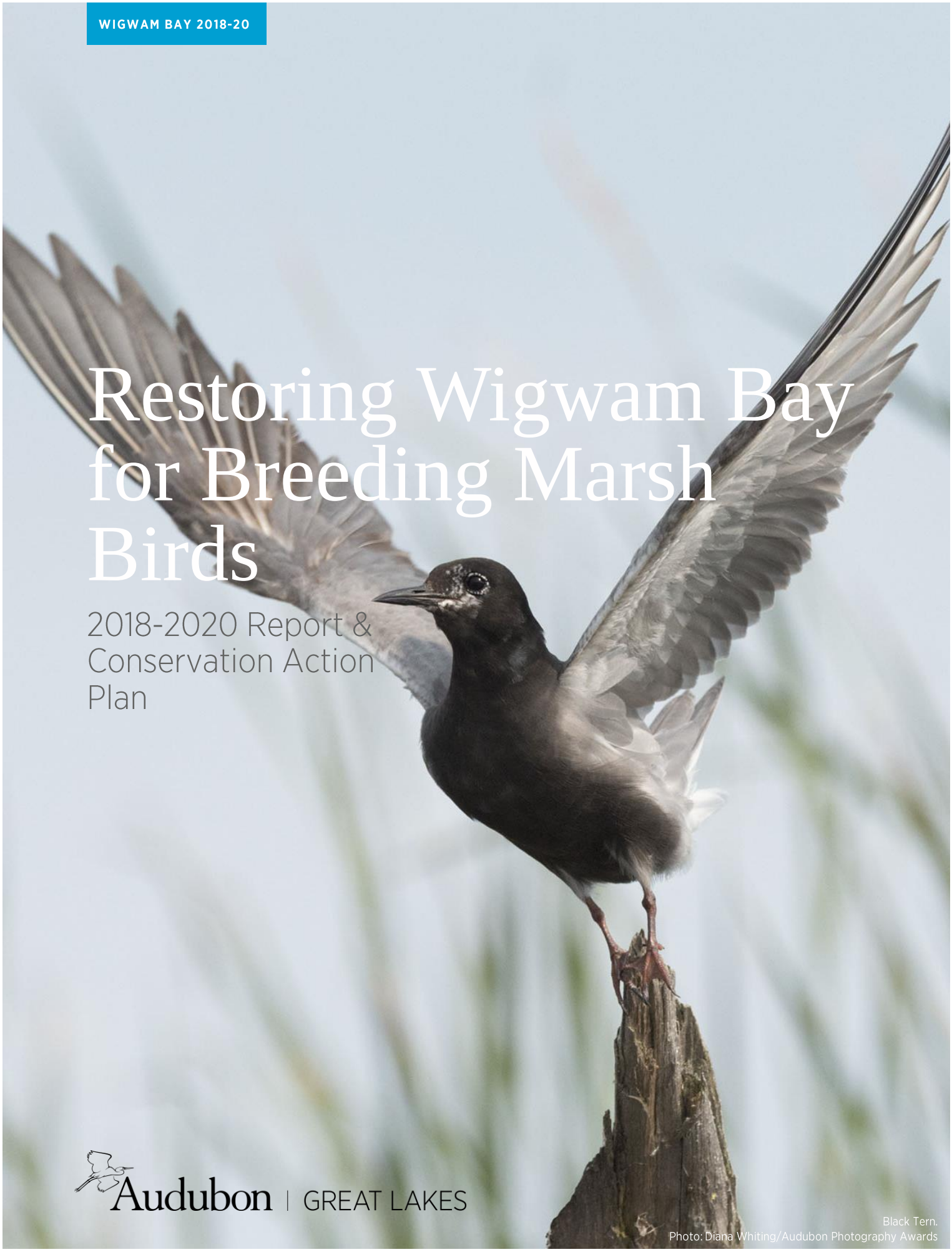
WIGWAM BAY 2018-20

Restoring Wigwam Bay for Breeding Marsh Birds

2018-2020 Report & Conservation Action Plan



Audubon | GREAT LAKES

Black Tern.
Photo: Diana Whiting/Audubon Photography Awards

Contents

Executive Summary **3**

Introduction **3**

Objectives 4

Management Summary **4**

Monitoring Methods **6**

Breeding marsh bird monitoring 6
Black Tern monitoring 6
Aerial imagery surveys 7

Management Impact on Interspersion and Birds **8**

Black Tern Monitoring Summary **10**

Recommendations and Conservation Opportunities **13**

Water level control feasibility 13
Management recommendations 13
Predator abatement 14
Monitoring plan 15
Engagement priorities 16
Conclusions 17

Acknowledgments: This report was made possible through funding by the U.S. Fish & Wildlife Great Lakes Coastal Program award #F17AC00430 and in cooperation with the Michigan Department of Natural Resources. Banding activities occurred under federal bird banding permit #23481, registered with the U.S. Geological Survey Bird Banding Laboratory.

We thank the following individuals and organizations who contributed to the findings in this report: Ava Landgraf, Detroit Audubon; Jenni Fuller, University of Michigan; Ava Gotthard, University of Redlands; Sarah Saunders, National Audubon Society, David Fuller; Caleb Putnam; Joe Kaplan, Common Coast Research & Conservation; Tri-County Aquatics LLC; Environmental Consulting & Technology, Inc.

Executive Summary

In 2018-20, 99 acres of invasive narrowleaf and hybrid cattail (*Typha angustifolia* and *Typha x glauca*, respectively) were treated with herbicide at Wigwam Bay State Wildlife Area, a diked cattail-dominated emergent marsh, in Arenac County, Michigan. Monitoring for breeding marsh birds and an analysis of interspersion metrics occurred pre- and post-treatment to detect impact of the treatment on habitat structure and breeding bird species of concern. Occupancy of several breeding marsh bird species of concern, such as American Bittern and Virginia Rail, tended to be high throughout the study. However, a significant impact of management on marsh bird populations was not observed. The data collected during this study will provide an important baseline comparison for future management and monitoring. We recommend continued monitoring of marsh bird populations, with a special emphasis on a declining species, the Black Tern at Wigwam Bay. In addition, future management activities should continue to investigate the use of water level control, prioritize the prevention of invasive vegetation spread to high quality sedge areas, and implement vegetation control aimed at creating greater patchiness and interspersion, all of which can serve as important tools for reestablishing hemimarsh conditions for a suite of declining marsh bird species.

Introduction

Audubon Great Lakes (AGL), a regional office of the National Audubon Society, and Michigan Department of Natural Resources (MI DNR) have partnered to conserve wetlands at Wigwam Bay State Wildlife Area (SWA), a diked 890-acre wetland along Saginaw Bay in Arenac County, Michigan, since 2018. This site has been targeted as a priority site for wetland restoration and monitoring by the US Fish & Wildlife Service Coastal Program and by Audubon Great Lakes' coastal wetland spatial prioritization (Grand et al., 2020). Wigwam Bay and adjacent coastal wetlands have also been dedicated as a state-level Important Bird Area, particularly for breeding American Bittern (*Botaurus lentiginosus*), Black Tern (*Chlidonias niger)* and Least Bittern (*Ixobrychus exilis*).

Wigwam Bay and adjacent marshes naturally interface with the waters of Lake Huron. But with the advent of low water levels of the Great Lakes in the 1970s, the diked unit at Wigwam Bay was originally created to provide managers with the ability to manipulate water level around the marsh and keep the water high for wetland wildlife, especially for the purpose of attracting furbearers and huntable waterfowl that use the bay's wetlands for breeding and migratory stopover habitat. MI DNR first dedicated Wigwam Bay as a SWA in 1966. More recently, MI DNR's goals for this site include the goal to maintain marsh habitat for wetland-dependent birds and furbearer species, in part to continue to provide recreational opportunities for hunters.

A study by Michigan Natural Features Inventory (MNFI) comparing marsh bird use at diked vs. undiked coastal marshes, which included Wigwam Bay as one of its study sites and took place during 2005-07, found that both types of wetlands equally provided important habitat for diverse breeding marsh birds (Monfils et al., 2014). The study also found that diked wetlands had higher density of cattail (*Typha* spp.) and deeper water levels compared to undiked wetlands and this also affected the community of birds that used the sites. Hybridized cattail dominance at Wigwam Bay continues to be an issue a decade later, and it has become a management priority for the MI DNR.

In order to be able to judge whether on-the-ground restoration work is successfully improving habitat at Wigwam Bay, we seek to measure progress toward two conservation targets: enhancing breeding marsh bird populations and restoring hemimarsh habitat.

Conservation target: Breeding marsh birds

Several species of marsh birds are in steep decline across the Laurentian Great Lakes region, with some declines exceeding 60% since the 1990s (Wires et al., 2010; Tozer, 2016; Soulliere et al., 2018). The first and second iteration of the Michigan Breeding Bird Atlas (MBBA) indicate losses of breeding marsh birds across Michigan, such as Common Gallinule, Blue-winged Teal, and Black Tern (Brewer et al., 1991; Chartier et al., 2013). However, the MBBA also showed that Saginaw Bay has persisted as a stronghold for several breeding marsh bird species such as Virginia Rail, Marsh Wren, Least Bittern, and Sora.

The Black Tern is a Michigan Species of Special Concern and State Wildlife Action Plan focal species. Black Tern populations have experienced a decline of 48-71% between 1991 and 2006 in Michigan, and range-wide losses of 61% across North America between 1966 and 1996 (Scharf, 2010) Additionally, small colony abandonment has occurred at a faster rate than the population decline, suggesting that large colonies, like those at St. Clair Flats and Wigwam Bay State Wildlife

Areas, hold high conservation value (Wyman and Cuthbert, 2017). The causes of the population decline are unclear, but are likely due in part to the loss and conversion of wetlands, and degradation of remaining wetlands across their breeding range due to invasions of narrowleaf and hybrid cattail and poor water quality.

Marsh-dependent bird species have been documented as declining in the Great Lakes in response to invasions of common reed (*Phragmites australius*) and narrowleaf and hybrid cattail that create habitat monocultures (Tozer, 2016; Tozer and Mackenzie, 2019). Thus, it is critical to maintain Saginaw Bay as a stronghold for multiple marsh bird species by prioritizing conservation of diverse marsh habitat structure (reducing the negative impact of an invasive emergent monoculture) and acting quickly to prevent further habitat degradation.

Conservation target: Hemimarsh

Hemimarsh is a type of mid- to deep water marsh characterized by a combination of emergent vegetation and open water. The exact ratio of emergent vegetation to open water is dynamic and fluctuating based on factors such as variation in water levels, bathymetry, plant establishment dynamics, herbivore activity, and invasive species impacts. The key condition that makes a marsh a functional hemimarsh is the level of interspersion between the vegetation and open water, i.e., both types occur in a mosaic characterized by a high edge to volume ratio. It is this relatively complex, open structure that provides habitat for diverse wetland wildlife, benefiting not only birds but also amphibians, fish, and aquatic mammals.

Just as the emergent portion of a hemimarsh is characterized by emergent marsh vegetation, the open water portion is characterized by submersed and/or floating-leaved vegetation, Audubon characterizes the potential to develop hemimarsh again in Wigwam and throughout the Saginaw Bay region as high priority restoration because this was once one of the dominant habitats in the region, and arguably the one suffering the greatest collapse due to the collective impact of changing conditions within the coastal system.

Breeding marsh birds depend on intact, healthy wetlands and therefore serve as an excellent indicator of wetland quality. Through hemimarsh restoration, a broad spectrum of wetland habitat conditions develop within the system, ensuring a diversity of nesting and foraging sites for breeding marsh birds. Wetland restoration, particularly hemimarsh restoration, needs to occur on the landscape level in Saginaw Bay, and in particular at Wigwam Bay, because both wetland quality and function is so strongly influenced by hydrologic dynamics at a broader scale.

Objectives

In 2018, AGL and MI DNR established plans to create openings in the dense cattail of the diked unit at Wigwam Bay with the goal of creating high quality habitat for breeding marsh birds including Black Terns. In creating these openings, we hypothesized that this management would enhance hemimarsh habitat for breeding marsh birds by creating greater interspersion and thus providing more hemimarsh habitat. To measure the impact of restoration on marsh bird populations, we conducted pre- (2018) and post-treatment (2019, 2020) surveys of breeding marsh birds. We also measured interspersion by conducting drone surveys, and analyzing results of imagery pre- (2018) and post-treatment (2019).

The purpose of this document is to summarize management actions and monitoring results from work led by Audubon at Wigwam Bay in 2018-2020 and outline future directions for management to enhance wetland habitat for birds. This document serves both as a report of results as well as a conservation planning document to frame future work. In addition to providing recommendations for future management, next steps also incorporate monitoring steps to be taken to provide feedback to managers on how birds are responding to management as well as opportunities to engage local audiences. The ultimate goal of engagement activities is to gain public support for continuing work while showing the benefits of investing in protecting and enhancing coastal wetlands.

Management Summary 2018-2020

Invasive narrowleaf and hybrid cattail tend to form thick monocultures and can replace native plants in wetlands, lowering the structural diversity of wetlands and minimizing the diversity of habitat niches for marsh birds and other marsh-dependent wildlife. This is of particular concern for Black Terns in Wigwam Bay, as they have been found to nest in habitats under serious encroachment by these invasive plants, which includes

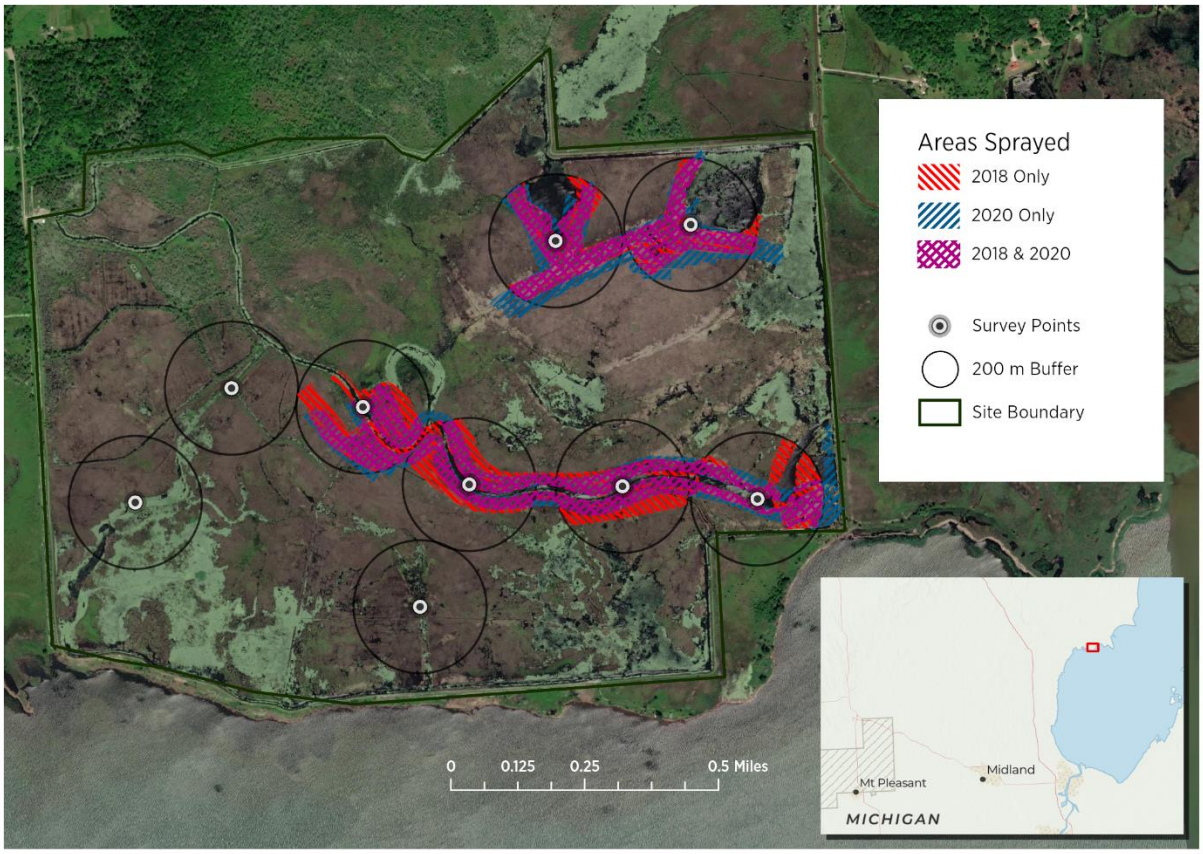


Figure 1. Map of Wigwam Bay State Wildlife Area diked unit and areas receiving herbicide treatment in 2018 and 2020. This map also shows the 9 marsh bird survey points including 6 that received treatment and 3 that did not, as well as a 200-m radius buffer around each point.

exposed mudflats and mats of cattail debris floating on the surface of the water. Reducing the encroachment of these plants in the Black Tern's preferred habitat was hypothesized to improve the marsh habitat for Black Terns and prevent any further decline of this species' breeding success at Wigwam Bay.

The management plan to remove encroaching cattail and thin extensive monocultures originally included a set of nine control plots with a radius of 200 meters. Three points would have no invasive control work performed within their boundary. The remaining six would be sprayed with herbicide to remove and thin out vegetation (Fig. 1). Three of those six plots would also include the cutting and/or flattening of the treated cattail in order to quickly create more open and flat space within the dense floating cattail mats. This series of experimental plots could explore see which level of management, if any, could generate conditions suitable for Black Tern nesting.

Unfortunately, the water levels within Wigwam Bay and the extent of the cattail vegetation made access by boat to conduct invasive control work impractical. Herbicidal spray was consequently shifted to an aerial application; helicopters were hired to spray the areas within the six experimental plots. Cutting, mowing, or flattening of the treated vegetation was simply not possible.

In the fall of 2018, contractors were able to aerially treat a total of 77.5 acres within the six experimental plots, with an average of 12.9 acres sprayed within each plot.

To compensate for the inability to cut or flatten cattails in, Audubon hired contractors for a follow up aerial application of herbicide in the fall of 2020. For this phase, a total of 82 acres were treated within the experimental plots, with an average of 13.6 acres sprayed within each plot. Vegetation monitoring performed by contractors a few weeks later found a significant die-off of treated cattail within these segments, though the cattail mats themselves were intact.

Monitoring Methods

Breeding marsh bird monitoring

Marsh bird surveys were conducted by a contracted surveyor using the widely recognized "Standardized North American Marsh Bird Monitoring Protocol" (Conway, 2011), developed by the U.S. Fish and Wildlife Survey as a continent-wide, standardized protocol for measuring breeding marsh bird densities.

The primary focal species for the study were marsh-dependent species that breed in coastal marshes of Saginaw Bay and tend to be "secretive" and thus not well sampled by other survey methods (Conway, 2011; Table 1). Primary focal species were: Least Bittern (*Ixobrychus exilis*), Sora *(Porzana carolina),* Virginia Rail (*Rallus limicola*), Common Gallinule (*Gallinula galeata*), Pied-billed Grebe (*Podilymbus podiceps*), American Bittern (*Botaurus lentiginosus*), and American Coot (*Fulica americana*). We also selected secondary species that are not as secretive, but we included them as species that are known to nest in cattail and could be potentially influenced by management influencing cattail density: Common Yellowthroat (*Geothlypis trichas*), Mallard (*Anas platyrhynchos*), Marsh Wren (*Cistothorus palustris*), Red-winged Blackbird (*Agelaius phoeniceus*), Swamp Sparrow (*Melospiza georgiana*), and Sedge Wren (*Cistothorus stellaris*).

Following the Standardized North American Marsh Bird Monitoring Protocol (Conway, 2011), surveyors conducted three point-count surveys at nine point-count locations (Fig. 1) during three survey periods (May 15-31, June 1-15, and June 16-30). Points were distributed at least 400-m apart and were distributed evenly along existing boat pathways to the marsh to prevent further disturbance. Repeat surveys at the same points were conducted at least 10 days apart.

Each point was visited by motorboat and surveyed for 10 minutes in sequence starting 30 minutes prior to sunrise and completed at the latest three hours post-sunrise. When morning surveys could not be completed due to scheduling or weather issues, surveys were conducted in the evening during a window of three hours before sunset to 30 minutes after sunset. To visit all nine points within this 3.5 hour window, two visits were needed per survey period to complete the survey route. At each point, a pre-recorded playback including vocalizations of each of five of the seven primary focal species were broadcast, with a five-minute period of silent listening before the recording. American Bittern and American Coot were not included in the audio broadcast because they typically are more readily detected without the use of playback than other "secretive" species (Conway and Gibbs, 2005). All visual and audio detections of primary and secondary species were recorded. In addition, we recorded information such as distance from the observer, the minute during the survey in which detections occurred, and the type of calls heard for primary focal species.

Black Tern monitoring

NEST MONITORING AND FLUSH COUNTS

Black Terns start establishing their nesting territories, displaying defensive behavior, and courting one another in mid-May. From 2018 – 2020, Audubon staff, technicians, and dedicated volunteers visited Wigwam Bay State Wildlife Area once weekly from mid-May through the end of July, to identify Black Tern nesting sub-colonies, conduct nest surveys, and capture and band adults and chicks following similar methods outlined by Shealer and Haverland (2000).

Once sub-colonies were identified, thorough nest surveys and flush counts were conducted primarily by kayak or canoe. In some instances, nests were visible from the dike, and allowed for easy surveying via spotting scope with minimal disturbance. Once nests were located, coordinates were recorded using Esri's Collector Application, along with nest substrate material, water depth, number of eggs present, estimated hatch date, and a unique identifying number. The nest was revisited weekly or biweekly until it hatched or failed. Adults and chicks were captured and banded at each nest site when possible. Some nests were not revisited due to time constraints in the field or inaccessibility due to high water levels and vegetation growth.

Flush counts of adults were done during nest visits in each sub-colony from early to mid-June, once most adults established their nesting territories. Ideally, the maximum flush count was also done prior to any large storm event that may have caused many nest failures and subsequent renesting attempts, which may cause adults to move from one sub-colony to another, increasing the likelihood of double counting individuals. While flush counts can provide an estimated number of adults present, the number of nests observed during this time was also referenced to assess whether the flush counts were accurate. For example, some adults do not flush if they are already incubating eggs at the time of the flush count, while others may be away from the nest foraging. It is possible that staff overlooked some nests and adults as well, simply due to how well they camouflage with their surroundings, and inaccessibility

to some of the inner wetlands due to dense stands of vegetation.

One to five nest cameras were also installed at nests where water levels would allow and rotated throughout each field season in an effort to better measure hatching and fledging success.

MARK-RECAPTURE

Adult Black Terns are most invested in their nest within 7-10 days of the estimated hatch date and are most likely to enter a chicken-wire walk-in or drop-in passive trap at that time. Peak hatch dates typically occur in mid-to-late June. During this period, field staff set up passive traps over nests. Real eggs were replaced with dummy eggs and were stored in a safe place away from the elements. Traps were set and watched from a distance. If adults were not captured or expressing interest in the trap within 30 minutes, the trap was removed, the eggs were returned to the nest, and field staff moved onto another nest or sub-colony. If adults were observed entering the trap, field staff paddled to the trap to retrieve the bird, which was then safely placed in a cotton bird bag and transported back to the canoe or dike to be banded, processed, and eventually released. After the first adult was captured, the trap was reset in an attempt to capture the second adult. The first adult was held during this time in a cotton bag to ensure it is not recaptured upon release. If the second adult did not express interest in the trap within 30 minutes, the trap was removed, eggs were replaced, and the first adult was released.

When adults were captured, they were banded with a stainless steel USGS bird band with a unique band number, and a yellow alpha-numeric color band (beginning in 2019). When adults were processed, their fat levels, body molt, flight feather molt, and flight feather wear were measured and their mass, wing chord, bill length, and bill plus head measurements were taken prior to release. These measurements help assess the overall health of the bird as well as determine its sex, when possible.

Chicks were captured by hand. Similar to adults, chicks were banded with a stainless steel USGS bird band and pink alpha-numeric color band (beginning in 2019). When chicks were processed, only mass was taken, and the amount of juvenile plumage present was recorded before they were returned to the nest.

Aerial imagery surveys

During summer of 2018-2019, experienced drone operators contracted through the Michigan Department of Natural Resources piloted a drone over the diked wetland unit to collect aerial imagery before (May 2018) and after (May 2019) management occurred. The purpose of the drone flights was to collect information on how management actions (aerial spraying of cattail) influenced the interspersion of emergent vegetation and open water. No flights were conducted in 2020 due to changes to staff availability and travel due to COVID-19 restrictions.

IMAGERY ANALYSIS

Aerial imagery collected in 2018-19 was subsequently processed and classified using ArcGIS, in partnership with University of Redlands. The imagery's landscape was classified in ArcGIS into the following landscape classes: open water, exposed mud, floating vegetation, emergent vegetation, trees, and other, which included fallen logs, vehicles, and impervious surfaces. Interspersion, or the measurement of the amount of patchiness within a landscape, was analyzed using these cover classes. This analysis helps clarify landscape cover change over time; as invasive vegetation was sprayed, this imagery analysis can identify and measure how the vegetation patches changed in response.

To meet this goal, partners from the University of Redlands used interspersion metrics at the landscape and class levels. Including the class level metric allowed for a deeper analysis on observed annual changes. As with the landscape level metric, the class level IJI function measures the interspersion of different patches in the landscape. Low values from 0-50% represent clumped or an overall disproportionate distribution, whereas higher values 50-100% mean that the patches are increasingly uniformly mixed or adjacent to each other.

These interspersion metrics were calculated in R, through a library called 'Landscapemetrics' (Hesselbarth et al., 2019). This is similar to FRAGSTAT software but accepts ArcGIS layers and can be re-used and modified to fine-tune results. The landscape metrics used in this particular study included the Interspersion and Juxtaposition Index (IJI), the mean of patch area, and total area. These were added for insight into the interspersion metric results as they help further explain the size and area of patches within the system.

These metrics were calculated separately for the imagery from 2018 and 2019. The results were compared to the source imagery to verify their accuracy, and, ultimately, used to compare how the landscape changed following 2018's herbicidal spray.

Management Impact on Interspersion and Birds

Management impact on interspersion

We evaluated the impact of management on interspersion by calculating the average proportion of interspersion of emergent vegetation by year (2018 and 2019) and treatment (control and herbicide) across the nine Wigwam sites. Interspersion was calculated from imagery analyses of sites. We found that interspersion significantly decreased (i.e., standard deviation [SD] bars did not overlap) at control sites, on average, between 2018 and 2019, but it did not significantly decrease at treatment (herbicide) sites (I.e., SD overlapped between years). On average, control sites had more interspersion than herbicide-treated sites, but this difference was not statistically significant (i.e., SD overlapped across treatments in each year). Please see Fig. 2 below, which summarizes these results.

Marsh bird response to management

STATISTICAL ANALYSES

We evaluated marsh bird response to management by conducting two occupancy analyses. In a first analysis, we used bird data collected in 2018 and 2019 and built species-habitat models using imagery-derived variables (landscape-level interspersion and emergent vegetation interspersion) as predictors of occupancy. We also included year to control for year-specific differences in occupancy, as well as treatment type as a site-specific variable. In a second analysis, we used bird data collected in 2018 – 2020 and included only year and treatment as predictor variables, as imagery-derived variables were unavailable in 2020. In both analyses, we built species-specific occupancy models for seven marsh bird species that had a sufficient number of detections (≥ 30 total detections) for analysis: American Bittern, Common Yellowthroat, Marsh Wren, Pied-billed Grebe, Red-winged Blackbird, Swamp Sparrow, and Virginia Rail.

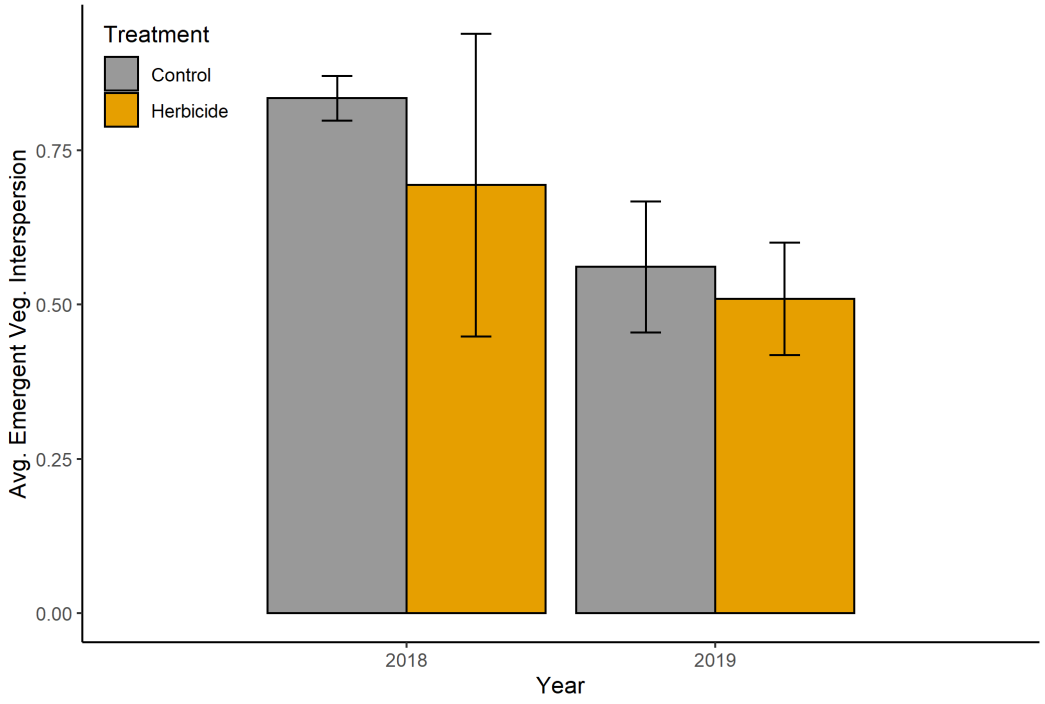


Figure 2. Average (avg.) emergent vegetation (emergent veg.) interspersion per year (2018 and 2019) and treatment type (control and herbicide), across 3 control sites (i.e., points) and 6 herbicide sites (9 total sites) at Wigwam Bay, MI.

We estimated occupancy and detection probability parameters for species with the unmarked package in R, version 3.6.1 (Fiske and Chandler, 2011). We estimated species-specific occupancy using the likelihood-based method (MacKenzie et al., 2002) and developed separate models for each species based on stacking data from repeated survey visits within years.

In both analyses, occupancy modeling was a multi-step process (adapted from Saunders et al., 2019). In our initial step, we examined the influence of survey-specific covariates on detection probability, while holding occupancy probability constant. We accounted for two processes known to influence detection probability and availability of marsh birds during surveys (Conway, 2011; Tozer, 2016): time of day and day of year (ordinal date). Both continuous explanatory variables were standardized to have a mean of zero and standard deviation (SD) of one. We assessed linear and quadratic terms (based on standardized values) for both variables and used Akaike's information criterion (AIC) to compare among models, which included a null (intercept-only) detection submodel. The model with the lowest AIC was used as a base model in the next step of model selection, where we evaluated additive effects of time and date. We selected the top-ranked model of this subset of detection models and incorporated this model into all subsequent occupancy models for each species.

After we developed detection models with appropriate covariates, we then examined the influence of several variables on marsh bird occupancy. As state above, in the first analysis, we tested for the effects of landscape-level interspersion, emergent vegetation interspersion, and treatment type. We also included year to control for year-specific differences in occupancy. In a second analysis, we only included year and treatment as predictors since imagery-derived variables of interspersion were unavailable in 2020. We note that prior to model fitting, we used Pearson's correlation coefficient (r) to examine correlations among variables and found that landscape-level interspersion and emergent vegetation were highly correlated (r = 0.6); thus, we did not include both of these variables simultaneously in models (i.e., we evaluated support for interspersion variables independently).

RESULTS

In both analyses, none of the covariates that we evaluated were considered significant. In other words, neither the inclusion of interspersion variables (first analysis only) nor treatment type (both analyses) lowered AIC relative to the null model, which included only year as a covariate on occupancy. Thus, we did not find evidence for significant responses of any marsh bird species to interspersion or management. We hypothesize that the lack of significant species-habitat relationships stems from the fact that occupancy for nearly all seven species was high (≥ 0.8) in all years. Thus, there is little variation in the response variable that could be associated with predictors. To illustrate this, we provide Fig. 3 below which shows species-specific mean

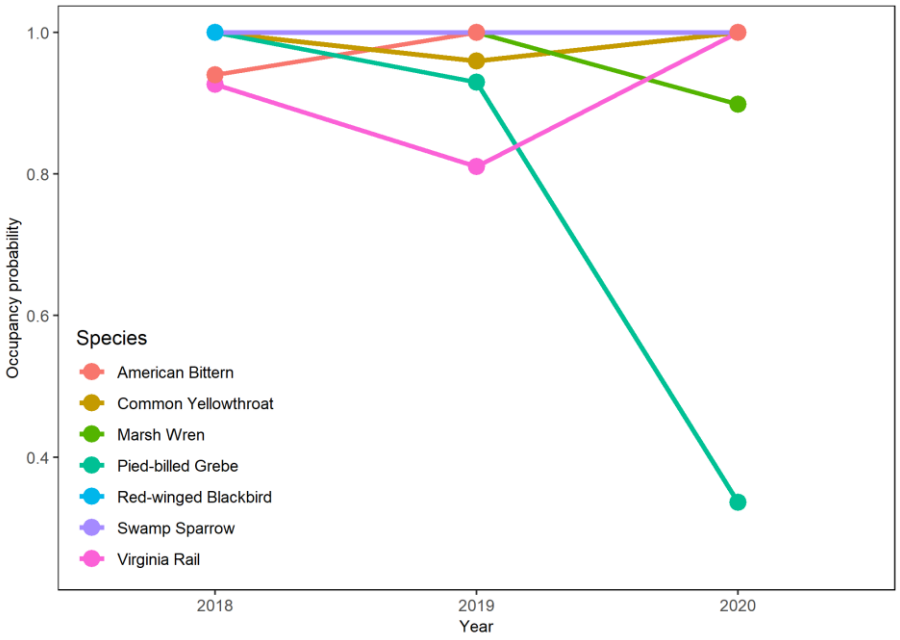


Figure 3. Mean occupancy probability per marshbird species (n = 7) and year (2018 – 2020) across nine total sites (i.e., points) at Wigwam Bay, MI. Note that fewer Pied-billed Grebe were detected in 2020, partly because fewer points were surveyed during 2020 due to the pandemic.

occupancy estimates per year estimated from year-only occupancy models fit during the second analysis (i.e., using bird data for 2018 – 2020; eBird, 2021). We also speculate that one or two years of post-management survey data may be insufficient to capture possible lag effects of habitat changes on marsh bird responses. Nevertheless, results from the relatively few (n = 9) points represented in our study indicate that marsh birds are using the Wigwam Bay area, so continued management efforts would presumably boost numbers and/or attract individuals to nearby sites that are not occupied but may be with improved habitat conditions.

Black Tern Monitoring Summary

Flush counts

Flush counts in 2018 resulted in an estimated 64 adults observed. In 2019, 106 adults were observed, and in 2020, an estimated 84 adults were observed (Table 1). This makes Wigwam Bay State Wildlife Area the second-largest known colony of Black Terns in the state and therefore of high conservation value. We suspect the decline in the number of adults in 2020 was in part due to higher water levels. Several nesting areas were flooded and less nesting substrate was observed in several sub-colonies compared to previous years.

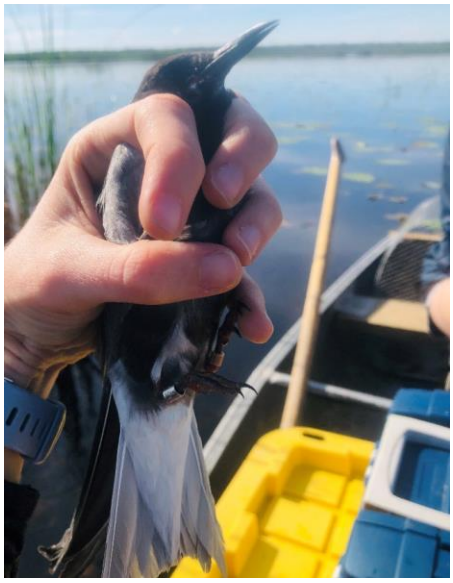
The number of nests observed during the flush counts each year coincided well with the flush count estimates. We are confident that these population estimates are accurate yet conservative, knowing that some nests were most certainly undetected by field staff due to either camouflage or inaccessibility. Please note that the total number of nests in Table 1. includes renesting attempts.

Hatching success

Ideally, fledging success would be measured by following the ultimate fate of each egg, but with current technology, this is not yet possible. Instead, hatching success was used as a surrogate for fledging success and was based on the estimated number of eggs hatched versus the estimated number of eggs failed (Table 1). In 2018 and 2019, hatching success was nearly identical (45%-82% and 46-82% respectively). In 2020, the hatching success was 35-71% likely due to a combination of increased predation and high water levels making existing nesting substrates less stable and more prone to flooding. Many nests still had unknown fates each year, and hatching success ranges account for these unknowns.

Table 1. Wigwam Bay State Wildlife Area: Black Tern Monitoring Results Summary 2018-2020

	YEAR		
	2018	2019	2020
TOTAL ADULTS COUNTED (FLUSH COUNT)	64	106	84
TOTAL NESTS	42	66	60
HATCHING SUCCESS	45-82%	46-82%	35-71%
ADULTS BANDED	27	15	4
CHICKS BANDED	1	22	19
RECAPTURES	0	3	0



Adult Black Tern with a band. Photo: Erin Rowan.

Mark-recapture

In 2018, 27 of the 64 adults present were captured and banded. Only one chick was banded due to a lack of bands at the end of the field season. In 2019, 15 adults were banded, 3 of which were recaptures from the previous year. This indicates some site fidelity in adults, which has been observed at other Black Tern colonies across the region (Costa, 2019; Matteson et al., 2012). Additionally, 22 chicks were banded in 2019. In 2020, 4 adults and 19 chicks were banded. Fewer adults were captured and banded in 2019 and 2020 due to field staff prioritizing chick banding in an effort to better measure hatching and fledging success.

Camera traps

Camera traps were deployed at four different sub-colonies or unique clusters of nests within the diked unit. These are named based on their cardinal direction within the unit: southwest, south, east, and north (Fig. 4) showing nest placement over time). The southwest subcolony was dominated by sedge vegetation, whereas the other three colonies used waterlily root masses. Three camera traps were installed in the southwest subcolony in 2018, two camera traps were installed in the southwest sub-colony in 2019, and five camera traps were installed within southwest, south-central, east, and north sub-colonies in 2020. Camera trap footage was reviewed by DNR technicians and AGL field staff and volunteer technicians who noted moments of disturbance when adults left the nest, the type of disturbance (e.g., weather, predator), the type of predator (when possible), the number of chicks present, and when chicks were last seen.

In 2018, two nest cameras resulted in two nest failures, and one nest camera resulted in an unknown nest status. One nest failure was caused by a storm event where the nest flooded, and the other had an unknown cause of failure due to a momentary lack of images over the course of five hours after a series of unknown disturbances were noted. We suspected a predator was in the area and was the likely cause of this nest failure. The unknown nest status likely hatched, as adults were seen at the nest two weeks after the expected hatch date. However, the nest and chicks were not within the field of vision of the camera unfortunately, so we were not able to confirm if these chicks successfully fledged.

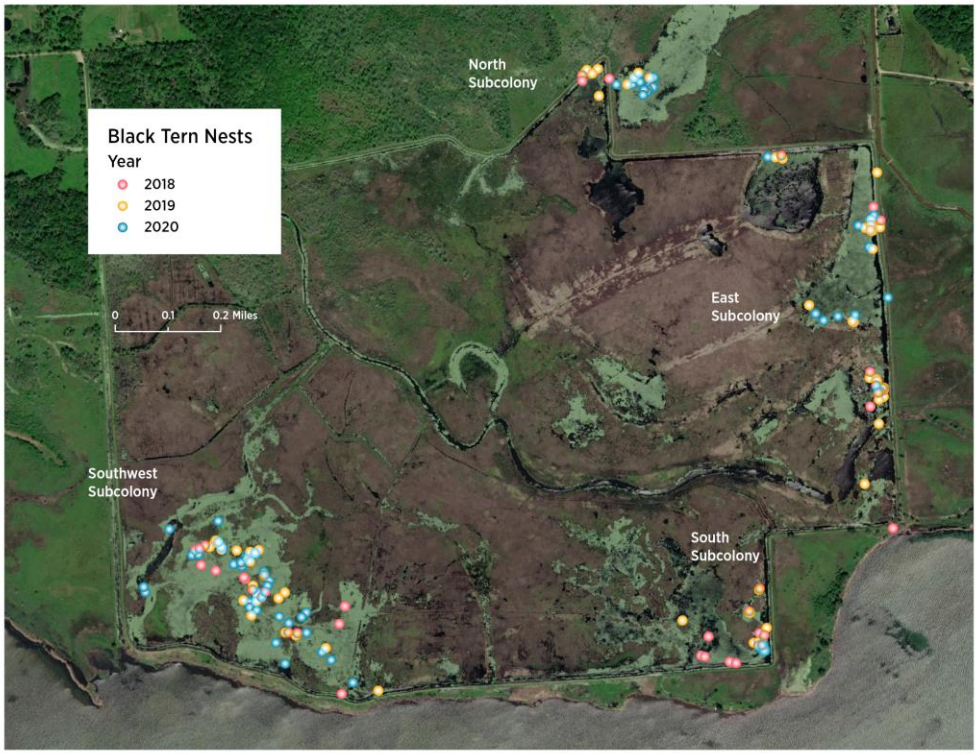


Figure 4. Wigwam Bay map showing Black Tern nest locations between 2018-20 at four subcolonies.

The two nests monitored in 2019, resulted in an unknown nest fate and a failed predated nest. The unknown nest hatched, but chicks and adults moved away from the nest for several days before leaving the area entirely. They could have relocated, or the nest could have failed. The other nest in the southwest sub-

colony was depredated by a raccoon (*Procyon lotor*, Fig. 5), as were several other nests in the area upon the return visit to the nest. Nests appeared to still be intact, but eggs were gone, and adults had left the area. We suspect this raccoon was able to depredate several nests in one night or returned to the area over the course of several nights.

In 2020, two of the five nests monitored failed due to predation. A raccoon was caught on camera, yet again, on a nest at the south subcolony and similar predation, where eggs were missing, but nests were left fully intact, occurred at east subcolony, but no predators were caught on camera. One nest was abandoned and failed, on July 24, the same day the nest camera was installed. The estimated hatch date of this nest was July 27, and it is possible the installation of the nest camera caused the adults to abandon the nest. The eggs were dead on July 28. This nest was also a renest attempt. In other tern species, renesting attempts tend to be less successful, with smaller brood sizes, lighter egg mass, and lower productivity (Massey and Atwood, 1981; Nisbet, 2020;



Black Tern chick. Photo: Stephanie Beilke.

Shugart et al., 1979). Additionally, less-experienced adults tend to have less success with renesting attempts and food availability is most certainly lower later in the season. The two nests with unknown fates hatched, but there was no confirmed evidence that chicks fledged or that the nests failed.

While some nest cameras still resulted in unknown nest fates, we did learn of a new predator, the raccoon, which appears capable of decimating several nests. Raccoons have now been observed within several subcolonies, including those with deeper water.

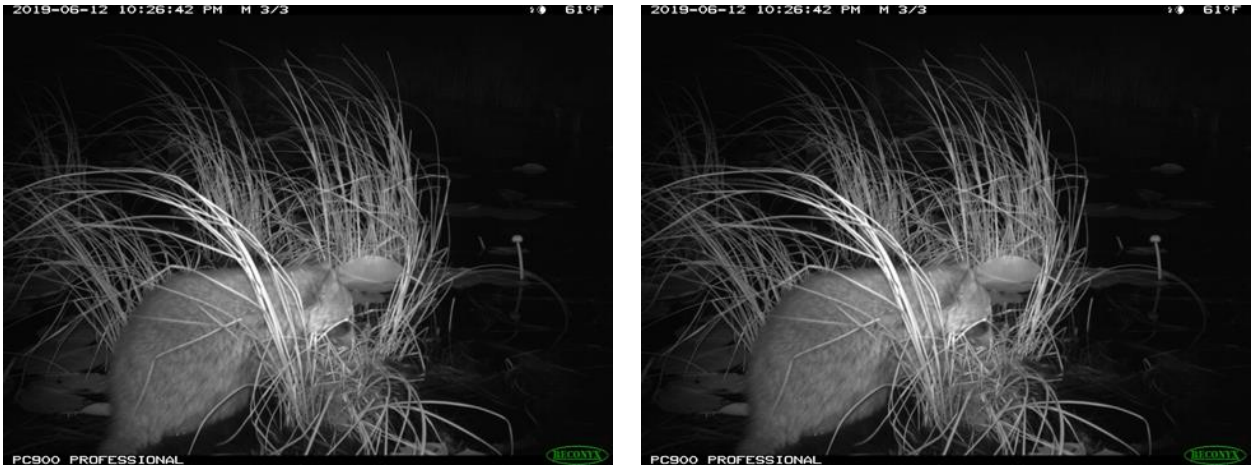


Figure 5. Nest camera images from Wigwam Bay State Wildlife Area Sedge Sub-colony, showing raccoon depredation in 2019.

Recommendations and Conservation Opportunities

Water level control feasibility

In the fall of 2020, contractors were hired to analyze Wigwam Bay's potential for hemi-marsh restoration through manipulation of the wetland's water levels. For the full report of the 2020 water feasibility analysis, see Appendix I. This work was originally set to begin in the Spring of 2020, but due to statewide COVID-19 restrictions on fieldwork and access, this was put on pause until it was reasonably safe to access the site. Consequently, the scope of the analysis was reduced to a feasibility study, with a 'phase 2' subject to future funding opportunities, which will detail hydrological analyses and restoration planning.

Hydrologists found that water levels within the impoundment were generally 0.5-1.2 ft above water levels measured outside of the impoundment. The fluctuation of water level within the impoundment should be monitored in future growing seasons to ensure that the processes in Lake Huron are not negatively impacting the vegetation community within the marsh. Assuming the projections showing Great Lakes water levels, currently near record high, continue to gradually fall, water level within the impoundment may also drop slightly. Marsh conditions suitable for Black Tern can be maintained with water depths between 0.5-6 ft.

Water can currently drain out of Wigwam via passive, gravity drainage. The ability to drop these water levels and the efficiency of the drainage is impacted by the water levels in the bay and river outside of Wigwam Bay, as well as seiche effects. There is currently no present means of adding water back into the system, which limits the current management strategy to drawdowns. Practical means to bring water back into the system, via pumps is worth considering to provide a broader scope of management strategies to the wetlands of Wigwam Bay.

To better understand precise water level management techniques available and understand the total area of vegetation that can be impacted by water level changes, contractors recommend a more detailed bathymetric study and assessment of current water control infrastructure. This recommendation would be part of the 'phase 2' outlined above.

Specific recommendations from the contractors include:

- Monitoring and recording water levels throughout the year to better understand the hydrology and to inform the water level management strategy.
- Actively open and close the existing gravity drain infrastructure to manage water levels
- Initiate a program to eliminate purple loosestrife and phragmites, and other invasive plants.
- Diversify the existing native plant composition of the wetlands by planting emergent and submersed native species during periods of drawdowns
- Utilize an adaptive management approach, develop a strategy to learn from mistakes and implement steps that can be taken to sustain and enhance the marsh and open water plant communities.

Management recommendations

In order to maintain and improve Wigwam Bay's wetland habitats for marsh birds and other marsh-dependent wildlife, it is necessary to focus on protection of high-quality portions of the managed impoundment, such as the tussock sedge meadows, and continue restoration and thinning efforts in areas of dense cattail and/or invasive plants. The strategies to protect and restore are similar, though the scale and methods of implementation may differ. Through this project period herbicidal application on cattail and/or invasive plants was a key strategy for maintenance, which can be readily implemented by the landowners via aerial or land-based applications. Water level control is the second recommended strategy for restoration, though further assessment is needed to fully define capacity and potential. Gravity flow out of Wigwam Bay is currently limited by Lake Huron's water levels and by seiche events.

CATTAIL AND INVASIVE CONTROL VIA HERBICIDE

Preventing further encroachment of invasive plants and cattail within the high quality tussock sedge habitat is an important strategy in maintaining habitat quality. Though overall marsh bird occupancy did not differ between the sedge and other cattail marsh at Wigwam, the tussock sedge habitat was frequently used as nesting habitat by Black Terns (southwest sub-colony, Fig. 4). It is necessary to utilize a more precise approach than conventional broadcast sprays that were implemented over the course of this project, which used aerial applications to treat the cattail dominated system.

Where possible, it is recommended to hand wick or use backpack sprayers to ensure that invasive species within and along the edge of the tussock sedge meadows are treated in a way that minimizes herbicide drift. This will maintain the ecological integrity of the high-quality tussock sedge areas.

It is also prudent to maintain larger open areas of dead and dying wetland vegetation within areas of dense cattail and phragmites. This has proven to help maintain a patchy habitat with the potential to create open areas of floating cattail mats for marsh birds such as the Black Tern. Even during the short time frame of this project, areas that were treated with herbicide maintained more interspersion than our controls. Maintaining open areas of water can be used to hold back invasive and aggressive species from dominating the wetland system. Regular (at least every other year) analysis of aerial imagery is a critical tool to track and improve interspersion.

Broadcast spraying performed via boat or aerial application is recommended. Areas were sprayed twice over the three-year project, with positive results indicating that the follow-up spray was effective in killing off extensive stands of the cattail. As years go by and these areas once again begin to revegetate with cattails, it would be prudent to conduct another treatment of herbicide or to direct broadcast spray in other areas where invasive and/or aggressive species have become a concern. This approach appears to be the most cost and time effective for thinning vegetation and creating suitable nesting sites for Black Terns, as this project found that the cutting and/or flattening of cattail mats was impractical in this system. The floating mats posed problems for aquatic vehicles accessing and treating cattail stands.

Consequently, the inability to flatten, cut, or remove dead cattail biomass via prescribed burns has altered the timescale in which Black Terns and other marsh birds could respond to clearings created by applications of herbicide. It was anticipated that at this site, marsh birds could respond to newly created openings in vegetation in the following growing season, because the cattail would be manually broken down and/or removed. However, response times for marsh birds will likely not be evident for at least two years, to account for the time it would take for sprayed cattails to naturally break down and decay and thus current objectives can focus on maintaining open areas and increasing interspersion with expected focal bird response to follow.

WATER LEVEL CONTROL

The ability to manage water levels can address wetland restoration efforts directly through the timing of drawdowns and floods, and indirectly through increasing accessibility into areas of Wigwam where boats or other amphibious equipment were previously unable to reach.

Water level control can be a cost-effective means of controlling the composition and structure of vegetation in Wigwam Bay. Drawdowns lower water levels and increases the sunlight, water temperature, and amount of exposed sediment in shallower areas. This encourages the germination of plants, allowing for a resurgence of native wetland emergent plants. Conversely, increased water levels can drown out and stunt the growth of wetland plants, killing off large stands of vegetation. The two methods, when used over the course of several years, can create a patchy balance of emergent vegetation and open water, promoting ideal hemi-marsh conditions.

Wigwam Bay's floating cattail mats may not react the same to water level control, considering the mats will adjust to whatever the resting water levels may be. However, lowering or raising water levels can allow for equipment to access more areas than previously possible. This will allow for a more balanced approach to invasive control through herbicidal spray and even potentially cut and/or flatten cattail vegetation.

Contractors identified that water control can feasibly alter water levels by a maximum of 1.2 feet relative to the conditions of water levels inside and outside of Wigwam Bay in the Fall of 2020. Further analysis will be needed to explore specific average changes in water level possible. Additionally, more detailed bathymetric analyses are needed to adequately understand the extent of impact that dropping or raising water levels can have on wetland vegetation. Current assessments conducted by contractors suggest that a 1.2 foot drop in water levels can encourage germination of emergent vegetation throughout certain areas of open water, though the exact acreage of potential hemi-marsh restoration or tussock sedge development is not yet entirely clear.

Predator abatement

Black Tern nest monitoring results suggest that potential management of raccoons may be necessary to protect this vulnerable species. Wigwam Bay SWA is used recreationally by fur trappers, so this activity could potentially assist with reducing raccoon populations. Continued use of nest cameras is recommended to help

measure nest success and identify potential causes of nest failure and depredation. If needed, targeted trapping of raccoons using the dikes could be used to remove or translocate raccoons that are predating nests. Alternatively, opening up more of the marsh on the interior of the diked unit, with greater distance from the dikes, and making these areas more attractive to Black Terns could provide a solution lowering the risk of predation by terrestrial meso-predators.

Monitoring plan

The full suite of monitoring activities undertaken during 2018-2020, which included 3 marsh bird surveys/year, weekly Black Tern nest checks, and aerial imagery surveys, were completed using dedicated funds from the U.S. Fish and Wildlife Service Coastal Program and these funds may not be available for this purpose every year. With that in mind, going forward we recommend a scaled-back approach to monitoring that will still prioritize monitoring activities that provide sufficient feedback to the MI DNR, while being sustainable with volunteer and Audubon support over an extended time period.

In order to continue to measure how management impacts marsh bird populations, Black Tern populations specifically (a species of special importance at Wigwam Bay), and interspersion, we recommend continuing marsh bird monitoring with original sampling methods, and a scaled back approach to measuring interspersion and the Black Tern colony.

MARSH BIRD MONITORING

For methods for the marsh bird survey, see the section Monitoring methods: Breeding marsh bird monitoring and Appendix II for the marsh bird survey datasheet. Note that the selection of primary and secondary species outlined in the methods may need to be adjusted over time depending on changes to species assemblages and potential other species of interest to MI DNR. We recommend adding the Black Tern as a primary focal species, in order to collect more data on this species that could potentially be missed with less intensive sampling for this species going forward. In addition, Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) may need to be added as a primary focal species in the case that a breeding population forms at Wigwam Bay. Yellow-headed Blackbirds are known to breed at a nearby coastal wetland, Nayanquing Point State Wildlife Area in Pinconning, Michigan, also part of Saginaw Bay. Forster's Tern (*Sterna forsteri*) is another example of a species that does not currently nest within the diked unit, but is a marsh-nesting species of concern that is breeding nearby and may be of interest to add to the focal species list. For species that were on our focal species list but were not detected or had a low sample size, we recommend not removing species from the list because this will allow us to retain the ability to compare future records to baseline data collected in 2018-20.

Audubon Great Lakes offers to oversee coordination of a volunteer monitor who will cooperate with MI DNR regarding access to Wigwam Bay. In addition, future data entry and occupancy analyses can be rolled into on-going marsh bird data entry and occupancy analyses led by Audubon Great Lakes. Audubon Great Lakes will make data products available to Michigan DNR within 6 months following the completion of the monitoring.

BLACK TERN MONITORING

We recommend a simplified method of tracking Black Tern nesting at Wigwam Bay in order to monitor Black Tern response to management. Additional components can be added to monitoring, such as weekly nest checks, mark-recapture, and nest camera monitoring as needed.

Audubon Great Lakes will be overseeing a new Great Lakes Black Tern nest monitoring network. The monitoring network relies on volunteers to collect important data on where within a site nests are located, approximately how many nests are visible, and how many adults or chicks are visible. The volunteer collected data can make use of a flush-count or a count from the nearest shoreline, depending on if the volunteer has access to a boat. These data are then submitted through an online portal using ArcGIS product, Survey123. Survey123 collected detail spatial data on where the counts take place. In addition, volunteers are requested to submit information on the habitat that the terns are using, such as percent cover for vegetation categories (e.g., floating vegetation, emergent vegetation), identification of dominant vegetation species for commonly known species (e.g., cattail, phragmites, water lily), and estimation of interspersion category. Training and resources will be provided to volunteers by Audubon Great Lakes. See Appendix III for more information on the Black Tern survey protocol.

We recommend that at the minimum, colony counts and habitat data are collected using the Great Lakes Black Tern nest monitoring protocol, once or twice a year during the peak of the breeding season (June-July).

HABITAT MONITORING

Habitat monitoring to collect basic data on interspersion and percent cover of dominant plant species at marsh

bird monitoring can be done using a method adapted by the Birds Canada Marsh Monitoring Program (MMP; Birds Studies Canada, 2009; See Appendix IV). This habitat survey should be completed at marsh bird monitoring points once per year, when sufficient resources do not exist to conduct a full analysis of drone-captured or satellite imagery. The MMP habitat survey can be done relatively efficiently, with approximately 5-10 minutes spent at each marsh bird survey point. The main drawback of the MMP survey, however, is that it may not work well when there is poor visibility at the survey point.

We recommend using the MMP to collect habitat data after the final marsh bird survey and submit using the Audubon Great Lakes Survey 123 application for submitting habitat data. Habitat data will be incorporated with marsh bird survey data in order to determine whether changes in interspersion and % cover of dominant plant species influence the bird species present. Habitat data collection will be especially important for capturing further changes in interspersion over time due to the cattail management that occurred at Wigwam in 2018.

MANAGEMENT DATA COLLECTION

We recommend submitting basic data on management activities that occur every year when marsh bird monitoring data are submitted. Audubon Great Lakes uses Survey 123 to collect management data from land managers. The data collected include items such as the type of management activity (burn, herbicide, etc.) and the extend of the activity as selected on a map. These data can then be correlated with marsh bird occupancy based on the overlap of management and marsh bird data collection.

Engagement priorities

When the field of conservation began, hunters and bird watchers worked together to help conserve migratory birds that were at risk of extinction. In Michigan, wildlife conservation has historically been supported by hunters with nearly 90% of the Department of Natural Resources Wildlife Division's budget reliant on hunter monies. With hunting on the decline since the 1990's, the Wildlife Division established guiding principles and strategies aimed at increasing partnerships to expand opportunities that diversify the wildlife-based recreation community, develop wildlife appreciation in non-traditional user groups, and promote wildlife-based recreation with conservation partners.

Michigan DNR owns and manages over half the Audubon Important Bird Areas in the state and is primed to increase engagement with the bird watching, or birding, community. In 2016, MI DNR's Wildlife Division and Audubon Great Lakes developed an outreach and engagement program, called MI Birds, which aims to increase all Michigander's engagement in the understanding, care, and stewardship of public lands that are important for birds and people. In particular, the program hopes to bridge the divide between birders and hunters for bird conservation across the state.

Wigwam Bay State Wildlife Area is an Audubon Important Bird Area and is in an ideal location to engage with birders each summer who attend the Tawas Point Birding Festival. Currently, Wigwam Bay State Wildlife Area is not well-known by bird watchers and only has 61 eBird checklists submitted compared to over 7,000 at nearby Tawas Point State Park and over 3,000 at Nayanquing Point State Wildlife Area. Working with the MI Birds program and the Tawas Point Birding Festival organizers to lead guided bird walks as part of the festival, as well as promote the area as a birding hotspot could increase engagement with local birding communities as well as the hundreds that travel from across the region to attend the Tawas Point Birding Festival each year. Acquiring additional eBird checklists from birders over time can also help fill knowledge gaps and provide managers with additional datasets outside of concerted monitoring efforts on a variety of species.

Additionally, the Black Tern is a species that is highly sought after by birders because they are not easily seen while on their breeding grounds, often hidden in emergent coastal and inland marshes with little accessibility. With their steep population declines, Black Terns are also becoming increasingly rare across the Great Lakes. Wigwam Bay State Wildlife Area offers fantastic viewing opportunities for bird watchers and wildlife photographers alike of breeding Black Terns from the dikes, with minimal to no disturbance to the Terns. Birders traveled from across the region to attend recent Black Tern Discovery Cruises at St. Clair Flats State Wildlife Area with Detroit Audubon aimed at increasing awareness of the conservation status of Black Terns and to raise funds for ongoing research. Similar chapter engagement could be done to help support continued monitoring, stewardship, and engagement at Wigwam Bay State Wildlife Area with local AuSable Valley Audubon and Saginaw Valley Audubon Society chapters.

Michigan's birding community is eager to engage with public lands and monitoring efforts across the state.

Conclusions

Although we did not find a significant effect of herbicide management of invasive cattail on marsh bird occupancy and interspersion at Wigwam Bay during the project period, we expect that more time and continued monitoring are needed to assess the full impact of the management that occurred in 2018-20. The main reason that herbicide spray of cattail did not significantly alter interspersion (and thus likely marsh bird occupancy) was because we were unable to remove dead cattail stems due to accessibility issues within the deep-water marsh, however dead stems should naturally degrade over time. Leaving the stems present in the marsh also potentially provides the benefit of being used by nesting marsh birds as nesting material.

While our initial investigation determined that water level control is feasible, further investigation is needed to determine what water level manipulation is most critical for future management. Manipulating water levels can potentially restore a more natural cycle of high and low water that can help reduce the amount of invasive vegetation (by drowning it) and increasing growth of native vegetation in the absence of competition, thus providing a patchier marsh habitat, also referred to as enhanced hemimarsh conditions.

Additional main findings of the work conducted over the last three years include:

- Drone imagery analysis can be used to measure interspersion, though this is a relatively time intensive process.
- Marsh bird occupancy at Wigwam Bay is relatively high throughout the site.
- Of 13 marsh bird species sampled, American Bittern, Common Yellowthroat, Marsh Wren, Pied-billed Grebe, Red-winged Blackbird, Swamp Sparrow and Virginia Rail had the highest occupancy.
- Black Tern colonies at Wigwam Bay were relatively consistent with number of adults ranging from 64-106, number of nests ranging from 42-66 and hatching success ranging from 35-82%.
- Black Tern colonies were located predominantly around the edges of the diked unit, often in sedge or water lily root mats in open water. Nest placement in proximity to the dikes made nests vulnerable to terrestrial mesopredators like raccoons.

With future management activities anticipated to impact marsh nesting bird communities at Wigwam Bay, we recommended several monitoring strategies targeting habitat, management, marsh bird populations, and Black Tern colonies, that will be sustainable over time. These strategies will be folded into Audubon Great Lakes' on-going work to measure marsh bird occupancy at restoration sites throughout the Great Lakes as well as a new Audubon Great Lakes initiative to work with community scientists to create an inventory of Black Tern nesting sites across Michigan.

We recognize that fostering community partnerships and engaging with the public on this work, in part through community science-based monitoring and through special conservation-focused programming with Audubon chapters and the broader public, are critical to our overall success in reaching our goals to restore important Great Lakes coastal wetlands such as Wigwam Bay. Our plan is to continue working closely with MI DNR to move monitoring and habitat management forward at Wigwam Bay. In addition, the MI Birds Program, a MI DNR & AGL co-sponsored engagement program will continue to bring public awareness and support for this important work.

For more information regarding how Audubon resolves to conserve high priority Great Lakes Coastal Wetlands, see Audubon's Vision: Restoring the Great Lakes for Birds and People, available at https://www.audubon.org/conservation/great-lakes-restoration

References

Birds Studies Canada, 2009. Marsh Monitoring Program participant's handbook for surveying marsh birds. Bird Studies Canada in Cooperation with Environment Canada and the U.S. Environmental Protection Agency.

Brewer, R., McPeek, G.A., Adams, R.J., 1991. The atlas of breeding birds of Michigan. Michigan State University Press, East Lansing.

Chartier, A.T., Baldy, J.J., Brenneman, J., Kalamazoo Nature Center, 2013. Michigan Breeding Bird Atlas II.

Conway, C.J., 2011. Standardized North American Marsh Bird Monitoring Protocol. Waterbirds 34, 319–346.

Conway, C.J., Gibbs, J.P., 2005. Effectiveness of call-broadcast surveys for monitoring marsh birds. The Auk 1, 26–35.

Costa, J., 2019. Black Tern study summary: Geolocator analysis, radio-transmitter detections and all other information. Environment Canada: Canadian Wildlife Service.

eBird, 2021. eBird: An online database of bird distribution and abundance [web application]. Cornell Lab. Ornithol. Ithaca NY. URL http://www.ebird.org (accessed 2.2.21).

Fiske, I., Chandler, R., 2011. Unmarked: An R Package for Fitting Hierarchical Models of Wildlife Occurrence and Abundance. J. Stat. Softw. 43.

Grand, J., Saunders, S.P., Michel, N.L., Elliott, L., Beilke, S., Bracey, A., Gehring, T.M., Gnass Giese, E.E., Howe, R.W., Kasberg, B., Miller, N., Niemi, G.J., Norment, C.J., Tozer, D.C., Wu, J., Wilsey, C., 2020. Prioritizing coastal wetlands for marsh bird conservation in the U.S. Great Lakes. Biol. Conserv. 249, 108708.

Hesselbarth, M.H.K., Sciaini, M., With, K.A., Wiegand, K., Nowosad, J., 2019. *landscapemetrics*: an open-source *R* tool to calculate landscape metrics. Ecography 42, 1648–1657.

MacKenzie, D.I., Nichols, J.D., Lachman, G.B., Droege, S., Andrew Royle, J., Langtimm, C.A., 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83, 2248–2255.

Massey, B.W., Atwood, J.L., 1981. Second-wave nesting of the California Least Tern: Age composition and reproductive success 98, 10.

Matteson, S.W., Mossman, M.J., Shealer, D.A., 2012. Population Decline of Black Terns in Wisconsin: A 30-Year Perspective. Waterbirds 35, 185–193.

Monfils, M.J., Brown, P.W., Hayes, D.B., Soulliere, G.J., Kafcas, E.N., 2014. Breeding bird use and wetland characteristics of diked and undiked coastal marshes in Michigan: Bird Use of Diked and Undiked Wetlands. J. Wildl. Manag. 78, 79–92.

Nisbet, I.C.T., 2020. Consequences of Renesting in Common Terns (*Sterna hirundo*): Changes in Clutch Size, Egg Mass, and Productivity. Waterbirds 42, 393.

Saunders, S.P., Hall, K.A.L., Hill, N., Michel, N.L., 2019. Multiscale effects of wetland availability and matrix composition on wetland breeding birds in Minnesota, USA. The Condor 121, duz024.

Scharf, W.C., 2010. Black Tern (*Chlidonias niger*), in: Chartier, A.T., Baldy, J.J., Brenneman, J.M. (Eds.), The Second Michigan Breeding Bird Atlas. Kalamazoo Nature Center.

Shealer, D.A., Haverland, J.A., 2000. Effects of Investigator Disturbance on the Reproductive Behavior and Success of Black Terns. Waterbirds Int. J. Waterbird Biol. 23, 15–23.

Shugart, G.W., Scharf, W.C., Cuthbert, F.J., 1979. Status and Reproductive Success of the Caspian Tern (Sterna caspia) in the U.S. Great Lakes. Proc. Colon. Waterbird Group 2, 146.

Soulliere, G.J., Al-Saffar, M.A., Pierce, R.L., Monfils, M.J., Wires, L.R., Loges, B.W., Shirkey, B.T., Miller, N.S., Schultheis, R.D., Nelson, F.A., Sidie-Slettedahl, A.M., Tonra, C.M., Holm, D.J., 2018. Upper Mississippi River and Great Lakes Region Joint Venture Waterbird Habitat Conservation Strategy – 2018 Revision. U.S.F.W.S, Bloomington, Minnesota, USA.

Tozer, D.C., 2016. Marsh bird occupancy dynamics, trends, and conservation in the southern Great Lakes basin: 1996 to 2013. J. Gt. Lakes Res. 42, 136–145.

Tozer, D.C., Mackenzie, S.A., 2019. Control of Invasive *Phragmites* Increases Marsh Birds but not Frogs. Can. Wildl. Biol. Manag. 8, 17.

Wires, L.R., Lewis, S.J., Soulliere, G.J., Matteson, S.W., Weseloh, R.P., Russell, R.P.,Cuthbert, F.J., 2010. Upper Mississippi Valley/Great Lakes Waterbird ConservationPlan. U.S.F.W.S, Fort Snelling, Minnesota, USA.

Wyman, K.E., Cuthbert, F.J., 2017. Black tern (*Chlidonias niger*) breeding site abandonment in U.S. Great Lakes coastal wetlands is predicted by historical abundance and patterns of emergent vegetation. Wetl. Ecol. Manag. 25, 14.

Appendix I. ECT Report: Hydrologic and Vegetation Study at Wigwam Bay

Environmental Consulting & Technology, Inc.
3399 Veterans Dr., Traverse City, MI, 49685



Hydrologic and Vegetation Study

Wigwam Bay State Wildlife Area
Arenac County, MI

Audubon Great Lakes
125 S Wacker Drive
Suite 2125
Chicago, IL 60602

September 2020

ECT No. 200560-0100

Document Review

The dual signatory process is an integral part of Environmental Consulting & Technology, Inc.'s (ECT's) Document Review Policy No. 9.03. All ECT documents undergo technical/peer review prior to dispatching these documents to any outside entity.

This document has been authored and reviewed by the following employees:

Lauren Edson	Tonya Lewandowski
Author	Peer Review
Signature	Signature
9/28/2020	09/28/2020
Date	Date

Executive Summary

The Wigwam Bay State Wildlife Area (hereinafter Wigwam Bay) is a 900-acre marsh area. Wigwam Bay is located to the north of Saginaw Bay. A large portion of Wigwam Bay can be characterized as a hemi-marsh, which is defined as an area with 50% open water and 50% marsh, with depths between 1.6-4.1 feet deep. There is a cannel of open water through the middle of the marsh from the northwest to the southeast corners. Gravel-topped dikes surround the marsh and at several locations there are water level control structures. Water within the impoundment does not to be consistently offset from the Great Lakes water level in Saginaw Bay.



Figure 1. A 2020 satellite image of Wigwam Bay. Courtesy of Google Earth.

The hydrology within the marsh is primarily driven by local precipitation and evaporation processes, with water level control structures situated along the dike. The water levels within the impoundment were slightly higher that the levels observed outside the dike. Water level in the impoundment currently varies around 582.285 to 582.323 feet above mean sea level (MSL) relative to the North American Vertical Datum of 1988 (NAVD88). It should also be noted that for the day of observation the nearest Lake Huron NOAA station recorded a Daily Average 9/1/2020: 177.41 meters (582.054 ft).

The existing vegetation community and the structure of the vegetation are such that achieving conditions of a hemi-marsh system are feasible. Maintaining the level of marsh succession with Wigwam Bay which allows for open water and grass stage marsh is ideal for providing nesting habitat for Black Terns. Vegetation includes species found on the MNFI Great Lakes Marsh list, however diversity could be improved. Invasive species such as phragmites and purple loosestrife pose a threat to the current vegetation structure, but these species are manageable at current levels.

The purpose of this document is to provide a report of the hydrologic and vegetation study that was performed in order to evaluate habitat conditions at Wigwam Bay and the feasibility of future work to restore and attract Black Terns to historic breeding sites.

1.0 Introduction

1.1 Site Description

The Wigwam Bay State Wildlife Area (hereinafter Wigwam Bay) is a 900-acre marsh area (Figure 1). Wigwam Bay is located to the north of Saginaw Bay. A large portion of Wigwam Bay can be characterized as a hemi-marsh, which is defined as an area with 50% open water and 50% marsh, with depths between 1.6-4.1 feet deep. The majority of the marsh seems to have a wide variety of hemi-marsh vegetation; however the dikes appear to be surrounded by common reed *(Phragmites australis*) and a mixture of weedy trees, shrubs, forbs, and grasses.

Observation points (Figure 2) were selected based on access and potential to provide habitat suitable for the Black Tern. Approximate sample locations were provided by Audubon Great Lakes, and the actual sample locations with GPS coordinates are provided in Figure 2. At each sample location, data was collected to assess the hydrology and vegetation conditions.

1.2 Purpose

Audubon Great Lakes (AGL), a regional office of the National Audubon Society, has a mission is to conserve and restore critical habitats for the benefit of birds and people. AGL works with partners to move bird conservation forward with a focus on Great Lakes coastal wetlands and high priority species of concern such as the Black Tern (*Chlidonias niger surinamensis).*

The North American Black Tern is rapidly disappearing from Great Lakes coastal wetlands and now requires urgent conservation action. The Black Tern is listed as a species of concern, threatened, or endangered in most of the Great Lakes states.

Primarily, the Black Tern uses marsh habitat within the state of Michigan for breeding habitat. Nesting usually occurs in large freshwater wetlands, usually in dense marshes on the edges of shallow lakes of the open prairies or northern forests. Black Terns normally select marshes that are 50 acres or larger for nesting. Male and female select the nest site together, usually protected from wind and wave action and where the water's surface is about half-covered in cattails, bulrushes, or other emergent vegetation. They often use areas with dead, floating vegetation on which to place the nest. Some nests are set on muskrat feeding platforms or lodges.

The purpose of this document is to provide a report of the hydrologic and vegetation study that was performed in order to evaluate habitat conditions at Wigwam Bay and the feasibility of future work to restore and attract Black Terns to historic breeding sites.

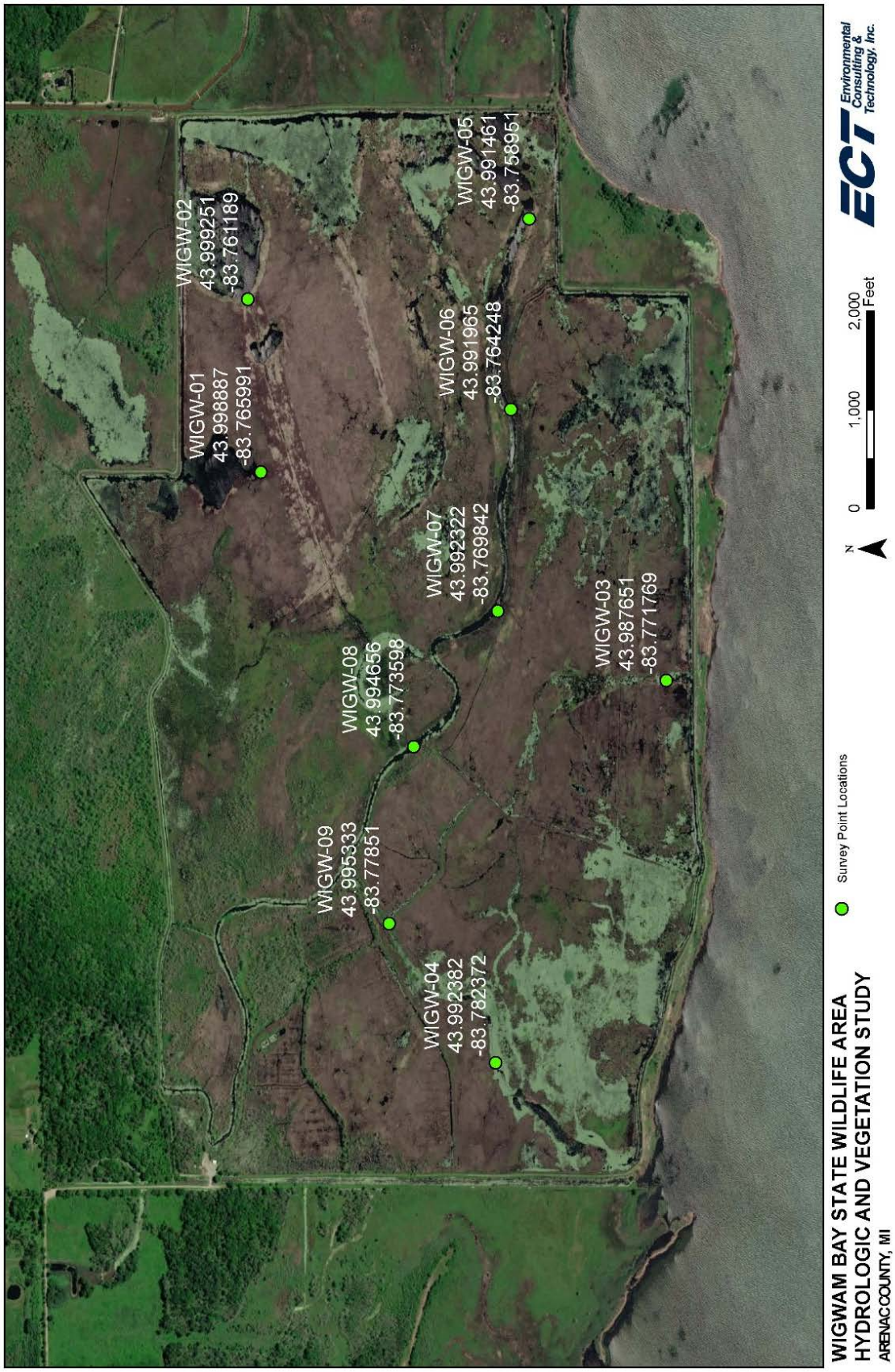


Figure 2. Observation points at Wigwam Bay State Wildlife Area

2.0 Hydrology

As part of the Black Tern habitat survey, ECT was asked observe water levels in the Wigwam Bay Habitat as well as surrounding areas including Lake Huron. ECT was provided some historic water elevation data from a Michigan Department of Natural Resources (MDNR) 2018 survey. Because the scope of work for water elevations was very limited under this contract, ECT focused on providing head elevation differences from the Wigwam impoundment to the surrounding surface waters. ECT staff utilized culvert invert data from the MDNR 2018 survey to derive the surface water elevations. ECT cannot say with certainty that these elevations are accurate. ECT can confidently say that the observed head differences between the impoundment and surrounding surface waters is accurate. It should also be noted that for the day of observation the nearest Lake Huron NOAA station recorded a Daily Average 9/1/2020: 177.41 meters (582.054 ft).

In addition to water elevations, ECT was asked to observe water depths at the requested potential Black Tern habitat observation points. Water depths at these points ranged from 1’ 8” to 4’ 1”. Actual observation depths are shown below in Table 2.

2.1 Hydrology Sampling Methods

Water surface elevations (Table 1)

Equipment

- Laser mounted on tripod
- 3-meter measuring stake with transducer

The tripod and laser were stationed on the impoundment dike. Elevation of the MDNR know culvert inverts were first collected to establish an elevation datum. Once the datum was established, water elevations on both sides of the dike were observed and recorded. Elevation data was observed at MDNR 2018 survey points A, B, G and E.

Black Tern Observation Point Depths (Table 2)

Equipment

- Weighted flexible measuring tape
- Kayak

Access to each of the observation points was achieved by kayak. Once at the given GPS coordinates a weighted measuring tape was lowered to the impoundment bed. Measurements were collected to the nearest inch.

2.2 Results

Table 1. Water Surface Elevations and Head Difference

Site	Measured water elevations (ft)		delta H (ft)
	Impoundment	Lake Huron, Perimeter Drain, Old Rifle River Channel[1]	
Site A	582.3	581.216	1.084
Site B	582.285	580.987	1.298
Site G	582.293	581.626	0.667
Site E	582.323	581.782	0.541

[1] Site A measured Lake Huron; Site B and G measured Perimeter Drain; Site E measured Old Rifle River Channel

Table 2. Observation points Water Depths

Observation Points	Water Depths
01	3' 6"
02	3' 6"
03	1' 8"
04	3' 4"
05	3' 7"
06	3' 6"
07	3' 9"
08	4' 1"
09	3' 4"

3.0 Vegetation

3.1 Vegetation Sampling Methods

The methodology followed at the observation points was based on the Audubon Habitat Assessment for the Indiana Marsh Bird Program. Observations at each location assessed the major habitat features within a radius of 15 meters by visual estimation. The major habitat features included types such as percent open water, percent submersed and floating herbaceous plants, percent emergent herbaceous plants, etc. Within the category of floating and submersed plants, presence of certain types of plants was recorded. Of the emergent plant cover, if any, the percent cover of the most prevalent type was recorded. Other observations, such as dispersion and interspersion, inundation permanency, human influences, signs of management, and signs of animal activity, were also recorded. Please see the provided data forms for details regarding what information was gathered. At each observation point, a data form was completed in addition to documenting the GPS coordinates of the actual sample location and taking photographs at each cardinal location.

3.2 Existing Vegetation at Observation Points

The observation points are shown in Figure 2. These waypoints were used to approximate the location of the field staff while on site, and actual coordinates of the observations were recorded. Several of the observation points, 05, 06, 07, and 08, were located along the water channel that traverses the marsh from the NW corner to the SE corner. These observation points tended to have characteristics of half marsh and half open water and the dispersion of the habitat features were more clustered. The amount of submerged vegetation in the open water varied from point to point. The remaining observation points, 01, 02, 03, 04, and 09, were selected around the outside of the marsh on the edge of several open water areas. These observation points tended to

have habitat features more intermixed, however the observation point was placed based on accessibility from a kayak and therefore would contain open water portions.

Table 3. Assessment of Major Habitat Features

Survey Site:	1	2	3	4	5	6	7	8	9
% open water with no obvious vegetation	5	20	0	0	30	20	0	30	5
% exposed mud, sand, or rock with no obvious vegetation	0	0	0	0	0	0	0	0	0
% submerged and floating herbaceous plants	60	40	30	75	10	40	60	50	15
% emergent (non-floating, but possibly in water or wet substrate) herbacuous plants	35	40	70	20	60	40	40	20	80
% shrubs (woody plants under 6m tall)	0	0	0	0	0	0	0	0	0
% trees (woody plants over 6m tall)	0	0	0	0	0	0	0	0	0
% pavement (or hard-scape trail)	0	0	0	0	0	0	0	0	0

Submersed vegetation most often included pondweed, water milfoil and water lilies. Water shield, duckweed, and algae were also common. No observation point was considered to have dense submersed or floating plant cover. Emergent vegetation was most frequently dominated by cattail, and sedges and grasses were often the next most dominant. No Phragmites were observed within the nine observation points, however it was observed along the dikes.

Table 4. Assessment of Floating/Submersed Plants

Survey Site:	1	2	3	4	5	6	7	8	9
Floating plant cover[2]:	slight -	slight	Mod. +	Mod.	none	none	Mod.	slight -	Mod.
Floating Plants Observed:									
duckweed (*lemna*)	X	X				X	X	X	X
water lillies (*Nymphaea*) and pond lilies (*Nuphar*)		X	X	X	X	X	X	X	X
pondweed (*Potamogeton*)		X	X	X	X	X	X	X	X
water shield (*Brasenia*)	X	X	X	X					X
water milfoil (*Myriophyllum*)		X	X	X	X	X	X	X	X
coontail (*Ceratophyllum*)		X	X						
algea (including *Chara*)		X	X		X		X	X	

[2] characterized as none, slight, moderate (mod.), dense, or unknown/hard to tell. Modifiers of + or – were used to better capture the conditions.

Table 5. Assessment of Emergent Plant Cover

Plants of Interest (% cover)	1	2	3	4	5	6	7	8	9
cattail (Typha)	62	15	65	95	40	55	53	55	50
common reed (Phragmites)	0	0	0	0	0	0	0	0	0
other grasses like blue joint (Calamagrostis), cut grass (Leersia), or reed canary (Phalaris)	2	2	0	0	5	15	5	15	15
sedges and sedge allies like Carex, Eleocharis, Cyperus, or Rhynchospora	5	15	0	0	15	5	10	10	10
rushes & bulrushes like Juncus, Scripus, or Schoenoplectus	2	0	0	0	0	0	0	2	0
purple loosestrife (Lythrum salicaria)	5	5	5	5	5	2	15	15	2
water willow (Decodon certicillatus)		5	0	0	0	0	0	3	0
pickeral weed (Pontederia)	2	2	0	0	0	5	0	0	1
arrowhead (Sagittaria)	0	0	0	0	5	0	2	0	0
smartweed (Persicaria or Polygonum)	5	10	0	0	0	5	5	0	0
bur-reed (Sparganium)	0	0	0	0	0	3	0	0	5
water plantain (Alisma)	2	5	0	0	0	0	0	0	0
Other[3]	15	25	30	0	30	15	10	0	17

[3] see Appendix 2 for notes of other species observed

Other species that were observed in the emergent plant cover assessment include false foxglove (*Agalinis spp.),* dogbane (*Apocynum cannabinum*), bur marigold (*Bidens aristosa*), hedge bindweed (*Calystegia sepium*), marsh cinquefoil (*Comarum palustre*), jewelweed (*Impatiens capensis*), lobelia (*Lobelia spp*.), common water horehound (*Lycopus americanus*), cottonwood seedling (*Populus deltoides*), and marsh fern (*Thelypteris palustris*).

Overall, the existing vegetation at the marsh is relatively good quality. While there were invasive species such as purple loosestrife, the population has not become dominant throughout the entire marsh. Additionally, the current management used on cattail and other grasses seems to be successful in maintaining the level of succession, i.e. grass-stage marsh with open water.

4.0 Conclusions

Water levels within the impoundment were generally 0.5-1.2 ft higher than the water levels measured outside of the impoundment. These water levels should be monitored in future growing seasons to ensure that the water levels in Lake Huron are not negatively impacting the vegetation community within the marsh. Assuming the projections showing the Great Lakes water levels, currently near record high, continue to gradually fall, water level within the impoundment may also drop slightly. Marsh conditions suitable for Black Tern can be maintained with water levels between 0.5-6 ft. Fluctuations in water levels is expected and should be varied to mimic the natural dynamics, if possible. Management of water levels in the future may be beneficial to the overall ecologic health and habitat management within the impoundment in the future due to an outside environmental and/or natural hydrologic change in conditions. Management of water levels within the impoundment is feasible due to the existing infrastructure surrounding the marsh as well as the ability to physically modify the dike itself.

Fortunately, no carp were observed during the field visit. However, this does not necessarily mean that there are no carp within the marsh and precautions to address carp or otherwise ensure no introduction of carp should be considered. The common carp has a feeding style that results in turbidity which prevents enough light penetration to germinate seeds to replace disturbed vegetation. The resulting turbid, vegetation-free conditions competitively favor the common carp population at the expense of native fish species. Assuming there are no carp in the system currently, additional modification to the water control structures should be incorporated to keep common carp from invading in the future.

Vegetation management should focus on addressing early infestations of invasive species like purple loosestrife and phragmites. Additionally, physical management techniques like disking and brush-hogging can be used in conjunction with herbicide and prescribed burn to set back the successional progress of the marsh. In general terms, a marsh will gradually fill in with sediment and vegetation thatch to transition from open marsh to hemimarsh to predominantly emergent cover. Wigwam Bay is currently at the grass stage and should be maintained at that succession

level in order to provide marsh nesting habitat for the Black Tern. Potential management techniques could include manipulation of the water levels within the impoundment; i.e. water levels could be raised in order to flood invasive species should Phragmites become more dominant in the future. Additionally, water levels could be lowered to affect the percentage of open water compared to emergent marsh within the impoundment. A more detailed bathymetric understanding of the existing conditions would be required to engage in either of these water level management techniques. Any manipulation of the water levels within the impoundment should only be undertaken with an understanding of potential impacts on wildlife and vegetation as a whole.

Specific recommendations include the following:

- Hydrology: monitor and record water levels throughout the year to better understand the hydrology and to inform the water level management strategy,
- Hydrology: potential modifications to water level control structures if required by future management strategy,
- Invasive plant species: initiate a program to eliminate purple loosestrife and phragmites, and other invasive plants,
- Enhance diversity: plant emergent and submersed species during drawdowns to establish a biologically diverse shallow emergent marsh, hemimarsh, and submersed aquatic community,
- Long-term management: utilizing an adaptive management approach, develop a strategy learn from mistakes and implement steps that can be taken to sustain and enhance the marsh and open water plant communities.

The ultimate balance between the marsh and open water habitat will in turn determine the potential extent of quality hemimarsh that can develop at Wigwam Bay. As in all restorations, the success of the efforts will ultimately depend upon the development and implementation of a well-conceived plan to adaptively manage this marsh area. If properly managed, Wigwam Bay could potentially offer a significant quantity of high quality hemimarsh and open water systems in the Saginaw Bay-Lake Huron area.

5.0 References

"Black Tern | Audubon Field Guide." Audubon, 13 Nov. 2014, https://www.audubon.org/field-guide/bird/black-tern.

"Black Tern Life History, All About Birds, Cornell Lab of Ornithology." Online Bird Guide, Bird ID Help, Life History, Bird Sounds from Cornell About Birds, https://www.allaboutbirds.org/guide/Black_Tern/lifehistory#habitat. Accessed 25 Sept. 2020.

Reed, PB Jr 1988. *National List of Plant Species that Occur in Wetlands.* Washington, DC: U.S. Fish and Wildlife Service.

Appendix A: Photographic Log

ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
1	9/1/2020

Direction Photo Taken:

North

Description:

Location 01
43.998887, -83.765991

Taken by: Eric Schwiderson



Photo No.	Date:
2	9/1/2020

Direction Photo Taken:

East

Description:

Location 01
43.998887, -83.765991

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
3	9/1/2020

Direction Photo Taken:

South

Description:

Location 01
43.998887, -83.765991

Taken by: Eric Schwiderson



Photo No.	Date:
4	9/1/2020

Direction Photo Taken:

West

Description:

Location 01
43.998887, -83.765991

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
5	9/1/2020

Direction Photo Taken:

North

Description:

Location 02
43.999251, -83.761189

Taken by: Eric Schwiderson



Photo No.	Date:
6	9/1/2020

Direction Photo Taken:

East

Description:

Location 02
43.999251, -83.761189

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
7	9/1/2020

Direction Photo Taken:

South

Description:

Location 02
43.999251, -83.761189

Taken by: Eric Schwiderson



Photo No.	Date:
8	9/1/2020

Direction Photo Taken:

West

Description:

Location 02
43.999251, -83.761189

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
9	9/1/2020

Direction Photo Taken:

North

Description:

Location 03
43.987651, -83.771769

Taken by: Eric Schwiderson



Photo No.	Date:
10	9/1/2020

Direction Photo Taken:

East

Description:

Location 03
43.987651, -83.771769

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
11	9/1/2020

Direction Photo Taken:

South

Description:

Location 03
43.987651, -83.771769

Taken by: Eric Schwiderson



Photo No.	Date:
12	9/1/2020

Direction Photo Taken:

West

Description:

Location 03
43.987651, -83.771769

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
13	9/1/2020

Direction Photo Taken:

North

Description:

Location 04
43.992382, -83.782372

Taken by: Eric Schwiderson



Photo No.	Date:
14	9/1/2020

Direction Photo Taken:

East

Description:

Location 04
43.992382, -83.782372

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
15	9/1/2020

Direction Photo Taken:

South

Description:

Location 04
43.992382, -83.782372

Taken by: Eric Schwiderson



Photo No.	Date:
16	9/1/2020

Direction Photo Taken:

West

Description:

Location 04
43.992382, -83.782372

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
17	9/2/2020

Direction Photo Taken:

North

Description:

Location 05
43.991461, -83.758951

Taken by: Eric Schwiderson



Photo No.	Date:
18	9/2/2020

Direction Photo Taken:

East

Description:

Location 05
43.991461, -83.758951

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
19	9/2/2020

Direction Photo Taken:

South

Description:

Location 05
43.991461, -83.758951

Taken by: Eric Schwiderson



Photo No.	Date:
20	9/2/2020

Direction Photo Taken:

West

Description:

Location 05
43.991461, -83.758951

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
21	9/2/2020

Direction Photo Taken:

North

Description:

Location 06
43.991965, -83.764248

Taken by: Eric Schwiderson



Photo No.	Date:
22	9/2/2020

Direction Photo Taken:

East

Description:

Location 06
43.991965, -83.764248

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
23	9/2/2020

Direction Photo Taken:

South

Description:

Location 06
43.991965, -83.764248

Taken by: Eric Schwiderson



Photo No.	Date:
24	9/2/2020

Direction Photo Taken:

West

Description:

Location 06
43.991965, -83.764248

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
25	9/2/2020

Direction Photo Taken:

North

Description:

Location 07
43.992322, -83.769842

Taken by: Eric Schwiderson



Photo No.	Date:
26	9/2/2020

Direction Photo Taken:

East

Description:

Location 07
43.992322, -83.769842

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
27	9/2/2020

Direction Photo Taken:

South

Description:

Location 07
43.992322, -83.769842

Taken by: Eric Schwiderson



Photo No.	Date:
28	9/2/2020

Direction Photo Taken:

West

Description:

Location 07
43.992322, -83.769842

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
29	9/2/2020

Direction Photo Taken:

North

Description:

Location 08
43.994656, -83.773598

Taken by: Eric Schwiderson



Photo No.	Date:
30	9/2/2020

Direction Photo Taken:

East

Description:

Location 08
43.994656, -83.773598

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
31	9/2/2020

Direction Photo Taken:

South

Description:

Location 08
43.994656, -83.773598

Taken by: Eric Schwiderson



Photo No.	Date:
32	9/2/2020

Direction Photo Taken:

West

Description:

Location 08
43.994656, -83.773598

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
33	9/1/2020

Direction Photo Taken:

North

Description:

Location 09
43.995333, -83.77851

Taken by: Eric Schwiderson



Photo No.	Date:
34	9/1/2020

Direction Photo Taken:

East

Description:

Location 09
43.995333, -83.77851

Taken by: Eric Schwiderson



ECT Environmental Consulting & Technology, Inc.

PHOTOGRAPHIC LOG

Project Name / Number:	Site Location:	Client Name:
Wigwam Bay State Wildlife Area / 200560	Wigwam Bay Marsh	Audubon Great Lakes

Photo No.	Date:
35	9/1/2020

Direction Photo Taken:

South

Description:

Location 09
43.995333, -83.77851

Taken by: Eric Schwiderson



Photo No.	Date:
36	9/1/2020

Direction Photo Taken:

West

Description:

Location 09
43.995333, -83.77851

Taken by: Eric Schwiderson



Appendix B: Vegetation Sampling Data

Wigwam Bay - Wetland Vegetation Monitoring Data

Data collected 9/1/20 and 9/2/2020 by Lauren Edson, Michelle Post, and Eric Schwiderson
Data entered 9/14/2020 by LE

Survey Site:	1	2	3	4	5	6	7	8	9
Observers:	ES/LE/MP	ES/LE/MP	ES/LE/MP	ES/LE/MP	ES/LE/MP	ES/LE/MP	ES/LE/MP	ES/LE/MP	ES/LE/MP
Date:	9/1/2020	9/1/2020	9/1/2020	9/1/2020	9/2/2020	9/2/2020	9/2/2020	9/1/2020	9/1/2020
Start Time:	3:00 PM	2:15 PM	12:40 PM	10:00 AM	12:30 PM	12:00 PM	11:40 AM	11:00 AM	11:00 AM
GPS Coordinates:	43.998887	43.999251	43.987651	43.992382	43.991461	43.991965	43.992322	43.994656	43.995333
GPS Coordinates:	-83.765991	-83.761189	-83.771769	-83.782372	-83.758951	-83.764248	-83.769842	-83.773598	-83.77851
Depth of Water	3' 6"	3' 6"	1' 8"	3' 4"	3' 7"	3' 6"	3' 9"	4' 1"	3' 4"
Photographs	Saved on drive								
Radius of Survey Area	15 m; visual	15 m; visual	15 m; visual	15 m; visual	15 m; visual	15 m; visual	15 m; visual	15 m; visual	15 m; visual

Assessment of Major Habitat Features

% open water with no obvious vegetation	5	20	0	0	30	20	0	30	5
% exposed mud, sand, or rock with no obvious vegetation	0	0	0	0	0	0	0	0	0
% submerged and floating herbaceous plants	60	40	30	75	10	40	60	50	15
% emergent (non-floating, but possibly in water or wet substrate) herbacuous plants	35	40	70	20	60	40	40	20	80
% shrubs (woody plants under 6m tall)	0	0	0	0	0	0	0	0	0
% trees (woody plants over 6m tall)	0	0	0	0	0	0	0	0	0
% pavement (or hard-scape trail)	0	0	0	0	0	0	0	0	0

Assessment of Dispersion & Interspersion

Dispersion Pattern:	Cluster	Cluster 20-25%	Cluster 20-25%	Cluster 20-25%	Cluster 20-25%	Dispersed 20-50%	Cluster 51-75%	Cluster 20-25%	Cluster 20-25%
Class:	L	L	L	L	L	M	L	L	L

Assessment of Floating/Submersed Plants

Floating plant cover:	slight -	slight	Moderate +	Moderate	none	none	Moderate	slight -	Moderate

Floating Plants Observed:

duckweed (*lemna*)	X	X				X	X	X	X
water lillies (*Nymphaea*) and pond lilies (*Nuphar*)		X	X	X	X	X	X	X	X
pondweed (*Potamogeton*)		X	X	X	X	X	X	X	X
water shield (*Brasenia*)	X	X	X	X					X
water milfoil (*Myriophyllum*)		X	X	X	X	X	X	X	X
coontail (*Ceratophyllum*)		X	X						
algea (including *Chara*)		X	X		X		X	X	
other, please list:			Horned bladderwort						Yellow nutsedge

Wigwam Bay - Wetland Vegetation Monitoring Data

Data collected 9/1/20 and 9/2/2020 by Lauren Edson, Michelle Post, and Eric Schwiderson
Data entered 9/14/2020 by LE

Assessment of Emergent Plant Cover

Plants of Interest % cover relative to all emergent plants

Survey Site:	1	2	3	4	5	6	7	8	9
cattail (*Typha*)	62	15%	65	95	40	55	53	55	50
common reed (*Phragmites*)									
other grasses like blue joint (*Calamagrostis*), cut grass (*Leersia*), or reed canary (*Phalaris*)	2	2%			5	15	5	15	15
sedges and sedge allies like *Carex, Eleocharis, Cyperus,* or *Rhynchospora*	5	15%			15	5	10	10	10
rushes & bulrushes like *Juncus, Scirpus,* or *Schoenoplectus*	2							2	
purple loosestrife (*Lythrum salicaria*)	5	5%	5	5	5	2	15	15	2
water willow (*Decodon certicillatus*)		5%						3	
pickeral weed (*Pontederia)*	2	2%				5			1
arrowhead (*Sagittaria*)					5		2		
smartweed (*Persicaria or Polygonum*)	5	10%				5	5		
bur-reed (*Sparganium*)						3			5
water plantain (*Alisma*)	2	5%							
Other, please list:	Common waterhorehound, thistle, marsh fern, cottonwood seedling; 15	thistle (15); common water horehound (10)	water cinquiefolia; false foxglove; water horehound; bur marigold; marsh fern; jewelweed; 30	Marsh fern, jewelweed, false foxglove	Marsh fern, water horehound, sensitive fern, lobelia; 30	water horehound, marsh fern, jewelweed, devil's beggarticks; 15	water horehound, jewelweed; 10		dogbane, false foxglove, bindweed, jewelweed, black raspberry, virginia creeper, thistle; 17

Other details of interest

Inundation Permanency:	permanent	permanent	permanent	permanent	permanent	permanent	permanent	permanent	permanent
Description of area:	hemi-marsh	hemi-marsh	marsh	marsh	marsh	hemi-marsh	hemi-marsh	marsh	marsh
Human influences:	channels, ditches, dams, dikes	channels, ditches, dams, dikes	channels, ditches, dams, dikes	channels, ditches, dams, dikes	channels, ditches, dams, dikes	channels, ditches, dams, dikes	channels, ditches, dams, dikes	channels, ditches, dams, dikes	channels, ditches, dams, dikes
Signs of management:	herbicide	herbicide; cutting	none	none	herbicide; cutting	herbicide; cutting	herbicide; cutting	herbicide	none

Wetland Animal Activity

Evidence of Carp:	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evidence of muskrats:	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Evidence of beaver:	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Appendix II. Wigwam Bay Marsh Bird Monitoring Datasheet

Wigwam Bay Marsh Bird Monitoring Survey Data Sheet

Observer(s): _____ **Survey Period (circle):** 1 2 3 **Start commute time:** _____ **End:**_____

Site: _____ **Date (e.g.: 15-May 2018):** _____ **Mileage:**_____

Please return to:
Audubon Great Lakes
17 N. State Street Ste 1690
Chicago, IL 60602
Phone: 312-453-0230
Email: sbeilke@audubon.org

Put an "S" in the appropriate column if the bird was seen, an "H" if the bird was heard, and "HS" if both heard and seen.
Primary species: record every minute seen/heard. Secondary species: record only first minute seen/heard and record # of individuals under the distance bins.
Record "no species" and a horizontal line through row when no primary/secondary species were detected.

Point	Start time (military)	Temp (◦F)	Wind Beaufort	Sky	Noise	Species	Detected (H/HS/S) during											Primary sp. only				Detected at a Previous Point (Y/N)	Secondary sp only			Breeding Code	Comments
							0-1 min	1-2 min	2-3 min	3-4 min	4-5 min	LEBI 5-6	SORA 6-7	VIRA 7-8	COGA 8-9	PBGR 9-10	Outside survey period only	Distance (m)	Direction	Call types	In Target Area? (Y/N)		0-50m	50-100m	>100m		

Call: LEBI: *coo, kak, ert, ank-ank* **SORA:** ***pw:*** *per-weep,* ***wh:*** *whinny,* ***kp:*** *keep* **VIRA:** ***g:*** *grunt,* ***ki:*** *kicker,* ***t:*** *tick-it,* ***s:*** *squawk,* ***kk:*** *kikik* **COGA: wo:** *wipe out,* ***kp:*** *keep,* ***gu:*** *giddy-up*
PBGR: ***oh:*** *ohwoop,* ***hy:*** hyena **AMBI:** ***pl:*** *pump-er-lunk,* ***cp:*** *chu-peep, kok* **AMCO:** ***bp:*** *burrup,* ***hc:*** *hiccup,* ***hk:*** *honk*
Primary species: LEBI Least Bittern, **SORA** Sora, **VIRA** Virginia Rail,**COGA** Common Gallinule, **PBGR** Pied-billed Grebe, **AMBI** American Bittern, **AMCO** American Coot
Secondary species: COYE Common Yellowthroat, **MALL** Mallard, **MAWR** Marsh Wren, **RWBL** Red-winged Blackbird, **SWSP** Swamp Sparrow, **SEWR** Sedge Wren
Background noise: 0 = *no noise;* 1 = *faint noise;* 2 = *moderate noise;* 3 = *loud noise (noise obscures birds > 50m away);* 4 = *intense noise (noise obscures birds > 25m away)*
Beaufort scale: 0=*smoke rises vertically;* 1=*wind direction shown by smoke drift;* 2=*wind felt on face; leaves rustle;* 3=*leaves & small twigs in constant motion and light flag extended;* 4=*raises dust and loose paper -- small branches are moved;* 5=*small trees with leaves sway -- crested wavelets on inland waters*
Sky: 0=*clear or a few clouds;* 1=*partly cloudy or variable sky;* 2=*cloudy or overcast;* 3=*sand or dust storm*; 4=*fog/smoke;* 5=*drizzle;* 6=*snow;* 7=*snow/sleet*

Appendix III. Black Tern Monitoring Handbook

Audubon | GREAT LAKES

Breeding Black Tern Survey Protocol

Introduction

Over the past half century, human activity surrounding the Great Lakes basin has significantly degraded habitats and water quality, and as a result, many marsh bird populations are in steep decline, with some regional population declines as high as 80% in recent decades. Statewide marsh bird surveys were conducted across Minnesota in an effort to better understand the abundance, distribution, and habitat use of several focal marsh bird species. Black Terns, Common Terns, and Yellow Rails appeared to be underrepresented in these surveys however all of which are species of increasing conservation concern in the Great Lakes.

The Black Tern is now listed as endangered or of "special concern" in all Great Lakes states and is receiving increasing attention by federal and state agencies, including the Upper Mississippi River/Great Lakes Joint Venture. Black Tern populations have experienced range-wide losses of 61% between 1966 and 1996 (Scharf 2011). This constitutes a three percent annual reduction in numbers. In Minnesota, however, the species has shown a far more dramatic, statistically significant decline of 6.29% per year since 1967, slowing only slightly to a loss of 5.61% per year from 2005 to 2015. The cumulative loss has been nearly 96% (Sauer et al 2017). Recent research (Wyman and Cuthbert 2017) shows that colony abandonment has occurred at a faster rate than the population decline, and suggests that large colonies hold the highest conservation value. Both the proximate and ultimate causes of the population decline and colony abandonment are unclear.

Audubon Great Lakes and the University of Minnesota Duluth Natural Resources Research Institute are working together to conduct Breeding Black Tern Surveys across Minnesota to identify important active breeding locations of Black Terns. This dataset will help identify wetlands and breeding Black Tern colonies that should be prioritized for future conservation, monitoring, and wetlands restoration work.

Direct any questions about the Breeding Black Tern Survey to Stephanie Beilke, Audubon Great Lakes Conservation Science Manager (stephanie.beilke@audubon.org; 920-366-5825) or Erin Rowan, Audubon Great Lakes Conservation Associate (erin.rowan@audubon.org; 310-383-7353).

Methods

A team of field researchers will scout wetlands in Minnesota where Black Terns have historically nested or been observed. Over the course of 2 site visits, surveyors will determine whether the site is active, how many breeding Black Terns are present, whether eggs or chicks are present, and whether the habitat is suitable for breeding Black Terns (Matteson et al 2019).

Audubon | GREAT LAKES

Breeding Black Tern Survey Protocol

Site Selection

Wetlands will be selected for Black Tern surveys, based on past presence of Black Terns determined by Breeding Bird Atlas, eBird, Minnesota Marsh Bird Survey, and Important Bird Area data. Wetland sites that overlap with Important Bird Areas will be prioritized for surveys.

Survey Protocol

Wetland locations should be surveyed by a single individual. Each wetland should be scanned from various locations along the shoreline with the aid of binoculars or spotting scope. At larger lakes or at wetlands with limited visibility from the shoreline, the observers should boat (via canoe or kayak) the wetland interior and perimeter to increase the probability of detecting breeding Black Terns.

Time of Year

The goal is two surveys conducted annually at each survey site. Each of the two replicate surveys should be conducted at least once in June and again in the month of July. Surveys should be at least two weeks apart. Follow these guidelines as closely as possible but if you must digress slightly, doing so is better than not conducting a survey at all. Please note that due to the need for favorable weather conditions (low wind, no precipitation), you may need to plan for several survey slots during each time period.

Time of Day

Surveys should ideally be conducted in the morning and no later than early afternoon, in order to allow the Black Tern colonies to recover from any potential disturbance caused by surveyor presence before dusk.

Suitable Weather Conditions

Surveys should only be conducted when there is no sustained rain or heavy fog, and when the wind speed is < 12 mph (20 km/hr). This wind speed corresponds to leaves and twigs in constant motion, or a Beaufort scale wind of 3 or less (leaves and small twigs in constant motion, light flag extended; NOT raising loose dust or paper). Black Terns are less likely to call and be found off the nest in inclement weather. Surveyors should postpone surveys if they believe winds are affecting probability of Black Tern detection. Wind could also impact surveyor ability to navigate easily in a canoe or kayak if flush counts are being conducted. If wind speed increases to above 20 km/hr during the survey or sustained rain begins while the survey is underway, surveyors should stop the survey and repeat the entire survey another day (i.e. don't just go back and survey the remaining area).

Shoreline Counts

All shoreline counts should be conducted by a single observer. Upon arrival, the wetland should be scanned from various locations along the shoreline using binoculars, a scope, or the trained eye. When Black Terns are detected, the shoreline count begins. For the purpose of these counts, a colony can consist of multiple sub-colonies 100-300 m apart. Groups of nest more than 800 m away should be treated as a separate colony.

Breeding Black Tern Survey Protocol

Once Black Terns are detected: Begin a single 10-minute unlimited radius point count of adult Black Terns should be conducted along the shoreline or edge of the wetland. All Black Terns seen in the air and resting on the surface of the marsh should be recorded. Observers should record weather data, GPS coordinates of the point location, count start and end times, and the total number of adult Black Terns observed.

Flush Counts

Following completion of shoreline counts, and if the site is accessible via canoe or kayak, the observer should approach each colony via the water for a flush count.

The observer should enter the wetland area of activity, either by canoe or kayak, and conduct a *flush count* of birds overhead to record the maximum number of Black Terns observed during the visit. Black Terns are colonial waterbirds and entering their breeding grounds will cause them to flush up off the marsh and collectively defend their territory. While paddling, keep an eye out for nests and chicks that can blend in well with their surroundings. If an adult is dive bombing you, you are too close to a nest or chick and should back away. Be careful not to double-count individuals in flight. For practical purposes, the flush count is the value representing the size of the colony. Observers should record weather data, GPS coordinates for the colony/subcolony flush count start location, start and end times, and the total number of adult Black Terns observed.

Flush Count Nesting Documentation: Following the flush counts, surveyors should paddle to an area where they can observe adult Black Terns return to their nests. If the adults don't settle down within 5-10 minutes, paddle farther away while still keeping the birds in your line of sight. The observer should note 1-4 potential nest locations where Black Terns have landed in the marsh and should make a brief paddle through the colony to document nesting at these sites. Observers should determine the relative stage of the breeding season, categorized as *incubation stage*, when only eggs are found (Images 1, 2), or *nestling stage*, when at least one of the nests contains chicks (Images 3, 4).

If a nest with eggs or chicks is observed, do not linger at the nest. No more than 1-2 minutes should be necessary to determine nesting status, document the number of eggs and/or chicks present, and record the GPS coordinates at a single nest. It is not necessary (or recommended) to find all Black Tern nests at a location since the flush count revealing the number of adults present is most important, and we want to limit human disturbance at the colony site.

If nests are not accessible and/or if flush counts are not possible, the observer should record best estimates of locations of 1-4 possible nests, based on where adults are seen settling within the marsh. If possible to view nests through binoculars or a scope, again note whether the nests are in *incubation stage* or *nestling stage.*

Breeding Black Tern Survey Protocol

Image 1. Black Tern nest with eggs on mat of Cattail and Bulrush (*Typha sp.)*



Image 2. Black Tern nest with eggs on Tussock Sedge muck mat (*Carex sp.*)

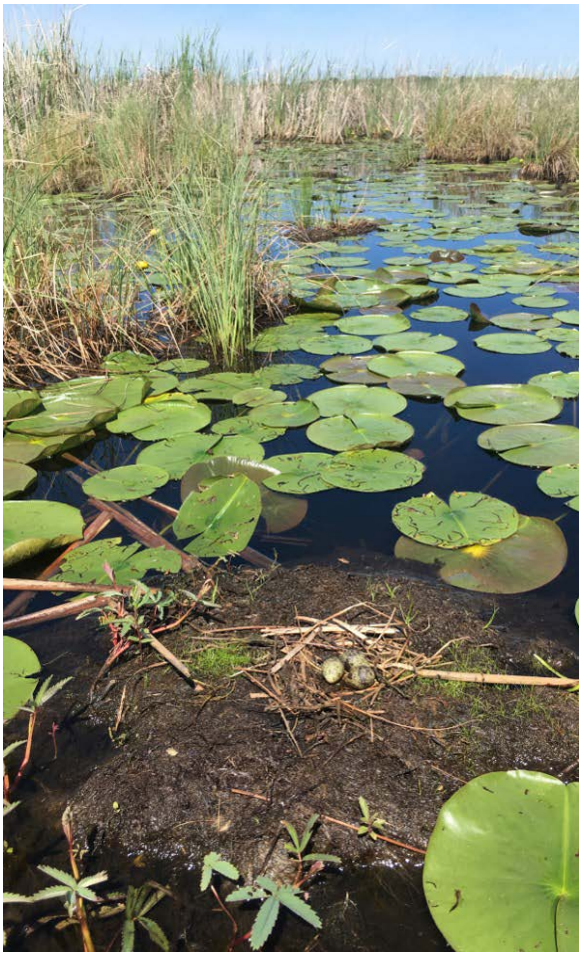


Image 3. Black Tern nest with chicks on Water Lily muck mat (*Nymphaea sp.*)

Breeding Black Tern Survey Protocol



Image 4. Black Tern nest with chick on mat of Bulrush (*Typha sp.)*



Breeding Black Tern Survey Protocol

Fill Out the Data Forms

An online 123 Survey form has been created for convenient and remote data entry.

For Shoreline Counts:

Monitor Name: *Please enter your first and last name.*
Email: *Please enter your preferred email address.*
Phone: *Please enter your phone number.*

Location name: *Please enter the location name*
Subcolony name (if applicable)*: Please name each subcolony if several are present (could be based on their location within the wetland complex, i.e. North Subcolony, East Subcolony)*
Survey Period: *Survey Period 1 (June 1-30) or Survey Period 2 (July 1-31)*
Date: *Please enter the date.*
Site Visit #: *Please enter your site visit #. We understand that two site visits might not be possible at some sites.*

Location (map): *If at an active colony location, enter GPS coordinates for point count location. If more than one sub-colony at a location, enter separate data entry form for each sub-colony.*

Weather: *Please record the weather prior to your flush count.*

- **Wind:** Categorize wind speed based on the Beaufort scale: 0=smoke rises vertically; 1=wind direction shown by smoke drift; 2=wind felt on face; leaves rustle; 3=leaves & small twigs in constant motion and light flag extended; 4=raises dust and loose paper -- small branches are moved; 5=small trees with leaves sway -- crested wavelets on inland waters
- **Cloud Cover:** 0-10%, 10-50%, 50-90%, 90-100%
- **Precipitation:** No precipitation, Fog, Drizzle, Rain, Snow, Snow/Sleet

Count Start Time: *Please enter the time at the start of your flush count.*
Count End Time: *Please enter the time at the end of your flush count.*

Colony active? Y/N

# of Adult Black Terns present:

Please review your data and ensure that all data fields are as accurately and completely filled out as possible before submitting your data.

For Flush Counts:

Monitor Name: *Please enter your first and last name.*
Email: *Please enter your preferred email address.*

Audubon | GREAT LAKES

Breeding Black Tern Survey Protocol

Phone: *Please enter your phone number.*
Location name: *Please enter the location name*
Colony name (if applicable*): Please create a unique name for each colony if several are present within the same complex (Use the name of the wetland complex, and number each colony).*
Survey Period: *Survey Period 1 (June 1-30) or Survey Period 2 (July 1-31)*
Date: *Please enter the date.*
Site Visit #: *Please enter your site visit #. We understand that two site visits might not be possible at some sites.*

Location (map): *If at an active colony location, enter GPS coordinates for flush count starting location. If more than one sub-colony at a location, enter separate data entry form for each sub-colony.*

Weather: *Please record the weather prior to your flush count.*

- **Wind:** Categorize wind speed based on the Beaufort scale: 0=smoke rises vertically; 1=wind direction shown by smoke drift; 2=wind felt on face; leaves rustle; 3=leaves & small twigs in constant motion and light flag extended; 4=raises dust and loose paper -- small branches are moved; 5=small trees with leaves sway -- crested wavelets on inland waters
- **Cloud Cover:** 0-10%, 10-50%, 50-90%, 90-100%
- **Precipitation:** No precipitation, Fog, Drizzle, Rain, Snow, Snow/Sleet

Count Start Time: *Please enter the time at the start of your flush count. If flush count is not conducted use this for time spent estimating nest locations.*
Count End Time: *Please enter the time at the end of your flush count. If flush count is not conducted use this for time spent estimating nest locations.*

Colony active? Y/N
Colony accessible for flush count? Y/N

If flushed, # of Adult Black Terns present:

Nesting Documentation (map): record the GPS coordinates for 1-4 nests identified after the flush count. Use estimates if you are able to detect nests but not able to access site for flush count.

For each nest, identify nesting stage:
Incubation Stage
Nestling Stage

Please review your data and ensure that all data fields are as accurately and completely filled out as possible before submitting your data.

Breeding Black Tern Survey Protocol

Vegetation Surveys

Delineate Boundaries of Vegetation Survey Location: Methods
Before conducting vegetation surveys, follow these instructions (based off Loges BW et al 2017) to delineate the boundaries of each vegetation survey within each Black Tern breeding colony.

Equipment needed
GPS
Printed aerial images
Range finder (optional)

Observers should define vegetation survey area boundaries for each Black Tern colony (and subcolony, where applicable). It is expected that the observer will be able to visually assess a large portion of the Black Tern colony surface area from the *shoreline point count location*. If an observer cannot visually assess a large portion of a colony's cover area from the shoreline count location alone, additional vantage points (no more than 2) should be added. We understand that visibility could be limited at some locations. Observers should estimate the percentage of the visible colony surface area to the nearest 10% (See Figure SOP-1.1). The boundaries of the vegetation survey area should allow for maximum possible visibility of open water, emergent vegetation, and dominant vegetation. Use of a rangefinder could be helpful in determining vegetation survey boundaries on the aerial map.

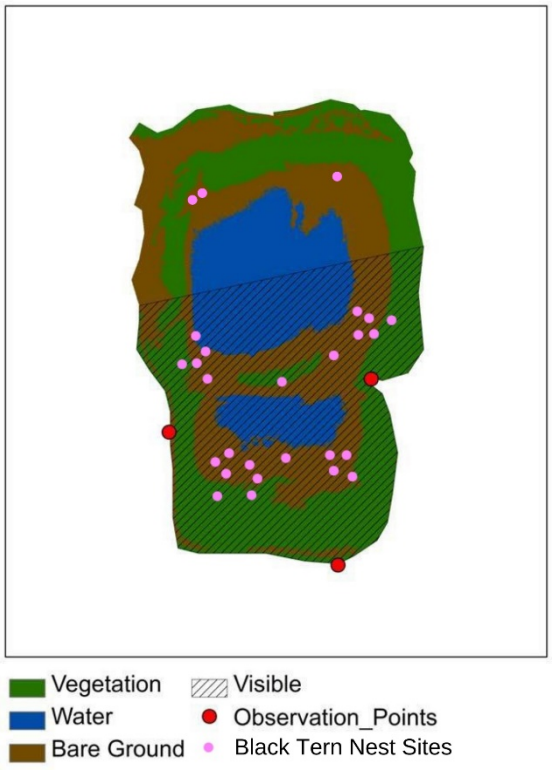


Figure SOP-1.1. Percentage of Black Tern colony surface area visible for vegetation surveys. In this case, 70% of the colony falls within the vegetation survey area.

On physical aerial map, please record:

Monitor Name: *First and last name.*
Email: *Preferred email address.*
Phone: *Preferred phone number.*
Location name:
Colony or Subcolony name:
Date:
Site Visit #:
Observation Points: *Identify location of 1-3 observation or vantage points on map, record GPS coordinates for each, and outline estimated range of visibility as in Figure SOP 1.1.*

Survey Location: Methods

Breeding Black Tern Survey Protocol

Use the point count location as the location for vegetation surveys. If additional vantage points needed, fill out a single vegetation survey form based on your overall assessment of the vegetation survey area from all vantage points (i.e. observers do not need to fill out a vegetation form for each vantage point). Use of a rangefinder could be helpful in identifying vegetation survey boundaries during the survey effort.

Vegetation Survey Protocol: Methods

Equipment needed
Map of the project and unit boundaries
Annual Vegetation Survey Form
Range finder (optional)

Survey Schedule
Vegetation surveys are to be completed once annually, typically late in the growing season (during Survey Period 2 would be ideal) when dominant plant species have reached maturity.

Habitat Cover
Use ocular estimation to assess what percentage of a survey unit is open water, bare ground/mudflat, emergent, scrub-shrub, or forest. These classes are defined using classes found in the *Classification of Wetland and Deepwater Habitats of the United States* (Cowardin et al. 1979). See Table SOP-2.5 for a crosswalk between IWMM's habitat classes and those found in Cowardin et al. (1979).

Table SOP-2.5. Habitat classification crosswalk between the IWMM Initiative Protocol and Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979).

IWMM Habitat Class	Wetlands and Deepwater Habitats Class
Open Water	See rock bottom, unconsolidated bottom, aquatic bed
Scrub-shrub	See scrub-shrub
Forest	See forest
Emergent	See emergent, vegetated unconsolidated shore
Bare ground	Streambed, rocky shore, unvegetated unconsolidated shore

The following conditions apply when estimating cover of the different habitat classes:

- Percent covers for individual classes are considered mutually exclusive, so percent cover estimates across all habitat classes must sum to 100%.
- Open water can include submerged aquatic vegetation and floating-leaved aquatics such as American lotus (*Nelumbo lutea*) and watershield **(***Brasenia schreberi*).
- Both open water and bare ground classes can include scattered emergent or woody vegetation up to 30 % areal cover.
- Mowed or harvested emergent vegetation should be treated as emergent unless submersed by open water.

- Crops planted in wetlands should be treated as emergent.
- Disked areas should be treated as bare ground unless litter residue > 30% areal cover.
- Because this measure is intended to assess habitat structure not energy content, senesced vegetation (i.e., dead vegetation) should be included in percent cover estimates for applicable habitat classes.

Interspersion

The configuration of vegetation and water/bare ground patches within a survey unit can influence habitat quality. For this metric, vegetation patches are defined to include scrub-shrub, forest, and emergent vegetation areas whereas water/bare ground patches are defined to include open water, submerged aquatic vegetation, floating-leaved aquatic vegetation, and bare ground. Units with little or no vegetation (60-100% open water) would fall into class L as a single large patch of open water, likewise units with 100% vegetation cover would fall into the S class. A survey unit can fall into one of three configuration classes (Figure SOP-2.2) based on Suir et al. (2013).

The three configuration classes are:

- Class L includes large and connected patches of water/bare ground features
- Class S contains small, disconnected patches of water/bare ground
- Class M contains discernible regions of both classes L and S

These classes reflect the interspersion, or inter-mising, of vegetation and water/bare ground patches. Assign the survey location to one of the configuration classes as an indicator of interspersion. Note that, when water/bare ground covers >60% of a unit, the only possible configuration class is L.

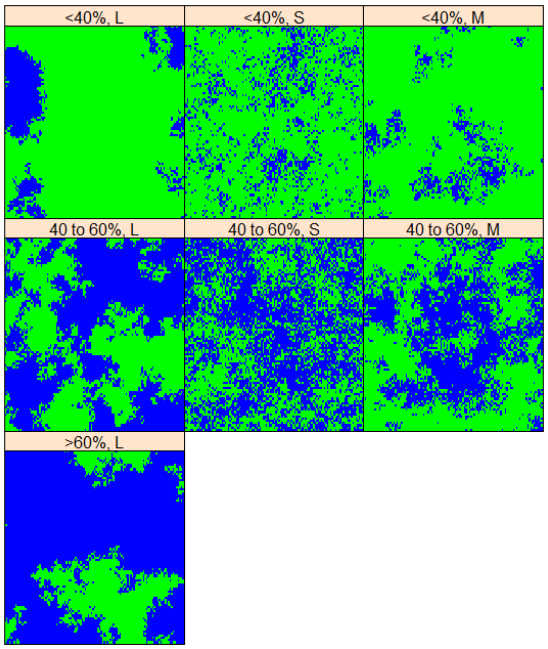


Figure SOP-2.2. Examples of three configuration categories (L; S; M). The three categories are illustrated for different levels of water/bare ground cover (<40%; 40 to 60%; >60%). Water/bare ground areas are represented in blue above whereas vegetated areas are represented in green.

Height

Use ocular estimation to assess what percentage of the unit is in each of seven categories of vegetation height (Table SOP-2.6). Note the height being measured is the uppermost canopy, so the percent cover estimates should sum to 100% across all categories.

Table SOP-2.6. Categories of vegetation height**.**

Category	Description
<2.5 cm	includes bare ground (e.g. mudflat) and water
2.5 to 15 cm	short vegetation, e.g. grazed grassland, sprouting crops, dwarf spikerush, etc.
15 to 30 cm	short herbaceous
30 to 60 cm	medium forbs and grasses
60 cm to 3 m	shrubs and low trees plus tall herbaceous vegetation and grasses.
3 to 6 m	shrubs, trees, tall herbaceous
>6 m	tall trees

% Vegetation Cover

Use ocular estimation to assess what percentage of a survey unit as a canopy cover for emergent, SAV, floating-leaved aquatic, scrub-shrub, or forest. Exclude portions that are 70% or more of bare ground, water with no vegetation, or litter from previous growing season. For example, a recently disked area with scattered living plants with a cover of only 15% would be assessed as non-vegetated.

Plant Community Composition

Plant community composition will be assessed by measuring the cover of individual, plant species in areas of wetland vegetation, including emergent, floating leaved, woody, or submersed vegetation, within the survey unit. **Only vegetation from the current growing season should be included in plant community composition assessments. For this protocol herbaceous crops should be consider emergent vegetation.**

Two major steps are involved in the assessment of plant community composition: (1) assessment of percent vegetation (emergent, floating leaved, or submersed) cover within the survey unit and (2) species inventory and species-specific percent cover assessments within areas of vegetation.

Breeding Black Tern Survey Protocol

Observers should determine the location of all wetland vegetation patches within a survey unit. This could be done through a visual assessment around the perimeter of the survey unit or by traversing across the unit. Preferably, patches would be identified via a combination of recent aerial photograph (e.g., Google Earth imagery) and field-based visual inspections. Once the observer is confident they have identified all emergent vegetation patches, they should estimate and record the percent of the survey unit covered by emergent vegetation. Percent cover is defined as the percentage of the survey unit covered by vertical projections from the outermost perimeter of plants' foliage (Anderson 1986) (Figure SOP- 5.1). Again, for this metric, percent cover assessments should exclusively consider vegetation from the current season's growth.

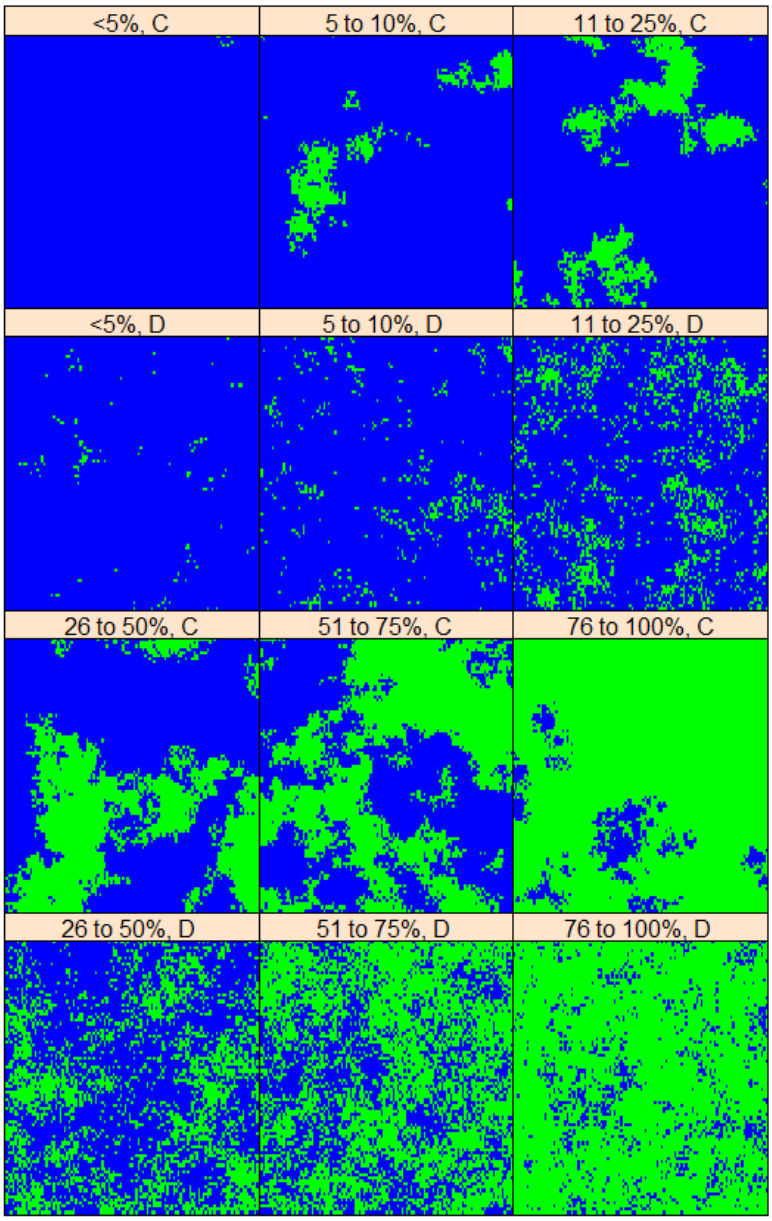


Figure SOP-5.1. Different levels of vegetation cover (green patches). Panels labeled with a "C" show clumped patches of vegetarian and water whereas those with a "D" show dispersed of spread out patches.

For a single composite representing all areas of emergent vegetation, cooperators will compile a list of common (>5% canopy cover) plant species and estimate each species' percent cover. For this assessment, the following pertains to percent cover estimates:

- For individual plant species, cover is defined as above except that it is *estimated as a percentage of the wetland vegetation area* **not** as a percentage of total survey unit area. As an example, consider a survey unit that contains only cattail as an emergent plant species. Cattail may cover 50% of the total survey unit area, but as an individual plant species, it covers 100% of the wetland vegetation area within a survey unit; report 100% as the estimate.
- Cover should be estimated only for common species, species covering >5% of the wetland vegetation area.
- Total cover across species can exceed 100% due to the stratification of plant species with varying heights and growth forms.

Observers have two options for creating a list of common plants and estimating their percent cover:

1. Entry, Ocular Assessments (Preferred)

   Preferably, cooperators will be able to physically enter the wetland to identify plant species and to assess their covers. Physical entry will especially help cooperators identify and account for plant species occupying lower strata that may be over-topped by taller growth forms.

2. Non-entry, Ocular Assessments (Non-preferred)

   While not the preferred option, cooperators can identify species and assess their covers entirely from vantage points from the point count location. Vantage points should offer cooperators a comprehensive view of the vegetation within the unit. This may be the only viable assessment option when the site is inaccessible.

Disturbance severity

Please record whether there is a disturbance affecting the behavior or number of waterbirds in the survey area either during your survey or immediately prior to it. Score the disturbance on a scale 1 to 4 (Table SOP-2.7).

Table SOP-2.7. Severity scale and associated definitions of waterbird response to disturbance.

Breeding Black Tern Survey Protocol

Scale	Severity	Definition
1	Light/none	no effect on waterbirds
2	Moderate	some waterbirds move but stay within unit
3	Heavy	some waterbirds leave unit
4	Limiting	most/all waterbirds leave the unit

Disturbance source

If there is a disturbance of waterbirds (see *Disturbance Severity* above), check the appropriate box to identify its source. Several sources can be ticked. For example, a fisherman in a boat should be ticked as both "Fishing" and "Boats". Potential sources are listed in Table SOP-2.8.

Table SOP-2.8. Types of disturbance.

Code	Description
1	Pedestrian
2	Loose dog
3	Hunting
4	Fishing
5	Boats
6	Motor vehicles
7	Aircraft
8	Raptor
9	Other

Breeding Black Tern Survey Protocol

Fill out the Vegetation Survey Data Form

Location Name:
Date:
Observer name:
Observation point #:
Start Temp:
Start Time:
End Time:
Wind (Beaufort scale):

Visibility (what percentage of the colony is visible from vantage point):

Local Tide Conditions (if applicable):

- 1 = high
- 2 = almost high, rising
- 3 = almost high, falling
- 4 = half tide, rising
- 5 = half tide, falling
- 6 = almost low, rising
- 7 = almost low, falling
- 8 = low
- 9 = not observed, not applicable, or observations made during more than one period

Water Gauge (if applicable):

- 1 = feet/tenths
- 2 = feet/inches
- 3 = meters

Water Depth: % of unit in each category (must sum to 100%)

- Dry:
- Saturated/mud:
- 0-5 cm (0-2”):
- 5-15 cm (2-6”):
- 15-25 cm (6-10”):
- >25 cm (>10”):

Plant Community Composition
Percent Habitat Cover: % of location in each category (sum to 100%)

- Water:
- Scrub-shrub:
- Forest:
- Emergent vegetation:
- Bare Ground:

Breeding Black Tern Survey Protocol

Interspersion: Class L, S, or M

- "L" = includes large water/bare ground features with connected patches and linear edge
- "S"= contains small, disconnected patches of water/bare ground with increased random distribution and fewer instances of connection;
- "M" = consists of patterns that contain discernible regions of both configuration classes L and S

Vegetation Height (%) of location in each category (Sum to 100%):

- <2.5 cm (<1"):
- 2.5 – 15 cm (1-6"):
- 15 – 30 cm (6-12"):
- 30cm – 60cm (1 – 2'):
- 60 cm – 3m (2 – 10'):
- 3 - 6 m (10-20'):
- >6m (>20'):

Identify plant species and their specific % cover within location:

Plant Species Name	% Cover

Disturbance Severity (1-4):

Disturbance Source (1-9):

Breeding Black Tern Survey Protocol

References

Anderson EW. 1986. A guide for estimating cover. Rangelands 8:236–238.

Cowardin LM, Carter V, Golet FC, LaRoe ET. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C.

Fredrickson LH, Reid FA. 1991. 13.1.1 Nutritional values of waterfowl foods, Waterfowl Management Handbook. U.S. Fish and Wildlife Service, Washington, D.C.

Kumlein, L. and N. Hollister (with revisions by Schorger 1951). The Birds of Wisconsin. Wisconsin Society for Ornithology, Madison, Wisconsin.

Loges BW and Others. 2017. National Protocol Framework for the Inventory and Monitoring of Waterbirds and their Habitats: An Integrated Waterbird Management and Monitoring (IWMM) Approach [Version 1-9, In Review]. This protocol is available from ServCat: [https://ecos.fws.gov/ServCat/Reference/Profile/83678]

Ma Z, Cai Y, Li B, Chen J. 2010. Managing wetland habitats for waterbirds: an international perspective. Wetlands 30:15–27.

Matteson, S.W., M.J. Mossman, and D.A. Shealer. 2012. Population decline of Black Terns in Wisconsin: a 30-year perspective. Waterbirds 35: 185-193.

Naylor LW, Eadie JM, Smith WD, Eichholz M, Gray MJ. 2005. A simple method to predict seed yield in moist-soil habitats. Wildlife Society Bulletin 33:1335–1341.

Sauer, John R., Daniel K. Niven, James E. Hines, David J. Ziolkowski Jr., Keith L. Pardieck, Jane E. Fallon, and William A. Link. 2017. *The North American Breeding Bird Survey, Results and Analysis 1966–2015.* Version 12.23.2015. Laurel, MD: U.S. Geological Survey Patuxent Wildlife Research Center. https://www.mbr-pwrc.usgs.gov/bbs/

Shealer, D.A. and S.W. Matteson. 2011. The 2011 Wisconsin Black Tern roadside transect survey and nest census. Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Madison, Wisconsin.

Shealer, D.A. and M.J. Alexander. 2013. Use of aerial imagery to assess habitat suitability and predict site occupancy for a declining wetland-dependent bird. Wetlands Ecology & Management 21: 289-296.

Suir GM, Evers DE, Steyer GD, Sasser CE. 2013. Development of a reproducible method for determining the quantity of water and its configuration in a marsh landscape. Journal of Coastal Research, Special Issue 63:110–117.

U.S. Fish and Wildlife Service. 2012. Data Delivery Standards and Specifications Template. USFWS, Pacific Southwest Region. Sacramento, California.

Appendix IV. Birds Canada Habitat Monitoring Datasheet

6263563562

Marsh Monitoring Program-Habitat Description Form

Please print with BLOCK CAPITALS, remain within the boxes and mark each individual choice by filling in the corresponding circle. Please use pen (not felt tip).

Day Month Year: 2 0 | Route #

Amphibian Survey Y/N: | Station Letter: (A - H)

Bird Survey Y/N: | Station Letter: (A - H)

Observer # | Observer Name

A % of major habitats in 100 metre radius station area

herbaceous emergent vegetation cover:	
large patches of open water/floating plants:	
exposed mud/sand/rock:	
trees:	
shrubs:	
Total:	1 0 0

Note: These must sum to 100%

B Floating plant cover in open water zones (fill in one)

none ◯ slight ◯ moderate ◯ dense ◯

unknown ◯ not applicable ◯

C Wetland Permanency (fill in one)

permanent ◯ semi-permanent ◯ seasonal ◯

D Overall marsh size (fill in one)

tiny ◯ small ◯ medium ◯ large ◯ huge ◯

E Area within 100 metres behind you is mainly (fill in one)

marsh ◯ field ◯ forest ◯ urban ◯ other

F Human influences affecting sample area (fill in one or more)

none ◯ dykes ◯ channels ◯ roadside ◯ sewage lagoon ◯

urban ◯ pollution ◯ industrial ◯ agriculture ◯

natural/protected area ◯

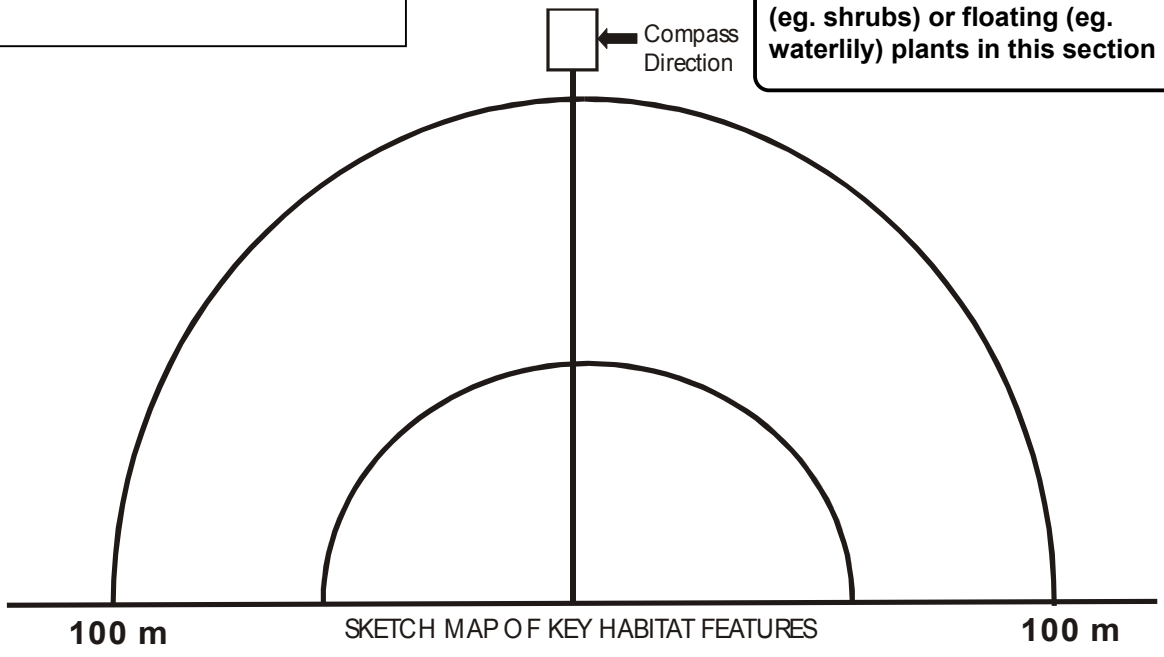
other

G Dominant Emergent Vegetation

Step 1: Identify the **herbaceous emergent plants** that dominate the station (see section A).
Step 2: Of the total percent emergent herbaceous vegetation cover, **select the top 4** and estimate the percent of their contribution.

cattail (*Typha*).....	
reeds (*Phragmites and Phalaris*)....	
grasses and grasslike sedges.....	
rushes/bulrushes (*Juncus/Scirpus*)	
purple loosestrife (*Lythrum*).....	
water willow (*Decodon*).....	
pickerel weed (*Pontederia*).....	
arrowhead (*Sagittaria*).....	
smartweed (*Polygonum*).....	
bur-reed (*Sparganium*).....	
wild rice (*Zizania*).....	
other	
other	
other	

Note:
- Sums of percentages must equal or be less than 100%, never more.
- Please DO NOT include woody (eg. shrubs) or floating (eg. waterlily) plants in this section



2213563563

Some Useful Reminders

You do not need to access the entire station area to describe the habitat. Merely stand at the focal point and record what you see within the bounds of the 100 m (110 yd) radius station area. The values you provide are **estimates** only and you don't need to spend a lot of time trying to calculate actual percentages. In fact, if you spend any more than a couple of minutes on this task, you're probaby overdoing it! See the MMP Training Manual for additional details.

Completing the left-hand side of the form (Sections A through F)

(A) Scan the 100 m (110 yd) radius sample area. Estimate the **percent of the total area** that is covered by emergent vegetation, open water (including floating plants), exposed mud/sand/rock, trees, and shrubs. These values must add up to 100%.

Definition: "open water" includes any and all pools of water that are at least the size of a standard sheet of plywood (4 x 8 ft). It supports little if any **emergent** vegetation. However, it may contain **floating plants**. As a rule of thumb, if you could float a small canoe in it (and maybe even paddle around a little), it is probably "open water."

(B) Look again at the open water zones. Categorize the amount of **floating plant cover**. If there is no open water, fill in the circle for "not applicable."

(C) **Wetland permanency** is categorized according to the following definitions:

permanent - almost never dries up; water is usually quite deep (knee to chest deep)
semi-permanent - can dry up in some years of low precipitation (or if water level is periodically drawn down); water is usually fairly shallow (not much more than knee deep)
seasonal - usually flooded in spring and early summer, but tends to dry up in late summer or in dry years. Even when flooded, the water is shallow (not much more than calf deep)

(D) Estimate the **size of the entire contiguous marsh complex**, excluding large bodies of navigable water like lakes and bays. For your information, one hectare (about 2.5 acres) measures 100 metres x 100 metres (e.g. a "tiny" marsh). 100 hectares is 1000 metres x 1000 metres (e.g. a "huge" marsh).

tiny - between 1.5 and 2.5 hectares (3.5 - 6 acres) **small** - between 2.5 and 5 hectares (6 - 12 acres) **medium** - between 5 and 25 hectares (12 - 60 acres)	**large** - between 25 and 50 hectares (60 - 125 acres) **huge** - greater than 50 hectares (>125 acres)

(E) Classify the **land use** (to 100 m (110 yd)) behind you as you face the station area. Choose only one category.

(F) Identify the obvious **human influences** that may be affecting the station area. Choose as many categories as you think apply.

Completing the right-hand side of the form (Section G)

(G) **The Dominant Emergent Vegetation Box**

The estimates you make in this section are based on the **total area covered by herbacousemergent vegetation only** (ignore open water/floating plant and shrub/tree zones). Scan the area and decide which kinds of herbaceous emergent vegetation dominate the area. Limit yourself to the **top four most common** species. Of the total herbaceous emergent vegetation cover, what proportions do each of these dominant plants occupy? (Because other less-common plants may be present, the dominants **do not need to add up to 100%).**

In some marshes, virtually all of the herbaceous emergent vegetation may be represented by a single dominant species (e.g. cattail = 100%) or by a couple of species (e.g. cattail =75%, grass = 20%). If so, you don't need to list any other species in the Dominant Emergent Vegetation box. As a general rule of thumb, any species that accounts for less than about 10% of the cover really can't be considered as a dominant. If a dominant species is not listed in the box, list it under **other** (be sure it is **herbaceous** (non-woody) and **emergent** (not floating). If you can't identify it, take your best guess, followed by a question mark (e.g. "Milkweed? = 25%").