2017

Prioritizing Migratory Bird Habitat Restoration in the Upper St. Marys River

Sault Ste. Marie Tribe of Chippewa Indians

Natural Resources Department

BACKGROUND

The Sault Ste. Marie Tribe of Chippewa Indians is based in Sault Ste. Marie, Michigan. The Sault Tribe Natural Resources Department (STNRD) is tasked with managing and monitoring inland subsistence harvest and managing wildlife habitat. Tribal members harvest waterfowl as part of subsistence hunting activities, a large portion of which occurs in the St. Marys River corridor. Up to 12% of tribal members participate in waterfowl harvest (STNRD, internal report). Developing a plan aimed at improving migratory bird habitat is critical to maintaining subsistence harvest activities on the St. Marys River into the future.

ST. MARYS RIVER

The St. Marys River is a connecting channel between Lake Superior and Lake Huron. Efforts were focused on the upper St. Marys River (Figure 1). The St. Marys River water level fluctuates annually and is dependent on Lake Superior and Lake Huron water levels. The river houses several large islands and hundreds of smaller within its extent. Sugar and Neebish Islands have ferry access to the mainland and have resident human populations. The smaller islands have both natural and man-made origins and are primarily uninhabited.

The coastline of the St. Marys River is home to Great Lakes coastal marsh. Coastal marsh is a declining and threatened ecosystem in the Great Lakes region (Albert 2003). Fluctuations in water level result in a very dynamic system that alters vegetation species (Albert 2003). Coastal marsh habitats have been declining in the Great Lakes region and losses of coastal marshes are estimated to range from 30 – 50% (Albert 2003). For further information on Great Lakes coastal wetlands see Albert (2003), where this topic is discussed extensively.

LANDSCAPE CHANGE

The upper St. Marys River has undergone many changes since the late 1800s. These changes include: increasing human population, development along its shore, the dredging of a shipping channel, alteration of hydrology, water flow regulation, erosion, and pollution. Details of these changes are well documented (e.g. Duffy et al. 1987; Kauss 1991. Bray 1992; Harris et al. 2009; Bain et al. 2010). However, in recent decades little land cover change has occurred (NOAA; Jodi Brandt, personal communication). Between 1996 and 2010, Chippewa County, Michigan (this county contains the entire St. Marys River watershed in the USA) experienced 4.56% land cover change, with primary changes occurring in the amount of forest cover (NOAA). For a breakdown where the land cover change occurred see the C-CAP (NOAA).

Primary changes in the St. Marys River involve changes in water level and invasive species colonization. As noted above, water levels in the St. Marys River naturally fluctuate with Great Lakes water levels, creating a dynamic wetland system. Fluctuations in water levels within the Great Lakes help to drive plant species composition in coastal wetlands (Wilcox and Nichols 2008). However, continual low water levels led to another major change on the St. Marys River, an increase in invasive species.

INVASIVE SPECIES

Water level fluctuations in the Great Lakes were consistently below average in the 2000s (Gronewold et al. 2013). The low water levels allowed many aquatic invasive species to become established and rapidly expand in the St. Marys River. These include: narrow leaf cattails (*Typha angustifolia*) and hybrid cattails (*Typha × glauca*), purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis* var. *australis*), and European frogbit (*Hydrocharis morsus-ranae*).

Of particular concern within the St. Marys River watershed are the hybrid cattail and narrow leaf cattail. The hybrid cattail occurs when the native broad-leaf cattail (*Typha latifolia*) hybridizes with invasive narrow leaf cattail (Smith 1967). Hybrid cattails are particularly aggressive, reproducing by seed and clonal growth. Hybrid cattails excel in habitats with recent disturbance, human stabilized wetlands, and areas with high nutrient loading (Woo and Zedler 2002; Boers and Zedler 2008; Lishawa et al. 2010). Persistent low water conditions in the 2000s promoted the colonization and spread of hybrid cattails in the St. Marys River (Lishawa et al. 2010).

There are several mechanisms that allow invasive species to outcompete native species allow them to overtake wetlands. For instance, hybrid cattails produce large amounts of litter biomass (Tuchman et al. 2009; Farrer and Goldberg 2014). Litter generated by hybrid cattails builds up and shades out native vegetation allowing the cattails to further expand (Tuchman et al. 2009; Farrer and Goldberg 2014). Invasive cattails also out-compete native plants in areas with high nutrient loading, as the cattails increase above ground biomass production in response to increases in nitrogen and phosphorous (Woo and Zedler 2002). Controlling and removing invasive species has the potential to improve native plant communities (e.g., Lishawa et al. 2015).

The relationship between invasive species and bird communities is full of studies with conflicting results in the Great Lakes Region and beyond. For example, multiple species of secretive marsh birds exhibit avoidance of reed canary grass (*Phalaris arundinacea*) when it reaches a threshold (Glisson et al. 2015). Marsh nesting birds had greatest abundance and species richness in native marshes when compared to wetlands dominated by non-native common reed (Meyer et al. 2010). However, within the same study researchers showed overall bird abundance and species richness was greatest in common reed wetlands (Meyer et al. 2010). In another study, wetlands dominated by non-native common reed had the lower diversity, evenness, and species richness when compared to native mixed-emergent wetlands (Whyte et al. 2015). Alternatively, there were marginal differences in occupancy, abundance, richness, and diversity in songbirds (Gagnon Lupien et al. 2014). Bird diversity was lower in wetlands dominated by purple loosestrife; however, bird densities were greater in wetlands with higher densities of purple loosestrife (Whitt et al. 1999). Trying to better understand the complex relationships between invasive species and migratory birds is of importance to the St. Marys River corridor, due to the recent increase of invasive species in the watershed.

MIGRATORY BIRDS

The St. Marys River hosts a variety of migratory birds. The St. Marys River corridor has been identified as an important stop over habitat for migratory shorebirds, waterfowl, and land birds (Duffy et al. 1987; Bookhout et al. 1989; Prince et al. 1992; Ewert et al. 2012; Monfils and Gehring 2013). The majority of migrating waterfowl using the St. Marys River and its corridor are primarily diving and sea ducks (Duffy et al. 1987; Bookhout et al. 1989; Prince et al. 1992; Monfils and Gehring 2013).

In addition to being an important migratory bird stopover habitat, the St. Marys River corridor provides important breeding habitat for many species of migratory birds. The region is an important nesting area for waterfowl (Duffy et al. 1987; Prince et al. 1992). Eastern Chippewa County was identified as a primary focus area for restoring and protecting waterfowl nesting habitat for the implementation of the North American Waterfowl Management Plan between 1998 and 2013 (MDNR). The St. Marys River corridor is also important breeding habitat for declining landbirds such as the American woodcock (*Scolopax minor*; Potter et al. 2007; Thogmartin et al. 2007). Coastal marshes within the region provide critical habitat for many declining wetland birds such as common tern (*Sterna hirundo*), black tern (*Chlidonias niger*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), sora (*Porzana carolina*), Virginia rail (*Railus limicola*), and marsh wren (*Cistothorus palustris*; Currier 2000; Monfils 2003; Monfils 2004; Monfils 2006; Soulliere et al. 2007; Monfils et al. 2012). Understanding how habitat is used by species of migratory birds in the St. Marys River corridor will feed into STNRD's development of a prioritization and restoration plan.

Given the importance of the St. Marys River corridor to migratory birds, the STNRD wanted to investigate migratory birds that are of importance to tribal members. Initial work was focused on migratory waterfowl, due to the fact that up to 12% of subsistence license holders participate in waterfowl harvest. The waterfowl species harvested most often by hunters routinely include mallard (*Anas platyrhynchos*), Canada goose (*Branta canadensis*), and wood duck (*Aix sponsa*). A variety of other ducks are also harvested, but in lesser numbers. In order to identify other species important to all tribal members, STNRD staff hosted a public meeting in January 2016.

Outcomes from the public meeting indicated that tribal members thought that waterfowl were most important. Members ranked breeding season as more important than migration and overwintering seasons, as many members thought that they primarily harvested ducks that bred locally. Attendees indicated that one of the major changes that they have observed in the region is a change in agricultural practices. Historically, many landowners planted and harvested small grains that helped to hold locally breeding ducks and hold migrants in the area longer. Many of those areas are now fallow or planted to alfalfa or other hay crops. Without a food supply, ducks move to the agricultural regions in southern Michigan. Attendees were unaware of several of the invasive species in the region and were excited about the work that the STNRD is conducting in the region. Members also believed that there had been in a decline in wetland quality in Lake Nicolet and Lake Munuscong, two different parts of the St. Marys River.

Our public meeting yielded similar information to what is in the literature. Most mallard harvest in the Great Lakes states of Michigan, Minnesota, and Wisconsin are locally reared birds (75%, 57%, and 80%, respectively; T. Arnold and C. de Sobrino, unpublished data, cited in Singer 2014). Based on the outcomes of the meeting, understanding nesting and brood rearing habitat for waterfowl became a priority for STNRD staff. We took the information of important areas provided by tribal members and used that information to structure a habitat assessment.

Efforts were also focused on duck nesting and brood rearing habitats, in part because nest success and duckling survival were both identified as life stages limiting population growth and recruitment of mallard in the Great Lakes region and mid-continent population (Hoekman et al. 2002; Coluccy et al. 2008). Mallard productivity has also been linked with fluctuations in nesting and brood rearing season in the Great Lakes region, specifically drought conditions (Singer 2014).

Understanding habitat use by nesting and brood rearing waterfowl in the St. Marys River is important to developing a habitat restoration plan, as nesting and brood rearing habitat are not well documented in the literature. In southern Ontario, breeding pairs of mallards, wood duck (*Aix sponsa*), and blue-winged teal (*Anas discors*) were documented to avoid large bodies of open water in southern Ontario and were more likely to select various types of small water bodies, depending on the species (Merendino et al. 1995). More recently, a study of breeding pairs of mallards exhibited positive relationships with emergent and temporary wetlands and total wetland area at the landscape scale (Messmer et al. 2015). Models with grasslands were not well supported in southern Ontario, which is well documented in the Prairie Pothole Region (Messmer et al. 2015). However, in another study nesting female mallards exhibited strong selection of grassland habitats in southern Ontario (Hoekman et al. 2006). Palustrine wetlands held the most breeding pairs of mallards in Michigan and Wisconsin (Yerkes et al. 2007). At the nest site scale within the Great Lakes Region, daily nest survival rate increased with increasing visual obstruction, indicating that as cover around the nest increases, nest survival increases (Davis 2008). Nest cavities were not found to be limiting cavity-nesting duck production and the number of nesting cavities has been predicted to increase in the Great Lakes region as forest stands age (Denton et al. 2012).

There is also a lack of information on duckling and brood habitat selection in the northern Great Lakes Region. Most of the known data is from southern Ontario, southern Michigan, and southern Wisconsin. In the southern Great Lakes Region, mallard duckling survival increased with the proportion of vegetated wetlands and decreased with the proportion of forested area (Simpson et al. 2007). In the Prairie Pothole Region, probability of brood occupancy decreased with increasing emergent cover on wetlands and increased with the amount of available grassland cover (Walker et al. 2013). Also in the Prairie Pothole Region, duckling survival and the probability of brood occupancy both increased with increasing wetland area (Amundson and Arnold 2011; Walker et al. 2013). In southern Ontario, wood duck broods selected swamp, scrub-shrub, and emergent marsh habitats (Dyson 2015). Identifying habitat that is important to waterfowl broods in the St. Marys River corridor will provide valuable information when developing a migratory bird restoration plan.

METHODS

Designing a study to address concerns raised during the public meeting became a priority. STNRD staff focused efforts on coastal marshes in the Lake Munuscong and Lake Nicolet region. There were additional areas that were included to get a wide variety of habitats and that the STNRD was able to gain permission to access. The study was designed to focus efforts on dabbling ducks nesting in the region, because tribal members were primarily harvesting species such as mallards and American black ducks (*Anas rubripes*). Efforts will also focus on areas in upland habitats such as the Munuscong WMA (restored wetland area) and the Sault Tribe’s Keldon wetland area.

Using an occupancy study design, STNRD was able to identify habitats that are critical for duck broods. Identifying these areas allowed STNRD to identify habitat types within the St. Marys River watershed that are important to protect or restore. Using randomly distributed points, STNRD was able to assess the use of a variety of wetland and upland habitat types by duck broods throughout the Upper St. Marys River.

In 2013 and 2014, we sampled 30 randomly selected islands in the Upper St. Marys River, stratified by size. We then conducted nest and brood surveys on the randomly selected islands. We categorized habitat on the islands using ArcGIS and aerial imagery. Islands were classified into three habitat types: woody vegetation, herbaceous vegetation, and bare ground. Detected nests were then categorized into one of these three habitat types. From there, we used the Neu et al. (1974) and Aebischer et al. (1993) methods to compare selected habitats against available habitats.

Due to unforeseen delays, we were unable to sample in 2015. For 2016, we randomly distributed points over the St. Marys River on properties that we obtained permission. This allowed us to sample a broader area and include areas on the mainland and on the larger islands in the St. Marys River, Sugar and Neebish Islands. We also included inland wetland habitats that fell within the St. Marys River watershed, to accommodate inland nesting waterfowl and due to a Michigan DNR report indicating high use by waterfowl and waterbirds at a restored grassland-wetland complex (Soulliere and Monfils 1996). We were able to work with universities, state agencies, and non-government associations to gain access to lands. We used a generalized random tessellation stratified (GRTS) sampling design with replacement to randomly distribute points among wetlands in the St. Marys River (Stevens and Olsen; 2004).

In 2017, in addition to surveying for waterfowl we also surveyed other marsh birds. We used call back surveys following Conway (2011). We also wrote down all birds detected during the survey period. Once all the data were collected and entered we used program R and the ‘unmarked’ package to estimate occupancy and abundance using covariates collected at all the data points.

RESULTS

2013

In 2013, initial efforts by the STNRD focused on habitats on small islands in the St. Marys River. There are over 180 small islands in the St. Marys River. Many of these islands are spoil piles from the dredging and excavation of the shipping channel. We randomly selected 30 islands to conduct nesting surveys and stratified the selection by size. Islands ranged in size from 0.004 – 18.711 acres. Total acreage of the surveyed islands was 54.129 acres. We categorized the vegetation on the islands into three categories (Herbaceous vegetation, woody vegetation, and bare ground). The categories were distributed as 48.16% herbaceous, 40.22% woody, and 11.62% bare ground. Waterbird nests found on the islands were: ring-billed gull (*Larus delawarensis*; 1,426), herring gull (*Larus argentatus*; 144), Canada goose (155), mallard (4), green heron (*Butorides virescens*; 1), and great blue heron (*Ardea herodias*; 5).

Canada geese located nests in all three broad categorizations. However, when comparing selected nesting sites to overall availability, Canada geese selected woody vegetation more often than would be expected (Table 1). Moreover, Canada geese avoided nesting in herbaceous vegetation than would be expected at random (Table 1). Canada geese nested in bare ground habitats in proportion to what would be expected (Table 1). Herring gulls had a very similar nest site selection to Canada geese. Herring gulls selected areas of woody vegetation, avoided herbaceous vegetation, and used bare ground habitats in proportion to what would be expected (Table 2). All detected nests of ring-billed gulls were exclusively in areas with bare ground or rocky substrate, indicating a strong selection for that type of substrate.

2014

In 2014, staff focused efforts on brood rearing habitats surrounding islands in the St. Marys River. The only broods detected by STNRD staff were 3 Canada goose broods. We also detected adults without broods at small island sites including 1 male American wigeon (*Anas americana*), 26 mallards (14 female, 12 male), 2 male common goldeneye (*Bucephala clangula*), 2 redhead (1 male, 1 female; *Aythya americana*), 1 female wood duck (*Aix sponsa*), and 8 common merganser (5 female, 3 male; *Mergus merganser*). Islands surveyed averaged 48.2% herbaceous vegetation, 40.2% woody vegetation, and 11.6% bare ground. Given the small sample size, STNRD staff members were unable to draw any major conclusions about brood rearing qualities of small islands in the St. Marys River.

2016

In 2016, STNRD again focused efforts on waterfowl nesting and brood rearing locations. In addition to waterfowl STNRD also conducted other migratory birds detected during brood surveys and conducted secretive marsh bird surveys as an aspect of another study. STNRD staff completed 148 15-min point counts broken into three blocks in order to assess waterfowl use throughout the St. Marys River corridor. During the survey, we detected 1,742 individuals of 14 different species across all surveys and sampling blocks.

Waterfowl detection rates were most influenced by temperature (Table 3). Waterfowl detection probability increased as temperature decreased. Percent cover of open water was the top predictor of landscape variables (Table 4). When pooling all waterfowl species detected together, landscape covariates were poor predictors of waterfowl abundance when compared to 4 m vegetation measurements (Table 5). In general, there was a negative relationship with vegetation covariates and a positive relationship with open water. Too much open water likely does not benefit all waterfowl species, however.

Mallards had the greatest abundance of duck species. The top ranked model for predicting mallard abundance was percent cover of water at the 4 m scale (Table 6). Mallard abundance increased with increasing percent cover of open water at the 4 m scale. Mallard detection decreased with increasing temperature.

Canada geese were the only other species where we had a large enough sample size to run abundance models. Canada geese abundance was best explained by a global model containing all the 4 m vegetation covariates (Table 7). Open water was the top landscape characteristic in explaining Canada goose abundance (Table 7). Canada goose abundance had a positive relationship with increasing water cover within the 4 m scale. All other vegetation covariates had negative relationships as they increased.

DISCUSSION

Based on these results, STNRD determined that small islands in the St. Marys River are important nesting locations for herring gulls, ring-billed gulls, and Canada geese. These species have been increasing within the St. Marys River corridor over the last several years. These species are not of major concern to STNRD.

Open water within the wetlands seems important to waterfowl. Invasive species reduce the amount of open water within marshes and decrease native plant diversity. Species such as hybrid cattail, narrow leaf cattail, and *Phragmites* can form dense monocultures, reducing the amount of habitat available to waterfowl species. Focusing our migratory bird restoration plan on invasive species control can go along ways to improving migratory waterfowl habitat.

STNRD will likely focus efforts on maintaining and improving waterfowl habitat in areas adjacent to the main land. The small islands in the St. Marys River don't appear to contribute much to the waterfowl population. Canada geese are doing well throughout the St. Marys River corridor, providing more habitat for them is likely unnecessary.

Upland nesting habitat and nest cavities are not limiting to waterfowl within the region. Land cover has remained relatively consistent for the past 40 years. Therefore, focusing on maintaining and restoring marsh complexes seems to be the most beneficial for improving waterfowl habitat.

MIGRATORY BIRD HABITAT RESTORATION PLAN

With invasive species in the St. Marys River corridor being one of the major landscape changes in the region, the STNRD will strategize to reduce invasive species in the area to improve migratory bird habitat. Aquatic invasive species such as hybrid cattail, *Phragmites*, and purple loosestrife pose a major threat to wetland habitats in the region. Wetlands provide critical stopover and nesting habitat for many bird species. By focusing on invasive species, STNRD can improve nesting habitat quality and maintain native plant diversity.

Much of the STNRD invasive plant removal has and will remain focused on controlling new populations of invasive plants. For instance, STNRD staff has targeted newly discovered *Phragmites* infestations and recently established purple loosestrife infestations (see additional attached report). STNRD is working with Loyola University Chicago to identify and treat new infestations of hybrid and narrow leaf cattail in the St. Marys River.

Eradicating invasive cattails where they are well established is a daunting task. It will likely be impossible to completely eradicate large populations of invasive cattail in areas like Munuscong Bay and Sand Island. In these areas, invasive cattails have likely been around for decades. Targeting management efforts in these areas should focus on establishing and maintaining openings in the invasive cattail. STNRD will work with local management agencies to create openings. By creating openings and removing the cattail biomass, we can improve natural plant diversity and create habitat needed by waterfowl.

An additional reason for the STNRD to focus efforts on aquatic invasive species is funding. Coastal and interior wetlands in the Great Lakes region are a high priority. There are many opportunities for STNRD to obtain funding to continue to improve wetlands. Migratory birds and fish, both taxa that tribal members actively harvest, benefit from removing invasive species wetlands by improving spawning and nesting habitats.

Other changes in the region to improve habitat has included planting more small grains in the region to increase migratory waterfowl stopover time and increase waterfowl hunting opportunities. Maintaining open grasslands and hayfields in the eastern Upper Peninsula will benefit spring migratory waterfowl. This area provides stopover habitat for many waterfowl species.

Due to funding delays, STNRD has already begun implementing much of the migratory bird plan. STNRD has established a network focused on research, monitoring, and restoration of wetlands in the St. Marys River. This network includes Loyola University Chicago, Boise State University, Oregon State

University, University of Michigan, Dartmouth College, University of Connecticut, Lake Superior State University, Three Shores Cooperative Invasive Species Management Area, Michigan Department of Natural Resources, and the Bay Mills Indian Community. Additionally, STNRD staff has secured permission to treat areas with invasive species on lands owned by the Michigan DNR, University of Michigan, Little Traverse Conservancy, and the Michigan Nature Association.

STNRD staff began removing invasive species from the upper St. Marys River in 2016 and restoring native plants to invaded wetlands (see attached report). The efforts continued in 2017, focused on retreating areas treated in 2016. In 2016, STNRD removed 85 trash bags (55 Gallon bags) of purple loosestrife from wetlands treated in 2016.

TIMELINE

2015 – Harvest seeds to grow hard stem bulrush plugs with commercial native plant nursery.

2016 – Locate invasive species populations within the St. Marys River corridor. We targeted hybrid cattail, purple loosestrife, and invasive *Phragmites*. Monitor waterfowl use in the St. Marys River corridor. Plant bulrush plugs in restored wetlands within the St. Marys River.

2017 – Retreat wetlands from 2016. Continue waterfowl and migratory bird monitoring. Monitor wetland plant restoration effectiveness.

2018 – Continue monitoring migratory birds. Continue to retreat wetlands treated in 2016. Locate new populations of invasive plants in wetlands.

2019 – Treat new populations of invasive plants located in 2018.

2020 – Monitor waterfowl in areas treated and untreated to compare usage. Also, continue monitoring and removing invasive species.

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TABLES

Table 1. Occurrence of Canada goose nests in herbaceous, woody, and bare ground habitat types on islands in the St. Marys River, Michigan in 2013 using the Neu et al. (1974) method.

Habitat Type	Observed Proportion	Lower 90% CI	Upper 90% CI	Expected proportions
Herbaceous	0.239	0.166	0.312	0.482
Woody	0.626	0.543	0.709	0.402
Bare Ground	0.135	0.077	0.193	0.116

Table 2. Occurrence of herring gull nests in herbaceous, woody, and bare ground habitat types on islands in the St. Marys River, Michigan in 2013 using the Neu et al. (1974) method.

Habitat Type	Observed Proportion	Lower 90% CI	Upper 90% CI	Expected proportions
Herbaceous	0.194	0.127	0.262	0.482
Woody	0.625	0.542	0.709	0.402
Bare Ground	0.181	0.115	0.246	0.116

Table 3. Model ranking of detection covariates, including wind speed, temperature, and time during the point count for all waterfowl species detected during the point count.

Model	K[a]	AICc[b]	ΔAICc[c]	w_i[d]	Deviance
Temp	3	3772.9	322.5	0.00	3766.8
Sky	3	3879.4	429.0	106.51	3873.3
Null	2	3909.2	458.8	136.31	3905.2
Wind	3	3910.2	459.8	137.30	3904.1
Time in point count	4	3912.0	461.6	139.11	3903.7

a. Number of parameters
b. Akaike's Information Criterion, corrected for a small sample size
c. Difference between model and top ranked model.
d. Akaike weights

Table 4. Model rankings using comparing waterfowl abundance percent cover of different land cover categories within 500 m from the point and holding detection constant. Land cover categories came from 30 m resolution C-CAP data from NOAA.

Model	K[a]	AICc[b]	ΔAICc[c]	w_i[d]	Deviance
Open Water	3	3567.6	0.0	1.00	3561.5
Scrub-Shrub Wetland	3	3785.9	218.2	0.00	3779.7
Aquatic Bed	3	3813.6	245.9	0.00	3807.4
Grasslands	3	3823.3	255.7	0.00	3817.1
Shore	3	3840.0	272.4	0.00	3833.8
Upland Forest	3	3852.7	285.1	0.00	3846.5
Emergent Wetland	3	3881.8	314.2	0.00	3875.7
Developed	3	3887.5	319.9	0.00	3881.4
Forested Wetland	3	3892.4	324.8	0.00	3886.3
Scrub Shrub	3	3902.7	335.1	0.00	3896.6
Null	2	3909.2	458.8	0.00	3905.2
Barren	3	3911.3	343.7	0.00	3905.2

a. Number of parameters
b. Akaike's Information Criterion, corrected for a small sample size
c. Difference between model and top ranked model.
d. Akaike weights

Table 5. Model rankings using abundance against percent cover of vegetation within 4 m of the point for all waterfowl species detected, holding detection constant. To estimate plant height, water depth, and visual obstruction we used a Robel pole. Vegetation cover was measured using a Daubenmire frame.

Model	K[a]	AICc[b]	ΔAICc[c]	w_i[d]	Deviance
Global[e]	10	3450.4	0.0	1.00	3428.8
Bulrush	3	3613.1	162.7	0.00	3607.0
Water+Forbs	4	3645.4	195.0	0.00	3637.1
Robel	3	3651.6	201.2	0.00	3645.4
Height	3	3659.0	208.6	0.00	3652.9
Water	3	3700.9	250.5	0.00	3694.8
Forbs	3	3749.0	298.5	0.00	3742.8
Cattail	3	3788.3	337.8	0.00	3782.1
Grass	3	3830.3	379.8	0.00	3824.1
Sedge	3	3874.1	423.7	0.00	3867.9
Bare	3	3881.4	431.0	0.00	3875.2
Litter	3	3895.5	445.1	0.00	3889.3
Shrub	3	3898.5	448.1	0.00	3892.3

a. Number of parameters
b. Akaike's Information Criterion, corrected for a small sample size
c. Difference between model and top ranked model.
d. Akaike weights
e. Global model contained percent cover of water, bulrush, forbs, grass, sedge, cattail, bare ground, litter, and shrub

Table 6. Model rankings using abundance against percent cover of vegetation within 4 m of the point for mallard detected and at the landscape scale. To estimate plant height, water depth, and visual obstruction we used a Robel pole. Vegetation cover was measured using a Daubenmire frame.

Model	K[a]	AICc[b]	ΔAICc[c]	w_i[d]	Deviance
Temp, Water	4	824.48	0.00	1.00	816.21
Global	10	835.88	11.39	0.00	814.27
Water + Forbs	4	843.53	19.04	0.00	835.25
Temp	3	845.47	20.99	0.00	839.30
Water	3	850.41	25.92	0.00	844.24
Forbs	3	851.60	27.12	0.00	845.44
Robel	3	855.61	31.13	0.00	849.44
Shore	3	858.65	34.17	0.00	852.49
Grasslands	3	862.92	38.43	0.00	856.75
Aquatic Bed	3	864.03	39.55	0.00	857.86
Open Water	3	864.91	40.43	0.00	858.74
Cattail	3	865.09	40.60	0.00	858.92
Bare	3	865.57	41.08	0.00	859.40
Bulrush	3	866.20	41.72	0.00	860.04
Height	3	869.34	44.86	0.00	863.18
Scrub Wetland	3	869.39	44.90	0.00	863.22
Upland Forest	3	869.51	45.02	0.00	863.34
Wind	3	870.41	45.93	0.00	864.25
Forested Wetland	3	870.58	46.09	0.00	864.41
Scrub Shrub	3	870.80	46.32	0.00	864.63
Grass	3	870.82	46.34	0.00	864.66
Visit	4	871.30	46.82	0.00	863.02
Null	2	871.41	46.92	0.00	867.33
Shrub	3	871.63	47.14	0.00	865.46
Litter	3	871.90	47.41	0.00	865.73
Emergent Wetland	3	872.15	47.66	0.00	865.98
Sky	3	872.49	48.01	0.00	866.33
Water Depth	3	872.97	48.49	0.00	866.81
Developed	3	873.11	48.62	0.00	866.94
Sedge	3	873.23	48.75	0.00	867.07
Barren	3	873.42	48.93	0.00	867.25

a. Number of parameters
b. Akaike's Information Criterion, corrected for a small sample size
c. Difference between model and top ranked model.
d. Akaike weights

Table 7. Model rankings using abundance against percent cover of vegetation within 4 m of the point for Canada goose detected and at the landscape scale. To estimate plant height, water depth, and visual obstruction we used a Robel pole. Vegetation cover was measured using a Daubenmire frame.

Model	K[a]	AICc[b]	ΔAICc[c]	w_i[d]	Deviance
Global	10	3001.11	0.00	1.00	2979.50
Open Water	3	3130.80	129.69	0.00	3124.63
Bulrush	3	3147.00	145.89	0.00	3140.83
Height	3	3176.33	175.22	0.00	3170.16
Robel	3	3202.85	201.74	0.00	3196.68
Water + Forbs	4	3223.35	222.24	0.00	3215.07
Temp, Water	4	3232.16	231.05	0.00	3223.88
Water	3	3256.25	255.14	0.00	3250.09
Scrub Wetland	3	3318.41	317.30	0.00	3312.25
Cattail	3	3328.02	326.91	0.00	3321.86
Forbs	3	3330.74	329.63	0.00	3324.57
Aquatic Bed	3	3363.80	362.69	0.00	3357.63
Grass	3	3374.83	373.72	0.00	3368.66
Sedge	3	3386.72	385.61	0.00	3380.55
Grasslands	3	3390.05	388.94	0.00	3383.88
Shore	3	3393.84	392.73	0.00	3387.67
Emergent Wetland	3	3398.48	397.37	0.00	3392.31
Bare	3	3401.68	400.57	0.00	3395.52
Upland Forest	3	3413.19	412.08	0.00	3407.02
Scrub Shrub	3	3423.77	422.66	0.00	3417.61
Temp	3	3424.70	423.59	0.00	3418.54
Wind	3	3425.09	423.98	0.00	3418.92
Litter	3	3432.41	431.30	0.00	3426.24
Developed	3	3433.61	432.50	0.00	3427.44
Forested Wetland	3	3433.98	432.87	0.00	3427.81
Sky	3	3437.64	436.53	0.00	3431.48
Shrub	3	3439.92	438.81	0.00	3433.75
Water Depth	3	3449.03	447.92	0.00	3442.86
Null	2	3450.22	449.11	0.00	3446.14
Visit	4	3450.64	449.53	0.00	3442.36
Barren	3	3452.23	451.12	0.00	3446.07

a. Number of parameters
b. Akaike's Information Criterion, corrected for a small sample size
c. Difference between model and top ranked model.
d. Akaike weights

FIGURES

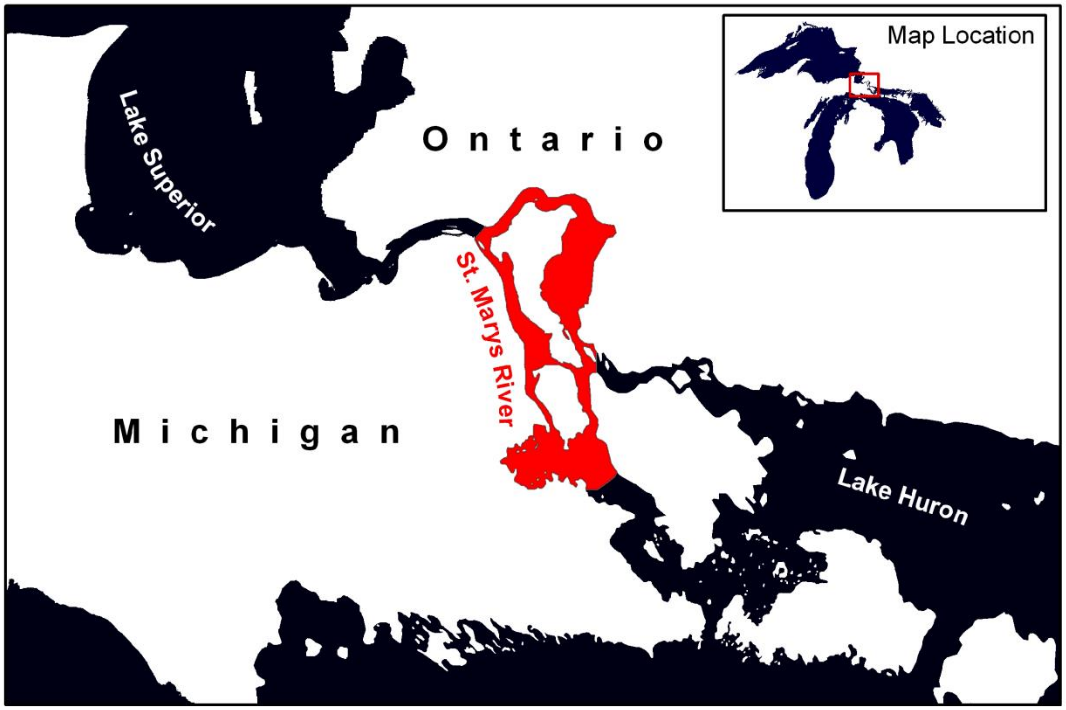

Figure 1. Study site for migratory bird prioritization and planning focusing on the upper St. Marys River in Michigan's eastern Upper Peninsula.