Appendix A

2016 St. Louis River AOC Bird Assessment Report

St. Louis River AOC R2R Support Projects: Ecological Monitoring and Assessment (CR#6403) Final Report

Objectives 1 & 2, Task D:
Sample Birds at R2R and Reference Locations
Compare bird use in historical (1976-1979) and recent (2010-2015) survey periods

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Executive Summary

The goal of this project was to provide a contemporary assessment of bird use of the St. Louis River Freshwater Estuary (SLR), a designated Great Lakes Area of Concern (AOC), located in the extreme western end of Lake Superior, Minnesota-Wisconsin, USA. These data and analyses will be used to assess the current status of the beneficial use impairment (BUI) on 'Degraded Fish and Wildlife Populations' that exists in the SLR. Removal of such a BUI is contingent upon evidence that native populations of fish and wildlife are not limited by physical habitat, food sources, water quality, or sediment contamination. To provide a perspective on the BUI, the project consisted of two broad objectives: 1) summarize and compare contemporary baseline data gathered on bird use at sites planned for restoration and reference sites with reduced disturbances within the SLR, and 2) synthesize and compare these contemporary bird use data with similar data gathered for sites in the late 1970s within the SLR.

Sites selected for contemporary sampling in objective 1 were those identified as the Remediation-to-Restoration (R2R) sites by the Minnesota Pollution Control Agency (MPCA), while reference sites were selected based on locations that were most relevant for comparison with R2R sites. A total of 10 R2R sites were selected and up to 10 potential reference sites were originally identified. Based on a review of these potential reference sites, five were selected as most appropriate for comparison with the R2R sites, but data for the remaining five sites were also included in the dataset as "additional sites." Sampling of these sites were grouped into breeding and migration (Spring and Fall) time periods. Bird counts during the breeding season were completed from fixed point count locations and gathered from 0.5 hr before sunrise to 4.5 hr after sunrise. Each count was 15 min in duration, which included use of playback recordings of hard to detect species, such as rails, and all individuals seen or heard from the point were recorded. Counts during the migration seasons were also recorded from a fixed point location from sunrise to early afternoon. Each count was 10 min in duration and all individuals seen or heard from the point were recorded. Depending on accessibility, sites were sampled either from the shoreline or by boat. All locations of observations, including flyovers, were estimated on aerial photo field sheets and digitized in ArcGIS®. For ease of interpretation, all observations were classified into 16 unique species groups based on taxonomy, life history, and physiological similarities; however, species of special concern (e.g., Common Tern and Piping Plover) were also considered separately.


Grassy Point, a Remediation-to Restoration site in the St. Louis River Estuary. Photo credit: A. Bracey

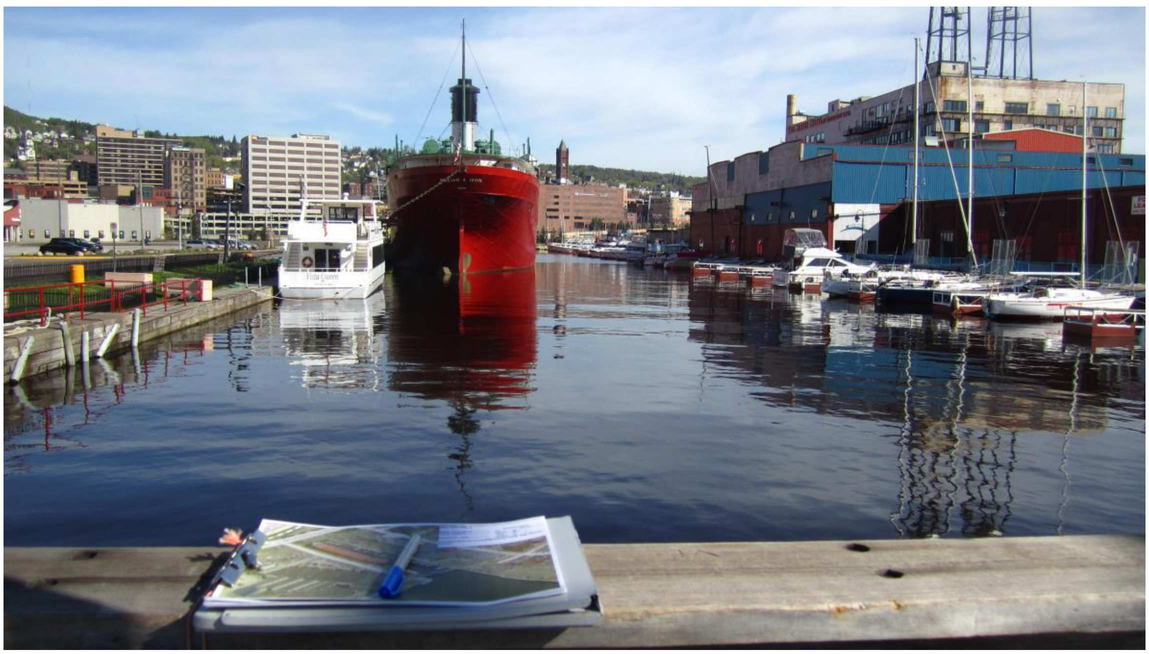
For objective 2, we identified 10 sites that matched the areas sampled in objective 1 with those sampled using similar techniques from 1976 to 1979 in the SLR. Major considerations included similar areas sampled, similar sampling techniques, close phenological time periods of sampling, and a representative distribution across the SLR. Although time of sampling varied in the 1970 counts, the major objective of both sampling regimes was to do a complete count of all bird species and individuals detectable within the sample area, therefore, we believe the methods are comparable. In addition, one of the co-authors, GJN, was involved in gathering the 1970s data and he verified their comparability at the ten sites selected. Data gathered in the 1970s were digitized from the original field sheets which were also gathered on aerial photos.


Interstate Island Wildlife Management Area. Photo credit: D. Hamilton

The focus of the analyses were to compare R2R with reference sites (Objective 1) and compare historical (1970s) with contemporary surveys (2010s); a difference of over 30 years (Objective 2). Various statistical techniques were used to determine overall differences in community composition, species richness, and to document differences for species of special interest or conservation concern, including the Least Bittern, Great Blue Heron, Great Egret, Piping Plover, Black Tern, Common Tern, and Forster's Tern. Groups of species of specific interest to the BUI included waterfowl, waterbirds, rails, raptors (e.g., Peregrine Falcon and Bald Eagle), or songbirds of concern such as Sedge and Marsh Wren. Special attention was also made with reference to potentially problematic or nuisance species such as Canada Goose and Ring-billed Gull.

Objective 1. A total of 117,235 individual bird observations of 177 species were recorded during the migratory and breeding seasons at all sites sampled from 2010-2015. Each site was sampled at least 10 times, including four during spring migration, four during fall migration, and two during the breeding season. Sites varied in size from 10 to 480 acres. Overall, cumulative species richness (SR) and water-obligate species richness did not differ between R2R and reference sites when all sites were pooled. However, site-specific comparisons provided mixed results. The 40th Avenue West R2R site had higher cumulative and water-obligate only SR, compared with its reference site (Little Pokegema Bay). The 21st Avenue West complex also had higher water-obligate SR compared with its reference site (Little Pokegema Bay). In contrast, the R2R sites Minnesota Slip and Slip C had low overall use by birds and lower SR for all species and water-obligate species only compared with their reference site (Minnesota Point). The R2R sites Cedar Yard Bay had lower SR when all species were included compared with its reference site (North Bay) and the R2R site Perch Lake had lower SR for water-obligate species compared with its reference site (Rask Bay). In general, the R2R and reference sites have substantial overlap in their respective bird communities, primarily because of the high variability in bird species found at R2R sites. This was especially due to the high use by many bird species at the 40th Avenue West and 21st Avenue West R2R sites. These data provide a solid baseline to assess future changes in these communities over time. Any future changes can be assessed within each respective area as a natural experiment in progress.

The SLR is a complex system which has been influenced by substantial human activity. The cumulative impacts of current activities, which vary from recreation to heavy industrial activity, and legacies of past activities (logging, shipping, development) influence both migratory and breeding bird communities in the estuary. Extensive and constant human activity at the Minnesota Slip and Slip C sites renders use of these areas by birds as extremely low. In contrast, the 40th Avenue West site is a very active industrial zone, but it is also very heavily used by birds. Despite the industrial activity, human activity levels in this area are very low because of its remoteness, plus it has a diverse habitat base with wetlands, open water, and shrubby, forested riparian areas. Cedar Yard Bay also has high potential for use by birds as it shares the low human activity and isolation with 40th Avenue West, despite major differences in industrial activity.


Minnesota Slip located in Canal Park. Photo credit: A. Bracey

Objective 2. A total of 16,911 individual bird observations of 133 species (historical) and 11,042 individual bird observations of 132 species (recent) were included in the analysis of historical and recent bird use in the estuary. Of the water-obligate species only, 13 were unique to the historical surveys and seven were unique to recent surveys. The number of surveys included ranged from 4-17 and was dependent on the number of replicate samples available between the time periods. Sites varied in size from 35 to 664 acres but were matched to be the same size in paired comparisons. Similar with the R2R and reference comparisons, we found no significant differences in SR between historical and recent surveys when all sites were pooled. However, comparisons of site-specific SR indicated significant differences (when all species were included and water-obligate species only) with higher cumulative SR for three historical sites compared with recent sites at 20th Avenue West, 27th Avenue West, and Spirit Lake West. However, recent counts at 40th Avenue West were higher than historical counts (water-obligate species only). In contrast with comparisons between R2R and reference sites, recent and historical sites did not overlap as extensively. Based on community composition, the most influential water-obligate species contributing to differences between the historical and recent surveys were the extremely high Canada Goose populations and lower Blue-winged Teal, American Coot, and Lesser Scaup populations observed during recent surveys compared with historic counts.

Interpretation of the differences between historical and recent surveys requires consideration of how populations of bird species have changed over the past 30 years independently of the changes that have occurred in the SLR. Many waterfowl are still common and widespread in the region and across North America and generally waterfowl populations have increased over the past five decades (NABCI 2016), while some have changed substantially – both increasing and decreasing. In contrast to many areas of North America that have continued to see reductions in water quality and expansion of agriculture and human populations, the SLR has improved in water quality with the addition of WLSSD and agriculture is a negligible issue in the region. In addition, DDT was banned in the early 1970s and overall contaminant levels have declined in exposure for aquatic-associated species. All of these factors have an effect on population levels for each bird species and interpretation of these interacting effects is beyond the scope of this report.

In general, comparison of recent and historical waterfowl populations indicate that Canada Geese have increased substantially in the SLR, but Wood Duck, Blue-winged Teal, and Northern Pintail were observed less frequently. Population changes in Canada Geese and Blue-winged Teal are consistent with regional changes in their populations over the past 40+ years, but Wood Duck and Northern Pintail have declined despite regional population increases. Other water-dependent bird species also indicate mixed results in these comparisons. Double-crested Cormorants have increased in the SLR compared with historical counts, while Common Loon, American Bittern, Great Blue Heron, American Coot, and Black Tern have declined. All of these changes, except for Common Loon, are consistent with regional population trends in these species over the past 40+ years. Fewer observations of Common Loon in the SLR compared with historical counts are inconsistent with their increases over the past 40+ years. However, the total number of observations of this species in the SLR was relatively small in both historical and recent periods.

Overall shorebird use was relatively low in the recent sampling periods. The lower number of observations during the recent sampling period for Killdeer, Spotted Sandpiper, and Wilson's Snipe are consistent with declining regional population trends for these species. However, the fewer observations for Black-bellied Plover, Pectoral Sandpiper, and Semipalmated Sandpiper compared with historical counts do not have regional population trends available for comparison. All three of these species are migrants that nest in the Arctic tundra. The overall lack of use by shorebirds in the SLR is a concern and deserves further study. It is unclear whether availability of suitable, breeding or stopover habitat is an issue in the SLR for shorebirds compared with the past.

Based primarily on observations, raptorial species, especially Bald Eagle and Peregrine Falcon, populations have increased substantially in the SLR compared with the historical period (1970s) when neither species nested. Several pairs of both species have nested or attempted to nest in the SLR over the past 5-10 years. Increases in their populations have largely been attributed to the banning of DDT and focused management such as reintroduction programs for Peregrine Falcons and nesting habitat protection for the Bald Eagle. The population recovery of these species represents a massive success story in wildlife species conservation. Analyses of two rail species, Sora and Virginia, plus two wren species, Sedge and Marsh, provided no significant differences in historical or current population levels in the SLR.

Background

The SLR was designated an AOC under the 1987 Great Lakes Water Quality Agreement, and efforts towards delisting this area are in progress. The MPCA is currently developing a comprehensive, long-term plan to delist the SLR AOC under a grant from the U.S. Environmental Protection Agency (EPA) and other project partners (MPCA 2013). The potential removal of beneficial use impairment (BUI) #2: 'Degraded Fish and Wildlife Populations' is contingent upon evidence that native populations of fish and wildlife are not limited by physical habitat, food sources, water quality, or sediment contamination (MPCA 2013). Documenting avian use throughout the AOC is fundamental to prioritizing project areas, establishing objectives, and successfully implementing R2R project activities. By documenting avian diversity and abundance, in conjunction with sediment, benthic, fish, vegetation and water quality sampling, it will be possible to better define biotic and abiotic relationships that collectively indicate ecological condition.

Our primary objective (Objective 1) of this report was to summarize the baseline data collected at priority sites selected for potential future restoration (R2R) and their corresponding reference sites in the SLR AOC (2010-2015) with a focus on the richness and abundance of species that use water as their primary habitat (i.e., waterfowl, waterbirds, shorebirds, rails). The secondary objective (Objective 2) was to compare historical (1978-1979) and recent (2010-2015) data on bird use at sites that were surveyed during both sampling periods. Both objectives involve comparisons, objective 1 contrasts R2R and reference sites using contemporary data, while objective 2 compares contemporary data with those sampled in the 1970s; albeit the latter with slightly different methodologies.

We will discuss how these data can be used to address BUI targets and provide a summary of species of particular interest (e.g., Piping Plover, Common Tern) identified by the Minnesota and Wisconsin Departments of Natural Resources (MDNR and WDNR, respectively). This information will be summarized in the context of abundance in the SLR as well as trends across each species range.

Methods

Objective 1. Documenting bird use in R2R and Reference sites in the SLR AOC

Sample Locations

To document bird use in the SLR AOC, we sampled 10 R2R sites and 5 reference sites. Reference sites were chosen based on location within the estuary and size of site (acres). Reference sites were also considered less impacted by human disturbance (e.g., farther from industrial activity, non-hardened shoreline). In addition to the five reference sites, during the first sampling period in 2013, we sampled 5 additional locations, considered potential reference sites, to determine locations that would be the most appropriate reference sites (i.e., met the criteria above and were accessible; Table 1: '*Additional Sites*'). Minnesota Point was chosen as the reference site for R2R sites: Minnesota Slip and Slip C. Little Pokegema Bay was selected as the reference site for R2R sites: 21st Avenue West, 40th Avenue West, and Grassy Point. Spirit Lake East was chosen as the reference site for R2R site: Spirit Lake West. North Bay was chosen as the reference site for R2R sites Cedar Yard Bay and Kingsbury Bay, and Rask Bay was chosen as the reference site for R2R sites: Mud Lake and Perch Lake.

In 2014-2015, we sampled a subset of all 10 R2R sites and 5 reference sites (Table 1, Fig. 1). R2R sites selected for sampling in 2014-2015 were selected primarily for logistical reasons: 1) to ensure that reference sites would be sampled in the same year as their corresponding R2R sites when possible, and 2) for consistent accessibility (i.e. boat vs. land surveys). Three of the R2R sites (21st Avenue West, 40th Avenue West, and Grassy Point) had been previously sampled by researchers at the Natural Resources Research Institute (NRRI) in 2010-2012 (Host et al. 2012, 2013). Because of the extensive data available for these sites, we limited our sampling to the fall of 2013. Cedar Yard Bay was also only sampled in fall 2013 and May-June 2014 because restoration activities were initiated in 2014. In lieu of sampling at Cedar Yard Bay, MPCA requested that we survey Kingsbury Bay in 2015 (Table 1, '*R2R Sites*').

Polygons for R2R sites were provided from the MPCA project officer to ensure all sampling occurred within appropriate site boundaries (Table 1, Fig 1). For sites where polygons were not provided, we created polygons using ArcGIS® software by Esri, version 10.2.2. Sampling density within each site was dependent on size and accessibility of each site (Table 1). Data were collected from each site either by boat or from land. A total of 12 surveys were conducted at most survey point from 2013 to 2015. Surveys were a minimum of seven days apart. Of the 12 surveys, five occurred during the spring migration (March-May), five during fall migration (August-November), and two during the breeding season (June). A few dates were logistically unfeasible for sampling because of unsafe conditions for water travel such as high winds or river was iced over. However, we attempted to conduct those remaining surveys in another year. Detailed methodology can be found in the MPCA Bird Sampling QAPP 'CR#6403: Migration and Breeding Bird Distribution and Abundance' as well as Host et al. (2012 & 2013).

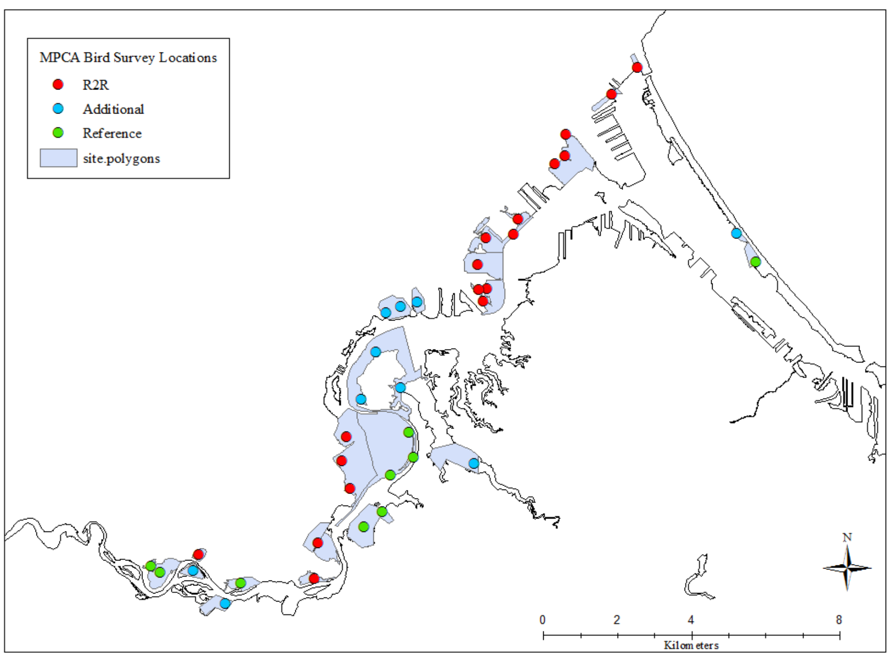


Figure 1. Location of sites surveyed in the St. Louis River Area of Concern (SLR AOC). A total of 10 R2R sites, 5 Reference sites, and 6 additional sites were surveyed (2010-2015).

Table 1. Location of sites surveyed in the St. Louis River Area of Concern (SLR AOC). A total of 10 R2R sites, 5 reference sites, and 6 additional sites were surveyed (2010-2015). For each site, the location of the centroid of each site polygon is provided in NAD_1983_UTM_Zone_15N, area of site surveyed (acres), number of survey points, and year(s) surveyed as well as number of replicates per season/year (Reps).

Site Name	Location (UTM)		Area (acres)	# of Points	Survey Year(s) and (Reps)		
	x coordinate	y coordinate			Fall	Spring	Summer
R2R Sites							
Minnesota Slip	568932.0987	5181429.415	10	1	2013(4), 2015(5)	2014(4), 2015(5)	2014(2), 2015(2)
Slip C	568146.893	5180336.653	28	1	2013(4), 2014(4), 2015(1)	2014(4)	2014(2)
21st Avenue West Complex*	567234.7284	5178629.812	201	3	2012(10), 2013(5)	2012(7)	2012(2)
40th Avenue West Complex*	565095.9511	5176399.507	321	4	2010(11), 2013(5)	2011(8)	2011(5)
Grassy Point Complex*	565084.7939	5174889.351	115	3	2010(11), 2013(4), 2014(3)	2011(8), 2014(4)	2011(5), 2014(2)
Spirit Lake West	561344.4729	5170475.449	250	3	2013(5), 2014(4)	2014(5)	2014(2)
*Kingsbury Bay****	562495.9847	5174547.985	36	2	2015(6)	2015(5)	2015(2)
Mud Lake East & West	560373.3906	5168013.218	123	2	2013(5), 2015(6)	2014(4), 2015(5)	2014(2), 2015(2)
Cedar Yard Bay**	560196.2854	5167027.719	38	1	2013(5)	2014(4)	2014(2)
Perch Lake	557172.1823	5167700.839	21	1	2013(5), 2014(3), 2015(3)	2014(4)	2014(2)
Reference Sites							
Minnesota Point	572077.3183	5176012.388	37	1	2014(2), 2015(6)	2014(4), 2015(5)	2014(2), 2015(2)
Little Pokegema Bay	561697.4797	5168511.646	189	2	2013(3), 2014(4)	2014(4)	2014(2)
Spirit Lake East	562218.5785	5170744.569	480	3	2013(5), 2014(3)	2014(4)	2014(2)
North Bay	558324.5876	5166891.417	60	1	2013(1), 2015(6)	2014(4), 2015(5)	2014(2), 2015(2)
Rask Bay	556137.9853	5167213.874	98	2	2013(5), 2014(4), 2015(2)	2014(4)	2014(2)
Additional Sites							
Southworth Marsh	571731.2127	5176570.682	18	1	–	–	2014(2)
Clough Island	562075.786	5172539.183	82	3	2013(6)	2014(1)	2014(1)
Pokegema Bay	564586.7451	5170216.221	70	2	2013(3)	–	–
*Stryker Bay****	563066.2283	5174737.414	42	1	2015(6)	–	–
Weasel Bay	557604.1257	5166309.617	59	1	2013(4)	–	–
Horseshoe Bay	556984.2951	5167216.649	36	1	2013(5)	2014(1)	–

*Site was sampled for entire year in previous study and therefore only surveyed in Fall 2013

**Site was undergoing remediation/restoration activities during sampling period and therefore only surveyed in Fall 2013 and once in May and June 2014

***Site included as an additional sample, not because it was considered a potential reference site but because of a request by MPCA

Data Collection

Due to differences in the seasonal distribution of species, sampling protocols varied between breeding (June) and migration (spring/fall) surveys. Surveys were designed to obtain a complete count of bird use in each survey location (site), during each visit. This technique was used in the late 1970s by Niemi et al. (1979; *see methods of Objective 2*). For all surveys, we used unlimited distance counts at designated point locations within each site and counted all species identified by both visual and auditory observations. All bird observations were identified to specific locations on aerial photo field sheets and digitized in ArcGIS® (e.g., Fig. 2). Accuracy was approximately 30 m in open water and 20 m near or on shore. Observation type was based on behavior and included 1) singing, 2) calling, 3) drumming (woodpeckers), 4) visual observation, or 5) flyover (i.e. species not actively using study area). Flyover observations are included in raw data and total species list, but excluded from site summaries and analyses. Species were classified into 16 unique groups based on taxonomy and physiological similarities as well as individual species groups of interest. These groups are as follows: gulls, waterfowl, waterbird, raptor, shorebird, blackbird, songbird, corvid, pigeon, woodpecker, dove, rail, hummingbird, pheasant, grouse, and invasive. Grouping individuals based on taxonomy and physiological similarities is useful to simplify mapping and to identify specific groups of species of interest (e.g., water associated species).

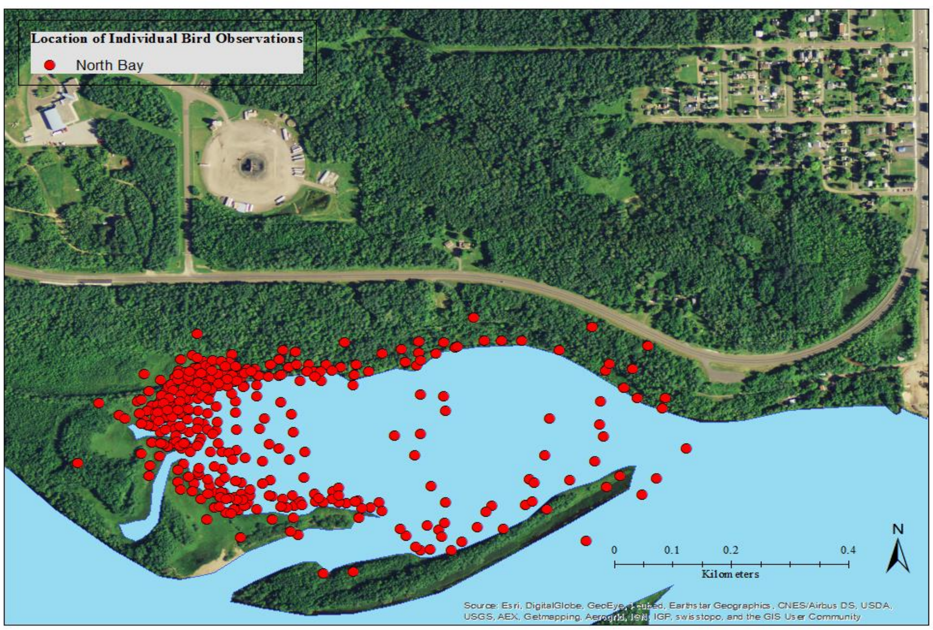


Figure 2. An example of the digitized spatial locations of individual bird observations in North Bay (reference site).

Spotting Scope used to identify birds on the water. Photo credit: A. Bracey

Surveys conducted during migration were completed from a fixed point location within each site for 10 min or, in rare situations when no birds were present; the count was abated early. During breeding season surveys, we extended our point counts to 15 minutes, which incorporated the use of playbacks, a series of recordings of secretive marsh bird calls, to target this group of hard to detect species. The broadcast calls consisted of 30 seconds of vocalization followed by 30 seconds of silence in the following order for each of six focal species: Least Bittern, Sora, Virginia Rail, a mixture of American Coot and Common Gallinule, and Pied-billed Grebe. Surveys were conducted from 0.5 hr before sunrise to 4.5 hr after sunrise in the breeding season and from sunrise until early afternoon during spring and fall migration; all completed during suitable weather conditions (e.g., minimal wind or precipitation). Detailed sampling methodology can be found in the MPCA Bird Survey Standard Operating Procedures document (Appendix A). For objective 1, we restricted analysis to include four spring surveys, two breeding surveys, and five fall surveys from each site. For sites with more than 11 samples, we randomly removed surveys by year and month, thereby making sample size equal and comparable between sites.

Objective 2: Comparison of bird use in the SLRAOC between historical (1976-1979) and recent (2010-2015) time periods

Sample Locations

St. Louis River historical bird survey data were obtained using original data sheets from three projects conducted in the 1970s: Phase I and Phase II of the Assessment of Habitat Types and Bird Populations in the Duluth-Superior Area (Niemi et al. 1977, Davis et al. 1978) and Distribution and Relationships of Habitats and Birds in the St. Louis River Estuary (Niemi et al 1979a). The original field data sheets were used, rather than the summarized data found in the appendices, to ensure that dates and locations of bird observations matched with those of the recent MPCA surveys (Table 2). Only historical data sheets with dates closely corresponding to dates of the recent MPCA surveys (e.g., within the same month) were used. Since the survey areas involved in this analysis were of varying shapes and sizes, ten sites that could be closely matched between the historical and recent survey data were selected. Site polygons were created in ArcGIS® to represent the locations where historical and recent data were collected (Fig. 3).

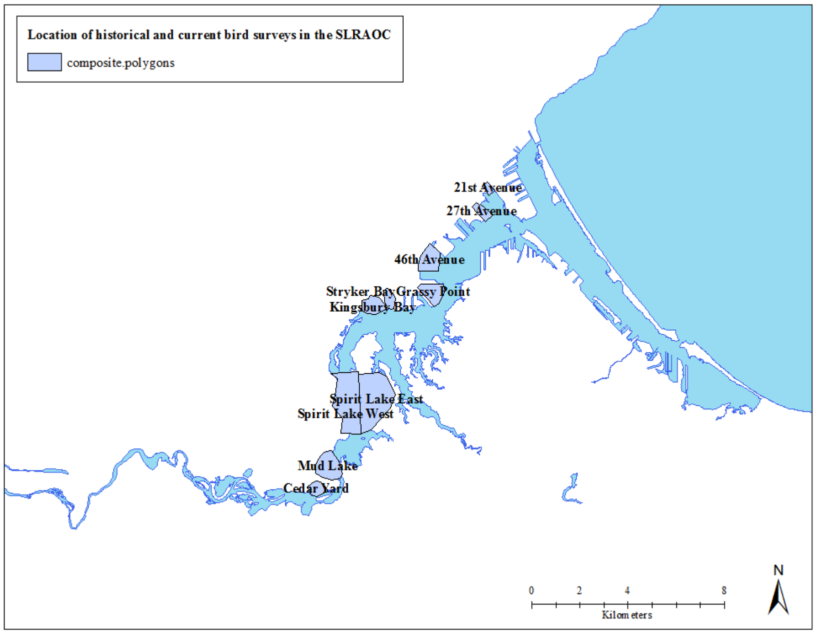


Figure 3. Location of historical (1976-1979) and recent (2010-2015) bird surveys in the St. Louis River Area of Concern (SLR AOC). Each of these 10 sites has both historical and recent bird data associated with them and are included in the temporal comparison.

The number of surveys included ranged from 4-17 and was dependent on the number of replicate samples available between the time periods, sites also varied in size from 35 to 664 acres (Table 2). Survey time and total effort were included whenever possible for historical surveys, but it was necessary to include historical surveys with missing effort information due to a large number of surveys that did not include this information. Co-author GJN was involved in these surveys and he confirmed that the overall objective of the surveys in the 1970s and the contemporary surveys was to obtain a complete count of the individual birds within a specific area. The historical data sheets included specific locations and area on aerial photographs that could be matched with the contemporary survey areas. Hence, we felt these comparisons were reasonable.

Table 2. Location of ten sites where historical (1977-1979) and recent (2010-2015) surveys were conducted. The location at each site is represented by the centroid of the polygon [Location (UTM)]. The total area in acres and the number of surveys included in the analyses are also provided for each location. At each site, the number of surveys was equal for both historical and recent surveys.

Site Name	Location (UTM)		Area (acres)	# of Surveys
	x coordinate	y coordinate		
20th Avenue West	567191.2395	5179207.368	35	10
27th Avenue West	566922.8469	5178263.966	76	12
40th Avenue West	564737.3271	5176323.484	190	14
Cedar Yard Bay	564865.6061	5175003.808	85	9
Grassy Point	562385.5466	5174472.7	157	8
Kingsbury Bay	560526.3187	5167964.834	142	10
Mud Lake	562418.634	5170684.202	231	17
Spirit Lake East	561342.3492	5170581.749	664	8
Spirit Lake West	560045.4171	5167080.039	579	11
Stryker Bay	563055.8593	5174736.049	74	4

Data Collection

Birds were surveyed during three sampling periods: fall migration - September 1 – December 31; spring migration - January 1 – May 31; and breeding season - June 1 – August 31. We used the following field methods: Waterbirds - by spot checks, transects, spotting with scopes from the bay or lakeshore, and by boat; Shorebirds – by boat and by spot checks at regular intervals (along shoreline when waves were hazardous); Colonial birds – estimated at each visit and, if accessible, site was visited once during breeding season on foot to accurately count all nests, eggs, and young; and all other bird species – by transect counts and modified transects or spot checks where terrain was difficult. For all observations the estimated location of the bird was recorded on maps of the area being surveyed. Surveys covered the area from the Arrowhead Bridge to Lake Superior, including Minnesota and Wisconsin Points, but excluded many industrial, residential, and recreational areas. Surveys at these sites included all open water to 0.25 mi inland from the land-water interface. As with the recent MPCA data, all bird observations were assigned to groups based on species associations.

Assessment of changes in bird species use of the SLR in the late 1970s with the contemporary counts were grouped into several categories based on comparisons of the paired study areas: 1) species observed less in contemporary versus historical counts, 2) species observed less in historical counts versus contemporary counts, and 3) species that are too rare to make confident comparisons between the two periods. In addition, we also consider the changes that have occurred in species populations from 1966 to 2013 using the North American Breeding Bird Survey, commonly known as the BBS (Sauer et al. 2014). We primarily used the changes that have occurred in the regional population defined as Bird Conservation Region 12 (BCR 12) which encompasses northern Minnesota, northern Wisconsin, northern Michigan, and southern/western Ontario – basically the area surrounding the western Great Lakes Region. In some cases where a species population is not assessed sufficiently within this region, we included a broader area of the BBS and used the survey-wide results.

Data Analyses

For both objective 1 and objective 2, we were interested in determining changes in community composition between R2R and reference sites (objective 1) and between historical and recent surveys (objective 2). The sample size of R2R and reference sites was unequal (10 and five, respectively), therefore we used the non-parametric Wilcoxon rank sum test to compare the median of the difference between R2R and reference sites for water-obligate species. The sample size of historical and recent surveys was equal and the same locations were surveyed in both time periods, therefore we used a paired t-test to compare means of water-obligate species.

To assess differences in community composition we compared species richness (SR) between communities using the package 'rich' in R, version 3.2.3 (Rossi 2011, R Core Team 2015). Using the function *c2cv*, we were able to compare cumulative richness between locations. This function calculates difference between the values (d=S_1-S_2) and compares to n similar differences d_{rand} obtained after randomizing samples between communities. This technique allows us to determine if differences in richness are significant or due to sampling fluctuations (Manly 1997). This function tests observed values of d as compared to the quantiles of the randomized values of a user-fixed probability level (Rossi 2011). For this analysis we used n=999 randomizations and a probability level for quantile computations of 0.025 – 0.975.

We calculated dissimilarity among samples (replicate and temporal) to determine if differences in community composition were larger than sampling variation alone. We calculated dissimilarity distances using nonmetric multidimensional scaling (NMDS) in R, using package 'vegan' (Oksanen et al. 2016). We created two-dimensional plots to visualize the dissimilarity distances. To measure the magnitude of change we used the Bray-Curtis distance (Bray and Curtis 1957), which is calculated from differences in species abundance. Because this distance measure uses abundance it can be influenced by large differences in species counts. Therefore, we first standardized the species data by converting species abundance to relative proportions of species across sites. We then transformed the proportions using an arcsine square root transformation. We used hierarchical clustering via Ward's Method on the set of calculated Bray-Curtis dissimilarities. We then used the function *adonis* in package 'vegan' (Oksanen et al. 2016) which calculates analysis of variance using distance matrices. Significance tests use F-tests based on sum of squares from permutations of the raw data.

We also calculated indices of beta diversity with package 'vegan' (Oksanen et al. 2016), using the most commonly used index of beta diversity: $\beta\_w = S/\alpha - 1$, where **S** is the total number of species and **α** is the average number of species per site (Whittaker 1960, 1972) and measured variance in beta diversity between groups using multivariate analysis of variance, with distance matrices describing how variation is attributed to different groups. Calculating the average distance of group members to the group centroid, we determined if variances were different between groups. PCoA axes represented distances between groups, with negative axes being a consequence of using a dissimilarity index other than Euclidean.

To determine which species were driving differences between groups we used the function *simper* (Clarke 1993) in package 'vegan' (Oksanen et al. 2016). *Simper* calculates the contribution of individual species to overall dissimilarity between two groups using Bray-Curtis dissimilarities. This function performs pairwise comparisons of groups and determines the average contribution of each species to the average overall Bray-Curtis dissimilarity, displaying the most important species for each pair of groups (Oksanen et al. 2016).

Results

A total of 196 bird species were observed in the SLRAOC (1977-2015; Appendix B). Not all of the species included in this list were included in the analysis. Excluded species were those only observed as flyovers or that fell outside of the survey boundaries delineated for the comparison of historical and recent surveys.

Objective 1. Documenting bird use in R2R and reference sites in the SLR AOC

A total of 117,235 individual bird observations and 177 species were recorded during migration and the breeding season in all sites surveyed (2010-2015; Fig. 4). Counts of individuals observed in each group are listed by site (Appendix C).

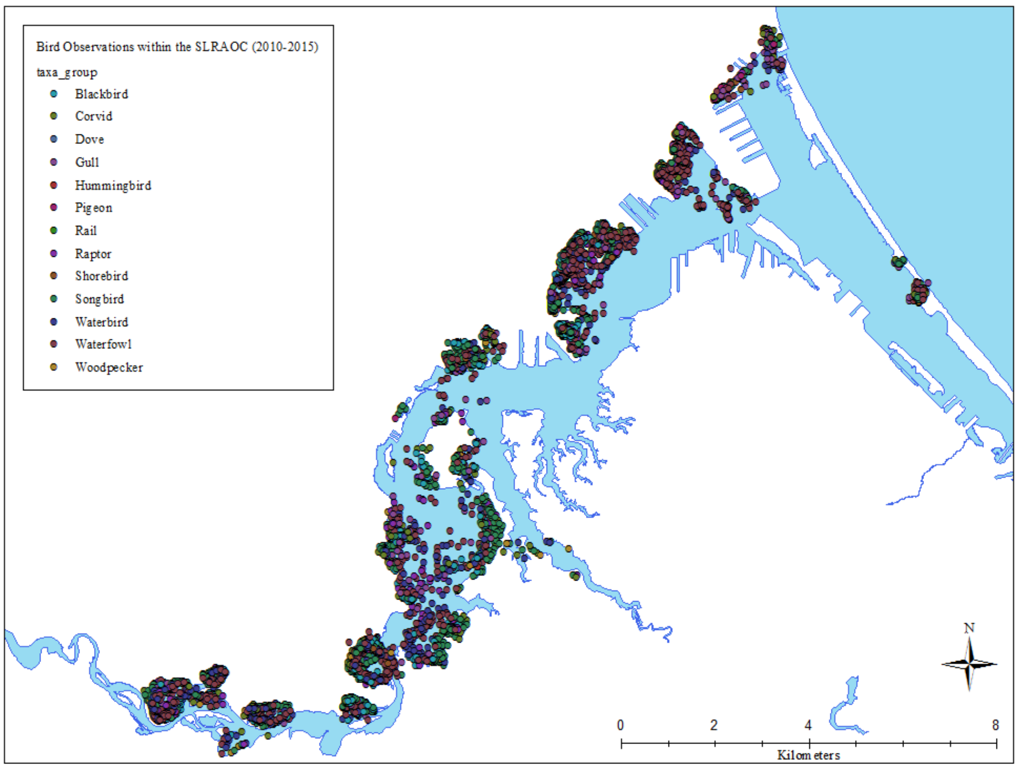


Figure 4. All bird observations digitized from aerial field sheets. Observations are based on bird groups.

Wilcoxon Rank Sum Test

Based on 11 surveys at each site, waterfowl and shorebirds were observed in R2R sites in greater abundance than reference sites. For waterfowl, there were approximately 880 individuals per R2R site (8,801 individuals/10 sites) and 288 individuals per reference site (1,438 individuals/5 sites; Table 3). Of the waterfowl species observed in R2R sites, 80% were Canada Geese and Mallards. For shorebird species, there were roughly six individuals per R2R site (61 individuals/10 sites) and two individuals per reference site (9 individuals/5 sites). The majority of the shorebird species were observed at the 40th Avenue West complex (72%). There were more waterbirds observed in reference sites than R2R sites, with roughly 67 individuals per R2R site (671 individuals/10 sites) and 386 individuals per reference site

(1,928 individuals/5 sites), the majority of which were observations of American Coot (88%). Rails and wrens were observed in low numbers and there were no differences between R2R and reference sites. There was an average of 1.6 rails per R2R site (16 individuals/10 sites) and 2.8 rails per reference site (14 individuals/5 sites) and an average of 1.5 wrens per R2R site (15 individuals/10 sites) and 0.8 wrens per reference site (4 individuals/5 sites).

Species observed in R2R sites only, included six species of shorebirds: Killdeer, Greater Yellowlegs, Dunlin, Least Sandpiper, White-rumped Sandpiper, and Semipalmated Sandpiper, most of which were observations of single individuals, five species of waterfowl: Gadwall, Northern Shoveler, Greater Scaup, Red-breasted Merganser and Ruddy Duck, and one Sedge Wren (Table 3). There were two species of waterfowl observed in reference sites only (Trumpeter Swan and Northern Pintail) and one shorebird (Pectoral Sandpiper).

Table 3. Number of water-obligate species observed in R2R and reference sites. Counts include four spring surveys, two breeding surveys, and five fall surveys from each site. Species absent from R2R or reference sites are highlighted in gray. Species with significantly different population medians between R2R and Reference sites, based on Wilcoxon rank sum test (95% CI), are highlighted in blue.

	R2R			Reference		
Species	**Mean**	**Range**	**Median**	**Mean**	**Range**	**Median**
Waterfowl						
Canada Goose	42.45	0-493	8	10.93	0-113	1
Trumpeter Swan	0	0-0	0	0.69	0-35	0
Tundra Swan	0.31	0-32	0	0.24	0-13	0
Wood Duck	0.19	0-6	0	0.09	0-3	0
Gadwall	0.05	0-2	0	0	0-0	0
American Wigeon	0.33	0-20	0	0.07	0-3	0
American Black Duck	0.17	0-7	0	0.02	0-1	0
Mallard	20.76	0-629	0.5	3.29	0-75	0
Blue-winged Teal	0.18	0-8	0	0.02	0-1	0
Northern Shoveler	0.31	0-20	0	0	0-0	0
Northern Pintail	0	0-0	0	0.18	0-10	0
Green-winged Teal	0.34	0-12	0	0.73	0-37	0
Canvasback	1.01	0-96	0	0.04	0-1	0
Redhead	3.14	0-220	0	0.45	0-12	0
Waterfowl, cont.						
Ring-necked Duck	3.02	0-179	0	1.85	0-21	0
Greater Scaup	0.07	0-8	0	0	0-0	0
Lesser Scaup	1.23	0-33	0	5.09	0-56	0
Bufflehead	1.05	0-35	0	1.53	0-20	0
Common Goldeneye	0.65	0-25	0	0.4	0-15	0
Hooded Merganser	0.42	0-14	0	0.18	0-8	0
Common Merganser	0.42	0-16	0	0.09	0-2	0

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Species	Mean	R2R Range	Median	Mean	Reference Range	Median
Waterfowl, cont.						
Red-breasted Merganser	0.18	0-7	0	0	0-0	0
Ruddy Duck	0.03	0-2	0	0	0-0	0
Horned Grebe	0.15	0-7	0	0.16	0-2	0
Waterbirds						
Common Loon	0.05	0-2	0	0.04	0-1	0
Pied-billed Grebe	0.52	0-10	0	0.36	0-7	0
Ring-necked Grebe	0.07	0-4	0	0.05	0-1	0
Double-crested Cormorant	1.99	0-50	0	2.22	0-69	0
American White Pelican	0.02	0-2	0	0.07	0-4	0
American Bittern	0.02	0-1	0	0.02	0-1	0
Great Blue Heron	0.33	0-5	0	0.04	0-1	0
Green Heron	0.03	0-1	0	0.02	0-1	0
American Coot	0.95	0-29	0	30.38	0-496	0
Common Tern	1.63	0-75	0	1.24	0-16	0
Belted Kingfisher	0.17	0-2	0	0.04	0-1	0
Shorebirds						
Killdeer	0.1	0-4	0	0	0-0	0
Spotted Sandpiper	0.32	0-10	0	0.04	0-2	0
Greater Yellowlegs	0.01	0-1	0	0	0-0	0
Dunlin	0.01	0-1	0	0	0-0	0
Least Sandpiper	0.02	0-2	0	0	0-0	0
White-rumped Sandpiper	0.01	0-1	0	0	0-0	0
Pectoral Sandpiper	0	0-0	0	0.11	0-6	0
Semipalmated Sandpiper	0.07	0-3	0	0	0-0	0
Wilson's Snipe	0.02	0-2	0	0.02	0-1	0
Rails						
Virginia Rail	0.06	0-2	0	0.05	0-1	0
Sora	0.08	0-2	0	0.15	0-2	0
Wrens						
Sedge Wren	0.11	0-3	0	0	0-0	0
Marsh Wren	0.03	0-2	0	0.07	0-2	0

Species Richness

Based on cumulative species richness (SR), there were no significant differences between R2R and reference sites when all sites were pooled. This included richness calculated for all species observations as well as for water-obligate species only (i.e., rails, waterbirds, waterfowl, and shorebirds; Fig. 5). However, comparisons of site-specific SR indicated significant differences in cumulative SR for four R2R sites: Minnesota Slip, Slip C, 40th Avenue West and Cedar Yard Bay (Fig. 6). For comparisons of water-obligate species only, five R2R sites had significant differences: Minnesota Slip, Slip C, 21th Avenue West, 40th Avenue West, and Perch Lake (Fig. 7). At sites where differences were significant, cumulative SR was higher in the reference site with the exception of 40th Avenue West, which had higher SR when all species were included as well as when only water-obligate species were included. 21st Avenue West also had significantly higher SR of water-obligate species compared to its reference site ($p \leq 0.05$).

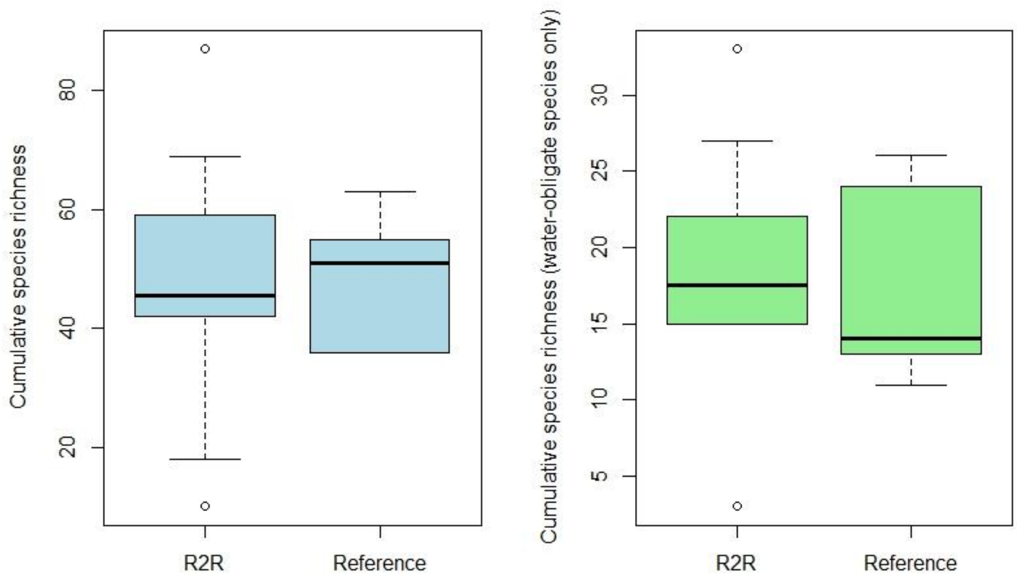

Figure 5. Cumulative species richness (SR) calculated using all species observations for R2R and reference sites (left) and for water-obligate species only (right).

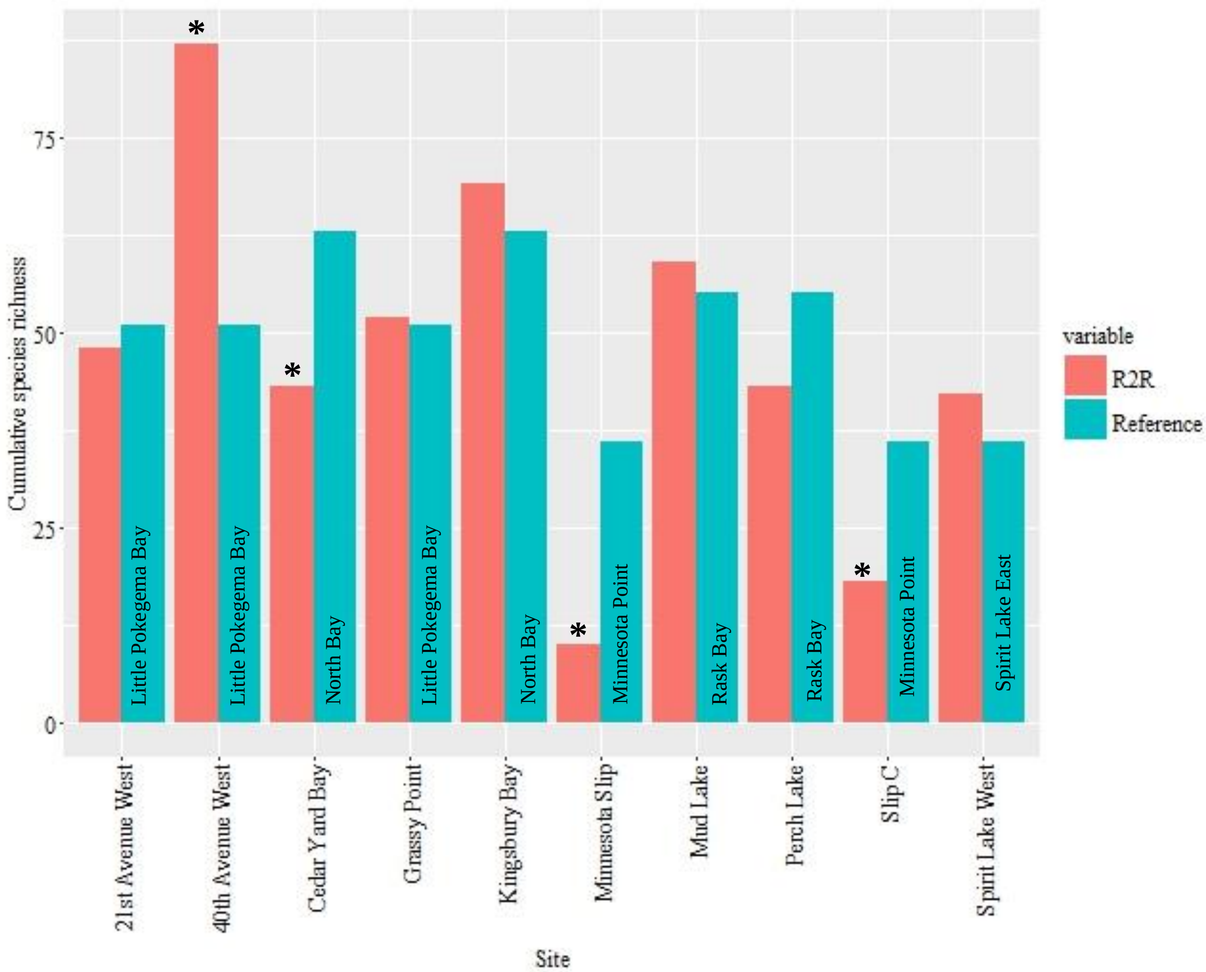

Figure 6. For each R2R site, the cumulative species richness (SR) of all species observed relative to their corresponding reference site. Asterisks represent sites where differences in SR were significant at $p \leq 0.05$.

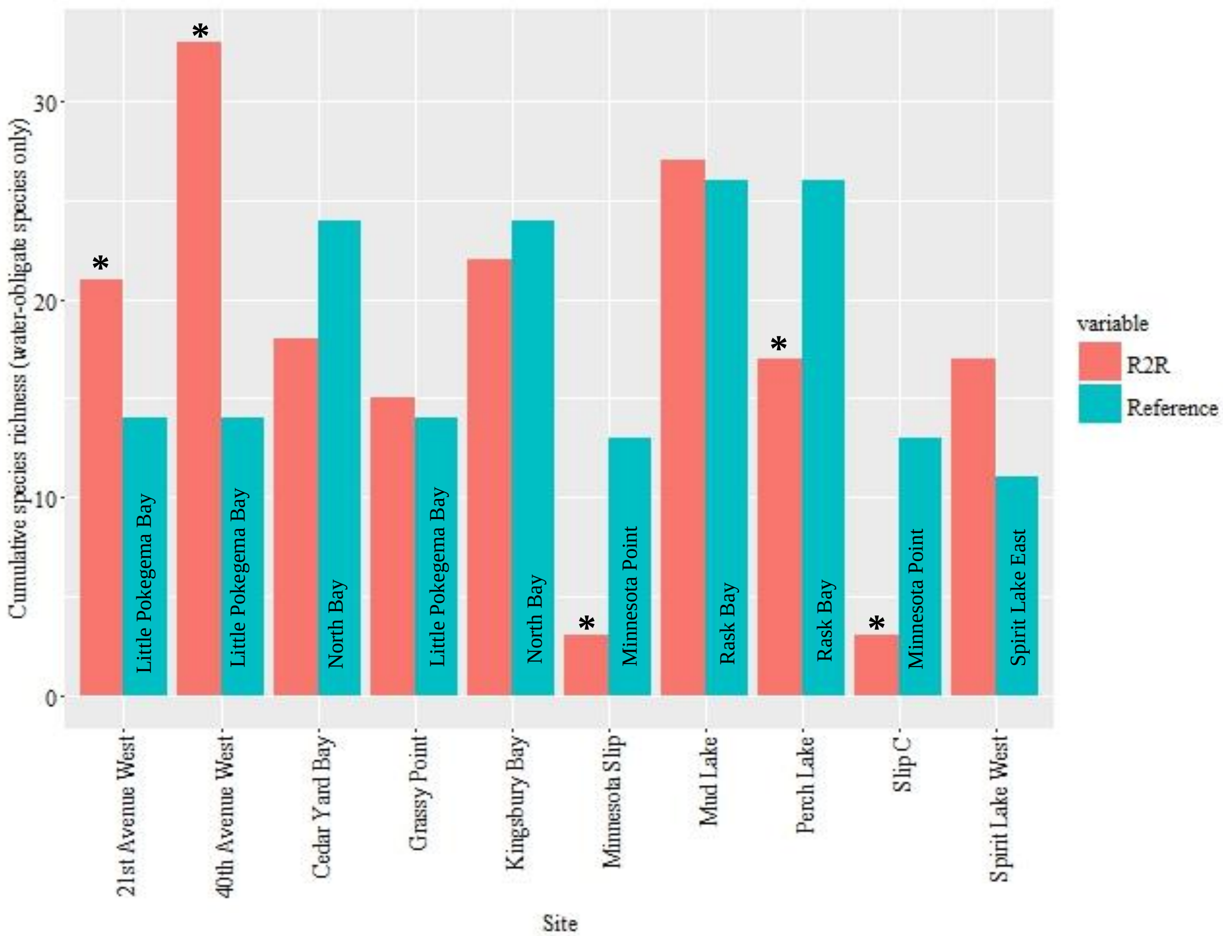

Figure 7. For each R2R site, the cumulative species richness (SR) of water-obligate species only relative to their corresponding reference site. Asterisks represent sites where differences in SR were significant at p≤0.05.

Dissimilarity

To visualize differences in water-obligate communities we first calculated dissimilarity indices using NMDS and then used hierarchal clustering based on those dissimilarity indices. These analyzes suggest that sites tend to cluster based on site type (i.e., reference or R2R). For instance, reference sites were more similar to other reference sites and R2R sites were more similar to other R2R sites (Fig. 8). There were no significant differences between R2R and reference sites based on beta diversity (Fig. 9) and the variability of species within the R2R sites completely encompassed that of the reference sites.

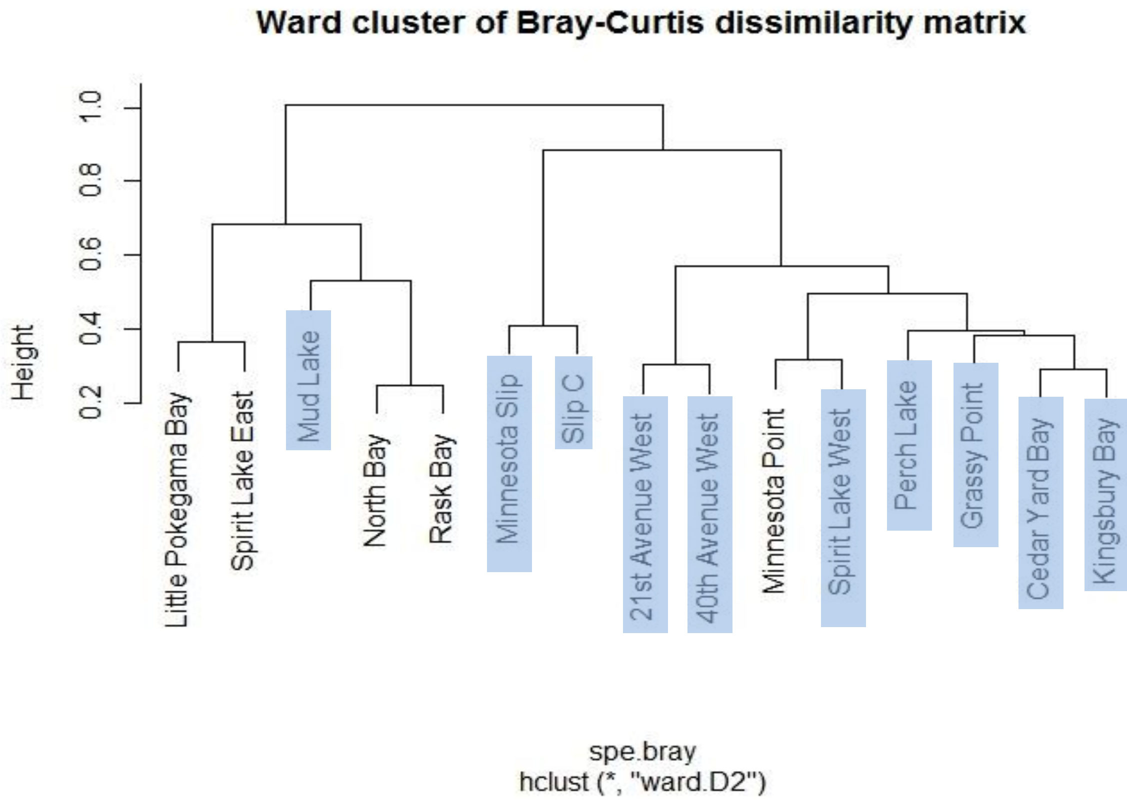

Figure 8. Cluster dendogram showing the relationship between R2R (blue) and reference sites in the St. Louis River based on a Bray-Curtis dissimilarity matrix using water-obligate species only.

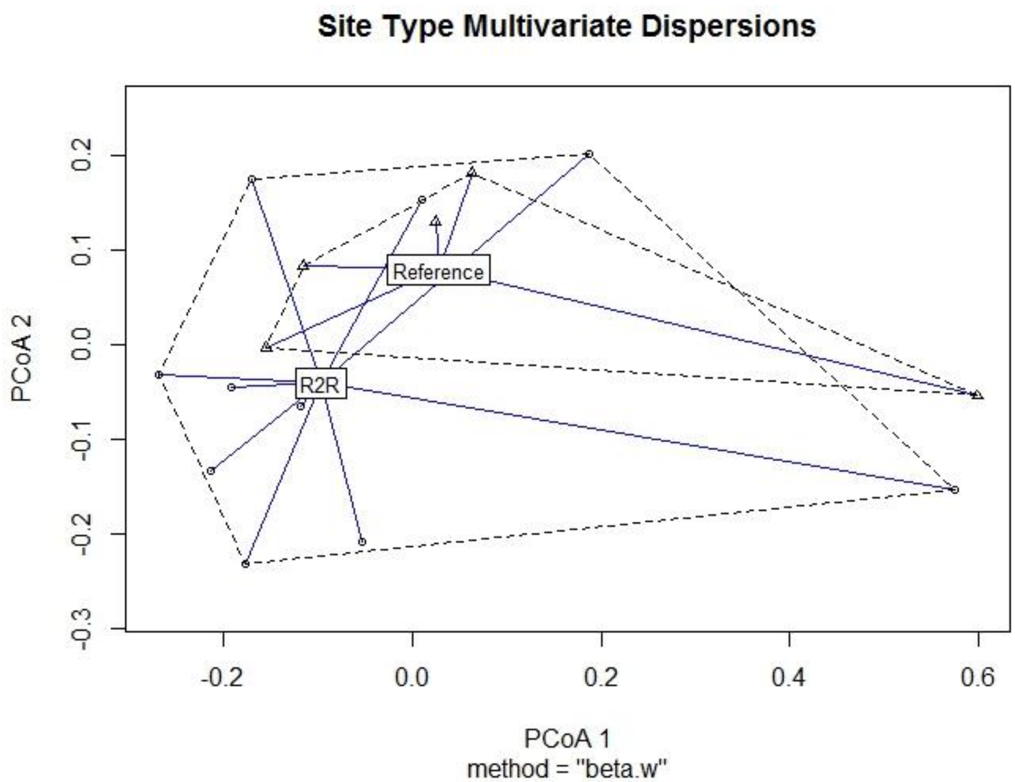

Figure 9. Measure of multivariate dispersion between site types (R2R and Reference), for water-obligate species only, for 11 surveys (4-spring, 2-breeding, and 5-fall) at 10 R2R sites and 5 Reference sites. Dispersions between groups (site type) were not significantly different.

Objective 2: Bird use in the SLR AOC a comparison of historical (1976-1979) and recent (2010-2015) data

A total 196 species were observed in the historical and recent surveys at the 10 sites sampled during both survey periods in the SLR (Appendix B). There were 16,911 individual bird observations of 133 species (historical) and 11,042 individual bird observations of 132 species (recent) included in the analysis. Of these species, 29 were observed in recent surveys only and 31 were observed in historical surveys only (Appendix D). However, many of the species unique to either historical or recent surveys were observed in small numbers (<5 individuals).

Paired t-test

For water-obligate species only, 13 were unique to the historical surveys and seven were unique to recent surveys (Table 4). For many of these species we include Breeding Bird Survey (BBS) trend estimates (1966-2013; Sauer et al. 2014) for Bird Conservation Region 12 (BCR-12) ‘Boreal Hardwood Transition’ (http://www.nabci-us.org/bcr12.html). If trends were not available for BCR-12, we list survey-wide trend estimates and denoted them with an asterisk (Table 4). Trend estimates were not available for species with breeding ranges that fall outside of the BBS survey area and were denoted with *NA*. We list BBS trend estimates for species if they are significantly increasing (+) or decreasing (-). There were no trend estimates for many of the shorebird species and some waterfowl and waterbirds due to the extent of their breeding ranges. Caveats associated with these trend estimates are provided in detail in Sauer et al. (2014) and should be considered when interpreting trends for any particular species.

Water-obligate species observed in recent counts but not in historical counts include the following: Trumpeter Swan, Canvasback, Greater Scaup, Red-breasted Merganser (-), Red-necked Grebe, American White Pelican (+), Great Egret (+*). In contrast, species found in historical surveys but not in recent surveys included American Bittern, Least Bittern, Black-crowned Night Heron (-), Black-bellied Plover, Semipalmated Plover, Killdeer (-), Solitary Sandpiper, Sanderling, Dunlin, White-rumped Sandpiper, Wilson's Phalarope, Black Tern (-) and Forster's Tern. All of these species are uncommon, rare, or very rare in the SLR and, therefore, the lack of observation of many of these species is partly due to their rarity. Observations of all species ($n \geq 10$ individuals) that were present in historical surveys but absent in recent surveys include: Black Tern (-), Purple Martin (-), and Yellow-headed Blackbird (-). In contrast, species observed in recent counts but not in historical counts included: Canvasback, Red-necked Grebe, Peregrine Falcon, Common Raven (+), and Black-and-white Warbler. Many of the species unique to the historical or recent surveys were either present in other areas of the estuary, were not included in analysis, or were observed in very low numbers.

Table 4. Species summaries for historical and recent surveys. The mean, range, and median are provided for each species within each group (*Waterfowl, Waterbirds, Shorebirds, Rails, and Wrens*). Species with significantly different population means between historical and reference sites, based on paired t-tests (*df*= 102, 95%CI), are highlighted in blue. When available, North American Breeding Bird Survey trends were provided from Sauer et al. (2014). Trends represent %change/year for the Bird Conservation Region 12 (BCR-12), the northern Great Lakes region of North America. When trend estimates were not available for BCR-12 we used survey-wide estimates (represented by an asterisk). When trend estimates were not available for a particular species it is denoted *NA*. Trend estimates judged significant based on 95% credible intervals are indicated in (red = significant decreases) and (green = significant increases).

Species	Historical Mean	Historical Range	Historical Median	Recent Mean	Recent Range	Recent Median	BBS Trend (%/yr)
Waterfowl							
Canada Goose	1.51	0-56	0	30	0-232	10.5	17.7
Trumpeter Swan	0	0-0	0	0.06	0-6	0	*NA*
Tundra Swan	0.15	0-8	0	0.31	0-32	0	*NA*
Wood Duck	0.64	0-13	0	0.03	0-1	0	3.1
Gadwall	0.07	0-5	0	0.05	0-2	0	2.65*
American Wigeon	1.21	0-18	0	0.53	0-20	0	-2.64*
American Black Duck	0.23	0-10	0	0.23	0-4	0	-3.93
Mallard	14.89	0-110	5.5	15.47	0-135	4	0.99
Blue-winged Teal	12.41	0-254	3.5	0.35	0-13	0	-3.8
Northern Shoveler	0.07	0-4	0	0.5	0-20	0	9.1
Northern Pintail	0.35	0-12	0	0.06	0-2	0	4.41
Green-winged Teal	1.75	0-80	0	0.4	0-9	0	-1.6
Canvasback	0	0-0	0	1.11	0-96	0	0.99*
Redhead	0.08	0-3	0	3.45	0-220	0	0.86*
Ring-necked Duck	5.86	0-212	0	2.9	0-179	0	2.69
Greater Scaup	0	0-0	0	0.08	0-8	0	*NA*
Lesser Scaup	7.78	0-210	0	1.96	0-58	0	-4.46

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Species	Historical Mean	Historical Range	Historical Median	Recent Mean	Recent Range	Recent Median	BBS Trend (%/yr)
Waterfowl, cont.							
Bufflehead	0.51	0-22	0	0.92	0-35	0	2.78*
Common Goldeneye	3.77	0-180	0	0.68	0-20	0	0.86
Hooded Merganser	0.28	0-6	0	0.49	0-19	0	4.29
Common Merganser	0.65	0-27	0	0.25	0-9	0	1.75
Red-breasted Merganser	0	0-0	0	0.24	0-7	0	-7.71
Ruddy Duck	0.06	0-3	0	0.02	0-2	0	0.81*
Waterbirds							
Common Loon	0.1	0-3	0	0.01	0-1	0	1.38
Pied-billed Grebe	0.29	0-4	0	0.44	0-10	0	0.42
Horned Grebe	0.15	0-12	0	0.14	0-7	0	-1.61*
Red-necked Grebe	0	0-0	0	0.05	0-4	0	3.36
Double-crested Cormorant	0.04	0-3	0	0.55	0-7	0	11.03
American White Pelican	0	0-0	0	0.19	0-17	0	9.08
American Bittern	0.04	0-1	0	0	0-0	0	-0.47
Least Bittern	0.03	0-2	0	0	0-0	0	7.57
Great Blue Heron	0.73	0-6	0	0.32	0-4	0	-1.73
Great Egret	0	0-0	0	0.03	0-1	0	2.11*
Green Heron	0.1	0-5	0	0.03	0-2	0	0.31
Black-crowned Night-Heron	0.02	0-1	0	0	0-0	0	-13.52
American Coot	26.65	0-318	0	1.05	0-29	0	-4.88
Black Tern	0.51	0-18	0	0	0-0	0	-3.58
Common Tern	0.66	0-17	0	0.36	0-11	0	0.09
Forster's Tern	0.02	0-2	0	0	0-0	0	-6.1
Belted Kingfisher	0.32	0-8	0	0.23	0-2	0	-1.57
Shorebirds							
Black-bellied Plover	0.2	0-8	0	0	0-0	0	*NA*
American Golden-Plover	0.19	0-9	0	0.01	0-1	0	*NA*
Semipalmated Plover	0.15	0-6	0	0	0-0	0	*NA*
Killdeer	2.39	0-28	0	0	0-0	0	-4.05
Spotted Sandpiper	0.73	0-14	0	0.25	0-5	0	-4.99
Solitary Sandpiper	0.02	0-2	0	0	0-0	0	-11.55
Lesser Yellowlegs	0.26	0-9	0	0.06	0-3	0	-4.76*
Stilt Sandpiper	0.02	0-2	0	0.01	0-1	0	*NA*
Sanderling	0.02	0-1	0	0	0-0	0	*NA*
Dunlin	0.35	0-20	0	0	0-0	0	*NA*
Least Sandpiper	0.09	0-4	0	0.03	0-1	0	*NA*
White-rumped Sandpiper	0.02	0-2	0	0	0-0	0	*NA*
Pectoral Sandpiper	0.21	0-3	0	0.02	0-1	0	*NA*
Semipalmated Sandpiper	2.77	0-120	0	0.03	0-3	0	*NA*
Wilson's snipe	0.34	0-13	0	0.02	0-2	0	-1.43
Wilson's Phalarope	0.15	0-15	0	0	0-0	0	*NA*
Rails							
Virginia Rail	0.06	0-3	0	0.03	0-1	0	0.13
Sora	0.11	0-2	0	0.06	0-2	0	-2.94
Wrens							
Sedge Wren	0.04	0-3	0	0.04	0-3	0	0.61
Marsh Wren	0.49	0-41	0	0.01	0-1	0	-3.35

Species Richness

Based on cumulative SR, there were no significant differences between historical and recent surveys when all sites were pooled. This included richness measured for all species observations as well as for water-obligate species only (Fig. 10). However, comparisons of site specific SR indicated significant differences in cumulative SR for three sites: 20th Avenue West, 27th Avenue West, and Spirit Lake West (Fig. 11). For comparisons of water-obligate species, four sites had significant differences: 20th Avenue West, 27th Avenue West, 40th Avenue West, and Spirit Lake West (Fig. 12). At each of these sites, with the exception of 40th Avenue West, cumulative SR was greater in historical surveys ($p \leq 0.05$).

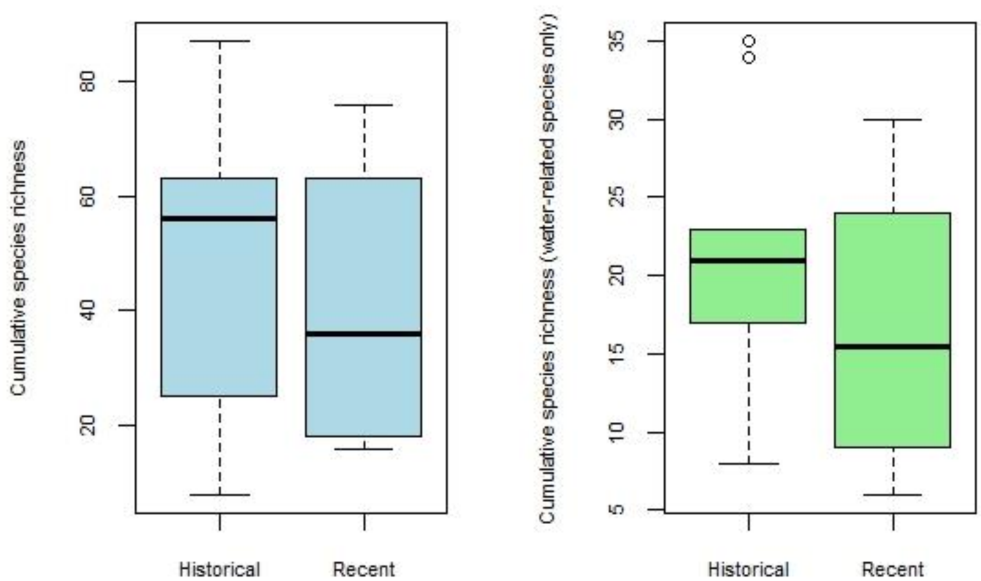

Figure 10. Cumulative species richness (SR) calculated using all species observations for historical and recent surveys (left) and for water-obligate species only (right).

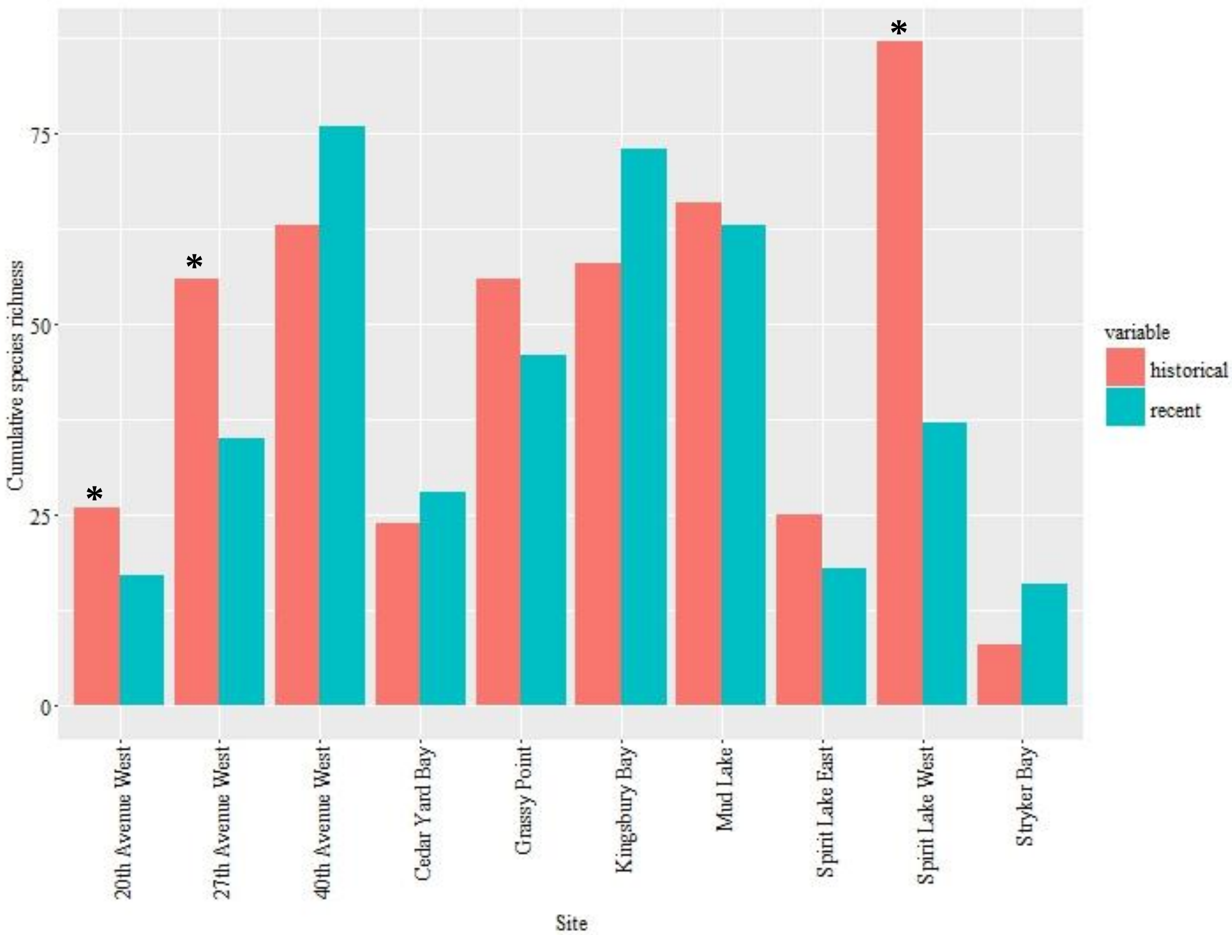

Figure 11. Cumulative species richness (SR) of all species by site. Asterisks represent sites where differences in historical versus recent SR was significant at $p \leq 0.05$.

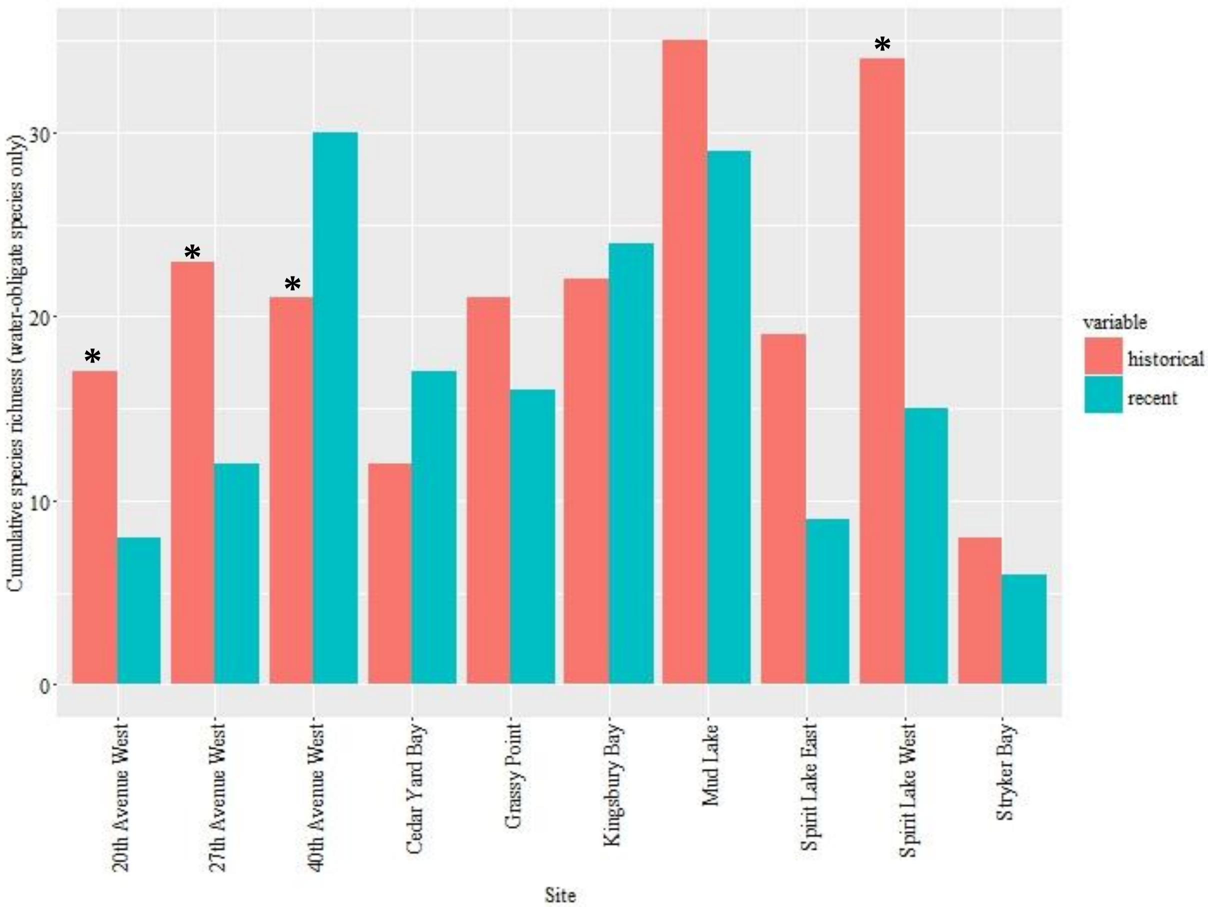

Figure 12. Cumulative species richness (SR) of water-obligate species by site. Asterisks represent sites where differences in SR were significant at $p \leq 0.05$.

Dissimilarity

As with comparisons of R2R and reference sites, we also calculated dissimilarity indices using NMDS and then used hierarchal clustering based on those dissimilarity indices. These results showed sites clustering primarily based on time period (historical vs. recent), which resulted in historical sites being more similar to other historical sites and recent sites being more similar to other recent sites (Fig. 13). In contrast with comparisons in R2R and reference sites, recent and historical sites did not overlap as extensively, primarily because of differences in several bird communities, with significant temporal difference in group heterogeneity based on beta diversity (F=5.1153, p=0.001; Fig. 13).

The cumulative impact of the five most influential water-obligate species, contributing to differences between the historical and recent surveys were the following, in order of highest to lowest contribution: Canada Goose (CANG; 0.29), American Coot (AMCO; 0.42), Mallard (MALL; 0.55), Blue-winged Teal (BWTE; 0.65), and Lesser Scaup (LESC; 0.72). These species accounted for ~72% of the explained dissimilarity (Figure 15). When comparing the site-specific influence for species, the top three influential species varied by location (Figure 16). At 20th Avenue West, Canada Goose, American Coot, and Mallard accounted for ~60% the dissimilarity, whereas for 27th Avenue and 40th Avenue West it was

~45%, Cedar Yard Bay - ~31%, Grassy Point -~38%, Kingsbury Bay - ~34%, Mud Lake -~34%, Spirit Lake East -~54%, Spirit Lake West-~63%, and Stryker Bay -~27%. Based on BBS trends (1966-2013) in BCR-12, Canada Geese have increased significantly and Blue-winged Teal have declined significantly (Sauer et al. 2014; Table 4). BBS trends for other species such as Mallard, American Coot, and Lesser Scaup were not significant (Sauer et al. 2014; Table 4).

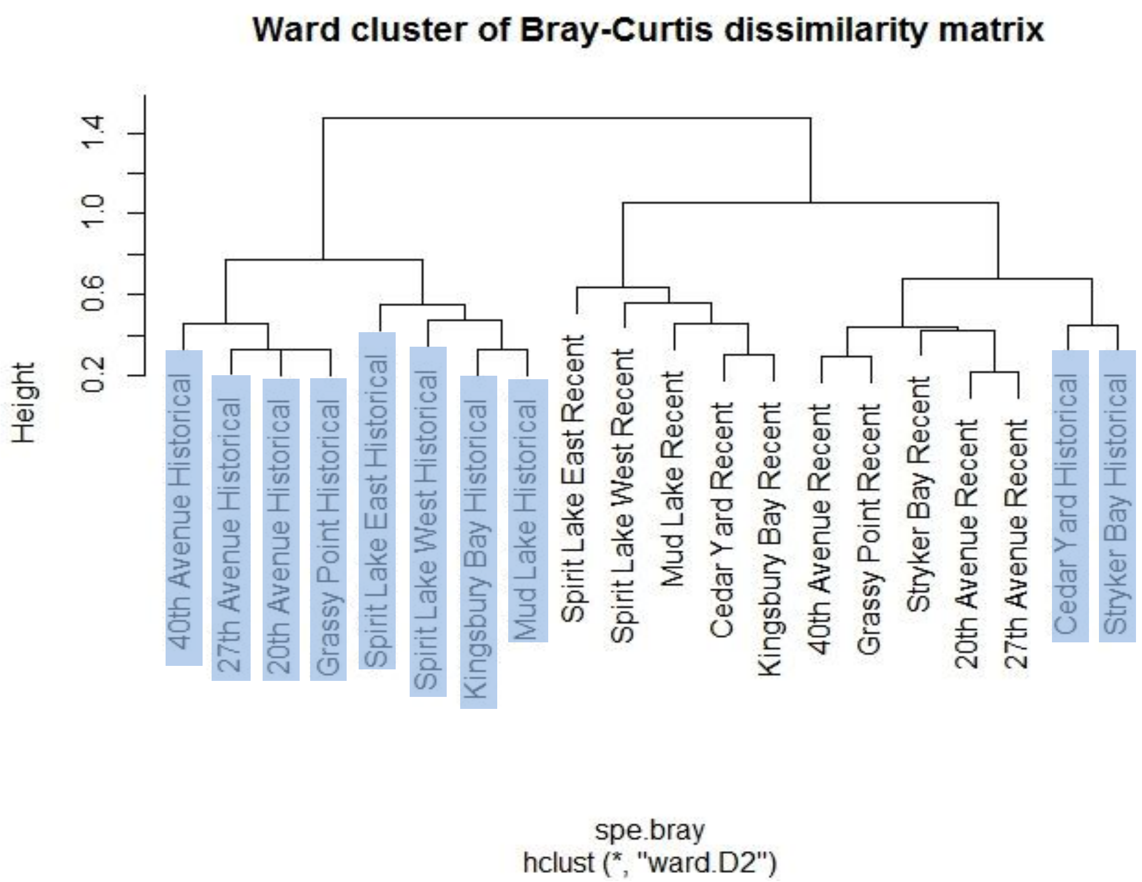

Figure 13. Cluster dendogram showing the relationship between historical (blue) and recent surveys at 10 sites located in the St. Louis River based on a Bray-Curtis dissimilarity matrix using water-obligate species only.

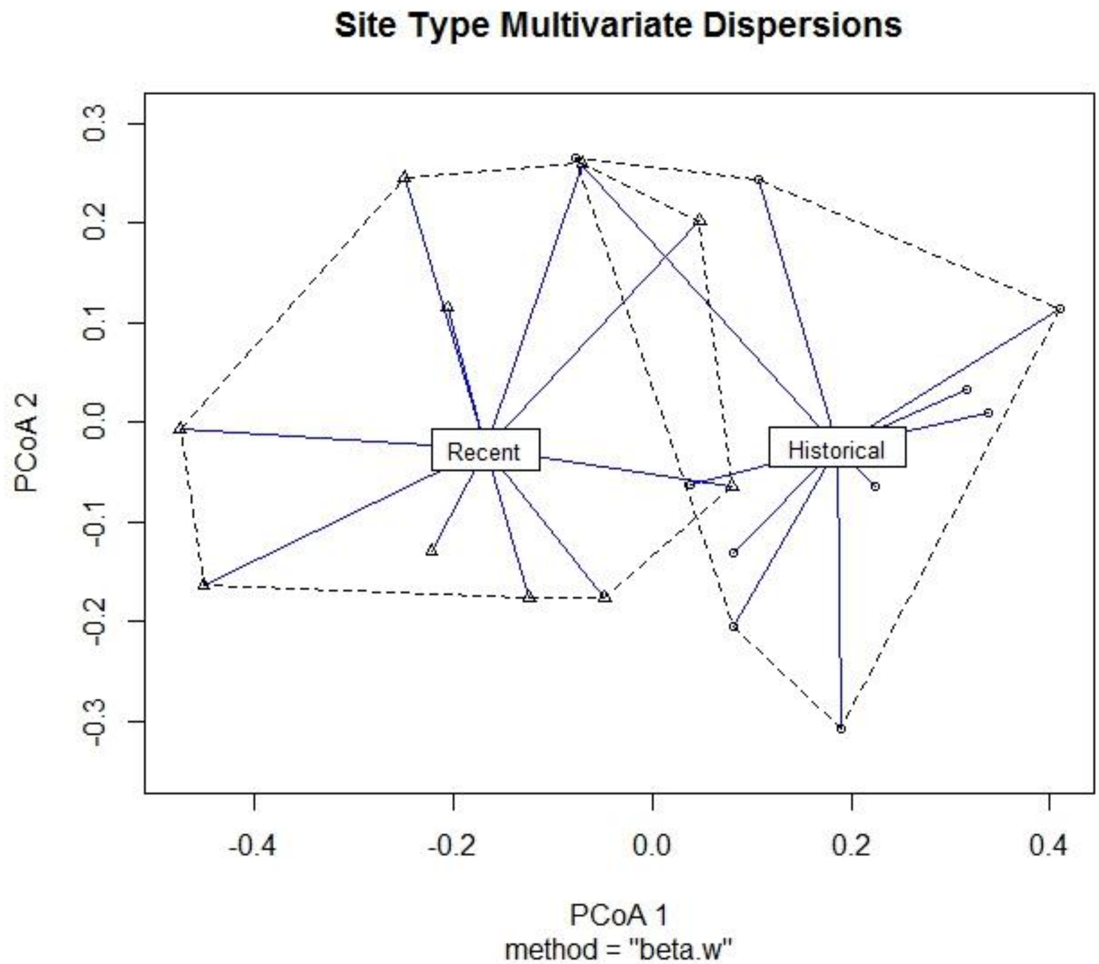

Figure 14. Measure of multivariate dispersion between site types (historical and recent) for water-obligate species only for 10 Recent and Historical sites. Dispersions between groups (site type) were significantly different at p = 0.001.

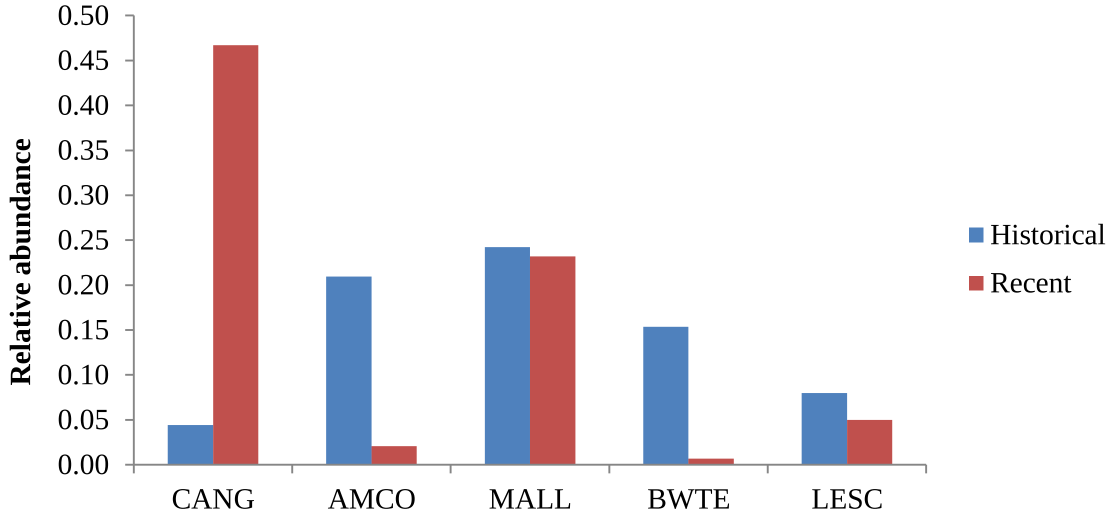

Figure 15. Relative abundance of the five most influential water-obligate species: Canada Goose (CANG), American Coot (AMCO), Mallard (Mall), Blue-winged Teal (BWTE) and Lesser Scaup (LESC). These species collectively account for ~72% of the explained dissimilarity between historical and recent surveys.

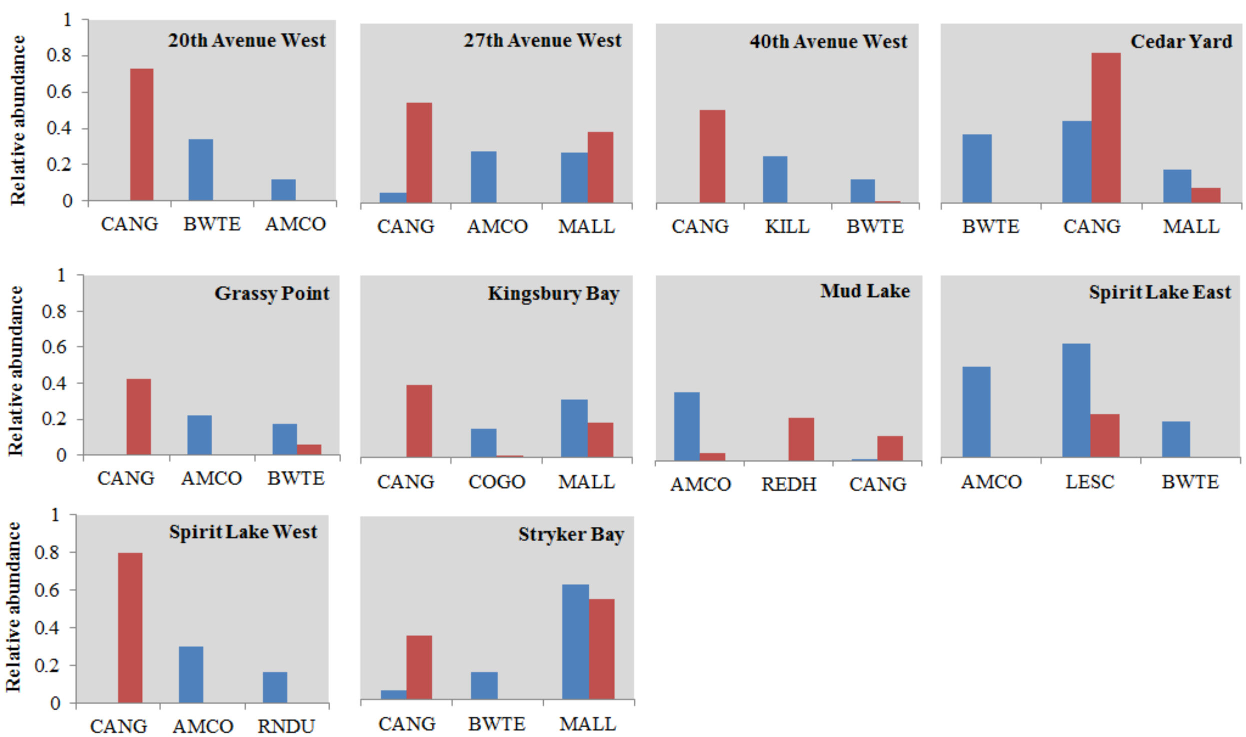

Figure 16. Relative abundance of the three most influential water-obligate species at each of the 10 sites based on Bray-Curtis dissimilarity. Species include Canada Goose (CANG), Blue-winged Teal (BWTE), American Coot (AMCO), Mallard (MALL), Killdeer (KILL), Common Goldeneye (COGO), Redhead (REDH), and Lesser Scaup (LESC). Blue bars represent historical surveys and red bars represent recent surveys.

Discussion

There are many reasons a species may be present or absent from a given location and although changes or differences in species composition can be quantified, they are not always easy to interpret (Philippi et al. 1998). The presence of a species at a given site or set of sites implies these locations provide a similar set of conditions which allows a species to exist and potentially persist (Borcard et al. 2011). However, if a species is absent, it is difficult or impossible to discern why it is not present. There are many reasons why a species may be absent or undetected including 1) poor site condition, 2) lack of detection, in which the species was present but not observed, and 3) factors outside the sampled area such as an overall declining population and a retraction of the species range.

Objective 1

Although there were not significant differences in overall species richness or species composition between R2R and reference sites, there were some notable, and significant, differences in the species found in individual R2R sites within the estuary relative to reference sites. For example, there were nearly 13 times as many Canada Geese and Mallards observed in R2R sites compared to reference sites. However, there were overall larger numbers of waterfowl and shorebirds observed in R2R sites, many of which were located in areas where shorelines and water depths have been manipulated by human activity For instance, at 40th Avenue West these changes have resulted in varied shoreline types and differences in bathymetry related to dredging of shipping canals and removal of vegetation and trees from the shoreline. These human disturbances have created different types of available habitat. For example, habitat suitability for diving ducks is species dependent, with some preferring shallower areas such as Redheads and others preferring greater depths such as Lesser Scaup. Many of the reference sites in the estuary were chosen, in part, because they were considered less disturbed by humans and therefore, tended to be in shallower, more protected areas, often with heavily vegetated shorelines. Therefore, shorebirds that prefer unvegetated shorelines and waterfowl that use deep water were less abundant in reference sites.

Based on cumulative SR of reference and R2R sites, Minnesota Slip and Slip C had lower SR relative to Minnesota Point likely because neither of these sites have a natural shoreline, plus human activity is very intense. Shorelines consist of cement shipping channels and most species were those associated with built environments such as Ring-billed Gull, Rock Pigeon, and House Sparrow. Cedar Yard Bay also had lower overall species richness relative to North Bay but still had relatively high SR relative to other R2R sites and was actively undergoing restoration activities during the survey period. Perch Lake had lower water-obligate species richness than Rask Bay, this may have been due to the more extensively vegetated shoreline and sheltered inlet at North Bay. The 21st Avenue West and 40th Avenue West sites both had higher SR than Little Pokegema Bay. These two sites are located in heavily industrialized areas of the SLR but despite being close to the city, are relatively isolated. Portions of their shorelines are sandy while others are vegetated. These factors may be associated with the high species diversity observed at these sites particularly during migration. Comparing R2R and reference sites based on dissimilarity indices suggested that although sites tended to cluster based on site type and in space, overall there were no significant differences in beta diversity among sites.

Objective 2

Interpretation of the historical surveys and recent surveys of the same area requires consideration of how populations of bird species have changed over the past 30 years independent of the changes that have occurred in the SLR. Many waterfowl and shorebird species were still common and widespread in the region and across North America. Overall waterfowl populations have increased over the past five decades (NABCI 2016), while some have changed substantially – both increasing and decreasing. In contrast to many areas of North America which have continued to see reductions in water quality and expansion of agriculture and human populations, the SLR has improved in water quality with the addition of WLSSD and agriculture is a negligible issue in the region. In addition, DDT was banned in the early 1970s and overall contaminant levels have declined.

Waterfowl. A total of 4 of 23 waterfowl species that were compared with paired t-tests of historical and recent surveys indicated one species, Canada Goose, was more abundant in recent surveys. Three species, Wood Duck, Blue-winged Teal, and Northern Pintail were more abundant in historical surveys than presently. Both Wood Duck, and Northern Pintail, were less abundant despite both species having increased regional populations from 1966 to 2013. These increased trends were only significant for the Wood Duck. Reduced populations of Blue-winged Teal in recent surveys are consistent with reductions in regional populations for this species. Overall, there is little basis to state that waterfowl populations have changed considerably in the SLR, except there clearly has been a massive increase in the Canada Goose population over the past 40 + years. The effect of this population increase on other species of waterfowl is unclear.

Waterbirds. Six of 17 species of waterbirds had significant differences in paired t-tests between historical and recent surveys. Five of the six species had consistent differences between the two periods that were also consistent with their regional population trends. Double-crested Cormorants have increased significantly over the past 40+ years, while the Great Blue Heron, American Bittern, American Coot, and Black Tern have all declined; though only significantly for the Great Blue Heron and Black Tern. The anomaly includes the fewer observations of the Common Loon in recent surveys compared with historical counts, despite significant increases in regional populations of the Common Loon. However, the number of observations of the Common Loon in the SLR is very small and provides limited emphasis on the overall interpretation of changes in the SLR. The rarity of the American Bittern in the SLR also must be considered cautiously. Reductions in the Great Blue Heron may be associated with changes in the location of their colony site. During the historical surveys, this species nested near Kimball's Bay, but its colony site no longer exists in close proximity to the SLR. We are unaware of the current location of the colony site. Presumably, its greater travel distance from its colony site has had some influence on its presence in the SLR. As with the waterfowl, there is no strong basis for major changes in the waterbird community in the SLR, except for the substantial increase in Double-crested Cormorants.

Shorebirds. Six of 16 species of shorebirds compared between historical and recent surveys were different and all indicated significantly fewer observations of shorebirds in the recent period. Three of the six species with fewer observations, Killdeer, Spotted Sandpiper, and Wilson's Snipe, were consistent with significant regional population declines. The fewer observations of Black-bellied Plover, Pectoral Sandpiper, and Semipalmated Sandpiper in recent surveys have no support from regional populations because none of these species nest in the continental U.S. They only occur in the SLR as migrants and all nest in the northern tundra. The overall lack of use by shorebirds in the SLR is a concern and is deserving of further study. It is unclear whether suitable breeding or stopover habitat is an issue in the SLR for shorebirds compared with the past.

Rails and Wrens. There were no significant differences in historical or recent surveys for the two rail species that were most common in the SLR or for the two wren species that have been identified at the state level or nationally as species of concern.

Species Richness and Composition. Based on cumulative SR of historical versus recent surveys, 20^{th} Avenue West, 40^{th} Avenue West, and Spirit Lake West had significantly higher SR in historical surveys than in recent surveys. This was also true for 27^{th} Avenue West, when only water-obligate species were included. These areas have undergone considerable changes in industrial activity over the past 30+ years. WLSSD in the 20^{th} to 27^{th} Avenue West area was being developed during the late 1970s and has considerably expanded its operation since the 1970s. Similarly, considerable changes have occurred in the 40^{th} Avenue West region at Erie Pier and the addition of the Bong Bridge. The piling of dredge material at Erie Pier had not begun in the late 1970s and construction of the Bong Bridge was initiated in 1982 and finished in 1985. All of these changes may have had considerable influence on the bird use of these areas.

It is not unusual for dissimilarity in species composition to increase with temporal separation (Philippi et al. 1998), which was the case with the historical and recent comparisons of species composition. In contrast to comparisons of R2R and reference sites, recent and historical surveys did not overlap as extensively, primarily because of differences in several bird species. The primary species associated with these differences included Canada Goose, whose presence throughout the estuary has increased immensely since the 1970s. Note that the Canada Goose population has increased by almost 18 %/yr in BCR-12 from 1966 to 2013. In contrast, American Coot was present in several locations within the estuary in historical surveys but absent from these areas in recent surveys. However, the species was still present in large numbers throughout the estuary in sites that were not included in these analyses (e.g., Rask Bay). Mallards remain an abundant species in the SLR but showed considerable variability among sites during both time periods. Overall differences between the two time periods appear to be minimal.

Individual Species Accounts

Piping Plover

Commercial hunting for feathers in the 19th century decimated the North American Piping Plover population. With the signing of the Migratory Bird Treaty Act in 1918 their population began to recover and the Great Lakes population was estimated to be as high as 802 breeding pairs in the 1930s (Russell 1983, Hyde 1999, Haig and Elliott-Smith 2004). This regional population began to decline again in the late 1970s and reached a low of only 17-19 nesting pairs in 1982 (Russell 1983). The Great Lakes population of Piping Plover was listed as federally endangered in 1985 (USFWS 2003).

The Piping Plover was first documented in the St. Louis River Estuary in 1936 when a few birds were found on Minnesota Point (Russell 1983, Price and Cuthbert 2002). Until the 1980s, the Duluth-Superior area had annually seen small numbers of nesting plovers. An average of five nesting pairs was common throughout the 1970s (Russell 1983) with a high of six pairs in 1977 (Davis et al. 1978, Niemi and Davis 1979b; Fig.17). This population steadily dwindled to 3 pairs in 1985, none of which successfully hatched young (Guertin and Pfannmuller 1985). The first year that Piping Plover were not observed nesting in the estuary was 1986 (Davis 1986).

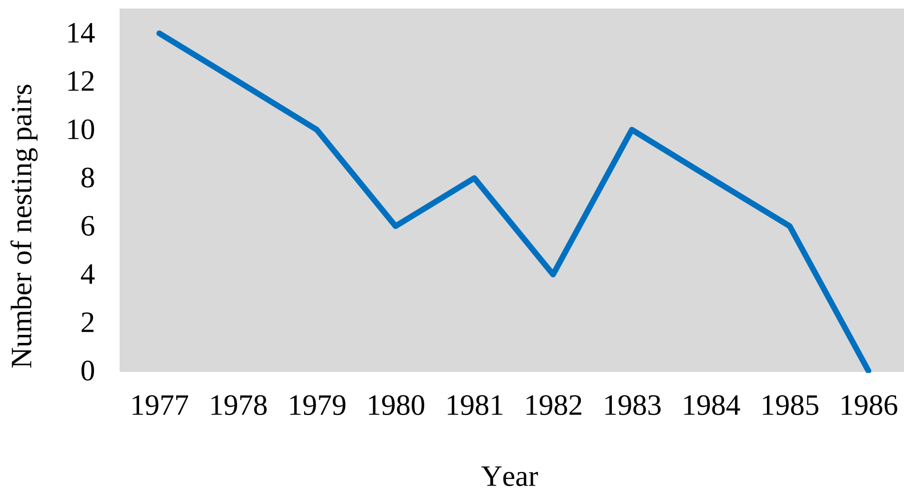

Figure 17. Summary of recent Piping Plover populations in the St. Louis River Estuary from 1977-1986. No nesting has been observed since 1986; though individuals have been regularly observed during migration since 1986 (Data from Guertin and Pfannmuller 1985).

Since 1986 there have been periodic observations of Piping Plovers in the estuary. For instance, according to eBird (http://ebird.org/content/ebird/), an on-line system for recording bird observations, the species has been observed every year for the last 10 years, except in 2011. Most observations are of a single bird, but occasionally two have been sighted. Locations of the observations were generally along the beach on Minnesota Point, Wisconsin Point, Hearding Island, or at Erie Pier. These data suggest that Piping Plovers are still returning to areas where nesting has been documented in the past.

Some of the factors that have contributed to the decline of the Piping Plover in the Great Lakes Region are habitat loss to development, disturbances from recreational activities, predation, and high lake water levels (Russell 1983). The Great Lakes shoreline experienced intense commercial and residential development during the post-World War II period. With new businesses, marinas, and homes being built wetlands were filled and erosion control methods were employed in areas that were prone to shifting shorelines. Additionally, recreational activities that accompany shoreline development such as frequent foot traffic, off-road vehicles, and fireworks may startle birds from their nests, endangering eggs and chicks at crucial stages of their development (USFWS 2003). There were also increased disturbance and predation by dogs, cats, and other predators such as skunks, raccoons, fox, and crows (USFWS 2003). High water levels also reduce suitable nesting habitat and increases nest vulnerability to wave action. The dramatic increase in the Ring-billed Gull population nesting throughout the Great Lakes has also contributed to further loss of habitat as well as increased risk of predation (Hyde 1999, Haig and Elliott-Smith 2004, Haig et al. 2005).

Successful recovery efforts in Michigan have led to the only sizable population in the Great Lakes region with 90 individuals reported in the most recent 2011 International Piping Plover Census (Elliot-Smith et al. 2011). This population has seen some fluctuations but has remained relatively stable through conservation efforts by the U.S. Fish and Wildlife Service (USFWS) in coordination with researchers who had developed strategies to improve fledging survival. The USFWS implemented nest patrolling in 1994 with volunteers monitoring known nests over holiday weekends. This program expanded to include other departments in Michigan and eventually expanded to the Apostle Islands area of Wisconsin. Currently all known nests are surrounded with an exclosure made of wire fencing and monofilament line to reduce disturbance and predation. In areas with frequent foot traffic, a 30 m buffer is placed around nest sites with signs to deter people from entering the area. A program has also been implemented to salvage eggs from abandoned nests to hatch and raise chicks in captivity. This program has been successful with a fledge rate of 90% compared to 25-76% in wild raised chicks (Hyde 1999, USFWS 2015).

Similar conservation efforts are being carried out by the St. Louis River Alliance's Piping Plover Monitoring Project over the past five years. This program trains volunteers to search area beaches for Piping Plover and inform beachgoers of the hazards these birds face from recreational activities and dogs running loose on the beach. The Alliance has also obtained permission from Douglas County to close Lakeshore Road leading to Shafer Beach on Wisconsin Point in an effort to minimize beach traffic. In May 2015 two birds were observed at the Park Point Recreation Area beach. Actions were immediately taken to close that area of the beach in an attempt to encourage the birds to nest but the birds did not stay in the area. If Piping Plovers do begin nesting in the area, the USFWS has plans to construct exclosures, close the beach, and potentially provide 24-hour surveillance to protect the nest site from intrusion or predation.

A Piping Plover habitat and recovery assessment for the St. Louis River Estuary was conducted in 2002 by Price and Cuthbert (2002). For the Great Lakes Piping Plover population to recover birds need to recolonize or colonize historic or new habitat. Eight sites in the Duluth-Superior Harbor were originally identified as having good potential (Wemmer et al. 2001, Price and Cuthbert 2002). Of these eight sites, Minnesota Point was considered the most suitable based on biophysical beach characteristics. The other seven sites were deemed unsuitable in their current condition due to human disturbance, development, heavy vegetation, narrow beaches, or large numbers of nesting gulls (Price and Cuthbert 2002). However, recommendations for restoration activities at each of these sites are provided in the document and should be used as a reference for any potential Piping Plover restoration projects in the SLR.

Attracting Piping Plovers to the SLR will remain a challenging task, but attraction of birds and protection of nest sites is essential. We believe that the main concerns for this species in the SLR are the availability of suitable, undisturbed sandy-cobble beach habitat, plus the low population levels of this species in the western Great Lakes region which restricts the availability of suitable colonizers. The two closest nesting areas for this species in the region include a small population in Ashland, Wisconsin and a small population on islands in Lake of the Woods, northern Minnesota. The latter population was recently confirmed as the only known population in Minnesota during the recent Minnesota breeding bird atlas project (2009-2013). In summary, the availability of suitable physical habitat is still a factor in restricting the re-establishment of this population in the SLR.

Common Tern

The number of Common Terns nesting in Minnesota was estimated at 2,000 pairs in the 1930s which at that time was still recovering from being hunted for the millinery trade in the late 1800s. By the 1970s the number of nesting pairs was again in decline and by 1984 only 880 pairs remained in the state (Pfannmuller 2014b). In Minnesota, Common Terns currently nest on four major sites including Mille Lacs Lake, Leech Lake, Lake of the Woods, and the St. Louis River Estuary (Pfannmuller 2014b).

Common Terns were first documented in the SLR when a breeding pair was discovered at the Sky Harbor Airport in 1937 (Engstrom 1940, Davis and Niemi 1980, McKearnan 1986). For about 50 years the tern population in this area continued to increase but then experienced a rapid decline in the 1980s (Penning 1993, Fig. 18). During the intensive study period by Niemi et al. (1979a), Common Terns were found nesting at four sites in the Duluth-Superior Harbor (number of breeding adults 1977-1979): Sky Harbor Airport (14-18), Port Terminal (296-370), Hibbard Power Plant (6-10), and Grassy Point Islands (22-40) (Davis and Niemi 1980). In the early 1980s Interstate Island was cleared of trees and the Port Terminal was being developed for increased shipping activity. Common Terns began to establish a colony on Interstate Island, an 8-acre dredge spoil island situated in the Duluth-Superior Harbor, in 1985 when 50 pairs were documented as nesting on the island. At that time Ring-billed Gulls were nesting in three main locations in the estuary: the Minnesota Power and Light Hibbard Plant, the Duluth Port Terminal, and very nearby at the Peavey Globe Elevator. By 1990, Ring-billed Gulls had begun nesting on Interstate Island when 572 nesting pairs were recorded (Penning 1993).

Common Terns nesting on Interstate Island. Photo credit: K. Rewinkel

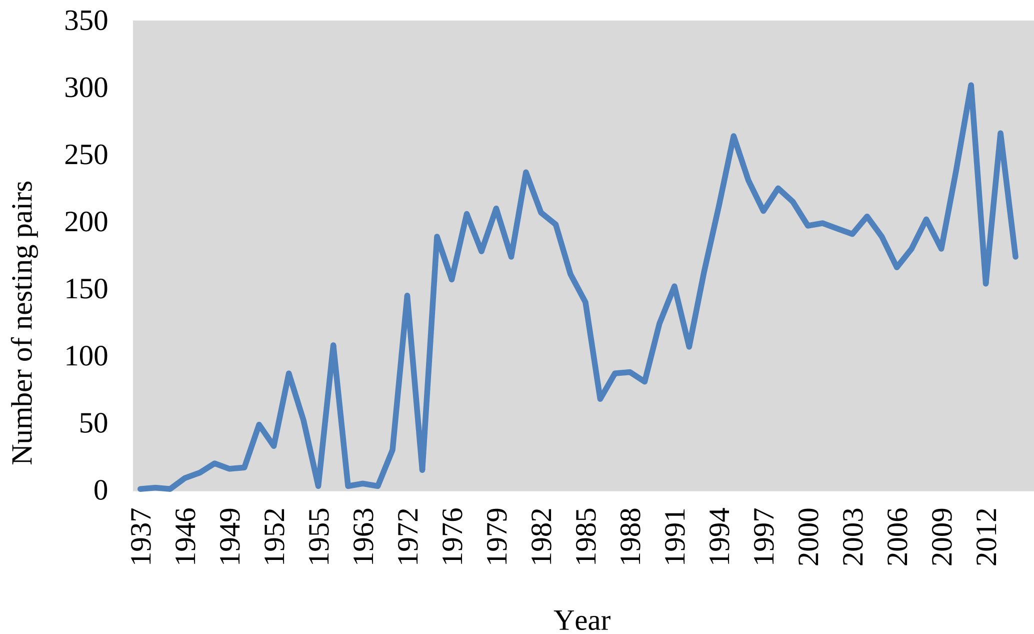

Figure 18. Estimated number of pairs of Common Terns nesting in the St. Louis River Estuary (1937-2015). Estimates from 1937-1984 from Penning (1993). Estimates from 1985-2015 for Interstate Island (data provided by F. Strand (WDNR)).

A number of factors, such as predation, human disturbance, and competition with Ring-billed Gulls for nesting habitat have contributed to their decline (Cuthbert et al. 2003, Pfannmuller 2014b). The rapidly increasing population of Ring-billed Gulls drastically reduced available breeding habitat for Common Terns (Fig. 19). Ring-billed Gulls arrive and begin nesting 2-4 weeks earlier in the spring than Common Terns and have effectively eliminated terns from many of their established colonies. (Courtney and Blokpoel 1980, Pfannmuller 2014b).

Great Horned Owls are also a major threat and have been known to cause frequent disturbances to Common Tern colonies. When adult terns temporarily abandon their nests in response to the threat of owl predation, unsheltered eggs and chicks become vulnerable to cooler nighttime temperatures and other predators such as raccoons, fox, rats, and other birds (Erwin et al. 2001,Wires and Cuthbert 2001). Total nest failure at Interstate Island was caused by a Great Horned Owl in 1985 and a history of owl predation has been documented at other sites in the St. Louis River Estuary (Penning 1993). Fluctuating water levels can also cause problems for colonies of nesting terns. Rising water levels reduce suitable nesting area along shorelines by erosion and can destroy nests in low lying areas during storms, whereas falling water levels can create land bridges to island colonies, which allow for increased access by mammalian predators and encroachment of vegetation (Wire and Cuthbert 2001). Terns on Interstate Island may be disturbed by human activity in the estuary as there is frequent boating and shipping traffic in the area due to the island's proximity to the shipping channel. This type of disturbance could cause the birds to abandon their chick and eggs at crucial times in their development leaving them prone to exposure and predation (Courtney and Blokpoel 1983).

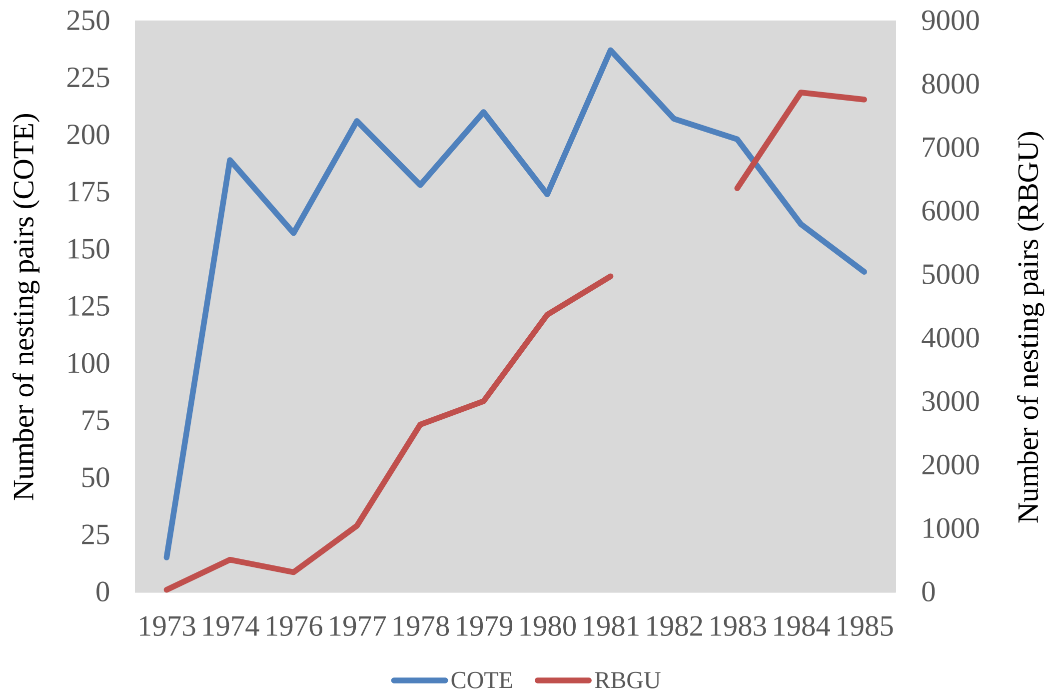

Figure 19. Total number of nesting pairs of Common Terns (COTE) and Ring-billed Gulls (RBGU) in the St. Louis River Estuary (1973-1985). Data from Penning (1993).

Most large Common Tern breeding colonies in the Great Lakes region require continuous management to sustain colony numbers (Cuthbert et al. 2003, Wires et al. 2010, Morris et al. 2012). Management techniques have included habitat restoration and protection, predator control, use of exclosures, and construction of artificial nesting structures (Jones and Kress 2011). Because the Common Tern is listed as threatened in Minnesota and endangered in Wisconsin, the legal status of the Common Tern requires that future development does not adversely impact this species.

Since 1985, the estimated number of nesting pairs on Interstate Island has ranged from 68 to 302 (Fig. 18). However, because birds are highly mobile, declines in colony size due to low productivity and survival may be masked by recruitment from a larger area (Weegman et al. 2016). Although counting breeding pairs of birds is a reliable indicator of colony stability, this method cannot differentiate between birth, immigration, death, and emigration events and is therefore unable to identify underlying factors driving population changes. For Common Terns breeding in Lake Superior nest success has varied significantly from year to year and from colony to colony and so it is important to identify site-specific reasons for nest failure and to estimate productivity over time.

A better understanding of the ecology and status of this species breeding in the Duluth-Superior harbor is essential to providing an accurate assessment of the status and condition of this important breeding colony in the SLR. Research and monitoring efforts are necessary to identify best management practices that minimize risk of local extirpation and enhance colony productivity. To achieve these goals it is imperative that these birds have suitable nesting habitat where predation risk is low. Pfannmuller (2014b) outlines and synthesizes state and federal conservation plans for the Common Tern. These goals and recommendations are useful guidelines for continual and effective conservation planning for Common Terns in the SLR and include: 1) protecting and maintaining three island nesting colonies in

Minnesota and *work to restore or enhance one nesting colony site*, 2) Minnesota colonies must produce at least 1.1 young per breeding pair for the state to maintain its current population. Minnesota's Common Tern nesting success rate has ranged from 0-1.35 fledglings/pair, with most falling below 1.0, with Interstate Island's annual reproductive success rate averaging 0.91 (1989-2010; Pfannmuller 2014b). Although below the target of 1.1 fledglings/pair, it is higher than the other Minnesota colonies that document fledgling rates. The Common Tern colony in the SLR needs continual management to sustain colony numbers and to insure successful reproduction. Compared with the late 1970s the Common Tern now only nests at one highly, vulnerable site in the SLR. Because Interstate Island is one of the most important nesting colonies in Minnesota and Lake Superior, we suggest protection and maintenance, including restoration and enhancement of the island be a priority to MPCA. Any delisting of the Fish and Wildlife BUI in the SLR should strongly consider its effect on the future of the Common Tern. We recommend that MPCA support current and future restoration efforts to maintain suitable breeding habitats and support continued intensive monitoring and management efforts.

Black Tern

The Black Tern is listed as endangered in Wisconsin and had been listed as a Species of Greatest Conservation Need in Minnesota; though it no longer has that designation (Shuford 1999, Pfannmuller 2014a). Breeding populations have significantly declined from 1966-2013 in Minnesota (-6.1%/year), Wisconsin (-5.6%/year), and throughout the United States (-2.9%/year) (Sauer et al. 2014). The decline in Minnesota translates into a 95% decline in the population over the last 50 years. The population in the Great Lakes Region has also been declining even more drastically. The Great Lakes Marsh Monitoring Program has reported that this species has declined at a faster rate than any other bird monitored in the program with a population decrease of 10.5% annually between 1995 and 2012 (Pfannmuller 2014a).

Black Terns are semi-colonial nesting birds that prefer breeding in shallow open wetlands larger than 20 ha with sparse emergent vegetation such as cattails, bulrush, or bur-reed. This type of habitat has been rapidly disappearing from the landscape with increased industrial, residential, and agricultural development and general degradation of wetlands (Dunn and Argo 1995, Pfannmuller 2014a).

There is little historical population information available for breeding Black Terns in the Duluth-Superior area. Reports from the Duluth Bird Club in June 1953 of nesting activity at what is now Southworth Marsh included eggs and hatched young (Bronoel 1953). He also mentions breeding activity observed in this location much earlier by Olga Lakela in 1937 and she noted that Black Terns were absent for a number of years after 1937 but had begun to return (Bronoel 1953). Niemi et al. (1979a) stated the Black Tern "nested in six marsh communities in the estuary" in the SLR from 1977-1979. They included the following areas with the number of breeding adults in parentheses (based on the number of nests found): Allouez Bay, WI (20 in 1977 and 32 in 1979), Pokegema River, WI (10 in 1978 and 8 in 1979), Indian Point, MN (2 each in 1978 and 1979), Morgan Park mudflats (50 in 1978 and 8 in 1979), Mud Lake, MN (4 in 1978), and South Spirit Lake, WI (20 in 1978 and 20 in 1979).

Allouez Bay and adjacent Wisconsin Point comprise one of the largest wetland complexes in the SLR (Niemi et al. 1977, Davis et al. 1978). The earlier observations of Black Terns by Lakela and Bronoel as well as the observations of nesting in the 1970s indicate that the species has been a frequent, if not permanent, breeding resident of the SLR in the past. The Wisconsin Breeding Bird Atlas documented nesting by the Black Tern in or near Allouez Bay during the period from 1995-2000 (Cutright et al. 2006). However, there is no other recent documentation of nesting by this species in other parts of the SLR. An extensive breeding bird inventory of the SLR in 1999 revealed no Black Tern observations (Niemi et al. 2000).

Since the late 1970s the SLR has had many changes and Black Tern populations have declined over a large area of their range. The species has seen extensive retraction of its range, especially in the northeastern portion of Minnesota. There are many potential reasons for its decline including increased eutrophication of water bodies, sedimentation, and pollutants such as mercury, dioxins, pcbs, and other xenobiotic chemicals. Wetlands in the SLR have also been affected by invasive aquatic plant species (Kitson and Jensen 2015). Studies of the Black Terns in South Dakota indicated that vegetation structure was more important than vegetation composition. Showing they required either short dense or tall sparse vegetation to provide them with enough cover for chicks to avoid predation and ease of flight for adults to defend nests (Naugle et al. 2000). Since these types of wetlands cycle through stages with differing levels of vegetation it would be necessary to preserve and manage several wetland areas in regenerative and degenerative states to attract and maintain a breeding population of Black Terns (Matteson et al. 2012).

Black Terns have been affected by anthropogenic habitat and landscape changes to wetlands, but they are also vulnerable to the effects of climate change. Freshwater wetlands will be affected by temperature increases and lower precipitation levels predicted to accompany climate change in this region. Hence, freshwater wetland habitats are predicted to become dryer with increased vegetation, which may further reduce their already limited habitat.

Although Black Terns have been known to nest in cattail marshes, the invasion of narrowleaf cattail (*Typha angustifolia*), and its hybridization with native broadleaf cattail (*Typha glauca*), may also be contributing to changes in habitat (Kudell-Ekstrum and Rinaldi 2004). The increased biomass and density of cattails reduce the available number of quality breeding sites through the loss of open water and sparsely vegetated areas. Quality food sources are also diminished by the lowered diversity of invertebrates found in these monotypic stands (Boers et al. 2006, Linz and Blixt 1997).

The creation of nest platforms can be beneficial for breeding Black Terns in areas where quality nesting habitat is limited. Although it can be difficult to attract the terns to use nest platforms, when they are used numbers of nesting birds and hatching success have both increased. (Shealer 2005). Wyman and Cuthbert (2016) found that key predictors of Black Tern colony persistence in the U.S. Great Lakes were wetland area, wetland type (emergent vegetation, open water, or combination), and area of wetlands available for foraging within 2 km of the colony.

In summary, the North American Black Tern population has declined substantially over the past 50 years. It is currently extirpated from the SLR as well as many areas in the northeastern distribution of the species range in Minnesota. It is unclear the extent that changes in the SLR have contributed to its extirpation or lack of re-colonization in the area. On the surface there appears to be suitable habitat still available in the SLR, especially in the Allouez Bay area. However, given the species steep population decline, recovery of its North American population may be a prerequisite for its return to the SLR. Substantial effort should be included every year to determine whether individuals are still being observed in mid to late May in the SLR and, as with the Piping Plover, efforts made to protect potential nesting activity. The substantial changes in water levels that have occurred over the past 50 years in the Great Lakes should also be examined with respect to Black Tern nesting. Higher water levels were purported to be a problem from 1978 to 1979 when the Black Tern colony at the Morgan Park mudflats dropped from 50 to 8 breeding pairs (Niemi et al. 1979a).

Caspian Tern

This species is listed as endangered in Wisconsin. It has primarily been recorded as a spring and fall migrant in the SLR. A variety of nesting records have been recorded in Wisconsin dating back to the late 1800s, primarily from Lake Michigan. The most recent nesting records are also from Lake Michigan, but “possible” nesting was identified in the 1995-2000 WI Breeding Bird Atlas project from Allouez Bay and the Ashland area of WI (Cutright et al. 2006). Historical accounts from Roberts (1932) indicate no nesting records in the state; though statewide coverage was sparse, especially in the northern portion up to the 1930s. The only known records of nesting in Minnesota are both from Leech Lake with two nests in 1969 (*Loon* 41: 83-84) and confirmed nesting during the MN Breeding Bird Atlas project (2009-2013) (www.mnbba.org). No nests were found during the 1970s in the SLR, but up to 100 individuals were observed during peak migration counts in late May (Niemi et al. 1979a). In addition, approximately 12 individuals were regularly sighted at Allouez Bay during the summer of 1979, but no nests were located.

Cuthbert and Wires (1999) report that the Caspian Tern has been increasing in the Great Lakes; likely due to protection and management of nesting sites as well as reduction in the use of organochlorines. The lack of history of nesting by the Caspian Tern in the SLR suggests that it does not enter into consideration regarding the Fish and Wildlife BUI. However, physical habitat protection of sandy-cobble nesting areas, similar to the Common Tern and Piping Plover, would potentially allow the species to colonize and use the SLR in the future. Caspian Terns nest within Common Tern colonies at Leech Lake, MN and have frequently nested in association with Ring-billed Gulls in Wisconsin (Cutright et al. 2006). Breeding activity of this species at Allouez Bay and other suitable nesting areas of the SLR should be monitored annually.

Forster’s Tern

There are no documented nesting records for this species in the SLR. Current nesting in Minnesota primarily occurs in the western and southern areas of the state. Roberts (1932) also emphasized its western breeding distribution and its primary occurrence as a migrant in the eastern portion. This is also true of the species in the SLR (Niemi et al. 1979a, Green and Niemi 2011). In Wisconsin, this species appears to be largely confined to the central and southern regions, in locations that were historically identified as important nesting sites, such as Winnebago Pool, Lake Puckaway, Rush Lake, Big Muskego Lake, Horicon Marsh, and Green Bay (Cutright 2006). Despite the species extensive use of large riverine wetland ecosystems, like the SLR in other parts of its range, so far it has not been found nesting here. However, there appears to be potential given the extensive wetlands that exist in the SLR. Currently there is no basis for consideration of this species in removal or maintaining the Fish and Wildlife BUI.

Great Blue Heron

The Great Lakes population of Great Blue Herons was flourishing between 1977 and 1991 when the Great Lakes Colonial Waterbird Censuses found an increase of 43% in the number of nests located in this region. After 1991 the population began to decline, with a decrease of 26% through 1999 and a continued decrease of 18% from 1999 to 2008. This decline can be attributed to changes in land use, water quality or food availability, frequent human or natural disturbance, interspecific competition, or predation (Rush et al. 2015). These birds are adaptable in their breeding habitat but appear to prefer locations that are inaccessible to predatory mammals and have low rates of human disturbance. They feed primarily on fish in slow moving or calm water and rarely nest more than 20 km from their foraging habitat. Colonies located in areas of high disturbance are prone to frequent relocation and may resettle in smaller groups (Vennesland and Butler 2011). Since trees used by nesting colonies of Great Blue Herons eventually die, due to old age or the acidity of the heron droppings, it is important that areas with appropriate nesting habitat be preserved for future colony locations (Danz et al. 2007).

The St Louis River Estuary was documented as hosting a colony of Great Blue Herons at the northernmost point of Kimball's Bay, with 110 to 186 breeding adults recorded from 1977 to 1979, respectively (Niemi et al. 1979a). This colony has since disappeared and a private residence has been developed in the former nesting area. It is unknown what prompted the species to desert their colony but encroaching development could have been a factor. Nest and colony abandonment have been known to increase in areas with high human activity. Most colonies require a buffer of at least 300 m where humans are excluded, especially during the breeding and nesting seasons, to prevent desertion (Watts and Bradshaw 1994, Vennesland and Butler 2011). Increased accessibility of this colony to predators which are more common in residential areas, such as raccoons, could also have contributed to the loss of this colony. Raccoons, once they locate a colony, will often prey on eggs and nestlings until none are left causing the birds to permanently abandon their colony (Rodgers 1987). A recent example of this would be the large colony at Peltier Lake in east central Minnesota. This colony at its peak in the 1990s contained more than 1,000 nests but for unknown reasons the population started to decline about ten years later and by 2005 only 25 nests remained. In 2004 cameras that were installed to monitor the colony showed raccoons preying on eggs and nestlings. Predation was so extreme that no young survived in 2004. Remediation efforts have been successful in preventing some of the raccoon predation and the following year four young survived (Von Duyke 2009).

Predation by Bald Eagles could also have contributed to this abandonment. Bald Eagles are one of the few predators of adult Great Blue Heron and frequently prey on nestlings and eggs (Forbes 1987, Norman et al. 1989). The enormous population recovery of the Bald Eagle has been shown to have been a factor in the desertion of colonies in the Pacific Northwest. As eagles became more prevalent in the post-DDT era they have been documented preying on nestlings at Great Blue Heron colonies which have resulted in colony abandonment (Kelsall and Simpson 1980, Norman et al. 1989, Jones et al. 2013). The Great Blue Heron colony located in Kimball's Bay could have faced similar pressures as eagle populations in Minnesota and the Great Lakes region have substantially increased (Bowerman et al. 1995).

Great Blue Heron colonies have been known to relocate if disturbance becomes too great and may attempt to resettle nearby often in smaller splinter colonies (Vennesland and Butler 2011). Attracting and reestablishing breeding Great Blue Herons in the SLR will most likely require keeping multiple large undisturbed areas of the appropriate habitat available or, if that is not feasible, possibly installing nest platforms. Many individual Great Blue Herons have been observed in the SLR during the current study period, but no colonies have been located for many years. Several local bird watchers in the area have suggested that a colony site exists in the Superior Municipal Forest. We suggest that an effort be made to search for the colony or colonies and provide adequate protection of these sites if possible.

American White Pelican

This species has experienced an exponential increase in its population since the turn of the century in 2000. Breeding Bird Survey trends in Minnesota and Wisconsin from 1966 to 2013 were 14%/yr (n = 37 routes) and 80%/yr (n = 6 routes), respectively (Sauer et al. 2014). Changes during the past 11 years (2003-2013) have been similar. Hence, even though a few American White Pelicans were observed in the 1970s, the much larger number observed during the recent period is a reflection of this large increase in the population. During the 1995-2000 WI Breeding Bird Atlas only two colonial nest sites were identified: Green Bay and Horicon Marsh. The MN Breeding Bird Atlas (2009-2013) revealed 13 colony sites ranging from Lake of the Woods, Leech Lake, and the remainder in southern and southwestern Minnesota.

The increase in American White Pelican has little to do with activities in the SLR where the species does not nest nor are there any historical records of nesting in the SLR. Banning of DDT and related organochlorine chemicals, protection and management of nest sites, and reduction in illegal shooting are among the reasons for the increase in the population of this species. There is a possibility that this species could nest in the SLR in the future. Like the Forster's Tern, this species should have little influence on determination of the Fish and Wildlife BUI because of its limited distribution in this region; however, improvements in fish populations, water quality, and availability of isolated islands or protected open gravel or sandy areas for nesting will greatly benefit this species.

Great Egret

The current breeding distribution of this species in Minnesota is primarily in southern, west-central, and southeastern portions of the state (Green and Janssen 1975, Janssen 1987). It was labelled a straggler from the south by Roberts (1932) and the first breeding records in the state were in the late 1930s (Green and Janssen 1975). The MN Breeding Bird Atlas project found confirmed nesting in 24 locations as far north as Becker County which is approximately the same latitude as Duluth. In Wisconsin where it is a threatened species, it is primarily found nesting along the Mississippi and Horicon Marsh/Lake Winnebago area (Cutright et al. 2006). It is a colonial nesting species that nests in large trees, most often in lowland forests adjacent to large rivers or lakes. The species has been significantly increasing from 1966-2013 based on the MN Breeding Bird Survey (4.8%/yr) and throughout the United States (2.1%/yr; Sauer et al. 2014).

The species was observed in the 1970s and during recent counts, but it is still rare and usually observed as single individual in the SLR. Because of its increasing population in Minnesota and to some extent in Wisconsin, we could expect more frequent observations of this species in the SLR as well as a potential nesting species in the future. As with the American White Pelican, we would not expect this species to be considered in the decisions regarding the Fish and Wildlife BUI because it likely was never part of the "recent" native avifauna of the SLR. From 1870-1910 over 95% of this species population was reduced by killing for their plumes. This was primarily an issue in the southern US states, but its recovery is still in process as evidenced by its continued population expansion. The species would greatly benefit from healthy fish, reptile and amphibian, and invertebrate populations; good water quality, and the availability of suitable, large trees relatively close to the SLR for potential nesting.

Black-crowned Night Heron

Like the Great Egret, the Black-crowned Night Heron is a rare species and represented by a few individual observations in the SLR; both in the 1970s and in recent surveys. In Wisconsin, its primary breeding range is in the central and southeastern parts of the state (Cutright et al. 2006). The MN Breeding Bird Atlas identified 10 nesting locations; all in southcentral Minnesota. The species has had a relatively stable population over the past 50 years but has not shown the same type of expansion in its population like the Great Egret. It is our opinion that the species should not be considered in the decisions regarding the Fish and Wildlife BUI in the SLR because of its rarity and low probability of future colonization in the future; though as with many species it would benefit from healthy, fish, reptile and amphibian, and invertebrate populations as well as the availability of large trees that it uses for its colonial nesting sites.

Least Bittern

This species is rare and one of the "least" known members of the heron family. It is a secretive species found in dense wetland vegetation, usually in emergent marshes, where it constructs its nest in cattails, bulrushes, or sedges (Poole et al. 2009). The species was formally recognized as a Species of Conservation Concern in the upper Midwest Region (USFWS 2008). Collectively, its status in Minnesota and Wisconsin, as documented by Roberts (1932), Green and Janssen (1975), Janssen (1987), Robbins (1991), and Cutright et al. (2006), suggests little evidence of nesting in northwestern Wisconsin or northeastern Minnesota. There is some suggestion that this species population has declined, likely with the reduction of available wetland habitat over the past 150 years (Poole et al. 2009). However, this species is very difficult to monitor because of its secretive habits, indistinct vocalizations, and the remoteness of its breeding habitat in wetlands. Niemi et al. (1979a) documented that this species "occurred regularly" in the Allouez Bay, Mud Lake, and Spirit Lake Marshes. It was not documented in counts of 39 wetland areas in the SLR in 1999 (Niemi et al. 2000). Recently Bracey (pers. comm.) has detected at least one individual in the wetland area around Clough Island in 2012 and in Little Pokegema River in 2014. These sites were sampled as part of the Great Lakes Coastal Wetland Monitoring Program (Cooper et al. 2014). Because there is little historical data on the presence of this species in the SLR, we cannot make an argument for its consideration in retaining or elimination of the BUI for fish and wildlife in the SLR at the current time.

Bald Eagle

This species has made a remarkable recovery since the banning of DDT in 1972. The last formal counts of nests in Minnesota in 2005 indicated 872 active nests and an estimated 1,312 nests in the state. The number has clearly grown since that time where the Minnesota Breeding Bird Atlas project recorded Bald Eagles nesting in nearly every county in the state, except Lincoln and Pipestone Counties in the extreme southwest. Wisconsin has shown similar results of expansion, documented by Cutright et al. (2006) in the Wisconsin Breeding Bird Atlas. Counts in the 1970s by Niemi et al. (1979a) did not document any nesting of this species in the SLR; however, several large concentrations (e.g., 44 individuals on April 7, 1978 in the Spirit Lake and Oliver Bridge areas) of migrating Bald Eagles were observed, especially prior to ice-out of interior

Bald Eagle at Boat Club Point near Spirit Lake West. Photo credit: E. Zlonis.

lakes. Today, there are up to five nesting Bald Eagle pairs in the SLR, but no information on their overall nesting success. It is highly likely that populations existed in the SLR during historical, pre-European times. Hence, the recovery of this species in the SLR is supportive of BUI removal, but its recovery has had little to do with changes in the SLR. The species has recovered because of the banning of DDT, the focused management efforts to protect nest sites, the improvement in reduced contaminant loads in food supplies, and its increased tolerance to human disturbance.

Peregrine Falcon

Peregrine Falcon populations were extremely low in the 1960s and no nesting was reported in Minnesota from 1965 to 1969 (Janssen 1987). A reintroduction program was initiated in 1982 at the University of Minnesota, Twin Cities (www.midwestperegrine.org). Since that time the population has increased substantially in Minnesota. The Minnesota Breeding Bird Atlas identified 79 nesting areas in Minnesota from 2009-2013. This species has nested successful at the Greysolon Plaza Hotel and most recently at the Torrey Building in downtown Duluth, plus a new site at the SP Duluth Ore Docks in 2015 (Fallon 2015). The species has also periodically nested or attempted to nest on the Blatnik and Bong Bridges as well as the Hibbard Steam Plant, but nesting success has been highly variable. This species has clearly increased in its population within the SLR since the 1970s, but nesting success continues to be highly variable and has been greatly aided by the successful, reintroduction program in the upper Midwestern U.S.

Problematic or nuisance species

Canada Goose

The rapid expansion of settlers throughout North America in the 19th century drastically reduced the population of Canada Geese across the continent. These people, who were often near starving after harsh winters with little available food, turned to hunting large numbers of geese as the birds returned from their wintering grounds. They also gathered goose eggs in spring as a supplemental food source. Many wetlands were also drained and developed for farmland during this time, reducing suitable habitat for these birds. The Canada Goose population began a slow recovery after the passing of the Migratory Bird Treaty Act of 1918 when unregulated hunting was abated and many wildlife refuges were created to preserve wetland habitat for use by breeding, migratory, and over-wintering waterfowl (Cooper 1978, Smith 1999).

In 1927, Kellogg Bird Sanctuary in Michigan established the first successful reintroduction of a breeding population of Canada Geese in North America. Since then many programs have restored populations of geese to areas where they had formerly occurred as well as to areas that were outside of their historical range (Cooper 1978). Since the diet of these birds includes a high proportion of grasses, they were naturally attracted to the manicured residential lawns, golf courses, and other large expanses of open grassy areas that many urban areas provide (Smith et al. 1999). Many groups of Canada Geese have recently been found to stay in their urban and suburban breeding areas year round. These permanent resident populations of Canada Geese experience increased survival and reproductive rates over wild populations because they are protected from hunting due to firearms laws within city limits, few predators, and are often fed by humans (Smith et al. 1999). Since the 1980s many populations of Canada Geese could be found wintering much farther north in agricultural areas where they consume carbohydrate-rich waste grain rather than the native wetland plants they had consumed historically. To reduce the number of nuisance geese, these birds have frequently been relocated to areas that are farther south than their historical range (Mowbray 2002). All of these situations have contributed to a huge increase in populations of Canada Geese.

Urban flocks of Canada Geese can number anywhere from 10s, to hundreds, to thousands, and even tens of thousands in some areas. Data from a country-wide survey of USDA State Directors found that geese were a problem for more than 100 urban areas in 37 states. These problem flocks numbered anywhere from 10 to 27,500 birds and surveys indicated that a total population of nuisance urban geese was estimated at 299,720 individuals (Forbes 1993). Droppings from flocks this large can create a number of public health issues such as closure of swimming areas and reduction in water quality. The high concentration of nitrogen can cause the eutrophication of urban ponds and lakes resulting in excessive growth of algae. The congregation of large numbers of geese on open grassy areas can also result in trampled grass and packed down soil leading to a ground surface devoid of vegetation which also results in erosion and destruction of habitat.

Ring-billed Gull

Ring-billed Gulls experienced a population explosion and expansion westward through the Great Lakes in the mid to late 1960s. By 1967 there were an estimated 300,000 individuals in Lakes Huron and Michigan (Ludwig 1974). The first nesting record of the species in the Duluth-Superior Harbor was at Barker's Island in 1957 within a Common Tern colony (Cohen 1958). He stated that the Ring-billed Gull "is the first found of that species in this area in recent years" which implies that the species was nesting in this area in previous years. In 1974, 500 pairs were documented at the Minnesota Power and Light Hibbard Plant and this population increased rapidly until it reached a high count of 8,361 breeding pairs in 1986 (Penning 1993). From 2000-current, an annual nest count of Ring-billed Gulls breeding in the SLR is conducted. From 2000-2004 nests were counted at Minnesota Power Hibbard Plant where nest numbers declined annually from 643 nests to 24. From 2000-2005 nests were counted at South Hibbard Islet, with nest numbers declining from 299 to 0. On Interstate Island total nest counts were conducted from 2000-2016 with nest numbers fluctuating from 8,734 – 14,383. The majority of nesting Ring-billed Gulls in the SLR currently nest on Interstate Island.

References

Boers, AM. 2006. *Typha x glauca* dominance and extended hydroperiod constrain restoration of wetland diversity. Ecological Engineering 29:232-244.

Borcard, D, F Gillet, and P Legendre. 2011. Numerical Ecology with R. Springer New York.

Bowerman, WW, JP Giesy, DA Best, and VJ Kramer.1995. A review of factors affecting productivity of bald eagles in the Great Lakes region: implications for recovery. Environmental Health Perspectives 103:51–59.

Bray, JR, and JT Curtis. 1957. An ordination of upland forest communities of southern Wisconsin. Ecological Monographs 27:325-349.

Bronoel, K. 1953. Black Tern Colony, St. Louis Bay. The Loon 25:26.

Butler, RW.1992. Great Blue Heron. The Birds of North America, No. 25.

Clarke, KR. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18:117-143.

Cohen, R. 1958. Common Tern colony on Barker's Island, St. Louis Bay. Flicker 30:39.

Cooper, JA. 1978. The history and breeding biology of the Canada Geese of Marshy Point, Manitoba. Wildlife Monographs 61:3-87.

Cooper, MJ, DG Uzarski, and VJ Brady. 2014. Implementing Great Lakes coastal wetland monitoring. 2014 Great Lakes Wetlands Day Proceedings, February 2014. Prepared by members of the Great Lakes Wetlands Conservation Action Plan, Toronto, Ontario, Canada. http://glwcap.ca/files/2013/10/WetlandsDayProceedings.pdf.

Courtney, PA, and H Blokpoel.1980. Behavior of Common Terns nesting near Ring-billed Gulls. Canadian Field-Naturalist 94:336-338.

Courtney, PA, and H Blokpoel. 1983. Distribution and numbers of Common Terns on the Lower Great Lakes during 1900-1980: A review. Colonial Waterbirds 6:107-120.

Cuthbert, FJ, and LR Wires.1999. Caspian Tern (*Hydroprogne caspia*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/403 doi:10.2173/bna.403

Cuthbert, FJ, LR Wires, and K Timmerman. 2003. Status assessment and conservation recommendations for the Common Tern (*Sterna hirundo*) in the Great Lakes region. U.S. Department of the Interior, Fish and Wildlife Service. Ft. Snelling, MN.

Cutright, N, BR Harriman, and RW Howe. 2006. Atlas of the breeding birds of Wisconsin. Wisconsin Society of Ornithology, Inc. Waukesha, WI, USA. 602 pp.

Danz, NP, GJ Niemi, J Lind, and JM Hanowski. 2007. Birds of Western Great Lakes forests. www.nrri.umn.edu/mnbirds.

Davis, TE, and GJ Niemi. 1980. Larid breeding populations in the western tip of Lake Superior. The Loon 52:3-14.

Davis, TE. 1986. St. Louis River Estuary colonial bird program 1986. Report to the Minnesota Department of Natural Resources, St. Paul, MN. 16 pg.

Davis, T, G Niemi, J Kotar, and P Hofslund. 1978. Assessment of habitat types and bird populations in the Duluth-Superior Harbor Phase II. Report to Metropolitan Interstate Committee by Biology Department and Lake Superior Basin Studies Center, University of Minnesota, Duluth. 95 pg.

Dunn, EH, and DJ Argo. 1995. Black Tern (*Chlidonias niger*). *In* The Birds of North America, No. 147 (A Poole and F Gill, Eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Elliot-Smith, E, M Bidwell, AE Holland, and SM Haig. 2015. Data from the 2011 international Piping Plover census: U.S. Geological Survey Data Series 922, 296 pg, http://dx.doi.org/10.3133/ds922.

Engstrom, H. 1940. 1939 Minnesota nesting records. Flicker 12:12.

Erwin, RM, BR Truitt, and JE Jiménez. 2001. Ground-nesting waterbirds and mammalian carnivores in the Virginia Barrier Island region: running out of options. Journal of Coastal Research 17:292-296.

Fallon, J. 2015. Minnesota 2015 Annual Peregrine Falcon Report. https://docs.google.com/viewerng/viewer?url=http://apps2.ahc.umn.edu/mwpsorg/assets/docs/MN_2015st.pdf)

Forbes, SL.1987. Predation on adult Great Blue Herons: is it important? Colonial Waterbirds 10:120-122.

Green, JC and RB Janssen. 1975. Minnesota birds: where, when and how many. University of Minnesota Press, Minneapolis, MN. 217 pp.

Green, JC and GJ Niemi. 2011. Minnesota important bird areas: nomination form for St. Louis River estuary and Minnesota Point. (Copies available from the authors – jgreen@d.umn.edu or gniemi@d.umn.edu)

Guertin, DS, and LA Pfannmuller. 1985. Colonial waterbirds in Minnesota: an update of their distribution and abundance. The Loon 57:67-78.

Haig, SM, and E Elliott-Smith. 2004. Piping Plover. Birds of North America 2 (revised). http://bna.birds.cornell.edu/BNA/account/Piping_Plover.

Haig, SM, CL Ferland, F Cuthbert, J Dingledine, P Goossen, A Hecht, and N McPhillips. 2005. A complete species census and evidence for regional declines in Piping Plovers. Unpubl. Manuscript. USGS Forest and Rangeland Ecosystem Science Center, Corvallis, OR.

Host, G, P Meysembourg, C Reschke, V Brady, G Niemi, A Bracey, and L Johnson. 2012. An ecological design for the 40th avenue west remediation to restoration project. NRRI Technical Report NRRI/TR-2012/27, University of Minnesota, Duluth, MN.

Host, G, P Meysembourg, C Reschke, V Brady, G Niemi, A Bracey, L Johnson, M James, J Austin, and E Buttermore. 2013. An ecological design for the 21st avenue west remediation to restoration project. NRRI Technical Report NRRI/TR-2013/24, University of Minnesota, Duluth, MN.

Hyde, DA. 1999. Special animal abstract for *Charadrius melodus* (piping plover). Michigan Natural Features Inventory, Lansing, MI. 4pp.

Janssen, R. 1987. Birds in Minnesota. University of Minnesota Press. Minneapolis, MN.

Jones, HP, and SW Kress. 2011. A review of the world's active seabird restoration projects. The Journal of Wildlife Management 76:2-9.

Jones, IM, RW Butler, and RC Ydenberg. 2013. Recent switch by the Great Blue Heron *Ardea herodias fannini* in the Pacific Northwest to associative nesting with Bald Eagles (*Haliaeetus leucocephalus*) to gain predator protection. Canadian Journal of Zoology 91:489-495.

Kelsall, JP, and K Simpson. 1980. A Three Year Study of the Great Blue Heron in Southwestern British Columbia. Proceedings of the Colonial Waterbird Group 3:69-74.

Kitson, M, and DA Jensen. 2015. Aquatic invasive species prevention plan. Report prepared for St. Louis County Board of Commissioners. St. Louis County, Minnesota.

Kudell-Ekstrum, J, and T Rinaldi. 2004. Conservation assessment for black tern (*Chlidonias niger*). USDA Forest Service, Eastern Region, Milwaukee, WI. 46pp.

Linz, GM, and DC Blixt. 1997. Black Terns benefit from cattail management in the Northern Great Plains. Colonial Waterbirds 20:617-621.

Ludwig, J. 1974. Recent changes in the Ring-Billed Gull population and biology in the Laurentian Great Lakes. The Auk 91:575-594.

Manly, B. 1997. Randomization and Monte Carlo Methods in Biology. Chapman & Hall, London, UK.

Matteson, SW, MJ Mossman, and DA Shealer. 2012. Population decline of Black Terns in Wisconsin: a 30 year perspective. Waterbirds 35:185-193.

McKearnan, JE, and SJ Maxson. 1986. Status and breeding success of common terns in Minnesota. (M.S. Thesis, University of Minnesota, St. Paul, Minnesota. 53 pp.)

Morris, RD, DV Weseloh, FJ Cuthbert, C Pekarik, LR Wires, and L Harper. 2010. Distribution and abundance of nesting common and caspian terns on the North American Great Lakes, 1976 to 1999. Journal of Great Lakes Research 36:44-56.

Mowbray, TB, CR Ely, JS Sedinger, and RE Trost. 2002. Canada Goose (*Branta Canadensis*). *In* The Birds of North America, No. 682 (A Poole and F Gill, Eds.). The Birds of North America, Inc., Philadelphia, PA.

MPCA. Minnesota Pollution Control Agency. 2013. St. Louis River Area of Concern implementation framework: roadmap to delisting (remedial action plan update), LimnoTech. St. Paul, Minnesota. July 15, 2013. http://www.pca.state.mn.us/index.php/view-document.html?gid=19677.

NABCI. North American Bird Conservation Initiative. 2016. The state of North America's birds, 2016. Environment and Climate Change Canada, Ottawa, Ontario. 8 pp. (www.stateofthebirds.org)

Naugle, DE. 2000. Local and landscape-level factors influencing Black Tern habitat suitability. The Journal of Wildlife Management 64:253-260.

Niemi, GJ, T Davis, J Kotar, and P Hofslund. 1977. Assessment of habitat types and bird populations in the Duluth-Superior Harbor area. Report to Metropolitan Interstate Committee, Duluth MN by Biology Department and Lake Superior Basin Studies Center, University of Minnesota, Duluth. 76 pp.

Niemi, G, T Davis, and P Hofslund. 1979a. Distribution and relationships of habitats and birds in the St. Louis River Estuary. Report to U.S. Fish and Wildlife Service, St. Paul, MN by Department of Biology and Lake Superior Basin Studies Center, University of Minnesota Duluth. 99 pp.

Niemi, GJ and TE Davis. 1979b. Notes on the nesting ecology of the Piping Plover. The Loon 51: 74-79.

Niemi, GJ, J Solin, D Waters, and P Wolter. 2000. Breeding bird inventory of the St. Louis River, Minnesota and Wisconsin, 1999. Natural Resources Research Institute, University of Minnesota Duluth technical report NRRI/TR-2000/34.

Norman, DM, AM Breault, and IE Moul. 1989. Bald Eagle incursions and predation at Great Blue Heron colonies. Colonial Waterbirds12:215-217.

Oksanen, J, F Guillaume Blanchet, R Kindt, P Legendre, PR Minchin, RB O'Hara, GL Simpson, P Solymos, M Henry, H Stevens, and H Wagner. 2016. Vegan: community ecology package. http://CRAN.R-project.org/package=vegan.

Penning, WL. 1993. The Common Tern (*Sterna Hirundo*) in Western Lake Superior: history, management, and population modeling (M.S. Dissertation, University of Minnesota, St. Paul, MN).

Pfannmuller, LA. 2014a. Black Tern Minnesota conservation plan. Blueprint for Minnesota Bird Conservation. Audubon Minnesota. http://mn.audubon.org/sites/g/files/amh601/f/black_tern_conservation_plan_10-21-2014.pdf.

Pfannmuller, LA. 2014b. Common Tern Minnesota conservation plan. Blueprint for Minnesota Bird Conservation. Audubon Minnesota: http://mn.audubon.org/sites/default/files/documents/common_tern_minnesota_conservation_plan_10-16-2014_0.pdf.

Philippi, TE, PM Dixon, and BE Taylor. Detecting trends in species composition. Ecological Applications 8:300-308.

Poole, AF, P Lowther, JP Gibbs, FA Reid, and SM Melvin. 2009. Least Bittern (*Ixobrychus exilis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online:http://bna.birds.cornell.edu/bna/species/017;doi:10.2173/bna.17.

Price EW, and FJ Cuthbert. 2002. Piping plover habitat and recovery assessment for St. Louis River Estuary, Minnesota/Wisconsin. Report submitted to: Twin Cities Field Office of the U.S. Fish and Wildlife Service.

R Core Team. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. Austria: http://www.R=project.org.

Robbins, SD. 1991. Wisconsin Birdlife. Univ. Wisconsin Press, Madison, WI.

Roberts, TS. 1932. The birds of Minnesota. Volumes 1 and 2. University of Minnesota Press, Minneapolis, MN.

Rodgers JA, Jr. 1987. On the antipredator advantages of coloniality: a word of caution. The Wilson Bulletin Vol. 99:269-271.

Rossi, J-P. 2011. Rich: An R package to analyze species richness. Diversity 3:112-120. doi: 10.3390/d3010112.

Rush, SA, C Pekarik, DV Weseloh, F Cuthbert, D Moore, and L Wires. 2015. Changes in heron and egret populations on the Laurentian Great Lakes and connecting channels, 1977-2009. Avian Conservation and Ecology 10(1): 7. http://dx.doi.org/10.5751/ACE-00742-100107.

Russell, R. 1983. The piping plover in the Great Lakes region. American Birds 37:951-955.

Sauer, JR., JE Hines, JE Fallon, KL Pardieck, DJ Ziolkowski, Jr., and WA Link. 2014. The North American Breeding Bird Survey, results and analysis 1966 - 2012. Version 01.30.2015 USGS Patuxent Wildlife Research Center, Laurel, MD. Online at: http://www.mbr-pwrc.usgs.gov/bbs/bbs.html.

Shealer, DA. 2005. Effect of floating nest platforms on the breeding performance of Black Terns. Journal of Field Ornithology 77:184-194.

Shuford, WD. 1999. Status assessment and conservation plan for the black tern (*Chlidonias niger surinamensis*) in North America. U.S. Department of Interior, Fish and Wildlife Service, Denver, CO.

Smith, AE, SR Craven, and PD Curtis. 1999. Managing Canada geese in urban environments. Jack Berryman Institute Publication 16, and Cornell University Cooperative Extension, Ithaca, N.Y.

USFWS.U.S. Fish and Wildlife Service. 2003. Recovery plan for the Great Lakes Piping Plover (*Charadrius melodus*). Ft. Snelling, Minnesota. Viii + 141 pp.

USFWS. U.S. Fish and Wildlife Service. 2008. Birds of conservation concern. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. 85 pp.

USFWS. U.S. Fish and Wildlife Service. 2015. Endangered species. Great Lakes Piping Plover conservation and management http://www.fws.gov/midwest/endangered/pipingplover/piplconservation.html

Vennesland, RG and RW Butler. 2011. Great Blue Heron (*Ardea Herodias*), the Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/025.

Von Duyke, AL. 2009. Conservation and restoration of a Great Blue Heron breeding colony in east central Minnesota. (M.S. Dissertation, University of Minnesota, St. Paul, MN).

Watts, BD, and DS Bradshaw. 1994. The influence of human disturbance on the location of Great Blue Heron colonies in the Lower Chesapeake Bay. Colonial Waterbirds 17:184-186.

Weegman, MD, S Bearhop, GM Hilton, A Walsh, and AD Fox. 2016. Conditions during adulthood affect cohort-specific reproductive success in an Arctic-nesting goose population. PeerJ 4:e2044, DOI 10.7717/peerj.2044.

Wemmer, LC, U Özesmi, and FJ Cuthbert. 2001. A habitat-based population model for the Great Lakes population of the piping plover (*Charadrius melodus*). Biological Conservation 99:169-181.

Wires, LR, and FJ Cuthbert. 2001. Prioritization of waterbird colony sites for conservation in the US Great Lakes. Final Report to USFWS.

Wires, LR, SJ Lewis, GJ Soulliere, SW Matteson, DV Weselooh, RP Russell, and FJ Cuthbert. 2010. Upper Mississippi Valley/Great Lakes waterbird conservation plan. A plan associated with the Waterbird Conservation for the Americas Initiative. Final Report submitted to the U.S. Fish and Wildlife Service, Fort Snelling, MN.

Whittaker, RH. 1960. Vegetation of Siskiyou mountains, Oregon and California. Ecological Monographs 30:279-338.

Whittaker, R. 1972. Evolution and measurement of species diversity. Taxon 21:213-215.

Wyman, KE, and FJ Cuthbert. 2016. Validation of landscape suitability indices for Black Tern (*Chlidonias niger*) in the U.S. Great Lakes region. The Condor 118:613-623.

Appendix A. St. Louis River AOC R2R Support Project: Ecological Monitoring and Assessment (CR#6403): Migration and Breeding Bird Distribution and Abundance Standard Operating Procedure.

Survey Protocol Summary

Spring/Fall Migration:

- Each point at each site needs to be surveyed for 10 minutes. If it is not possible to count all birds within 10 minutes, stay until all birds have been counted and write survey duration on accompanying field sheet
- All birds seen or heard should be placed on the maps in the location in which it was observed. Observation type (e.g. singing, observed, flyover) should also be recorded.
- A field sheet will be provided with each map and should be filled out completely during each visit. This will contain site level information (e.g. date, survey duration, location, observer, temperature, etc.).

Breeding Season:

- Breeding season surveys will be extended to 15 minute surveys and include use of playbacks

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1. Samples: Bird surveys will be conducted 16 times at each point annually.
    a. Surveys will be conducted:
        i. 6 times during spring migration (March- May)
        ii. 4 times during the breeding season (May-July)
        iii. 6 times during fall migration (August-November)

    b. Sites will be revisited with a minimum of:
        i. 5 days between surveys during the breeding season
        ii. 7 days between surveys during migration periods

2. Survey weather
    a. Because the majority of observations will be visual, wind strength is less likely to affect the quality of the survey. However, it is optimal to conduct surveys when the wind strength is less than 4 on the Beaufort wind scale (i.e. wind < 15 mph or < 20 kmh) for identifying birds aurally.
    b. Surveys should only be conducted when there is little or no precipitation.
        i. If the precipitation is heavier than a drizzle, you should discontinue the survey. Moderate to heavy rain will decrease bird vocalization and other activity levels.
    c. Wind and precipitation during breeding season surveys could affect your ability to detect territorial vocalizing males and therefore it is more important that survey conditions are optimal.
    d. The decision to discontinue a survey due to weather conditions is made at the discretion of the field crew leader.
    e. If survey is conducted during questionable weather conditions, be sure to provide comments on the data sheet, such as why the survey was continued.

3. Sample periods
    a. Be sure to get accurate sunrise and sunset times for your location
    b. All breeding season surveys are morning surveys: sampling can begin from 0.5hr before sunrise to 4.5hrs after sunrise.
    c. Surveys during migration can begin at sunrise and continue into the afternoon.
    d. Surveyors will survey each point within a given location until all birds present have been counted (approximately 10 minutes at each point within a site).

4. Sites and sample points
    a. Each site can contain from 1-4 bird sample points
    b. Sample points
        i. Points will be located near the most convenient access point
        ii. The location of each point will be marked using a GPS unit prior to the first sampling period (June 2013). These locations will not change during the project, unless a safety or accessibility issue arises during the project.
        iii. Points will be saved in the GPS unit as a waypoint as well as in an excel database.
        iv. Once point locations have been established, proceed to the provided point location to conduct surveys.
        v. All points must be marked on the field maps, and notes such as how to access each point must be recorded.

5. Record site data
    a. Before beginning the survey, fill out the following:
        i. Date: Format of MM/DD/YY (e.g. 06/04/13)
        ii. Point ID: Each point has an associated ID (e.g. Site 1 pt.1)
        iii. Observer: Observer first initial and last name (J. Doe)
        iv. Time (start): Record in 24-hour format (e.g. 4:30am is 0430)
        v. Temperature: Record in ^{o} Celsius
        vi. Wind (code): Beaufort wind scale codes (see chart below)
        vii. Sky (code): Assign and record the appropriate sky cover code (see chart below)
        viii. Noise (code): Assign and record the appropriate background noise code (see chart below)
        ix. Weather: Circle the appropriate description: dry, damp/haze/fog, drizzle, or rain
        x. Site description/notes: Any additional information that you think will be important to record about the survey location. Observations that could affect counts (e.g. ice covering the bay, boat activity in the area) or any other information that may be of interest (e.g. other animals using the area, e.g. beaver or otter)

BEAUFORT WIND SCALE

0	Calm; smoke rises vertically
1	Light air movement; smoke drifts; leaves barely move
2	Slight breeze; wind felt on face; small twigs move
3	Gentle breeze; leaves & small twigs in constant motion
4	Moderate breeze; small branches moving, raises dust & loose paper
5	Large branches & small trees sway

NOISE CODES

0	No appreciable effect (owl calling)
1	Slightly affecting sampling (distant traffic, dog barking, car passing)
2	Moderately affecting sampling (distant traffic, 2-5 cars passing)
3	Seriously affecting sampling (continuous traffic nearby, 6-10 cars passing)
4	Profoundly affecting sampling (continuous traffic passing, construction noise)

SKY CODES

0	clear (<10%)
1	scattered (10-50%)
2	broken (60-90%)
3	overcast (>90%)
4	fog
5	light mist
6	water dripping off vegetation
7	rain during last 5 minutes of census
8	rain during last 7 minutes of census
9	rain during entire census

6. Conduct the survey
    a. Each survey point will be visited for approximately 10 minutes, or until all observations have been recorded.
        i. Using a spotting scope and binoculars, make a preliminary scan of the survey location to identify all individuals present. This is important, as some species may leave the area due to your presence.

    b. We will use unlimited-distance counts, to complete a thorough inventory of bird use, counting all species identified by both visual and aural surveys

c. All bird observations will be identified to specific locations on aerial photo field sheets; accuracy will be approximately 25 m in open water and 10 m near or on shore.

   i. Record the 4-letter alpha code for each species observed at the corresponding spatial location on the aerial map provided for each point.

   ii. Each individual bird observed must be recorded, whether you were able to identify it or not. Individuals which cannot be positively identified should be recorded as unidentified (e.g. unidentified sparrow (USPA), unidentified passerine (UPBD). See < http://www.birdpop.org/alphacodes.htm > for alpha codes). The inability to identify every individual bird is expected. However, not recording individuals because you are unable to identify them is not acceptable, as this can greatly affect survey results.

d. Flyover observations will be excluded because these birds are not using the study area.

e. Record the behavior of the individual. Notation is listed below and on each data sheet. For instance, if it was singing, circle the alpha code; if it was calling, underline it. "Observed" means you saw the bird and it wasn't doing anything else such as calling, singing, or drumming. NOTE: record the "highest" level of observation. For instance, if a bird is first observed calling and later sings, record that observation as singing. This is most important to record during the breeding season when territorial males are singing.

   i. 1. The order of observations is as follows (highest to lowest):

      1. a. 2 males simultaneous singing
         b. Singing/woodpecker drumming
         c. Calling
         d. Observed (sight only)

NAWA	NAWA	NAWA	NAWA | ~~|NA~~WA	DOWO$_D$
observed	calling	singing	2 males simultaneous singing	woodpecker drumming

f. For surveys conducted during the breeding season (June-July), record the breeding evidence code by using a subscript after the alpha code. Evidence codes can be found, along with descriptions, see <http://www.mnbba.org/pdf/BreedingEvidenceCodes_Tips.pdf >. Record the "highest" level of breeding evidence. For instance, if a bird is first observed doing a distraction display and later you see it occupying a nest, record it as occupied nest. This is a definite breeding observation, whereas a distraction display is a probable breeding observation.

   i. **Examples:**

TRES$_{ON}$	MOWA$_{NB}$	RWBL$_{FY}$
Observed an occupied nest cavity of a Tree Swallow (adult seen entering/exiting)	Observed a Mourning Warbler building a nest	Observed a Red-winged Blackbird carrying food for young

g. If a bird moves to a different location during the survey, only record the location where the bird was originally detected within the site. If a bird is initially not using the site but moves in during the survey, it should be recorded.

h. If a bird is detected at multiple points, record it on the data sheet for each of the points where it is observed. The location where the bird was first detected is where the observation should be recorded. At all other locations where the bird was observed record the bird and use a superscript asterisk. In the site description/notes section, write that this bird is a duplicate seen at point X. When entering the data, do not enter birds that have an asterisk denoting a duplicate observation.

i. Observations of large groups of birds (single species) should be recorded with the number of individuals in parentheses in front of the species code. For example, a group of 80 Double-crested Cormorants observed on the water would be recorded as:

(80) DCCO

j. Aerial foragers that <u>are foraging</u> should be recorded. A bird that is aerial foraging is using the airspace above the territory for foraging, catching insects in the air, using the airspace for fishing (terns), etc. It is different from a flyover in that a bird flying over the territory is traveling, not foraging.

7. Breeding Season Surveys
    a. During the 4 breeding season surveys, surveys will last 15 minutes and will be broken down in the following way;
        i. 0-5 minutes: passive listening (0:00 to 5:00)
        ii. 5-10 minutes: broadcast (5:00 to 10:00)
        iii. 10-15 minutes: passive listening (10:00 to 15:00)
    b. Equipment must be capable of broadcasting at an 80 dB level with minimal distortion. A decibel meter should be used at the beginning of the first survey each day to determine that speakers are projecting at 80dB at 1m distance from the speaker.
    c. Hold speaker above the level of vegetation and broadcast in the direction of the site you are surveying.
    d. Broadcast order:
        i. 30 seconds LEAST BITTERN (LEBI)
        ii. 30 seconds silence
        iii. 30 seconds SORA (SORA)
        iv. 30 seconds silence
        v. 30 seconds VIRGINIA RAIL (VIRA)
        vi. 30 seconds silence
        vii. 30 seconds COMMON MOORHEN(COMO)
        viii. 30 seconds silence
        ix. 30 seconds PIED-BILLED GREBE (PBGR)
        x. 30 seconds silence

8. Data Management
    a. Crews will check over data sheets after each survey, checking that all fields have been filled in, filled in properly and for readability.

    b. Data sheets will be maintained at the Natural Resources Research Institute in Duluth, Minnesota. Results from the field surveys will be stored in an excel database. They will eventually be deposited in a location to be designated by the MPCA project officer.

c. Recommended prep for entering data:
    i. Using a red ultra-fine sharpie marker, number each species code/observation in sequential order on the data sheet. This method allows you to easily follow along the numbering system during actual entry into the database and helps to eliminate mistakes.

9. Safety, Materials & Equipment
    a. a. Because bird surveys are being conducted during daylight hours, observers may survey alone but are required to check in with their field crew leader on a daily basis. Field crew leaders will work out a feasible daily check-in system with their crew to ensure safety in the field.
    b. This survey can be a single or multiple observer protocol.
    c. Surveyors will be equipped with the following:
        i. Data sheets
        ii. Standard Operating Procedures
        iii. Clipboard
        iv. Waterproof, permanent pens/markers (Rite in the Rain pen, ultra-fine tip Sharpie marker)
        v. Thermometer, in metal or plastic case
        vi. Site/point map(s)
        vii. GPS unit, with points loaded
        viii. Extra batteries
        ix. Each crew will carry spare equipment and materials

Appendix B. List of all 197 species observed in the St. Louis River Estuary (1977-2015). Not all of the species included in this list were included in the analysis. Excluded species were those only observed as flyovers or that fell outside of the survey boundaries (for historical vs. recent surveys). The 4-letter (English Name) Alpha Code and Scientific Name are listed for each bird species in accordance with the 56th AOU Supplement (2015). Species detected in a survey = Yes and species not detected = No.

English Name	Scientific Name	Taxa Code	Historical	Recent
Snow Goose	*Chen caerulescens*	SNGO	Yes	Yes
Canada Goose	*Branta canadensis*	CANG	Yes	Yes
Trumpeter Swan	*Cygnus buccinator*	TRUS	No	Yes
Tundra Swan	*Cygnus columbianus*	TUSW	Yes	Yes
Wood Duck	*Aix sponsa*	WODU	Yes	Yes
Gadwall	*Anas strepera*	GADW	Yes	Yes
American Wigeon	*Anas americana*	AMWI	Yes	Yes
American Black Duck	*Anas rubripes*	ABDU	Yes	Yes
American Black Duck X Mallard Hybrid	*Anas rubripes x platy.*	ABDH	No	Yes
Mallard	*Anas platyrhynchos*	MALL	Yes	Yes
Blue-winged Teal	*Anas discors*	BWTE	Yes	Yes
Northern Shoveler	*Anas clypeata*	NSHO	Yes	Yes
Northern Pintail	*Anas acuta*	NOPI	Yes	Yes
Green-winged Teal	*Anas crecca*	GWTE	Yes	Yes
Canvasback	*Aythya valisineria*	CANV	No	Yes
Redhead	*Aythya americana*	REDH	Yes	Yes
Ring-necked Duck	*Aythya collaris*	RNDU	Yes	Yes
Greater Scaup	*Aythya marila*	GRSC	No	Yes
Lesser Scaup	*Aythya affinis*	LESC	Yes	Yes
White-winged Scoter	*Melanitta fusca*	WWSC	No	Yes
Bufflehead	*Bucephala albeola*	BUFF	Yes	Yes
Common Goldeneye	*Bucephala clangula*	COGO	Yes	Yes
Hooded Merganser	*Lophodytes cucullatus*	HOME	Yes	Yes
Common Merganser	*Mergus merganser*	COME	Yes	Yes
Red-breasted Merganser	*Mergus serrator*	RBME	Yes	Yes
Ruddy Duck	*Oxyura jamaicensis*	RUDU	Yes	Yes
Ring-necked Pheasant	*Phasianus colchicus*	RNEP	Yes	No
Ruffed Grouse	*Bonasa umbellus*	RUGR	Yes	No
Common Loon	*Gavia immer*	COLO	Yes	Yes
Pied-billed Grebe	*Podilymbus podiceps*	PBGR	Yes	Yes
Horned Grebe	*Podiceps auritus*	HOGR	Yes	Yes
Red-necked Grebe	*Podiceps grisegena*	RNGR	No	Yes
Double-crested Cormorant	*Phalacrocorax auritus*	DCCO	Yes	Yes
American White Pelican	*Pelecanus erythrorhynchos*	AWPE	No	Yes
American Bittern	*Botaurus lentiginosus*	AMBI	Yes	Yes
Least Bittern	*lxobrychus exilis*	LEBI	Yes	No

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English Name	Scientific Name	Taxa Code	Historical	Recent
Great Blue Heron	*Ardea herodias*	GBHE	Yes	Yes
Great Egret	*Ardea alba*	GREG	No	Yes
Green Heron	*Butorides virescens*	GRHE	Yes	Yes
Black-crowned Night-Heron	*Nycticorax nycticorax*	BCNH	Yes	Yes
Turkey Vulture	*Cathartes aura*	TUVU	Yes	Yes
Osprey	*Pandion haliaetus*	OSPR	No	Yes
Bald Eagle	*Haliaeetus leucocephalus*	BAEA	Yes	Yes
Northern Harrier	*Circus cyaneus*	NOHA	Yes	Yes
Sharp-shinned Hawk	*Accipiter striatus*	SSHA	Yes	Yes
Cooper's Hawk	*Accipiter cooperii*	COHA	No	Yes
Broad-winged Hawk	*Buteo platypterus*	BWHA	Yes	Yes
Red-tailed Hawk	*Buteo jamaicensis*	RTHA	Yes	Yes
Rough-legged Hawk	*Buteo lagopus*	RLHA	Yes	Yes
Virginia Rail	*Rallus limicola*	VIRA	Yes	Yes
Sora	*Porzana carolina*	SORA	Yes	Yes
American Coot	*Fulica americana*	AMCO	Yes	Yes
Sandhill Crane	*Grus canadensis*	SACR	No	Yes
Black-bellied Plover	*Pluvialis squatarola*	BBPL	Yes	Yes
American Golden-Plover	*Pluvialis dominica*	AMGP	Yes	Yes
Semipalmated Plover	*Charadrius semipalmatus*	SEPL	Yes	No
Killdeer	*Charadrius vociferus*	KILL	Yes	Yes
Spotted Sandpiper	*Actitis macularius*	SPSA	Yes	Yes
Solitary Sandpiper	*Tringa solitaria*	SOSA	Yes	No
Greater Yellowlegs	*Tringa melanoleuca*	GRYE	Yes	Yes
Willet	*Tringa semipalmata*	WILL	No	Yes
Lesser Yellowlegs	*Tringa flavipes*	LEYE	Yes	Yes
Stilt Sandpiper	*Calidris himantopus*	STSA	Yes	Yes
Sanderling	*Calidris alba*	SAND	Yes	No
Dunlin	*Calidris alpina*	DUNL	Yes	Yes
Baird's Sandpiper	*Calidris bairdii*	BASA	No	Yes
Least Sandpiper	*Calidris minutilla*	LESA	Yes	Yes
White-rumped Sandpiper	*Calidris fuscicollis*	WRSA	Yes	Yes
Buff-breasted Sandpiper	*Calidris subruficollis*	BBSA	No	Yes
Pectoral Sandpiper	*Calidris melanotos*	PESA	Yes	Yes
Semipalmated Sandpiper	*Calidris pusilla*	SESA	Yes	Yes
Wilson's Snipe	*Gallinago delicata*	WISN	Yes	Yes
Wilson's Phalarope	*Phalaropus tricolor*	WIPH	Yes	No
Bonaparte's Gull	*Chroicocephalus philadelphia*	BOGU	Yes	Yes
Ring-billed Gull	*Larus delawarensis*	RBGU	Yes	Yes
Herring Gull	*Larus argentatus*	HERG	Yes	Yes
Lesser Black-backed Gull	*Larus fuscus*	LBBG	No	Yes

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English Name	Scientific Name	Taxa Code	Historical	Recent
Glaucous Gull	*Larus hyperboreus*	GLGU	No	Yes
Great Black-backed Gull	*Larus marinus*	GBBG	No	Yes
Caspian Tern	*Hydroprogne caspia*	CATE	Yes	No
Black Tern	*Chlidonias niger*	BLTE	Yes	No
Common Tern	*Sterna hirundo*	COTE	Yes	Yes
Forster's Tern	*Sterna forsteri*	FOTE	Yes	No
Rock Pigeon	*Columba livia*	ROPI	Yes	Yes
Mourning Dove	*Zenaida macroura*	MODO	Yes	Yes
Black-billed Cuckoo	*Coccyzus erythropthalmus*	BBCU	No	Yes
Common Nighthawk	*Chordeiles minor*	CONI	Yes	Yes
Chimney Swift	*Chaetura pelagica*	CHSW	Yes	Yes
Ruby-throated Hummingbird	*Archilochus colubris*	RTHU	Yes	Yes
Belted Kingfisher	*Megaceryle alcyon*	BEKI	Yes	Yes
Red-headed Woodpecker	*Melanerpes erythrocephalus*	RHWO	Yes	No
Red-bellied Woodpecker	*Melanerpes carolinus*	RBWO	No	Yes
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA	No	Yes
Downy Woodpecker	*Picoides pubescens*	DOWO	Yes	Yes
Hairy Woodpecker	*Picoides villosus*	HAWO	Yes	Yes
Northern Flicker	*Colaptes auratus*	NOFL	Yes	Yes
Pileated Woodpecker	*Dryocopus pileatus*	PIWO	No	Yes
American Kestrel	*Falco sparverius*	AMKE	Yes	Yes
Merlin	*Falco columbarius*	MERL	Yes	Yes
Peregrine Falcon	*Falco peregrinus*	PEFA	No	Yes
Alder Flycatcher	*Empidonax alnorum*	ALFL	Yes	Yes
Least Flycatcher	*Empidonax minimus*	LEFL	Yes	Yes
Eastern Phoebe	*Sayornis phoebe*	EAPH	Yes	Yes
Great Crested Flycatcher	*Myiarchus crinitus*	GCFL	Yes	Yes
Eastern Kingbird	*Tyrannus tyrannus*	EAKI	Yes	Yes
Northern Shrike	*Lanius excubitor*	NSHR	Yes	Yes
Yellow-throated Vireo	*Vireo flavifrons*	YTVI	No	Yes
Blue-headed Vireo	*Vireo solitarius*	BHVI	No	Yes
Warbling Vireo	*Vireo gilvus*	WAVI	Yes	Yes
Red-eyed Vireo	*Vireo olivaceus*	REVI	Yes	Yes
Gray Jay	*Perisoreus canadensis*	GRAJ	Yes	No
Blue Jay	*Cyanocitta cristata*	BLJA	Yes	Yes
American Crow	*Corvus brachyrhynchos*	AMCR	Yes	Yes
Common Raven	*Corvus corax*	CORA	No	Yes
Horned Lark	*Eremophila alpestris*	HOLA	No	Yes
Purple Martin	*Progne subis*	PUMA	Yes	No
Tree Swallow	*Tachycineta bicolor*	TRES	Yes	Yes
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	NRWS	Yes	Yes

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English Name	Scientific Name	Taxa Code	Historical	Recent
Bank Swallow	*Riparia riparia*	BANS	Yes	Yes
Cliff Swallow	*Petrochelidon pyrrhonota*	CLSW	Yes	Yes
Barn Swallow	*Hirundo rustica*	BARS	Yes	Yes
Black-capped Chickadee	*Poecile atricapillus*	BCCH	Yes	Yes
Red-breasted Nuthatch	*Sitta canadensis*	RBNU	No	Yes
White-breasted Nuthatch	*Sitta carolinensis*	WBNU	No	Yes
Brown Creeper	*Certhia americana*	BRCR	No	Yes
House Wren	*Troglodytes aedon*	HOWR	Yes	Yes
Winter Wren	*Troglodytes hiemalis*	WIWR	Yes	Yes
Sedge Wren	*Cistothorus platensis*	SEWR	Yes	Yes
Marsh Wren	*Cistothorus palustris*	MAWR	Yes	Yes
Golden-crowned Kinglet	*Regulus satrapa*	GCKI	No	Yes
Ruby-crowned Kinglet	*Regulus calendula*	RCKI	Yes	Yes
Veery	*Catharus fuscescens*	VEER	Yes	Yes
Gray-cheeked Thrush	*Catharus minimus*	GCTH	Yes	No
Swainson's Thrush	*Catharus ustulatus*	SWTH	No	Yes
Hermit Thrush	*Catharus guttatus*	HETH	No	Yes
American Robin	*Turdus migratorius*	AMRO	Yes	Yes
Gray Catbird	*Dumetella carolinensis*	GRCA	Yes	Yes
Brown Thrasher	*Toxostoma rufum*	BRTH	Yes	Yes
European Starling	*Sturnus vulgaris*	EUST	Yes	Yes
American Pipit	*Anthus rubescens*	AMPI	Yes	Yes
Cedar Waxwing	*Bombycilla cedrorum*	CEDW	Yes	Yes
Lapland Longspur	*Calcarius lapponicus*	LALO	Yes	Yes
Snow Bunting	*Plectrophenax nivalis*	SNBU	Yes	Yes
Ovenbird	*Seiurus aurocapilla*	OVEN	Yes	Yes
Northern Waterthrush	*Parkesia noveboracensis*	NOWA	Yes	Yes
Black-and-white Warbler	*Mniotilta varia*	BAWW	No	Yes
Tennessee Warbler	*Oreothlypis peregrina*	TEWA	Yes	No
Orange-crowned Warbler	*Oreothlypis celata*	OCWA	Yes	Yes
Nashville Warbler	*Oreothlypis ruficapilla*	NAWA	Yes	Yes
Mourning Warbler	*Geothlypis philadelphia*	MOWA	Yes	Yes
Common Yellowthroat	*Geothlypis trichas*	COYE	Yes	Yes
American Redstart	*Setophaga ruticilla*	AMRE	Yes	Yes
Cape May Warbler	*Setophaga tigrina*	CMWA	No	Yes
Northern Parula	*Setophaga americana*	NOPA	No	Yes
Magnolia Warbler	*Setophaga magnolia*	MAWA	Yes	Yes
Blackburnian Warbler	*Setophaga fusca*	BLBW	No	Yes
Yellow Warbler	*Setophaga petechia*	YEWA	Yes	Yes
Chestnut-sided Warbler	*Setophaga pensylvanica*	CSWA	Yes	Yes
Blackpoll Warbler	*Setophaga striata*	BLPW	Yes	Yes

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English Name	Scientific Name	Taxa Code	Historical	Recent
Palm Warbler	*Setophaga palmarum*	PAWA	Yes	Yes
Yellow-rumped Warbler	*Setophaga coronata*	YRWA	Yes	Yes
Black-throated Green Warbler	*Setophaga virens*	BTNW	No	Yes
Canada Warbler	*Cardellina canadensis*	CAWA	No	Yes
Wilson's Warbler	*Cardellina pusilla*	WIWA	Yes	Yes
American Tree Sparrow	*Spizelloides arborea*	ATSP	Yes	Yes
Chipping Sparrow	*Spizella passerina*	CHSP	Yes	Yes
Clay-colored Sparrow	*Spizella pallida*	CCSP	Yes	Yes
Vesper Sparrow	*Pooecetes gramineus*	VESP	Yes	Yes
Savannah Sparrow	*Passerculus sandwichensis*	SAVS	Yes	Yes
Fox Sparrow	*Passerella iliaca*	FOSP	No	Yes
Song Sparrow	*Melospiza melodia*	SOSP	Yes	Yes
Lincoln's Sparrow	*Melospiza lincolnii*	LISP	Yes	Yes
Swamp Sparrow	*Melospiza georgiana*	SWSP	Yes	Yes
White-throated Sparrow	*Zonotrichia albicollis*	WTSP	Yes	Yes
Harris's Sparrow	*Zonotrichia querula*	HASP	Yes	No
White-crowned Sparrow	*Zonotrichia leucophrys*	WCSP	Yes	Yes
Dark-eyed Junco	*Junco hyemalis*	DEJU	Yes	Yes
Scarlet Tanager	*Piranga olivacea*	SCTA	No	Yes
Northern Cardinal	*Cardinalis cardinalis*	NOCA	No	Yes
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR	Yes	Yes
Indigo Bunting	*Passerina cyanea*	INBU	Yes	No
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL	Yes	Yes
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	YHBL	Yes	No
Rusty Blackbird	*Euphagus carolinus*	RUBL	Yes	Yes
Brewer's Blackbird	*Euphagus cyanocephalus*	BRBL	Yes	No
Common Grackle	*Quiscalus quiscula*	COGR	No	Yes
Brown-headed Cowbird	*Molothrus ater*	BHCO	Yes	Yes
Baltimore Oriole	*Icterus galbula*	BAOR	Yes	Yes
Pine Grosbeak	*Pinicola enucleator*	PIGR	Yes	No
House Finch	*Haemorhous mexicanus*	HOFI	No	Yes
Purple Finch	*Haemorhous purpureus*	PUFI	Yes	Yes
Common Redpoll	*Acanthis flammea*	CORE	Yes	Yes
Pine Siskin	*Spinus pinus*	PISI	Yes	Yes
American Goldfinch	*Spinus tristis*	AMGO	Yes	Yes
Evening Gosbeak	*Coccothraustes vespertinus*	EVGR	Yes	No
House Sparrow	*Passer domesticus*	HOSP	Yes	Yes

Appendix C. Total number of birds observed per bird group per site for current surveys of R2R, reference, and additional sites, excluding flyover observations.

Site	Blackbird	Corvid	Dove	Gull	Hummingbird	Invasive	Pigeon	Rail	Raptor	Shorebird	Songbird	Waterbird	Waterfowl	Woodpecker
21st Avenue West	227	2256	0	64839	0	3284	170	0	29	70	915	543	13406	5
40th Avenue West	557	156	2	954	1	34	19	5	39	196	1368	412	9366	38
Cedar Yard Bay	105	5	0	43	0	0	0	2	0	0	74	47	138	0
Clough Island	24	14	0	37	0	0	0	1	6	0	71	16	68	10
Grassy Point	363	7	5	8	1	1	0	1	13	17	365	73	894	9
Horseshoe Bay	1	6	0	0	0	0	0	0	3	0	7	64	80	1
Kingsbury Bay	294	15	1	7	1	4	0	8	3	5	325	56	750	4
Little Pokegema Bay	57	10	0	2	1	0	0	2	8	0	90	216	241	3
Minnesota Point	91	33	0	164	0	4	0	1	1	23	184	22	281	13
Minnesota Slip	0	12	0	201	0	20	28	0	0	1	37	114	78	0
Mud Lake	255	22	1	7	0	0	0	7	5	5	287	139	1623	6
North Bay	220	24	0	7	1	0	0	11	2	2	183	430	376	6
Perch Lake	39	9	0	0	0	0	0	2	3	0	76	54	561	3
Pokegema Bay	0	5	0	0	0	0	0	0	0	0	6	4	0	3
Rask Bay	33	9	0	13	0	0	0	5	7	0	85	1615	1058	4
Slip C	2	2	1	2	0	2	26	0	1	0	149	4	54	0
Southworth Marsh	9	3	0	0	0	0	0	0	1	0	28	2	1	0
Spirit Lake East	41	8	0	1	0	0	0	0	6	0	87	41	311	4
Spirit Lake West	115	14	0	40	0	0	0	0	16	2	141	50	788	5
Stryker Bay	18	12	0	2	0	0	8	0	0	0	24	6	106	2
Weasel Bay	2	0	0	0	0	0	0	0	1	0	8	93	13	2

Appendix D. Species not observed in historical or recent surveys. This list includes all species observations.

Species	Historical	Recent	Species	Historical	Recent
Trumpeter Swan	0	6	Eastern Phoebe	0	2
Northern Shoveler	0	20	Northern Shrike	0	1
Canvasback	0	113	Common Raven	0	11
Greater Scaup	0	8	Purple Martin	3	0
Red-breasted Merganser	0	24	Bank Swallow	37	0
Ring-necked Pheasant	2	0	White-breasted Nuthatch	0	2
Red-necked Grebe	0	5	Winter Wren	0	1
American White Pelican	0	19	Golden-crowned Kinglet	0	1
American Bittern	4	0	Gray-cheeked Thrush	1	0
Least Bittern	3	0	Swainson's Thrush	0	1
Great Egret	0	3	Brown Thrasher	4	0
Black-crowned Night-Heron	2	0	Snow Bunting	27	0
Turkey Vulture	0	8	Black-and-white Warbler	0	1
Cooper's Hawk	0	2	Tennessee Warbler	5	0
Rough-legged Hawk	11	0	Mourning Warbler	0	1
Black-bellied Plover	22	0	Cape May Warbler	0	2
Semipalmated Plover	15	0	Magnolia Warbler	1	0
Killdeer	244	0	Blackburnian Warbler	0	1
Solitary Sandpiper	2	0	Blackpoll Warbler	0	1
Sanderling	2	0	Canada Warbler	0	1
Dunlin	36	0	Wilson's Warbler	0	4
White-rumped Sandpiper	2	0	Clay-colored Sparrow	1	0
Wilson's Phalarope	15	0	Vesper Sparrow	3	0
Black Tern	52	0	Savannah Sparrow	20	0
Forster's Tern	2	0	Indigo Bunting	1	0
Black-billed Cuckoo	0	1	Yellow-headed Blackbird	43	0
Common Nighthawk	1	0	Brewer's Blackbird	3	0
Red-bellied Woodpecker	0	1	Evening Gosbeak	31	0
Yellow-bellied Sapsucker	0	1	House Sparrow	7	0
Pileated Woodpecker	0	6			
Peregrine Falcon	0	4			