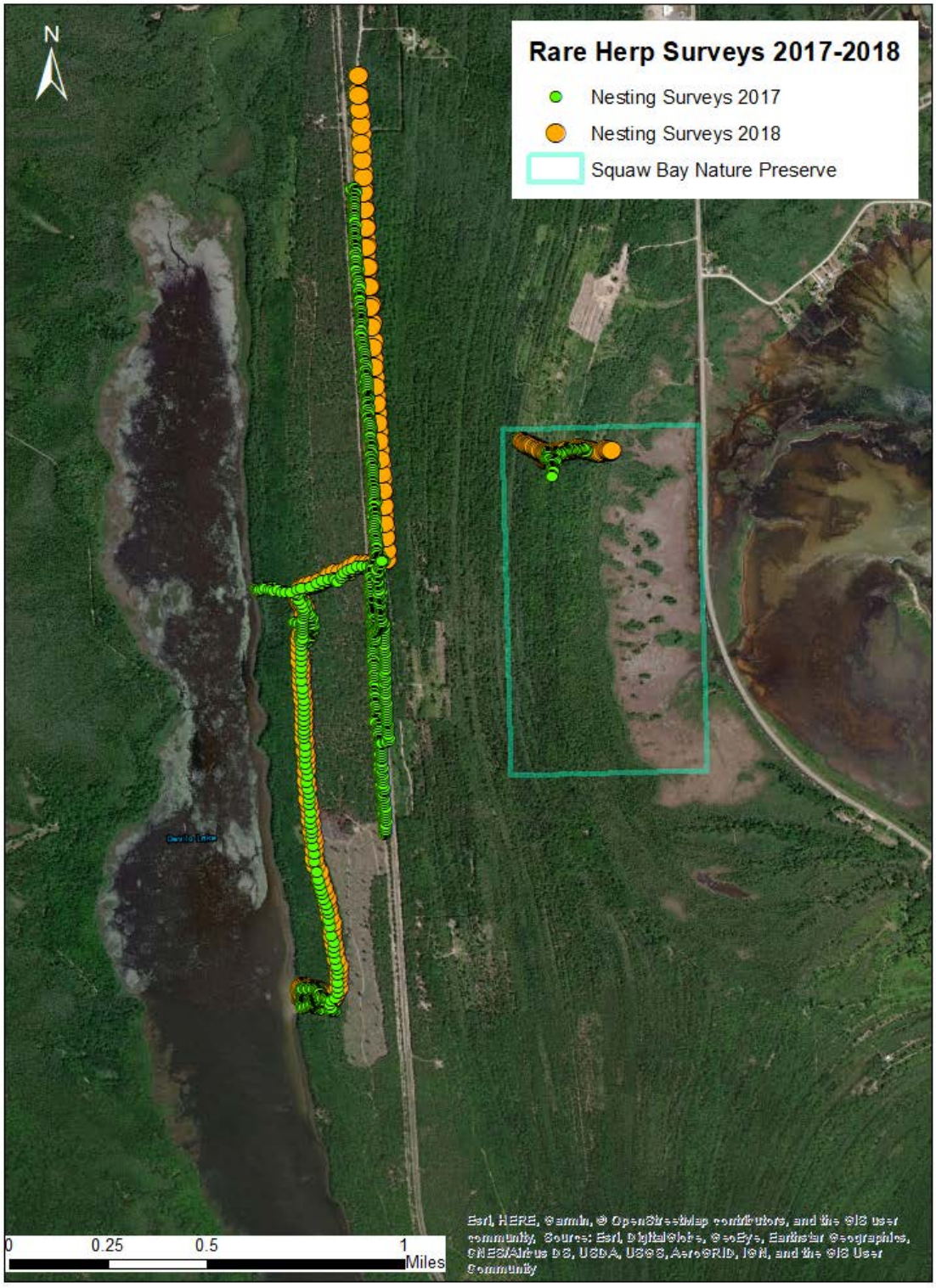


Figure 4. Rare herp nesting surveys in 2017 and 2018 at Squaw Bay Nature Preserve, Alpena, MI.

Results

Amphibian and Reptile Surveys

Rare herp surveys at Squaw Bay Nature Preserve documented two rare species, Blanding's turtle and Butler's garter snake (Table 1.) A juvenile Blanding's turtle was captured in an aquatic funnel trap in the southern half of the preserve on July 10,2018. An adult Blanding's turtle and shell fragments of a Blanding's turtle were found in the fen during visual surveys on April 24,2017. Unfortunately, the juvenile Blanding's turtle captured in 2018 was too small to be fitted with a radio transmitter, and the Blanding's turtle found in 2017 was captured prior to obtaining the transmitters. Although we were not successful in fitting one or more Blanding's turtles with radio transmitters to implement the radio telemetry study, we did identify several areas with suitable nesting habitat including one area that other turtle species were documented using for nesting along Devils Lake. In addition, an adult Butler's garter snake was found under a coverboard in the middle of the fen on May 24, 2017 and on July 10, 2018. No eastern massasaugas were documented during herp surveys at Squaw Bay in 2016, 2017 or 2018.

Several additional amphibian and reptile species were documented at Squaw Bay during surveys in 2016-2018 (Table 1.). These include an American toad (*Anaxyrus americanus*), northern leopard frogs (*Lithobates pipiens*), green frogs (*Lithobates clamitans*), spring peepers (*Pseudacris crucifer*), wood frogs (*Lithobates sylvaticus*), bullfrogs (*Lithobates catesbeianus*), gray treefrogs (*Hyla versicolor*), eastern brown snakes (*Pseudonaja textilis*), eastern garter snakes (*Thamnophis sirtalis sirtalis*), northern ribbon snakes (*Thamnophis sauritus septentrionalis*), northern water snakes (*Nerodia sipedon sipedon*), painted turtles (*Chrysemys picta*), and snapping turtles (*Chelydra serpentina*). Aquatic funnel trapping documented painted turtles, snapping turtles, bullfrogs, and green frogs. These included five juvenile painted turtles and three juvenile snapping turtles. In addition to amphibians and reptiles, aquatic funnel trapping in 2018 captured a number of bullheads (*Ameiurus* sp.), sunfish (*Centrarchidae*), bowfin (*Amia calva*), other small fishes, crayfish, giant water bugs (*Belostomatidae*), and predacious diving water beetles (*Dytiscidae*).

Nesting surveys in 2018 documented one snapping turtle preparing to nest and several depredated turtle nests at an open sandy area along the eastern shoreline of Devils Lake. This area is used for recreation including all-terrain vehicle (ATV) use. Depredated turtle nests were found in this same area in 2017. Several additional areas with suitable nesting habitat for turtles were surveyed in 2017 and 2018 (Fig. 4) but no nesting turtles or depredated turtle nests were found in these areas.

No Blanding's turtles or other turtles were observed basking on the logs that were placed in the ditch along the eastern border of the fen. However, most of the logs had floated to the edges of the ditch or downstream and were not located where they had been initially placed in 2017. Also, no snakes or turtles were observed in or near the brush piles of glossy buckthorn that were created and placed along the edge of the fen during invasive species removal efforts.

Table 1: Amphibians and Reptiles Documented at Squaw Bay, Alpena Co. MI. 2016-2018					
Species	**Visual Encounter**	**Coverboard**	**Aquatic Funnel Trap**	**Basking**	**Nesting**
Turtles					
Blanding's turtle	2017		2018		
Painted turtle	2017		2017, 2018		
Snapping turtle			2018		2018
Snakes					
Eastern brown snake		2017			
Butler's garter snake		2017, 2018			
Eastern garter snake	2017, 2018	2017, 2018			
Northern ribbon snake	2017				
Northern water snake	2017	2017, 2018			
Frogs/Toads					
American toad	2017				
Bullfrogs	2017		2018		
Gray treefrogs	2017				
Green frogs	2017, 2018		2018		
Northern leopard frogs	2016-2018				
Spring peeper	2017				
Wood frog	2017				

Community Outreach and Training

A key objective of this project was to showcase native wetland "viewsheds" along the US 23 corridor to visitors and community members through training volunteer monitors and conducting local outreach about coastal wetland communities. We trained community members in standard protocols for monitoring and inventory of native animals as well as invasive species in order to establish a confident corps of observers that could monitor changes in the coastal wetlands beyond the length of this project. We worked with AmeriCorps members from Huron Pines, Grand Traverse Regional Land Conservancy and Michigan Natural Features Inventory. These members were involved in conducting surveys and implementing management recommendations at Squaw Bay Nature Preserve. In addition, they became ambassadors within the local community and, in turn, helped to train local volunteers.

In 2016 and 2017, members of Friends of Negwegon, (Negwegon State Park), assisted with herp surveys at Squaw Bay Nature Preserve as well as the fen south of the Ossineke State Forest Campground (Fig 5). In 2017, volunteers from the Alpena Wildlife Sanctuary assisted with herp surveys at the Squaw Bay Nature Preserve. In addition, Michigan Natural Features Inventory and Huron Pines staff trained Girls Scouts from Alpena High School to assist with coverboard surveys for herps at Squaw Bay (Fig 6.). Ten coverboards were set throughout the fen on April 24, 2017, and were checked nine times throughout the spring, summer, and early fall by MNFI staff, AmeriCorps members, and volunteers.

We were impressed by the passion and dedication of local community members who assisted with surveys and became engaged in protecting this unique coastal wetland. Their curiosity in learning more about this valuable resource and interest in sharing what they learned with others is inspiring. These trained volunteers can be a resource for future monitoring and stewardship efforts in Alpena's coastal wetlands.

Figure 5. Friends of Negwegon members assist Yu Man Lee with herp surveys in 2016. From Left: Bob Sherrar, Sue Keller, Yu Man Lee and Mary Culik.

Figure 6. Wendy Lemon (Huron Pines AmeriCorp) trains Alpena High School Girl Scouts to assist with herp surveys.

Discussion

Amphibian and Reptile Surveys

Although eastern massasaugas were not documented during this project, this species likely still occurs within the Squaw Bay Nature Preserve. The species was last documented at this site in 2010, and a specimen was collected from a site two miles south of Alpena in the late 1950s (MNFI 2018). Eastern massasaugas can be fairly long-lived (i.e., potentially 10-15 years in the wild, up to 20 years in captivity), and extensive suitable habitat for massasaugas appears to be available within the preserve. Glossy buckthorn and shrub and tree encroachment have reduced habitat availability and quality in parts of the fen, but extensive areas of open habitat still exist. Given the species' long history of occurring in the area, potential longevity, and extensive habitat available at this site, massasaugas likely still occur at Squaw Bay. Additionally, eastern massasaugas are cryptic, tend to hide in or under vegetation, and can be challenging to find in the field. Surveys and monitoring should continue to determine the species' status, distribution, and viability at this site. Surveys to identify massasauga hibernacula and gestation/parturition sites at Squaw Bay also should be conducted so that these important areas can be protected, and access to these habitats should be maintained. Research to identify additional threats to the massasauga population at this site (e.g., road mortality, disease) also is needed. In the future, creating some forest openings or canopy gaps in the forest adjacent to the fen also could create or enhance habitat for thermoregulation if snakes are using these areas for overwintering which seems likely. If upland openings are large enough, gravid EMR females also might use them for gestation/parturition sites, especially since massasaugas prefer drier areas for parturition and a much of the fen was pretty wet the last couple of years.

Survey results from this project indicate the Blanding's turtle population at Squaw Bay occurs throughout the fen and may be a reproducing, viable population. A Blanding's turtle had been previously documented at the north end of the fen in 2010 (MNFI 2018). Blanding's turtle shell fragments found in 2017 during this project were found at the north end of the fen but the two Blanding's turtles encountered in 2017 and 2018 were found in the southern half of the fen. The juvenile Blanding's turtle found in 2018 suggests some successful recruitment is occurring within this population. Extensive habitat for Blanding's turtles appears to be available within the coastal fen and surrounding forested wetlands and uplands and waterbodies. Additional surveys and research should be conducted to determine the size and extent of this population within and outside of the preserve, identify nesting and overwintering areas, and threats to the population. In addition, it would be ideal if larger logs could be added for cover in the fen if possible as well as additional basking sites. Some of the turtle nesting areas that were documented during surveys are also actively used by all-terrain vehicles (ATVs). We recommend that nesting surveys be continued to see if Blanding's turtles use these areas for nesting. If Blanding's turtles are documented using these areas, then it would be prudent to discuss with the DNR the idea of limiting ATV use of these areas during the nesting season. Another potential idea is to implement predator control or nest protection during the nesting season perhaps with the assistance of volunteers.

A new element occurrence of Butler's garter snake was documented at the Squaw Bay Nature Preserve during this project in 2018. This sighting also fills a data gap in the Michigan Herp Atlas as the species had not been reported from Alpena County but had been reported from Alcona County to the south and Presque Isle County to the north (Michigan Herp Atlas 2018). The Butler's garter snake was added as a

state special concern species in Michigan in 2016, and information on the species' current status and distribution in the state is limited. Additional surveys and research on this species should be conducted within and outside of the preserve to determine the status, distribution, and extent of this population as well as threats to the population.

Given the small number or lack of observations of eastern massasaugas and Blanding's turtles documented during surveys in 2016-2018 and limited duration of this project, it is difficult to assess impacts of management activities (i.e., invasive species removal, basking logs, brush piles) on these species at Squaw Bay. Management also was fairly limited in scope and extent at Squaw Bay during this project given the extensive amount of available habitat at this site. Continued surveys and monitoring of these species over a longer period of time using standard and consistent methodologies and study design are needed to detect species' responses and better understand potential impacts of management activities. Additionally, given how large the fen is at Squaw Bay, increased survey and monitoring effort would enhance the ability to detect these species and management impacts.

Due to the occurrence of several rare herp species and extensive availability of suitable habitat within and around the Squaw Bay Nature Preserve, continuing to protect and maintain suitable habitat at this site is critical for sustaining populations of these and other herp species in the area. Maintaining a large, contiguous wetland complex, minimizing additional habitat fragmentation, and maintaining connectivity between suitable wetland habitats and between wetland and adjacent upland habitats would greatly benefit the eastern massasauga, Blanding's turtle, Butler's garter snake, and other herp species in and around the Squaw Bay Preserve. Maintaining open habitat conditions with some cover (e.g., dense thatch layer, downed woody debris, scattered areas with taller herbaceous vegetation, shrubs or trees), providing additional structures for basking (e.g., logs, basking platforms), and reducing glossy buckthorn and woody encroachment would provide these species with suitable habitat for thermoregulation and refugia from predators. Studies have shown that common reed (*Phragmites australis*) can have a negative impact on amphibian and reptile distribution, habitat and/or reproductive success (Meyer 2003, Bolton and Brooks 2010, Mifsud 2014a). Monitoring and controlling the spread of common reed in the preserve and along Squaw Bay would benefit these and other herp species.

Management activities such as prescribed burning and mowing have potential for adversely impacting these species. Conducting these activities during the inactive season (i.e., November through early April) or on days when herps are unlikely to be basking or above ground (e.g., on cloudy/overcast days with air temperatures below 55^{o}F) and providing refugia during burns would reduce the potential for impacting these species. Raising the mower deck to at least six inches in height and mowing along the edges of waterbodies and wetlands and in upland areas where turtles may be nesting in late summer after the turtle nesting season also would reduce the potential for adversely impacting amphibians and reptiles. If road mortality is a threat (e.g., along US-23), installing large or oversized culverts with open metal grate tops and soil bottoms or road underpasses for wildlife crossings, and/or installing road fencing or barriers can facilitate safe road crossings, reduce road mortality, and improve habitat connectivity for amphibians and reptiles (Mifsud 2014b). Suitable nesting habitat seems to be limited within and around the preserve. Maintaining, creating, and/or restoring open, sandy areas near the preserve away from roads would provide suitable nesting habitat for turtles that are potentially safe from predators. Control of meso-predators (e.g., raccoons), particularly during the turtle nesting season, would help reduce predation of turtle nests and enhance reproductive success and population recruitment.

Additional best management practices for amphibians and reptiles are provided in Kingsbury and Gibson (2012), Mifsud (2014b), and Michigan's Candidate Conservation Agreement with Assurances for the Eastern Massasauga Rattlesnake (MDNR 2016). Public education and outreach also are needed to help facilitate proper identification of amphibians and reptiles, increase public awareness and engagement, and discourage illegal persecution, harassment, and collection, particularly regarding rare species.

Squaw Bay

Botanical Surveys:
Floristic Quality Assessments (FQAs) were conducted and general observations made separately for the open fen zone west of US-23 and the Lake Michigan portion of the site, which grades into emergent marsh, east of US-23. The focal species for treatment in the west side open fen was glossy buckthorn while, invasive phragmites was the target on the east side.

West side coastal fen: Meander surveys were conducted on-foot in 2016 throughout the open fen and all species observed were recorded for the FQA prior to treatment. Treatment for glossy buckthorn was implemented in 2017 by the Nature Conservancy in the areas shown in pink in Figure 7. Post-treatment meander-surveys were conducted on-foot in 2018. All species were recorded for the follow-up FQA, and treatment areas were examined for evidence of glossy buckthorn.

Pre-treatment results: The open fen area was very diverse with scattered forested islands dominated by cedar and smaller islands of dense herbaceous vegetation and small shrubs of cedar (*Thuja occidentalis*), paper birch (*Betula papyrifera*) and balsam fir (*Abies balsamea*). Many large shrubs (stem diameter > 1 in) of glossy buckthorn were observed in the forested islands and smaller shrubs and seedlings were common in the smaller vegetated islands. Few, but occasional stems were observed in the open fen. The FQA results are shown below and the species list is included in Appendix 2.

Conservation-Based Metrics:	
Total Mean C:	5
N Mean C:	5.3
Total FQI:	37.4
N FQI:	38.6
Adjusted FQI:	51.6
% C value 0:	7.1
% C value 1-3:	28.6
% C value 4-6:	30.4
% C value 7-10:	33.9
N Tree Mean C:	3
N Shrub Mean C:	4.9
N Herbaceous Mean C:	5.7

Species Richness:		
Total Species:	56	
N Species:	53	94.60%
Non-native Species:	3	5.40%
Species Wetness:		
Mean Wetness:	-2.7	
N Mean Wetness:	-2.9	
Physiognomy Metrics		
Tree:	7	12.50%
Shrub:	8	14.30%
Vine:	0	0%
Forb:	24	42.90%
Grass:	5	8.90%

Duration Metrics:		
Annual:	1	1.80%
Perennial:	54	96.40%
Biennial:	1	1.80%
Native Annual:	1	1.80%
Native Perennial:	51	91.10%
Native Biennial:	1	1.80%
Physiognomy Metrics cont.		
Sedge:	8	14.30%
Rush:	3	5.40%
Fern:	1	1.80%
Bryophyte:	0	0%

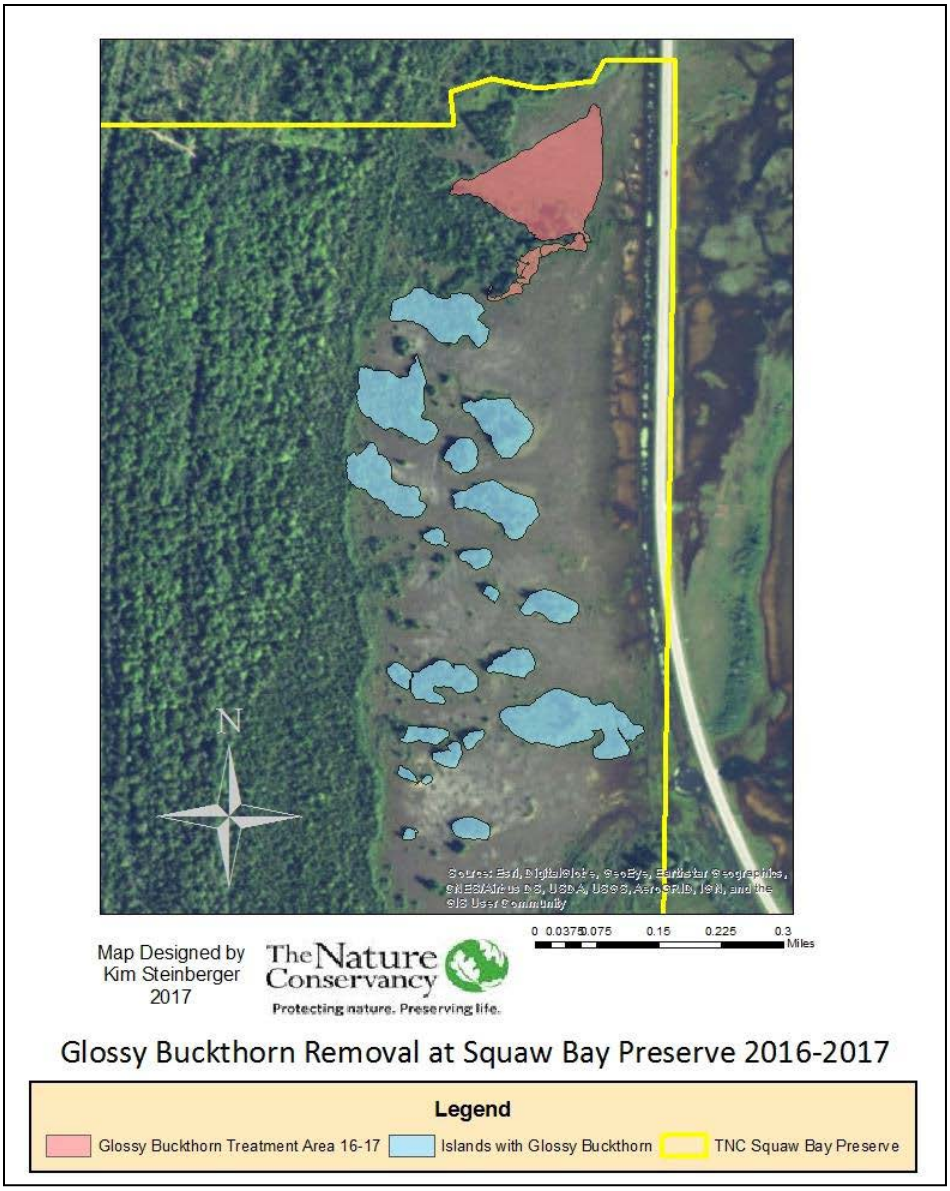


Figure 7. Glossy buckthorn removal at Squaw Bay Preserve by The Nature Conservancy.

Post-treatment results: There was little change in diversity with almost all the same species noted as during the pre-survey. Few glossy buckthorn stump-sprouts were found, and occasional large diameter glossy buckthorn shrubs were observed in the treated areas (Fig. 8). However, hundreds of seedlings and occasional small diameter shrubs (stem diameter < 1 in) were observed in the ground layer and understory of the forested islands (Fig. 9, 10), and seedlings and occasional small glossy buckthorn sprouts were seen in the smaller vegetated islands that were not treated in 2017 (Fig. 11). As noted in the TNC treatment report, virtually all the vegetation islands have been colonized by buckthorn seedlings (shown in blue in Figure 7), and our surveys confirmed that. The FQA results are shown below and the species list can be found in Appendix 2.

Squaw Bay Coastal Fen FQA Summary Metrics 2018.

Conservation-Based Metrics:		**Species Richness:**			**Duration Metrics:**		
Total Mean C:	4.9	Total Species:	55		Annual:	1	1.80%
N Mean C:	5.3	N Species:	51	92.70%	Perennial:	53	96.40%
Total FQI:	36.3	Non-native Species:	4	7.30%	Biennial:	1	1.80%
N FQI:	37.8	**Species Wetness:**			Native Annual:	1	1.80%
Adjusted FQI:	51	Mean Wetness:	-2.6		Native Perennial:	49	89.10%
% C value 0:	9.1	N Mean Wetness:	-2.8		Native Biennial:	1	1.80%
% C value 1-3:	29.1	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	29.1	Tree:	8	14.50%	Sedge:	6	10.90%
% C value 7-10:	32.7	Shrub:	10	18.20%	Rush:	1	1.80%
N Tree Mean C:	2.8	Vine:	0	0%	Fern:	1	1.80%
N Shrub Mean C:	5.2	Forb:	23	41.80%	Bryophyte:	0	0%
N Herbaceous Mean C:	5.9	Grass:	6	10.90%			

Comments: While cut-stump treatment and foliar spray with glyphosate were effective, more stems need to be treated and management of the seed bank will be necessary for long-term control at this site. Without continued control, the high-quality fen will be gradually degraded through buckthorn establishment. Consideration should be given to establishing a broader scale management plan, that accounts for the dense source patches of glossy buckthorn around much of the perimeter of the site, both west and east of US-23.

Figure 8. Large glossy buckthorn observed post treatment.

Figure 9. Small diameter shrubs of glossy buckthorn observed post treatment.

Figure 10. Buckthorn seedlings in ground layer of forested habitat islands.

Figure 11. Buckthorn seedlings in smaller vegetated islands.

East Side Emergent Marsh Complex: The lakeward side was meander-surveyed by wading and all species were recorded for the FQA in 2016. Invasive phragmites was treated by TNC in the areas shown in red in Figure 12. The pre-treatment survey was only conducted in the vegetated area closest to US-23 and did not capture the north shoreline by the homes or eastward into the Bay treatment areas. Post-survey monitoring was conducted by kayak, due to high water levels, and covered the entire treatment area. All species observed were recorded for the pre and post FQAs and phragmites points were mapped and categorized by status.

Figure 12. Invasive phragmites treatment areas in East Squaw Bay Preserve 2017.

Pre-treatment results: This area is a mosaic of emergent marsh, with northern fen along the northwest corner and pockets of northern wet meadow and zones dominated by wetland shrubs to the south. Several small vegetated islands were scattered in the marsh. Large, dense patches of invasive phragmites were observed in the emergent zone, several of which had occasional stems that appeared to be native growing within them (Fig. 13). Substantial, dense stands of large diameter (>1-2 in), tall glossy buckthorn occur along the northeast edge of the site and occasional smaller buckthorn shrubs were observed on some of the vegetated islands. The FQA metrics are shown below and the species list is included in Appendix 2.

Squaw Bay Emergent Marsh FQA Summary Metrics 2016

Conservation-Based Metrics:		**Species Richness:**			**Duration Metrics:**		
Total Mean C:	3.6	Total Species:	56		Annual:	3	5.40%
N Mean C:	4.6	N Species:	44	78.60%	Perennial:	50	89.30%
Total FQI:	26.9	Non-native Species:	12	21.40%	Biennial:	3	5.40%
N FQI:	30.5	**Species Wetness:**			Native Annual:	2	3.60%
Adjusted FQI:	40.8	Mean Wetness:	-2		Native Perennial:	42	75%
% C value 0:	23.2	N Mean Wetness:	-3		Native Biennial:	0	0%
% C value 1-3:	21.4	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	39.3	Tree:	4	7.10%	Sedge:	6	10.70%
% C value 7-10:	16.1	Shrub:	6	10.70%	Rush:	0	0%
N Tree Mean C:	3.5	Vine:	0	0%	Fern:	3	5.40%
N Shrub Mean C:	3.6	Forb:	30	53.60%	Bryophyte:	0	0%
N Herbaceous Mean C:	4.9	Grass:	7	12.50%			

Figure 13. Native stems observed within invasive phragmites patch in 2016.

Post-treatment results: As noted, the treatment area included areas further lakeward than were surveyed pre-treatment (Fig. 12). However, the overall post-treatment FQA covered the entire treatment area, and eleven additional species were documented. On the west end of the site, many patches of invasive phragmites were observed with low kill rates and aggressive re-growth and fewer patches were observed with high kill rates (Fig. 14, 15). Some small patches of apparently native phragmites were observed in the near shore zones by the homes lining the north shore. Further lakeward to the east, there were many thriving patches of what appears to be native phragmites (Fig. 16). No non-native phragmites was observed in this portion of the site. Because this area was not surveyed during pre-monitoring, it is uncertain whether significant patches of invasive phragmites occurred there previously and were selectively treated. Figure 17 shows a map of native and non-native phragmites that was observed during surveys. Points are categorized as native live, non-native and native (mixed), non-native dead, non-native live and dead (mixed) and non-native live. The FQA metrics are shown below and the species list is included in Appendix 2.

Conservation-Based Metrics:		**Species Richness:**			**Duration Metrics:**		
Total Mean C:	3.5	Total Species:	68		Annual:	4	5.90%
N Mean C:	4.3	N Species:	55	80.90%	Perennial:	59	86.80%
Total FQI:	28.9	Non-native Species:	13	19.10%	Biennial:	5	7.40%
N FQI:	31.9	**Species Wetness:**			Native Annual:	3	4.40%
Adjusted FQI:	38.7	Mean Wetness:	-1.9		Native Perennial:	50	73.50%
% C value 0:	23.5	N Mean Wetness:	-2.6		Native Biennial:	2	2.90%
% C value 1-3:	23.5	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	38.2	Tree:	4	5.90%	Sedge:	7	10.30%
% C value 7-10:	14.7	Shrub:	7	10.30%	Rush:	1	1.50%
N Tree Mean C:	3.5	Vine:	1	1.50%	Fern:	3	4.40%
N Shrub Mean C:	3.2	Forb:	36	52.90%	Bryophyte:	0	0%
N Herbaceous Mean C:	4.6	Grass:	9	13.20%			

Figure 14. Phragmites patch with a low kill rate.

Figure 15. Phragmites patch with high kill rate.

Figure 16. Many patches of what is likely native phragmites were observed.

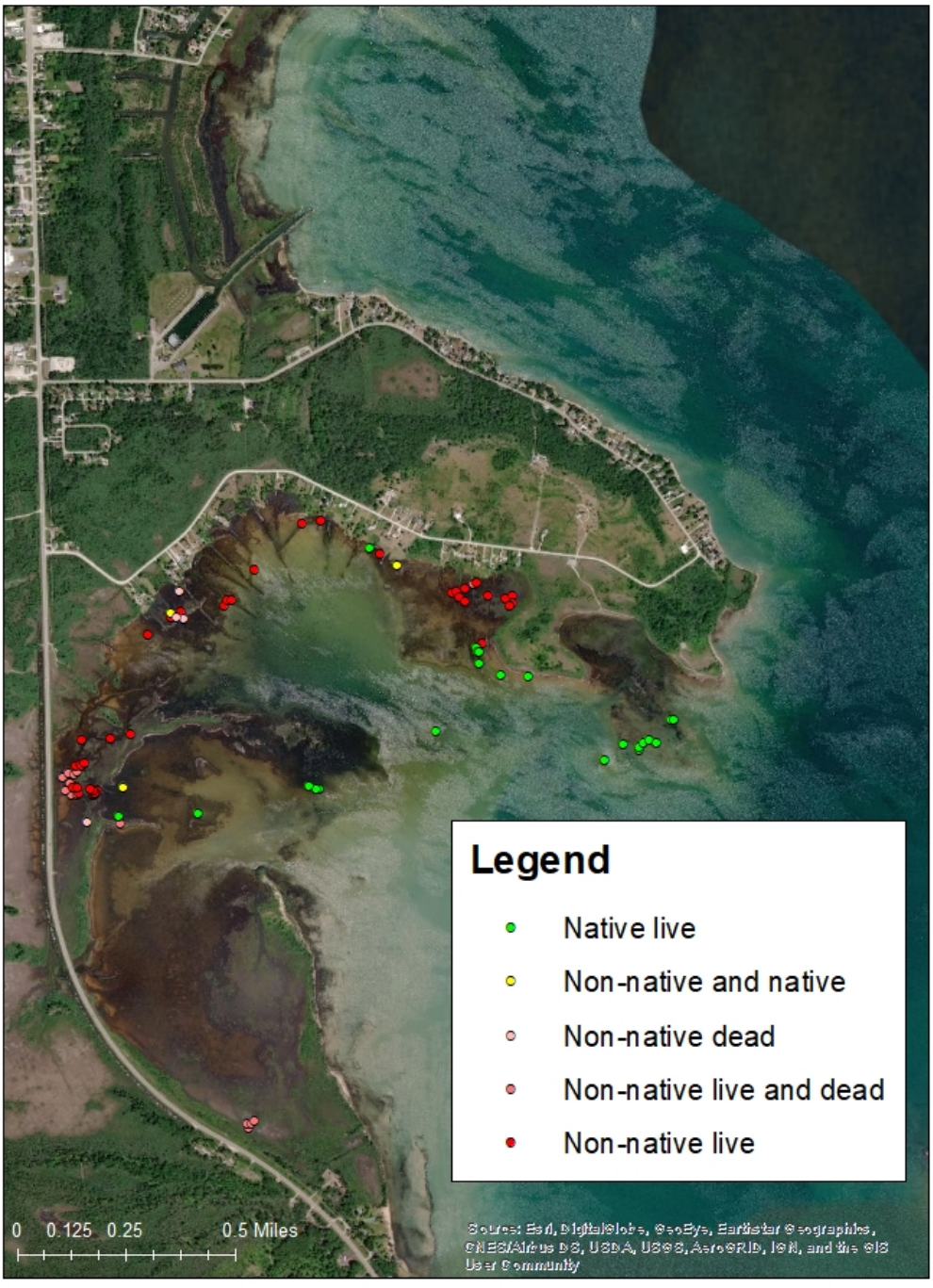


Figure 17. Map of observations of native and non-native phragmites in Squaw Bay.

Comments: It is unusual to see such vigorous re-growth of invasive phragmites the first year after treatment. It would be useful to review the specifics of the herbicide mixes used, the application methods, the timing and weather conditions during application, as well as consider whether there are other factors that may have contributed to the observed vigor and regrowth of many of the invasive patches.

The apparently native phragmites patches in the eastern portion of the site should genetically tested to confirm their native status. Although hybridization has been documented in the field, it has not been reported frequently. Genetic information from this site, may yield information relevant to hybridization mechanisms, frequency and potential invasion impacts.

This site offers an opportunity to study the feasibility of sustaining native phragmites colonies within a site that is largely dominated by non-native phragmites. There are many sites in Michigan where native and non-native are intermixed or are very close to one another, and managers frequently opt to treat both native and non-native plants. The apparently native colonies at this site are substantial and appear isolated enough that it seems possible to selectively treat just invasive plants. The apparently native colonies should be allowed to grow, but monitored for invasiveness themselves, along with aggressive treatment of the large known invasive patches to the west and rapid response to any outliers that begin to encroach upon the native patches.

While treatment at this site focused on phragmites, the stands of glossy buckthorn at the north edge of the site, will provide a continual source of propagules to the entire Squaw Bay site. Successful expansion of glossy buckthorn will depend upon water levels, however, some of the vegetated islands already support buckthorn and it is almost certain to expand, particularly in low water years.

Alpena Township Nature Preserve/El Cajon Bay

Meander surveys were conducted in the open fen on the east side of the peninsula and in the adjacent near-shore emergent vegetation. All species observed were recorded for the FQAs of each community and any occurrences of phragmites and glossy buckthorn were noted.

Pre-treatment results: FQAs were completed separately for the fen and for the emergent marsh zone and the metrics for each are shown below. The fen was highly diverse and no phragmites was observed. The emergent marsh had low species diversity and only one small patch of phragmites was observed in shallow water. The FQA's of the fen and marsh cannot be directly compared to one another due to the differing intrinsic diversity of each community type. However, the marsh was very sparsely vegetated and on the low end of the diversity range when compared to many other emergent marshes.

Alpena Township Nature Preserve Coastal Fen FQA Summary Metrics 2016.

Conservation-Based Metrics:		**Species Richness:**			**Duration Metrics:**		
Total Mean C:	5.7	Total Species:	82		Annual:	3	3.70%
N Mean C:	6.1	N Species:	77	93.90%	Perennial:	76	92.70%
Total FQI:	51.6	Non-native Species:	5	6.10%	Biennial:	3	3.70%
N FQI:	53.5	**Species Wetness:**			Native Annual:	3	3.70%
Adjusted FQI:	59.1	Mean Wetness:	-1.7		Native Perennial:	72	87.80%
% C value 0:	7.3	N Mean Wetness:	-1.9		Native Biennial:	2	2.40%
% C value 1-3:	25.6	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	20.7	Tree:	8	9.80%	Sedge:	13	15.90%
% C value 7-10:	46.3	Shrub:	9	11%	Rush:	3	3.70%
N Tree Mean C:	2.8	Vine:	1	1.20%	Fern:	1	1.20%
N Shrub Mean C:	7	Forb:	40	48.80%	Bryophyte:	0	0%
N Herbaceous Mean C:	6.4	Grass:	7	8.50%			

Alpena Township Nature Preserve Emergent Marsh FQA Summary Metrics 2016.

Conservation-Based Metrics:		**Species Richness:**			**Duration Metrics:**		
Total Mean C:	5.3	Total Species:	17		Annual:	0	0%
N Mean C:	5.6	N Species:	16	94.10%	Perennial:	17	100%
Total FQI:	21.9	Non-native Species:	1	5.90%	Biennial:	0	0%
N FQI:	22.4	**Species Wetness:**			Native Annual:	0	0%
Adjusted FQI:	54.3	Mean Wetness:	-3.8		Native Perennial:	16	94.10%
% C value 0:	5.9	N Mean Wetness:	-3.9		Native Biennial:	0	0%
% C value 1-3:	17.6	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	41.2	Tree:	1	5.90%	Sedge:	7	41.20%
% C value 7-10:	35.3	Shrub:	4	23.50%	Rush:	1	5.90%
N Tree Mean C:	4	Vine:	0	0%	Fern:	0	0%
N Shrub Mean C:	5.3	Forb:	3	17.60%	Bryophyte:	0	0%
N Herbaceous Mean C:	5.9	Grass:	1	5.90%			

Post-treatment results: Post-treatment monitoring for the Township Nature Preserve was not conducted because no treatment occurred there. Treatment was conducted in a portion of El Cajon Bay (Fig. 18, 19) that was not surveyed pre-treatment. An FQA was conducted in the treatment area during post-monitoring in 2018, and the area was inspected for the presence of invasive phragmites and glossy buckthorn. The post-treatment surveys had lower species diversity and fewer highly conservative species than the Alpena Township Nature Preserve fen, likely driven by hydrological differences resulting in denser vegetation and less marl development. One sparse patch of invasive phragmites was observed along the Bay west of the treatment area and one small seedling of glossy buckthorn was also observed outside of the treatment area (Fig. 20). The FQA metrics are shown below and the species list is in Appendix 2.

Figure 18. El Cajon fen complex.

Figure 19. Treatment area El Cajon Bay.

Figure 20. Glossy buckthorn seedling.

El Cajon Coastal Fen FQA Summary Metrics 2018.

Conservation-Based Metrics:		Species Richness:			Duration Metrics:		
Total Mean C:	5.1	Total Species:	59		Annual:	1	1.70%
N Mean C:	5.6	N Species:	54	91.50%	Perennial:	58	98.30%
Total FQI:	39.2	Non-native Species:	5	8.50%	Biennial:	0	0%
N FQI:	41.2	**Species Wetness:**			Native Annual:	1	1.70%
Adjusted FQI:	53.6	Mean Wetness:	-2.7		Native Perennial:	53	89.80%
% C value 0:	8.5	N Mean Wetness:	-2.8		Native Biennial:	0	0%
% C value 1-3:	25.4	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	33.9	Tree:	6	10.20%	Sedge:	10	16.90%
% C value 7-10:	32.2	Shrub:	10	16.90%	Rush:	4	6.80%
N Tree Mean C:	3.2	Vine:	0	0%	Fern:	2	3.40%
N Shrub Mean C:	6.9	Forb:	22	37.30%	Bryophyte:	0	0%
N Herbaceous Mean C:	5.7	Grass:	5	8.50%			

Ossineke State Forest Campground Area

Meander-surveys focused on the emergent zone along a sand spit where invasive phragmites was observed at the north end of the Campground where invasive phragmites was observed (Fig. 21). All species observed were recorded in the emergent zone along the spit.

Pre-treatment results: Only a small zone of emergent plants was documented along the spit where phragmites was observed, which graded into a narrow sand bar with low overall low species diversity. A large patch of native phragmites was observed inland behind a low foredune to the south (Figure 21). The FQA metrics are shown below and the species list is included in Appendix 2.

Ossineke State Forest Campground Emergent Marsh FQA Summary Metrics 2016:

Conservation-Based Metrics:		Species Richness:			Duration Metrics		
Total Mean C:	3.7	Total Species:	24		Annual:	0	0%
N Mean C:	4.9	N Species:	18	75%	Perennial:	24	100%
Total FQI:	18.1	Non-native Species:	6	25%	Biennial:	0	0%
N FQI:	20.8	**Species Wetness:**			Native Annual:	0	0%
Adjusted FQI:	42.4	Mean Wetness:	-2.4		Native Perennial:	18	75%
% C value 0:	25	N Mean Wetness:	-3.6		Native Biennial:	0	0%
% C value 1-3:	16.7	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	45.8	Tree:	1	4.20%	Sedge:	6	25%
% C value 7-10:	12.5	Shrub:	6	25%	Rush:	1	4.20%
N Tree Mean C:	n/a	Vine:	0	0%	Fern:	1	4.20%
N Shrub Mean C:	6.2	Forb:	4	16.70%	Bryophyte:	0	0%
N Herbaceous Mean C:	4.5	Grass:	5	8.30%			

Post-treatment results: Post-treatment surveys were not conducted for this site, since treatments were not implemented there. However, like the Squaw Bay emergent marsh area, this site provides an opportunity to selectively control invasive phragmites and sustain the nearby inland native phragmites colony that is extremely vulnerable to invasion. Currently the native colony appears to be isolated from invasive phragmites, but regular monitoring is recommended to ensure no future invasion occurs. Treatment of invasive phragmites along the shoreline and regular monitoring of threats to the native phragmites is warranted. Genetic testing should be done to confirm the status of both the native and non-native colonies. Michigan is currently a refugia for native phragmites and wherever possible, efforts to sustain native occurrences isolated from the invasive phragmites are critical to the longevity of this species in Michigan.

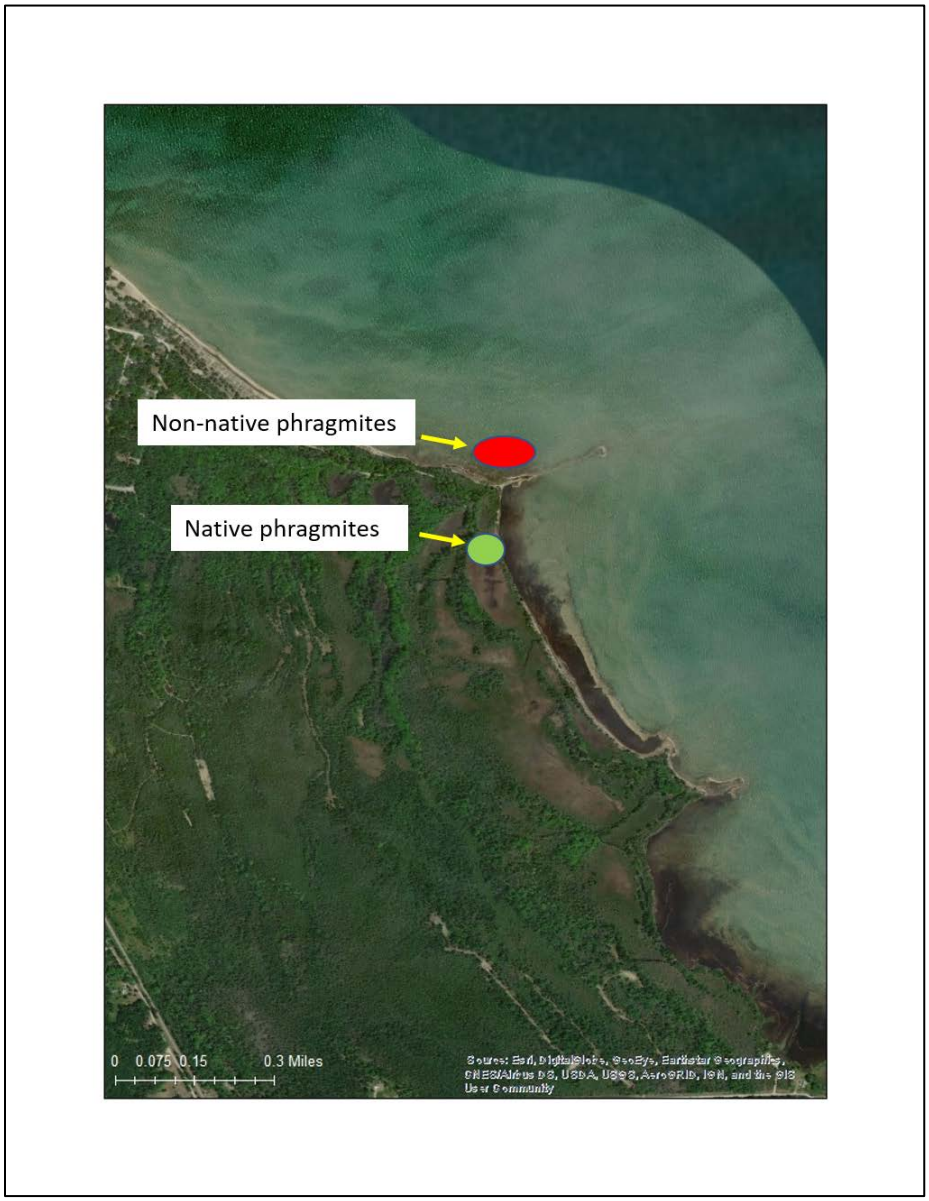


Figure 21. Areas of native and non-native phragmites documented at the Ossineke State Forest Campground.

Acknowledgements

It was a pleasure collaborating with Huron Pines staff to envision and implement this project to protect Alpena's unique coastal wetlands. The expertise and professionalism of Huron Pines is a model for conservation organizations statewide. This project was greatly enhanced through the hard work and dedication of numerous AmeriCorps members including Dan Earl, Kailyn Atkinson, Wendy Lemon, Tyler Dula, Kathryn Gopelrud, Christina Hamilton, Kristin Wing, Benjamin Bravo, Zach Zeillman, Wade Gibson and Kevin Drotos. The assistance and good-natured spirit of volunteers, Sue Keller, Mary Culik, Bob Sherrar, Karen Enterline from Friends of Negwegon and Deb Brisch and Bob Theiner from the Alpena Nature Preserve was much appreciated. Finally, it was heartening to witness the interest of the four Girl Scouts from Alpena High School. It is encouraging to see young people take an interest in protecting natural resources in their community. This project received valuable administrative and technical support from Michigan Natural Features Inventory staff Ashley Adkins, Helen Enander, Kraig Korroch and Nancy Toben.

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.

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

Bolton, R.M. and R.J. Brooks. 2010. Impact of the seasonal invasion of *Phragmites australis* (common reed) on turtle reproductive success. Chelonian Conservation Biology 9:238–243.

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.

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.

DeGregorio, B.A., J.V. Manning, N. Bieser, and B.A. Kingsbury. 2011. The spatial ecology of the eastern massasauga (*Sistrurus c. catenatus*) in northern Michigan. Herpetologica 67(1):71-79.

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

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

Ernst, C.H., J.E. Lovich, and R.W. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Inst. Press, Washington, D.C. 578 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.

Harding, J.H. and D.A. Mifsud. 2017. Amphibians and Reptiles of the Great Lakes Region, Revised Edition. University of Michigan Press, Ann Arbor, MI. 408 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.

Kingsbury, B.A. and J. Gibson (editors). 2012. Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States. Partners in Amphibian and Reptile Conservation Technical Publication HMG-1, 2nd Edition. 155 pp.

Lee, Y. 1999. Special animal abstract for *Emydoidea blandingii* (Blanding's turtle). Michigan Natural Features Inventory. Lansing, MI. 4 pp.

Lee, Y. and J. T. Legge. 2000. Special animal abstract for *Sistrurus catenatus catenatus* (eastern massasauga). Updated 2013. Michigan Natural Features Inventory, Lansing, MI. 8 pp.

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.

Meyer, S.W., 2003. Comparative use of *Phragmites australis* and other habitats by birds, amphibians, and small mammals at Long Point, Ontario. Ph.D. dissertation, Department of Zoology, University of Western Ontario, London. 128 pp.

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

Michigan Herp Atlas. 2018. Michigan Herp Atlas - A statewide herpetological atlas and data hub. Michigan, U.S.A. Available http://www.miherpatlas.com. (Accessed: November 15, 2018).

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

Mifsud, D.A. 2014a. A status assessment and review of the herpetofauna within the Saginaw Bay of Lake Huron. Journal of Great Lakes Research Supplement 40 (2014): 183-191.

Mifsud, D.A. 2014b. Michigan amphibian and reptile best management practices. Herpetological Resource and Management Technical Publication 2014. 165 pp.

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.

NatureServe. 2018. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: November 15, 2018).

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

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.

Weatherhead, P. J., & Prior, K. A. (1992). Preliminary observations of habitat use and movements of the eastern massasauga rattlesnake (Sistrurus c. catenatus). Journal of Herpetology, 26(4), 447-452.

Appendix 1. Photos- Herps Surveys at Squaw Bay

Photos: Squaw Bay Nature Preserve Herp Surveys 2018

Top and Middle Photos: Juvenile Blanding's Turtle captured in aquatic funnel trap on 7/10/18, photo by Yu Man Lee

Bottom Photos: Butler's garter snake found under coverboard on 7/10/18, photo by Yu Man Lee

Photos: Squaw Bay Nature Preserve Herp Surveys 2018

Top Left: Aquatic funnel trap – new set up in 2018.

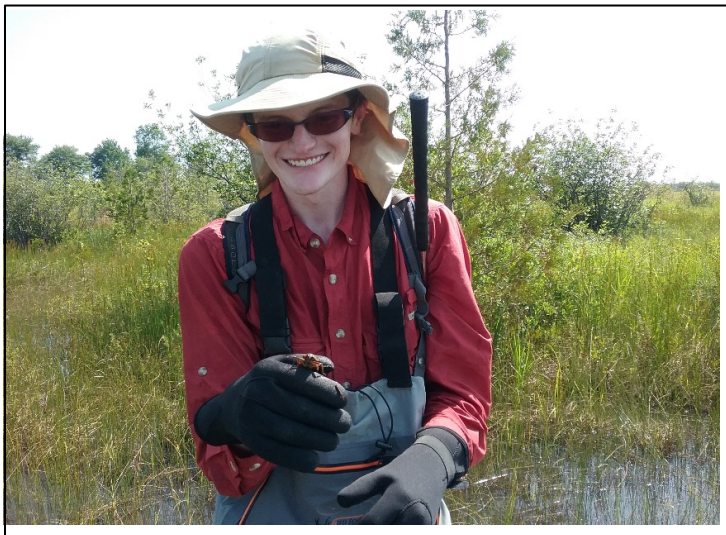
Top Right: Painted Turtle, aquatic funnel trapping, June 2018

Middle Right: Crayfish, aquatic funnel trapping, June 2018.

Bottom Left: Snapping Turtle, aquatic funnel trapping, June 2018.

Photos by Yu Man Lee

Photos: Squaw Bay Nature Preserve Herp Surveys 2018



Top Photo: Kailyn Atkinson setting aquatic funnel trap, June 2018.

Middle Photo: Kailyn Atkinson, aquatic funnel trapping, June 2018.

Bottom Photo: Zach Zeillman, aquatic funnel trapping, July 2018.

Photos by Yu Man Lee.

Photos: Squaw Bay Nature Preserve Herp Surveys 2017

Top: AmeriCorps member, Dan Earl, setting aquatic funnel trap for turtle trapping at Squaw Bay Nature Preserve

Middle Left and Right: Coverboards set for herp surveys at Squaw Bay Nature Preserve.

Bottom: Eastern garter snake found under one of the coverboards at Squaw Bay Nature Preserve.

Photos: Squaw Bay Nature Preserve Herp Surveys 2017

Top: Painted turtle travelling in area with suitable turtle nesting habitat west of fen at Squaw Bay Nature Preserve

Middle: ATV use area southwest of fen at Squaw Bay Nature Preserve with suitable turtle nesting habitat

Bottom: Depredated turtle nest found along edge of ATV use area southwest of Squaw Bay Nature Preserve

Photos by Yu Man Lee.

Photos: Squaw Bay Nature Preserve Herp Surveys 2017

Top: Aquatic funnel trap for turtle trapping survey

Middle left: Painted turtle caught in turtle trap

Middle right: Pike caught in turtle trap

Bottom: Pumpkinseed

Photos by Yu Man Lee.

Photos: Squaw Bay Nature Preserve Herp Surveys 2017

Top left: Juvenile bowfin caught in turtle trap

Middle left: Bullhead caught in turtle trap

Middle right: Pickerel caught in turtle trap

Bottom left: Crayfish caught in turtle trap

Photos by Yu Man Lee.

Appendix 2. Species Lists for Project Sites

Squaw Bay Coastal Fen FQA 2016

Conservation-Based Metrics:		Species Richness:			Duration Metrics:		
Total Mean C:	5	Total Species:	56		Annual:	1	1.80%
N Mean C:	5.3	N Species:	53	94.60%	Perennial:	54	96.40%
Total FQI:	37.4	Non-native Species:	3	5.40%	Biennial:	1	1.80%
N FQI:	38.6	**Species Wetness:**			Native Annual:	1	1.80%
Adjusted FQI:	51.6	Mean Wetness:	-2.7		Native Perennial:	51	91.10%
% C value 0:	7.1	N Mean Wetness:	-2.9		Native Biennial:	1	1.80%
% C value 1-3:	28.6	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	30.4	Tree:	7	12.50%	Sedge:	8	14.30%
% C value 7-10:	33.9	Shrub:	8	14.30%	Rush:	3	5.40%
N Tree Mean C:	3	Vine:	0	0%	Fern:	1	1.80%
N Shrub Mean C:	4.9	Forb:	24	42.90%	Bryophyte:	0	0%
N Herbaceous Mean C:	5.7	Grass:	5	8.90%			

Species documented:

Scientific Name	Common Name	Native?	C	W	Physiog.	Duration
Abies balsamea	balsam fir	native	3	0	tree	perennial
Agrostis gigantea	redtop	non-nat	0	-3	grass	perennial
Asclepias incarnata	swamp milkweed	native	6	-5	forb	perennial
Betula papyrifera	paper birch	native	2	3	tree	perennial
Calamagrostis canadensis	blue-joint	native	3	-5	grass	perennial
Calamagrostis stricta	narrow-leaved reedgrass	native	10	-3	grass	perennial
Campanula aparinoides	marsh bellflower	native	7	-5	forb	perennial
Carex flava	sedge	native	4	-5	sedge	perennial
Carex lasiocarpa	sedge	native	8	-5	sedge	perennial
Carex stricta	sedge	native	4	-5	sedge	perennial
Cirsium muticum	swamp thistle	native	6	-5	forb	biennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	perennial
Comarum palustre	marsh cinquefoil	native	7	-5	forb	perennial
Danthonia spicata	poverty grass; oatgrass	native	4	5	grass	perennial
Dasiphora fruticosa	shrubby cinquefoil	native	8	-3	shrub	perennial
Doellingeria umbellata	flat-topped white aster	native	5	-3	forb	perennial
Eleocharis palustris	spike-rush	native	5	-5	sedge	perennial
Eleocharis rostellata	spike-rush	native	10	-5	sedge	perennial
Equisetum variegatum	variegated scouring rush	native	6	-3	fern	perennial
Euthamia graminifolia	grass-leaved goldenrod	native	3	0	forb	perennial
Fragaria virginiana	wild strawberry	native	2	3	forb	perennial
Frangula alnus	glossy buckthorn	non-nat	0	0	shrub	perennial
Fraxinus pennsylvanica	red ash	native	2	-3	tree	perennial
Gentianopsis virgata	small fringed gentian	native	8	-5	forb	annual
Hypericum kalmianum	Kalm's St. Johns-wort	native	10	-3	shrub	perennial
Juncus balticus	rush	native	4	-5	rush	perennial
Juncus brachycephalus	rush	native	7	-5	rush	perennial

Juncus brevicaudatus	rush	native	8	-5	rush	perennial
Larix laricina	tamarack	native	5	-3	tree	perennial
Lobelia kalmia	bog lobelia	native	10	-5	forb	perennial
Parnassia glauca	grass-of-parnassus	native	8	-5	forb	perennial
Picea glauca	white spruce	native	3	3	tree	perennial
Poa compressa	Canada bluegrass	non-nat	0	3	grass	perennial
Populus balsamifera	balsam poplar	native	2	-3	tree	perennial
Primula mistassinica	birds-eye primrose	native	10	-3	forb	perennial
Prunella vulgaris	self-heal	native	0	0	forb	perennial
Rhynchospora capitellata	beak-rush	native	6	-5	sedge	perennial
Rudbeckia hirta	black-eyed susan	native	1	3	forb	perennial
Salix discolor	pussy willow	native	1	-3	shrub	perennial
Salix exigua	sandbar willow	native	1	-3	shrub	perennial
Salix myricoides	blueleaf willow	native	9	-3	shrub	perennial
Salix petiolaris	slender willow	native	1	-3	shrub	perennial
Sarracenia purpurea	pitcher-plant	native	10	-5	forb	perennial
Schoenoplectus pungens	threesquare	native	5	-5	sedge	perennial
Solidago altissima	tall goldenrod	native	1	3	forb	perennial
Solidago canadensis	Canada goldenrod	native	1	3	forb	perennial
Solidago ohioensis	Ohio goldenrod	native	8	-5	forb	perennial
Solidago rugosa	rough-leaved goldenrod	native	3	0	forb	perennial
Solidago uliginosa	bog goldenrod	native	4	-5	forb	perennial
Spiraea alba	meadowsweet	native	4	-3	shrub	perennial
Spiranthes cernua	nodding ladies-tresses	native	4	-3	forb	perennial
Symphyotrichum lanceolatum	panicled aster	native	2	-3	forb	perennial
Thuja occidentalis	arbor vitae	native	4	-3	tree	perennial
Triadenum fraseri	marsh St. Johns-wort	native	6	-5	forb	perennial
Triantha glutinosa	false asphodel	native	10	-5	forb	perennial
Triglochin maritima	common bog arrow-grass	native	8	-5	forb	perennial

Squaw Bay Coastal Fen FQA 2018

Conservation-Based Metrics:		Species Richness:			Duration Metrics:		
Total Mean C:	4.9	Total Species:	55		Annual:	1	1.80%
N Mean C:	5.3	N Species:	51	92.70%	Perennial:	53	96.40%
Total FQI:	36.3	Non-native Species:	4	7.30%	Biennial:	1	1.80%
N FQI:	37.8	**Species Wetness:**			Native Annual:	1	1.80%
Adjusted FQI:	51	Mean Wetness:	-2.6		Native Perennial:	49	89.10%
% C value 0:	9.1	N Mean Wetness:	-2.8		Native Biennial:	1	1.80%
% C value 1-3:	29.1	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	29.1	Tree:	8	14.50%	Sedge:	6	10.90%
% C value 7-10:	32.7	Shrub:	10	18.20%	Rush:	1	1.80%
N Tree Mean C:	2.8	Vine:	0	0%	Fern:	1	1.80%
N Shrub Mean C:	5.2	Forb:	23	41.80%	Bryophyte:	0	0%
N Herbaceous Mean C:	5.9	Grass:	6	10.90%			

Species Documented:

Scientific Name	Common Name	Native?	C	W	Physiog	Duration
Abies balsamea	balsam fir	native	3	0	tree	perennial
Agrostis gigantea	redtop	non-nat	0	-3	grass	perennial
Asclepias incarnata	swamp milkweed	native	6	-5	forb	perennial
Betula papyrifera	paper birch	native	2	3	tree	perennial
Calamagrostis canadensis	blue-joint	native	3	-5	grass	perennial
Calamagrostis stricta	narrow-leaved reedgrass	native	10	-3	grass	perennial
Campanula aparinoides	marsh bellflower	native	7	-5	forb	perennial
Carex flava	sedge	native	4	-5	sedge	perennial
Cirsium muticum	swamp thistle	native	6	-5	forb	biennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	perennial
Comarum palustre	marsh cinquefoil	native	7	-5	forb	perennial
Cornus sericea	red-osier	native	2	-3	shrub	perennial
Danthonia spicata	poverty grass; oatgrass	native	4	5	grass	perennial
Dasiphora fruticosa	shrubby cinquefoil	native	8	-3	shrub	perennial
Doellingeria umbellata	flat-topped white aster	native	5	-3	forb	perennial
Eleocharis elliptica	golden-seeded spike rush	native	6	-5	sedge	perennial
Eleocharis palustris	spike-rush	native	5	-5	sedge	perennial
Equisetum variegatum	variegated scouring rush	native	6	-3	fern	perennial
Euthamia graminifolia	grass-leaved goldenrod	native	3	0	forb	perennial
Fragaria virginiana	wild strawberry	native	2	3	forb	perennial
Frangula alnus	glossy buckthorn	non-nat	0	0	shrub	perennial
Fraxinus pennsylvanica	red ash	native	2	-3	tree	perennial
Gentianopsis virgata	small fringed gentian	native	8	-5	forb	annual
Hypericum kalmianum	Kalms St. Johns-wort	native	10	-3	shrub	perennial
Juncus brevicaudatus	rush	native	8	-5	rush	perennial
Larix laricina	tamarack	native	5	-3	tree	perennial
Lobelia kalmii	bog lobelia	native	10	-5	forb	perennial

Parnassia glauca	grass-of-parnassus	native	8	-5	forb	perennial
Physocarpus opulifolius	ninebark	native	4	-3	shrub	perennial
Picea glauca	white spruce	native	3	3	tree	perennial
Poa compressa	Canada bluegrass	non-nat	0	3	grass	perennial
Poa pratensis	Kentucky bluegrass	non-nat	0	3	grass	perennial
Populus balsamifera	balsam poplar	native	2	-3	tree	perennial
Populus tremuloides	quaking aspen	native	1	0	tree	perennial
Primula mistassinica	birds-eye primrose	native	10	-3	forb	perennial
Prunella vulgaris	self-heal	native	0	0	forb	perennial
Rhamnus alnifolia	alder-leaved buckthorn	native	8	-5	shrub	perennial
Rudbeckia hirta	black-eyed susan	native	1	3	forb	perennial
Salix discolor	pussy willow	native	1	-3	shrub	perennial
Salix exigua	sandbar willow	native	1	-3	shrub	perennial
Salix myricoides	blueleaf willow	native	9	-3	shrub	perennial
Sarracenia purpurea	pitcher-plant	native	10	-5	forb	perennial
Schoenoplectus acutus	hardstem bulrush	native	5	-5	sedge	perennial
Schoenoplectus pungens	threesquare	native	5	-5	sedge	perennial
Solidago canadensis	Canada goldenrod	native	1	3	forb	perennial
Solidago ohioensis	Ohio goldenrod	native	8	-5	forb	perennial
Solidago rugosa	rough-leaved goldenrod	native	3	0	forb	perennial
Solidago uliginosa	bog goldenrod	native	4	-5	forb	perennial
Spiraea alba	meadowsweet	native	4	-3	shrub	perennial
Spiranthes cernua	nodding ladies-tresses	native	4	-3	forb	perennial
Symphyotrichum lanceolatum	panicled aster	native	2	-3	forb	perennial
Thuja occidentalis	arbor vitae	native	4	-3	tree	perennial
Triantha glutinosa	false asphodel	native	10	-5	forb	perennial
Triglochin maritima	common bog arrow-grass	native	8	-5	forb	perennial
Utricularia cornuta	horned bladderwort	native	10	-5	forb	perennial

Squaw Bay Emergent Marsh FQA 2016

Conservation-Based Metrics:		Species Richness:			Duration Metrics:		
Total Mean C:	3.6	Total Species:	56		Annual:	3	5.40%
N Mean C:	4.6	N Species:	44	78.60%	Perennial:	50	89.30%
Total FQI:	26.9	Non-native Species:	12	21.40%	Biennial:	3	5.40%
N FQI:	30.5	**Species Wetness:**			Native Annual:	2	3.60%
Adjusted FQI:	40.8	Mean Wetness:	-2		Native Perennial:	42	75%
% C value 0:	23.2	N Mean Wetness:	-3		Native Biennial:	0	0%
% C value 1-3:	21.4	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	39.3	Tree:	4	7.10%	Sedge:	6	10.70%
% C value 7-10:	16.1	Shrub:	6	10.70%	Rush:	0	0%
N Tree Mean C:	3.5	Vine:	0	0%	Fern:	3	5.40%
N Shrub Mean C:	3.6	Forb:	30	53.60%	Bryophyte:	0	0%
N Herbaceous Mean C:	4.9	Grass:	7	12.50%			

Species documented:

Scientific Name	Common Name	Native?	C	W	Physiog.	Duration
Alnus incana	speckled alder	native	5	-3	shrub	perennial
Asclepias syriaca	common milkweed	native	1	5	forb	perennial
Calamagrostis canadensis	blue-joint	native	3	-5	grass	perennial
Calamagrostis stricta	narrow-leaved reedgrass	native	10	-3	grass	perennial
Carex lacustris	sedge	native	6	-5	sedge	perennial
Carex lasiocarpa	sedge	native	8	-5	sedge	perennial
Carex stricta	sedge	native	4	-5	sedge	perennial
Cirsium arvense	Canada thistle	non-nat	0	3	forb	perennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	perennial
Comarum palustre	marsh cinquefoil	native	7	-5	forb	perennial
Cornus sericea	red-osier	native	2	-3	shrub	perennial
Daucus carota	queen-annes-lace	non-nat	0	5	forb	biennial
Eleocharis palustris	spike-rush	native	5	-5	sedge	perennial
Eupatorium perfoliatum	boneset	native	4	-3	forb	perennial
Euphorbia virgata	leafy spurge	non-nat	0	5	forb	perennial
Eutrochium maculatum	Joe-pye-weed	native	4	-5	forb	perennial
Frangula alnus	glossy buckthorn	non-nat	0	0	shrub	perennial
Gentianopsis virgata	small fringed gentian	native	8	-5	forb	annual
Larix laricina	tamarack	native	5	-3	tree	perennial
Leucanthemum vulgare	ox-eye daisy	non-nat	0	5	forb	perennial
Melilotus albus	white sweet-clover	non-nat	0	3	forb	biennial
Mentha x piperita	peppermint	non-nat	0	-5	forb	perennial
Myrica gale	sweet gale	native	6	-5	shrub	perennial
Najas flexilis	slender naiad	native	5	-5	forb	annual
Onoclea sensibilis	sensitive fern	native	2	-3	fern	perennial
Osmunda regalis	royal fern	native	5	-5	fern	perennial
Parnassia glauca	grass-of-parnassus	native	8	-5	forb	perennial

Persicaria amphibia	water smartweed	native	6	-5	forb	perennial
Phalaris arundinacea	reed canary grass	native	0	-3	grass	perennial
Phragmites australis var. australis	reed	non-nat	0	-3	grass	perennial
Pinus strobus	white pine	native	3	3	tree	perennial
Plantago lanceolata	English plantain	non-nat	0	3	forb	perennial
Populus balsamifera	balsam poplar	native	2	-3	tree	perennial
Potamogeton richardsonii	Richardsons pondweed	native	5	-5	forb	perennial
Potentilla anserina	silverweed	native	5	-3	forb	perennial
Rudbeckia hirta	black-eyed susan	native	1	3	forb	perennial
Sagittaria latifolia	common arrowhead	native	4	-5	forb	perennial
Salix petiolaris	slender willow	native	1	-3	shrub	perennial
Schizachyrium scoparium	little bluestem	native	5	3	grass	perennial
Schoenoplectus acutus	hardstem bulrush	native	5	-5	sedge	perennial
Solidago altissima	tall goldenrod	native	1	3	forb	perennial
Solidago canadensis	Canada goldenrod	native	1	3	forb	perennial
Solidago ohioensis	Ohio goldenrod	native	8	-5	forb	perennial
Solidago uliginosa	bog goldenrod	native	4	-5	forb	perennial
Sonchus asper	prickly sow-thistle	non-nat	0	3	forb	annual
Sorghastrum nutans	Indian grass	native	6	3	grass	perennial
Spartina pectinata	cordgrass	native	5	-3	grass	perennial
Spiraea alba	meadowsweet	native	4	-3	shrub	perennial
Symphyotrichum lanceolatum	panicled aster	native	2	-3	forb	perennial
Thelypteris palustris	marsh fern	native	2	-3	fern	perennial
Thuja occidentalis	arbor vitae	native	4	-3	tree	perennial
Typha angustifolia	narrow-leaved cat-tail	non-nat	0	-5	forb	perennial
Utricularia intermedia	flat-leaved bladderwort	native	10	-5	forb	perennial
Vallisneria americana	eel-grass	native	7	-5	forb	perennial
Verbascum thapsus	common mullein	non-nat	0	5	forb	biennial
Verbena hastata	blue vervain	native	4	-3	forb	perennial

Squaw Bay Emergent Marsh Complex FQA 2018

Conservation-Based Metrics:		**Species Richness:**			**Duration Metrics:**		
Total Mean C:	3.5	Total Species:	68		Annual:	4	5.90%
N Mean C:	4.3	N Species:	55	80.90%	Perennial:	59	86.80%
Total FQI:	28.9	Non-native Species:	13	19.10%	Biennial:	5	7.40%
N FQI:	31.9	**Species Wetness:**			Native Annual:	3	4.40%
Adjusted FQI:	38.7	Mean Wetness:	-1.9		Native Perennial:	50	73.50%
% C value 0:	23.5	N Mean Wetness:	-2.6		Native Biennial:	2	2.90%
% C value 1-3:	23.5	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	38.2	Tree:	4	5.90%	Sedge:	7	10.30%
% C value 7-10:	14.7	Shrub:	7	10.30%	Rush:	1	1.50%
N Tree Mean C:	3.5	Vine:	1	1.50%	Fern:	3	4.40%
N Shrub Mean C:	3.2	Forb:	36	52.90%	Bryophyte:	0	0%
N Herbaceous Mean C:	4.6	Grass:	9	13.20%			

Species documented:

Scientific Name	Common Name	Native?	C	W	Physiog.	Duration
Alnus incana	speckled alder	native	5	-3	shrub	perennial
Andropogon gerardii	big bluestem	native	5	0	grass	perennial
Asclepias syriaca	common milkweed	native	1	5	forb	perennial
Calamagrostis canadensis	blue-joint	native	3	-5	grass	perennial
Calamagrostis stricta	narrow-leaved reedgrass	native	10	-3	grass	perennial
Carex lacustris	sedge	native	6	-5	sedge	perennial
Carex lasiocarpa	sedge	native	8	-5	sedge	perennial
Carex stricta	sedge	native	4	-5	sedge	perennial
Cirsium arvense	Canada thistle	non-nat	0	3	forb	perennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	perennial
Comarum palustre	marsh cinquefoil	native	7	-5	forb	perennial
Conyza canadensis	horseweed	native	0	3	forb	annual
Cornus foemina	gray dogwood	native	1	0	shrub	perennial
Cornus sericea	red-osier	native	2	-3	shrub	Perennial
Daucus carota	Queen-Annes-lace	non-nat	0	5	forb	Biennial
Eleocharis palustris	spike-rush	native	5	-5	sedge	Perennial
Elodea canadensis	common waterweed	native	1	-5	forb	Perennial
Erigeron annuus	daisy fleabane	native	0	3	forb	Biennial
Eupatorium perfoliatum	boneset	native	4	-3	forb	Perennial
Euphorbia virgata	leafy spurge	non-nat	0	5	forb	Perennial
Eutrochium maculatum	Joe-pye-weed	native	4	-5	forb	Perennial
Frangula alnus	glossy buckthorn	non-nat	0	0	shrub	Perennial
Gentianopsis virgata	small fringed gentian	native	8	-5	forb	Annual
Juncus canadensis	Canadian rush	native	6	-5	rush	Perennial
Larix laricina	tamarack	native	5	-3	tree	Perennial
Leucanthemum vulgare	ox-eye daisy	non-nat	0	5	forb	Perennial
Melilotus albus	white sweet-clover	non-nat	0	3	forb	Biennial

Mentha x piperita	peppermint	non-nat	0	-5	forb	Perennial
Myrica gale	sweet gale	native	6	-5	shrub	Perennial
Myriophyllum spicatum	Eurasian water-milfoil	non-nat	0	-5	forb	Perennial
Najas flexilis	slender naiad	native	5	-5	forb	Annual
Oenothera biennis	common evening-primrose	native	2	3	forb	Biennial
Onoclea sensibilis	sensitive fern	native	2	-3	fern	Perennial
Osmunda regalis	royal fern	native	5	-5	fern	Perennial
Parnassia glauca	grass-of-parnassus	native	8	-5	forb	Perennial
Persicaria amphibia	water smartweed	native	6	-5	forb	Perennial
Phalaris arundinacea	reed canary grass	native	0	-3	grass	Perennial
Phragmites australis var. americanus	reed	native	5	-3	grass	Perennial
Phragmites australis var. australis	reed	non-nat	0	-3	grass	Perennial
Pinus strobus	white pine	native	3	3	tree	Perennial
Plantago lanceolata	English plantain	non-nat	0	3	forb	Perennial
Populus balsamifera	balsam poplar	native	2	-3	tree	Perennial
Potamogeton richardsonii	Richardsons pondweed	native	5	-5	forb	Perennial
Potentilla anserina	silverweed	native	5	-3	forb	Perennial
Rudbeckia hirta	black-eyed susan	native	1	3	forb	Perennial
Sagittaria latifolia	common arrowhead	native	4	-5	forb	Perennial
Salix petiolaris	slender willow	native	1	-3	shrub	Perennial
Schizachyrium scoparium	little bluestem	native	5	3	grass	Perennial
Schoenoplectus acutus	hardstem bulrush	native	5	-5	sedge	Perennial
Schoenoplectus pungens	threesquare	native	5	-5	sedge	Perennial
Solidago altissima	tall goldenrod	native	1	3	forb	Perennial
Solidago canadensis	Canada goldenrod	native	1	3	forb	Perennial
Solidago ohioensis	Ohio goldenrod	native	8	-5	forb	Perennial
Solidago uliginosa	bog goldenrod	native	4	-5	forb	Perennial
Sonchus asper	prickly sow-thistle	non-nat	0	3	forb	Annual
Sorghastrum nutans	Indian grass	native	6	3	grass	Perennial
Spartina pectinata	cordgrass	native	5	-3	grass	Perennial
Spiraea alba	meadowsweet	native	4	-3	shrub	Perennial
Symphyotrichum lanceolatum	panicled aster	native	2	-3	forb	Perennial
Thelypteris palustris	marsh fern	native	2	-3	fern	Perennial
Thuja occidentalis	arbor vitae	native	4	-3	tree	Perennial
Triglochin maritima	common bog arrow-grass	native	8	-5	forb	Perennial
Typha angustifolia	narrow-leaved cat-tail	non-nat	0	-5	forb	Perennial
Utricularia intermedia	flat-leaved bladderwort	native	10	-5	forb	Perennial
Vallisneria americana	eel-grass	native	7	-5	forb	Perennial
Verbascum thapsus	common mullein	non-nat	0	5	forb	Biennial
Verbena hastata	blue vervain	native	4	-3	forb	Perennial
Vitis riparia	river-bank grape	native	3	0	vine	Perennial

Alpena Township Nature Preserve FQA 2016

Conservation-Based Metrics:		Species Richness:			Duration Metrics:		
Total Mean C:	5.7	Total Species:	82		Annual:	3	3.70%
N Mean C:	6.1	N Species:	77	93.90%	Perennial:	76	92.70%
Total FQI:	51.6	Non-native Species:	5	6.10%	Biennial:	3	3.70%
N FQI:	53.5	**Species Wetness:**			Native Annual:	3	3.70%
Adjusted FQI:	59.1	Mean Wetness:	-1.7		Native Perennial:	72	87.80%
% C value 0:	7.3	N Mean Wetness:	-1.9		Native Biennial:	2	2.40%
% C value 1-3:	25.6	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	20.7	Tree:	8	9.80%	Sedge:	13	15.90%
% C value 7-10:	46.3	Shrub:	9	11%	Rush:	3	3.70%
N Tree Mean C:	2.8	Vine:	1	1.20%	Fern:	1	1.20%
N Shrub Mean C:	7	Forb:	40	48.80%	Bryophyte:	0	0%
N Herbaceous Mean C:	6.4	Grass:	7	8.50%			

Species documented:

Scientific Name	Common Name	Native?	C	W	Physiog.	Duration
Abies balsamea	balsam fir	N	3	0	tree	perennial
Agalinis purpurea	purple false foxglove	native	7	-3	forb	annual
Agrostis gigantea	redtop	non-nat	0	-3	grass	perennial
Arctostaphylos uva-ursi	bearberry	native	8	5	shrub	perennial
Arnoglossum plantagineum	tuberous indian plantain	native	10	0	forb	perennial
Asclepias incarnata	swamp milkweed	native	6	-5	forb	perennial
Asclepias syriaca	common milkweed	native	1	5	forb	perennial
Betula papyrifera	paper birch	native	2	3	tree	perennial
Calamagrostis canadensis	blue-joint	native	3	-5	grass	perennial
Calopogon tuberosus	grass-pink	native	9	-5	forb	perennial
Campanula aparinoides	marsh bellflower	native	7	-5	forb	perennial
Campanula rotundifolia	harebell	native	6	3	forb	perennial
Carex aurea	sedge	native	3	-3	sedge	perennial
Carex buxbaumii	sedge	native	10	-5	sedge	perennial
Carex capillaris	sedge	native	9	-3	sedge	perennial
Carex crawei	sedge	native	10	-3	sedge	perennial
Carex eburnea	sedge	native	7	3	sedge	perennial
Carex flava	sedge	native	4	-5	sedge	perennial
Carex interior	sedge	native	3	-5	sedge	perennial
Castilleja coccinea	Indian paintbrush	native	8	0	forb	biennial
Cirsium muticum	swamp thistle	native	6	-5	forb	biennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	perennial
Clinopodium arkansanum	limestone calamint	native	10	-3	forb	perennial
Comandra umbellata	bastard-toadflax	native	5	3	forb	perennial
Comarum palustre	marsh cinquefoil	native	7	-5	forb	perennial
Cypripedium parviflorum	yellow lady-slipper	native	5	0	forb	perennial
Danthonia spicata	poverty grass	native	4	5	grass	perennial

Dasiphora fruticosa	shrubby cinquefoil	native	8	-3	shrub	perennial
Daucus carota	Queen-Annes-lace	non-nat	0	5	forb	biennial
Deschampsia cespitosa	hair grass	native	9	-3	grass	perennial
Eleocharis palustris	spike-rush	native	5	-5	sedge	perennial
Elymus repens	quack grass	non-nat	0	3	grass	perennial
Equisetum variegatum	variegated scouring rush	native	6	-3	fern	perennial
Euthamia graminifolia	grass-leaved goldenrod	native	3	0	forb	perennial
Fragaria virginiana	wild strawberry	native	2	3	forb	perennial
Fraxinus pennsylvanica	red ash	native	2	-3	tree	perennial
Gentianopsis virgata	small fringed gentian	native	8	-5	forb	annual
Hypericum kalmianum	Kalms St. Johns-wort	native	10	-3	shrub	perennial
Iris lacustris	dwarf lake iris	native	9	0	forb	perennial
Juncus brachycephalus	rush	native	7	-5	rush	perennial
Juncus brevicaudatus	rush	native	8	-5	rush	perennial
Juncus dudleyi	Dudleys rush	native	1	-3	rush	perennial
Juniperus horizontalis	creeping juniper	native	10	3	shrub	perennial
Larix laricina	tamarack	native	5	-3	tree	perennial
Lobelia kalmii	bog lobelia	native	10	-5	forb	perennial
Lythrum salicaria	purple loosestrife	non-nat	0	-5	forb	perennial
Melampyrum lineare	cow-wheat	native	6	3	forb	annual
Packera paupercula	balsam ragwort	native	3	0	forb	perennial
Parnassia glauca	grass-of-parnassus	native	8	-5	forb	perennial
Picea glauca	white spruce	native	3	3	tree	perennial
Poa compressa	Canada bluegrass	non-nat	0	3	grass	perennial
Pogonia ophioglossoides	rose pogonia	native	10	-5	forb	perennial
Polygala paucifolia	gay-wings	native	7	3	forb	perennial
Populus balsamifera	balsam poplar	native	2	-3	tree	perennial
Populus tremuloides	quaking aspen	native	1	0	tree	perennial
Primula mistassinica	birds-eye primrose	native	10	-3	forb	perennial
Prunella vulgaris	self-heal	native	0	0	forb	perennial
Rhynchospora capillacea	beak-rush	native	10	-5	sedge	perennial
Rhynchospora capitellata	beak-rush	native	6	-5	sedge	perennial
Rudbeckia hirta	black-eyed susan	native	1	3	forb	perennial
Salix candida	hoary willow	native	9	-5	shrub	perennial
Salix discolor	pussy willow	native	1	-3	shrub	perennial
Salix exigua	sandbar willow	native	1	-3	shrub	perennial
Salix myricoides	blueleaf willow	native	9	-3	shrub	perennial
Sarracenia purpurea	pitcher-plant	native	10	-5	forb	perennial
Schizachyrium scoparium	little bluestem	native	5	3	grass	perennial
Schoenoplectus acutus	hardstem bulrush	native	5	-5	sedge	perennial
Shepherdia canadensis	soapberry	native	7	5	shrub	perennial
Solidago canadensis	Canada goldenrod	native	1	3	forb	perennial
Solidago ohioensis	Ohio goldenrod	native	8	-5	forb	perennial
Solidago ptarmicoides	upland white goldenrod	native	6	3	forb	perennial

Solidago rugosa	rough-leaved goldenrod	native	3	0	forb	perennial
Solidago uliginosa	bog goldenrod	native	4	-5	forb	perennial
Symphyotrichum boreale	northern bog aster	native	9	-5	forb	perennial
Symphyotrichum lanceolatum	panicled aster	native	2	-3	forb	perennial
Thuja occidentalis	arbor vitae	native	4	-3	tree	perennial
Tofieldia pusilla	false asphodel	native	10	-3	forb	perennial
Trichophorum cespitosum	bulrush	native	10	-5	sedge	perennial
Triglochin maritima	common bog arrow-grass	native	8	-5	forb	perennial
Triglochin palustris	slender bog arrow-grass	native	8	-5	forb	perennial
Utricularia cornuta	horned bladderwort	native	10	-5	forb	perennial
Vitis riparia	river-bank grape	native	3	0	vine	perennial

Alpena Township Nature Preserve Emergent Marsh FQA 2016

Conservation-Based Metrics:		**Species Richness:**			**Duration Metrics:**		
Total Mean C:	5.3	Total Species:	17		Annual:	0	0%
N Mean C:	5.6	N Species:	16	94.10%	Perennial:	17	100%
Total FQI:	21.9	Non-native Species:	1	5.90%	Biennial:	0	0%
N FQI:	22.4	**Species Wetness:**			Native Annual:	0	0%
Adjusted FQI:	54.3	Mean Wetness:	-3.8		Native Perennial:	16	94.10%
% C value 0:	5.9	N Mean Wetness:	-3.9		Native Biennial:	0	0%
% C value 1-3:	17.6	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	41.2	Tree:	1	5.90%	Sedge:	7	41.20%
% C value 7-10:	35.3	Shrub:	4	23.50%	Rush:	1	5.90%
N Tree Mean C:	4	Vine:	0	0%	Fern:	0	0%
N Shrub Mean C:	5.3	Forb:	3	17.60%	Bryophyte:	0	0%
N Herbaceous Mean C:	5.9	Grass:	1	5.90%			

Species documented:

Scientific Name	Common Name	Native?	C	W	Physiog.	Duration
Carex aquatilis	sedge	native	7	-5	sedge	perennial
Carex stricta	sedge	native	4	-5	sedge	perennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	perennial
Dasiphora fruticosa	shrubby cinquefoil	native	8	-3	shrub	perennial
Eleocharis rostellata	spike-rush	native	10	-5	sedge	perennial
Juncus balticus	rush	native	4	-5	rush	perennial
Phragmites australis var. australis	reed	non-native	0	-3	grass	perennial
Potamogeton alpinus	pondweed	native	10	-5	forb	perennial
Potamogeton gramineus	pondweed	native	5	-5	forb	perennial
Salix lucida	shining willow	native	3	-3	shrub	perennial
Salix myricoides	blueleaf willow	native	9	-3	shrub	perennial
Salix petiolaris	slender willow	native	1	-3	shrub	perennial
Schoenoplectus acutus	hardstem bulrush	native	5	5	sedge	perennial
Schoenoplectus pungens	threesquare	native	5	5	sedge	perennial
Schoenoplectus tabernaemontani	softstem bulrush	native	4	5	sedge	perennial
Solidago altissima	tall goldenrod	native	1	3	forb	perennial
Thuja occidentalis	white cedar	native	4	-3	tree	perennial

El Cajon Coastal Fen FQA 2018

Conservation-Based Metrics:		Species Richness:			Duration Metrics:		
Total Mean C:	5.1	Total Species:	59		Annual:	1	1.70%
N Mean C:	5.6	N Species:	54	91.50%	Perennial:	58	98.30%
Total FQI:	39.2	Non-native Species:	5	8.50%	Biennial:	0	0%
N FQI:	41.2	**Species Wetness:**			Native Annual:	1	1.70%
Adjusted FQI:	53.6	Mean Wetness:	-2.7		Native Perennial:	53	89.80%
% C value 0:	8.5	N Mean Wetness:	-2.8		Native Biennial:	0	0%
% C value 1-3:	25.4	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	33.9	Tree:	6	10.20%	Sedge:	10	16.90%
% C value 7-10:	32.2	Shrub:	10	16.90%	Rush:	4	6.80%
N Tree Mean C:	3.2	Vine:	0	0%	Fern:	2	3.40%
N Shrub Mean C:	6.9	Forb:	22	37.30%	Bryophyte:	0	0%
N Herbaceous Mean C:	5.7	Grass:	5	8.50%			

Species Documented:

Scientific Name	Common Name	Native?	C	W	Physiog.	Duration
Agrostis gigantea	redtop	non-nat	0	-3	grass	Perennial
Arctostaphylos uva-ursi	bearberry	native	8	5	shrub	Perennial
Betula papyrifera	paper birch	native	2	3	tree	Perennial
Calamagrostis canadensis	blue-joint	native	3	-5	grass	Perennial
Calamagrostis stricta	narrow-leaved reedgrass	native	10	-3	grass	Perennial
Carex flava	sedge	native	4	-5	sedge	Perennial
Carex lasiocarpa	sedge	native	8	-5	sedge	Perennial
Carex stricta	sedge	native	4	-5	sedge	Perennial
Cirsium arvense	Canada thistle	non-nat	0	3	forb	Perennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	Perennial
Dasiphora fruticosa	shrubby cinquefoil	native	8	-3	shrub	Perennial
Doellingeria umbellata	flat-topped white aster	native	5	-3	forb	Perennial
Eleocharis rostellata	spike-rush	native	10	-5	sedge	Perennial
Epilobium coloratum	cinnamon willow-herb	native	3	-5	forb	Perennial
Eriophorum viridi-carinatum	green-keeled cotton-grass	native	8	-5	sedge	Perennial
Euthamia graminifolia	grass-leaved goldenrod	native	3	0	forb	Perennial
Fragaria virginiana	wild strawberry	native	2	3	forb	Perennial
Frangula alnus	glossy buckthorn	non-nat	0	0	shrub	Perennial
Gentianopsis virgata	small fringed gentian	native	8	-5	forb	Annual
Hypericum kalmianum	Kalms st. johns-wort	native	10	-3	shrub	Perennial
Juncus alpinoarticulatus	rush	native	5	-5	rush	Perennial
Juncus balticus	rush	native	4	-5	rush	Perennial
Juncus brevicaudatus	rush	native	8	-5	rush	Perennial
Juncus canadensis	Canadian rush	native	6	-5	rush	Perennial
Larix laricina	tamarack	native	5	-3	tree	Perennial

Linnaea borealis	twinflower	native	6	0	forb	Perennial
Liparis loeselii	Loesels twayblade	native	5	-3	forb	Perennial
Lobelia kalmii	bog lobelia	native	10	-5	forb	Perennial
Lycopus uniflorus	northern bugle weed	native	2	-5	forb	Perennial
Lythrum salicaria	purple loosestrife	non-nat	0	-5	forb	Perennial
Muhlenbergia glomerata	marsh wild-timothy	native	10	-5	grass	Perennial
Myrica gale	sweet gale	native	6	-5	shrub	Perennial
Osmunda regalis	royal fern	native	5	-5	fern	Perennial
Parnassia glauca	grass-of-parnassus	native	8	-5	forb	Perennial
Phragmites australis var. australis	reed	non-nat	0	-3	grass	Perennial
Picea glauca	white spruce	native	3	3	tree	Perennial
Pinus strobus	white pine	native	3	3	tree	Perennial
Populus balsamifera	balsam poplar	native	2	-3	tree	Perennial
Primula mistassinica	birds-eye primrose	native	10	-3	forb	Perennial
Rhynchospora capitellata	beak-rush	native	6	-5	sedge	Perennial
Rudbeckia hirta	black-eyed susan	native	1	3	forb	Perennial
Salix candida	hoary willow	native	9	-5	shrub	Perennial
Salix myricoides	blueleaf willow	native	9	-3	shrub	Perennial
Salix petiolaris	slender willow	native	1	-3	shrub	Perennial
Schoenoplectus acutus	hardstem bulrush	native	5	-5	sedge	Perennial
Schoenoplectus pungens	threesquare	native	5	-5	sedge	Perennial
Schoenoplectus tabernaemontani	softstem bulrush	native	4	-5	sedge	Perennial
Shepherdia canadensis	soapberry	native	7	5	shrub	Perennial
Solidago ohioensis	Ohio goldenrod	native	8	-5	forb	Perennial
Solidago ptarmicoides	upland white goldenrod	native	6	3	forb	Perennial
Solidago rugosa	rough-leaved goldenrod	native	3	0	forb	Perennial
Spiraea alba	meadowsweet	native	4	-3	shrub	Perennial
Spiranthes cernua	nodding ladies-tresses	native	4	-3	forb	Perennial
Symphyotrichum lanceolatum	panicled aster	native	2	-3	forb	Perennial
Symphyotrichum lateriflorum	calico aster	native	2	0	forb	Perennial
Thelypteris palustris	marsh fern	native	2	-3	fern	Perennial
Thuja occidentalis	arbor vitae	native	4	-3	tree	Perennial
Triadenum fraseri	marsh St. Johns-wort	native	6	-5	forb	Perennial
Utricularia cornuta	horned bladderwort	native	10	-5	forb	Perennial

Ossineke Emergent Marsh FQA 2016

Conservation-Based Metrics:		Species Richness:			Duration Metrics		
Total Mean C:	3.7	Total Species:	24		Annual:	0	0%
N Mean C:	4.9	N Species:	18	75%	Perennial:	24	100%
Total FQI:	18.1	Non-native Species:	6	25%	Biennial:	0	0%
N FQI:	20.8	**Species Wetness:**			Native Annual:	0	0%
Adjusted FQI:	42.4	Mean Wetness:	-2.4		Native Perennial:	18	75%
% C value 0:	25	N Mean Wetness:	-3.6		Native Biennial:	0	0%
% C value 1-3:	16.7	**Physiognomy Metrics**			**Physiognomy Metrics cont.**		
% C value 4-6:	45.8	Tree:	1	4.20%	Sedge:	6	25%
% C value 7-10:	12.5	Shrub:	6	25%	Rush:	1	4.20%
N Tree Mean C:	n/a	Vine:	0	0%	Fern:	1	4.20%
N Shrub Mean C:	6.2	Forb:	4	16.70%	Bryophyte:	0	0%
N Herbaceous Mean C:	4.5	Grass:	5	8.30%			

Species Documented:

Scientific Name	Common Name	Native?	C	W	Physiog.	Duration
Agrostis gigantea	redtop	non-nat	0	-3	grass	Perennial
Alnus incana	speckled alder	native	5	-3	shrub	Perennial
Calamagrostis canadensis	blue-joint	native	3	-5	grass	Perennial
Carex stricta	sedge	native	4	-5	sedge	Perennial
Centaurea stoebe	spotted knapweed	non-nat	0	5	forb	Perennial
Cladium mariscoides	twig-rush	native	10	-5	sedge	Perennial
Eleocharis palustris	spike-rush	native	5	-5	sedge	Perennial
Equisetum hyemale	scouring rush	native	2	0	fern	Perennial
Hypericum kalmianum	Kalms st. johns-wort	native	10	-3	shrub	Perennial
Juncus balticus	rush	native	4	-5	rush	Perennial
Lonicera tatarica	tartarian honeysuckle	Non-nat	0	3	shrub	perennial
Myrica gale	sweet gale	native	6	-5	shrub	perennial
Phragmites australis var. americanus	reed	native	5	-3	grass	perennial
Phragmites australis var. australis	reed	non-nat	0	-3	grass	perennial
Poa compressa	Canada bluegrass	non-nat	0	3	grass	perennial
Potamogeton gramineus	pondweed	native	5	-5	forb	perennial
Potentilla anserina	silverweed	native	5	-3	forb	perennial
Robinia pseudoacacia	black locust	non-nat	0	3	tree	perennial
Salix exigua	sandbar willow	native	1	-3	shrub	perennial
Salix myricoides	blueleaf willow	native	9	-3	shrub	perennial
Schoenoplectus acutus.	hardstem bulrush	native	5	-5	sedge	perennial
Schoenoplectus pungens	threesquare	native	5	-5	sedge	perennial
Schoenoplectus tabernaemontani	softstem bulrush	native	4	-5	sedge	perennial
Solidago canadensis	Canada goldenrod	native	1	3	forb	perennial

Appendix 3. Native Plants Observed During Surveys in 2018

Native plants observed during botanical surveys in 2018

Top left: Small fringed gentian (*Gentianopsis virgata*)

Top right: Bird's eye primrose (*Primula mistassinica*)

Middle left: Horned bladderwort (*Utricularia cornuta*)

Middle right: Grass-of-parnassus (*Parnassia glauca*)

Bottom left: Rush (*Juncus canadensis*)

Photos by Phyllis Higman