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GRADUATE SCHOOL

EVALUATION OF THE OHIO RAPID ASSESSMENT METHOD FOR WETLANDS IN THE WESTERN GREAT LAKES: AN ANALYSIS USING BIRD ASSEMBLAGES

A THESIS SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL OF THE UNIVERSITY OF MINNESOTA
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Introduction

Coastal wetlands are among the most threatened ecosystems in the Great Lakes basin. Less than one-third of the pre-settlement wetlands within the basin remain today (Government of Canada and U.S. EPA 1995). The U.S. Environmental Protection Agency's Wetlands Program (U.S. EPA 2005) and the United States Clean Water Act (Section 404b, U.S. EPA 2003) have established the need for wetland assessments to monitor and evaluate anthropogenic impacts to wetland ecosystems. Step 3 of the Guidelines in Section 404b of the U.S. Clean Water Act specifically calls for an assessment of impacts to a wetland of which an application to fill or dredge has been filed (Ainslie 1994). Currently, over 50 wetland assessment methods have been developed and are used nationwide. Several Great Lakes states have taken the initiative to focus on Great Lake coastal wetlands and have detailed the need to develop a basin-wide wetland assessment method (Kusler et al. 1990, Epstein et al. 2002, GLC 2005).

The most commonly used wetland assessment approach is the rapid assessment method (Thiesing 1998). This approach uses scientifically based methods to assess overall wetland quality and condition during a very short period of time. A review of rapid assessment methods for wetlands conducted by Fennessy et al. (2004) identified methods from which a template for development of a wetland monitoring and assessment program could be created. One of the methods selected in this review, the Ohio Rapid Assessment Method (ORAM), resembles the data gathering and assessment structure of many other rapid assessment methods (Fennessy et al. 2004) as well as acts as a template for

developing rapid assessment methods (Collins 2003, Mack personal communication 2004).

Although not intended to replace more biologically detailed wetland assessments, rapid assessment methods are constructed to provide a quantitative assessment of wetland quality and condition. Van Dam et al. (1998) report on the ability of rapid assessment methods to reflect anthropogenic disturbance in wetlands. Anthropogenic disturbance and habitat condition are also reflected in the biotic communities of many different systems, including wetlands (Findlay and Houlahan 1997, Innis et al. 2000). Rapid assessment methods should therefore not only provide information on the quality and condition of a wetland, but also on the quality and condition of the biota in a wetland ecosystem. Two recent studies support this generalization with regard to ORAM. Mack (2001b) and Micacchion (2002) found ORAM to reflect the diversity of plants and amphibians in wetlands, respectively.

Birds have long been used as terrestrial indicators of environmental condition (O'Connell et al. 2000, Niemi and McDonald 2004) and are affected by habitat structure and condition of breeding sites (Stauffer and Best 1980, Murkin et al. 1997, Whitt et al. 1999). Birds are also sensitive to a wide range of environmental and anthropogenic changes including vegetative structure, water level and extent, water quality, landscape changes and anthropogenic disturbance (Finch 1991, Blair 1996, Mensing et al. 1998). Wetland birds are an integral part of a wetland ecosystem and are reflective of wetland ecosystem integrity (Croonquist and Brooks 1991, Galatowitsch et al. 1999, Bryce et al.

2002). Therefore, wetland assessments should reflect the quality of bird assemblages in wetlands. One study conducted by Stapanian et al. (2004) focused specifically on the ORAM's ability to predict bird species richness in Ohio wetlands. In this study, ORAM scores reliably predicted total species richness and mean species richness of wetland birds of special concern in Ohio.

Several Great Lakes state agencies have developed or are in the process of developing state specific wetland assessments, yet methods vary in type, procedure, and inter-state coordination (MBWSR 2003, WIDNR 1992, Merkey and Seelbach 2002). Mack (2001) states that although ORAM was developed for use in Ohio, ORAM ". . . may have broader geographic applications." ORAM's potential to be used as a general model in a wetland assessment program and its potential for regional application make this method a possible template for a Great Lakes basin-wide wetland assessment method.

The purpose of this study is to evaluate the use of a rapid assessment method for wetlands on coastal wetlands in the western Great Lakes region and if necessary, make suggestions for method improvement. I am specifically evaluating ORAM because of its current use, broad applications, and structural similarity to existing rapid assessment methods for wetlands. To evaluate the usefulness of this rapid assessment method in the western Great Lakes region, I used a comparison of the presence and abundance of wetland bird assemblages, independent measures of anthropogenic stress, habitat variables, and wetland condition according to ORAM.

Methods

Study Area

Wetlands sampled in this study represent a subset of sites identified for the Great Lakes Environmental Indicators (GLEI) project (glei.nrri.umn.edu) as described by Danz et al. (2005). All coastal wetlands identified for the GLEI project occur within 1 kilometer of a Great Lake coastline. From these wetland sites I selected riverine coastal wetlands, which are defined as wetlands that have a direct water connection to a river and a Great Lake (Keough et al. 1999). Wetland selection was also limited to in the Laurentian Mixed Forest ecoprovince (Keys et al. 1995) of which riverine wetlands were the most abundant coastal wetland type. Using these criteria, I selected 51 coastal wetland sites that occurred along the south coast of Lake Superior and both the east and west coasts of Lake Michigan (Figure 1).

Field Methods

Bird Sampling. I used standardized point counts following the National Marsh Bird Monitoring Program (Conway 2003) and included regional modifications. Point counts were conducted once at every wetland site from one half hour before sunrise to four hours after sunrise during June of 2003. I recorded all male breeding birds detected (visually and audibly) within a 100-meter semi-circle established at the perimeter of the wetland during three continuous 5-minute intervals. During the second 5-minute interval, playbacks were used to solicit calls from five wetland dependent species: Pied-billed Grebe

(*Podiceps nigricollis*), Least Bittern (*Ixobrychus exilis*), Common Moorhen (*Gallinula chloropus*), Sora (*Porzana carolina*), and Virginia Rail (*Rallus limicola).*

Breeding bird species recorded during surveys were divided into two categories: riverine wetland associated and non-wetland associated species. Only riverine wetland associated bird species as defined by Hanowski et al. (2003) were retained for analysis. Riverine wetland associated birds were further split into two groups: wetland obligate and wetland ubiquitous bird species. I defined wetland obligate species as birds entirely dependent on wetlands in the western Great Lakes region (Hanowski et al. 2003) and/or wetland bird species with high regional Partners in Flight (PIF) scores (Rich et al. 2004). I defined wetland ubiquitous species as birds not entirely dependent on wetlands and/or birds that do not have high regional PIF scores in the western Great Lakes region.

ORAM. For consistency and accuracy, I attended training in wetland delineation and in using the Ohio Rapid Assessment Method (ORAM; Mack 2001a) in spring 2003. I conducted all ORAM assessments at wetland sites during July 2003. The ORAM users manual and evaluation methods are described by Mack (2001a). Although ORAM consists of two portions, narrative and quantitative, I used only the quantitative portion of ORAM in order to assess wetland condition in this study.

The quantitative portion of ORAM consists of six metrics that represent attributes of wetland function and condition (Table 1). Each ORAM metric is further comprised of one to six different submetrics designed to evaluate wetland

quality and condition. A submetric receives a higher score as the element of wetland condition being evaluated increases with respect to overall condition and quality. The total ORAM score is the sum of all the submetric scores. An increase in total ORAM score reflects an increase in wetland quality and condition. I evaluated wetland quality and condition according to ORAM at the submetric level as well as using total ORAM score.

Habitat Proportions. I visually recorded habitat type and habitat abundance as a percentage of the wetland area sampled using the following categories: forest, shrub vegetation, emergent vegetation, mud/sand/rock, open water, and other (e.g., docks and boat ramps). The type of emergent vegetation was also recorded as a percentage of the total emergent vegetation present in the sample area.

Data Analysis

Anthropogenic Stressors. Danz et al. (2005) developed an anthropogenic stress gradient for GLEI wetlands by subjecting hundreds of anthropogenic stress measurements available for each coastal wetland watershed to several principal components analyses (PCAs). The anthropogenic stress measurements used for this study included five categories: agriculture, atmospheric deposition, land cover, human population, and point source pollution. These stress categories were reflected in five different PCA ordinations. The principal component one (PC1) score gradients from each PCA were interpreted by Danz (2005) to represent the following anthropogenic

stressors potentially influencing the watersheds of the wetlands sampled. Agriculture PC1 scores reflected an increase in overall agricultural practices within a wetland watershed. Atmospheric deposition PC1 scores reflected an increase in the amount of deposition within a wetland watershed. Land Cover PC1 scores reflected an increase in agricultural land cover classes and a decrease in forest land cover classes within a wetland watershed. Human population PC1 scores reflected an increase in human population density within a wetland watershed. Point source pollution PC1 scores reflected an increase in point source pollution within a wetland watershed.

Ordination of ORAM Submetrics. ORAM was designed to weight the effect of each submetric on the total ORAM score according to its importance in wetland function and quality requirements (Mack 2001a). For example, hydrology based submetrics make up 30% of the total contribution to total ORAM score due to the importance of hydrologic features for wetland sustainability and processes (Mitsch and Gosselink 1996). To gain insight into the influence of each submetric on the variation in total ORAM score in this study, a principal components analysis (PCA) of the covariance matrix was performed using the Proc Princomp procedure in SAS (SAS Institute 1999). High eigenvalue loadings indicated ORAM submetrics most influential to the submetric score variation on principal component one.

Ordinations of Wetland Sites. To describe differences in common wetland bird composition among wetlands sampled, an ordination was performed. I chose to use a correspondence analysis (CA) because of this ordination's use of

the Chi-squared distance for interpretation of abundance data. Wetlands located near each other in multivariate space shared similar wetland bird abundances. In this ordination, I used only riverine wetland associated birds that occurred in over 5% of the wetlands sampled. Hereafter, these species are referred to as "common wetland bird species". I performed the CA using PC-ORD for Windows (McCune and Mefford 1997) and the Proc Corresp procedure in SAS (SAS Institute 1999). Axis one was interpreted using an overlay of habitat proportion data in PC-ORD. The 'down-weight rare species' option in PC-ORD was also applied.

An additional CA ordination was used to examine the differences in habitat proportions among wetlands sampled. Here, wetlands located near each other in multivariate space shared similar habitat types and proportions. Axis one was interpreted using an overlay of common wetland bird species composition data. The analysis software and techniques used for the wetland bird CA were also applied here.

Comparisons of Birds, ORAM, Habitat, and Stressors. I calculated three bird metrics in addition to common wetland species-specific abundances to evaluate ORAM's ability to reflect bird assemblages in western Great Lakes coastal wetlands: wetland breeding bird species richness, obligate breeding bird abundance, and ubiquitous breeding bird abundance. Wetland bird species richness was calculated as the total number of riverine wetland associated species recorded at each wetland site. Obligate bird abundance was calculated as the total number of obligate individuals recorded at each wetland site.

Ubiquitous bird abundance was calculated in a similar fashion. I compared all bird metrics to the total ORAM score and ORAM submetric scores. For these analyses, linear regressions were performed. All linear regression analyses in this study used a confidence level of 0.99 ($\alpha = 0.01$) and the Proc Reg procedure in SAS (SAS Institute 1999).

To relate the distribution of common wetland birds and habitat proportions at wetlands sampled, axis one from the common wetland bird CA and axis one from the habitat proportion CA were compared using linear regression analysis. Linear regression analyses were also used to examine significant relationships among the following: bird metrics and habitat proportions, common wetland species-specific abundance and habitat proportions, bird metrics and anthropogenic stress PC1 scores, and common wetland species-specific abundance and anthropogenic stress PC1 scores. The most significant bird metric and submetric associations were further examined to explore ways to improve ORAM's ability to reflect wetland bird assemblages. For an independent measure of ORAM's ability to reflect wetland condition, anthropogenic stress PC1 scores were compared to ORAM scores also using linear regression analysis.

Results

Total ORAM scores ranged from 29 to 78 points (theoretical range 0 – 90, due to the elimination of metric 5) for the 51 wetlands sampled. During wetland bird surveys I recorded a total of 55 breeding bird species. Sixteen of these

species met the definition of riverine wetland associated breeding birds. Of these 16 wetland associated bird species, 13 species met the obligate species definition criteria and three met the ubiquitous species definition criteria (Table 2). A total of four obligate bird species (Alder Flycatcher (*Empidonax alnorum*), Sedge Wren (*Cistothorus palestris*), Swamp Sparrow (*Melospiza georgiana*), and Virginia Rail) and three ubiquitous bird species (Common Yellow-throat (*Geothlypis trichas*), Red-winged Blackbird (*Agelaius phoeniceus*), and Yellow Warbler (*Dendroica petechia*)) were common or recorded in more than 5% of the wetlands sampled. Because of the high variation in abundance of Canada Geese (*Branta canadensis*) at wetlands sampled that resulted in less meaningful data interpretations, this species was excluded from the metric obligate bird abundance.

Ordinations

A principal components analysis (PCA) of ORAM submetrics showed that considered collectively, the first two principal components explained 61.5% of the total variation in ORAM submetrics scores (PC1 = 46.9% and PC2 = 14.6%). The submetrics with the highest PC1 eigenvalue loadings, indicated by a natural break in loading values, were identified as most influential to the total variation among ORAM submetrics in this study. These submetrics included Buffer Width, Modifications to Hydrologic Regime, Habitat Development, Vegetative Communities, and Coverage of Invasive Plants (Table 3), all five of which are directly or indirectly associated with anthropogenic disturbance. The submetric

Buffer Width is the measure of distance between the edge of the wetland and an anthropogenic landscape disturbance up to 50 meters in width. The score for this submetric decreased as the width of the buffer decreased. Any visual modification to the natural hydrology of a wetland such as a dike was recorded and decreased the score for the submetric Modifications to Hydrologic Regime. The submetric Vegetative Communities asked that the evaluator identify and rate six wetland communities including: aquatic bed, emergents, shrubs, forests, mudflats, and open water. The community rating incorporated community quality and coverage area. A vegetative community that received high points indicated that the community was of high quality and covered a significant portion of the wetland. The submetric Habitat Development asked the evaluator to rate the wetland according to how developed the wetland appeared when compared to regional reference wetlands with regards to hydrologic structure, vegetative structure, and local landscape. The submetric Coverage of Invasive Plants measured the aerial coverage of invasives present in the wetland, decreasing in score as coverage increased.

Hydrology related ORAM submetrics were designed to be the most influential submetrics (30%) in contributing to total ORAM score. Of the hydrology submetrics (Table 1), only the submetric Modifications to Natural Hydrologic Regime had a high influence on submetric score variation according to the ORAM PCA. This result is due to the sampling of hydrogeomorphically similar wetlands.

Considered collectively, axes one and two of the wetland bird correspondence analysis (CA) explain 54.5% of the total inertia (36.6%, $\lambda = 0.26$; 17.9%, $\lambda = 0.13$, respectively, Figure 2). Wetlands with high Red-winged Blackbird and Virginia Rail abundance had lower axis one scores. Alternately, wetlands with low Red-winged Blackbird and Virginia Rail abundance had high Alder Flycatcher abundance and higher axis one scores. An interpretation of axis one using an overlay of habitat proportion data showed wetlands associated with Virginia Rails and Red-winged Blackbirds were dominated by emergent plants while wetlands associated with Alder Flycatchers were dominated by shrubs. Axis two was difficult to interpret and showed little variation in scores based on a low contribution to the total inertia.

Emergent and shrub vegetation varied considerably at wetland sites as demonstrated by the habitat proportion CA (Figure 3). Axes one and two of the CA explained 58.5% of the total inertia (39.6%, $\lambda = 0.27$; 18.9%, $\lambda = 0.13$, respectively). Higher axis one scores reflected a decrease in the proportion of emergent vegetation and an increase in the proportion of shrub vegetation at wetland sites. An interpretation of axis one using an overlay of common wetland bird data showed that wetlands dominated by emergent plants were more likely to be utilized by Red-winged Blackbirds while a shrub dominated habitat was more likely to be utilized by Alder Flycatchers. This interpretation mirrors the bird CA axis one interpretation. Axis two showed little variation in scores based on a low contribution to the total inertia and proved difficult to interpret.

Comparisons of Birds and ORAM

A comparison of total ORAM score and axis one of the common wetland bird CA showed that total ORAM score had a significantly positive relationship with axis one scores ($r^2 = 0.16$, $p = 0.00$, Figure 4). Comparisons of bird metrics and total ORAM score revealed that ubiquitous bird abundance had a significant negative relationship with increasing ORAM score ($r^2 = 0.18$, $p = 0.00$). However, neither obligate bird abundance nor wetland breeding bird species richness had significant relationships with total ORAM score ($r^2 = 0.08$, $p = 0.05$ and $r^2 = 0.05$, $p = 0.13$ respectively, Table 4). Of the seven common wetland birds, only Red-winged Blackbird and Alder Flycatcher abundances had significant relationships with total ORAM score ($r^2 = 0.17$ $p = 0.00$, $r^2 = 0.13$ $p = 0.01$ respectively, Table 4).

The vegetation submetrics Vegetative Communities and Coverage of Invasive Plants, the landscape related submetric Intensity of Surrounding Land Use, and the submetric Habitat Development were important to wetland bird assemblages. Species richness and obligate species abundance had significant relationships with the submetric Wetland Vegetation Communities ($r^2 = 0.15$, $p = 0.01$ and $r^2 = 0.14$, $p = 0.01$ respectively, Table 5). Ubiquitous species abundance was significantly related to the submetrics Intensity of Surrounding Land Use ($r^2 = 0.20$, $p = 0.00$), Habitat Development ($r^2 = 0.22$, $p < 0.001$), Wetland Vegetation Communities ($r^2 = 0.15$, $p = 0.01$), and Coverage of Invasive Plants ($r^2 = 0.20$, $p < 0.001$, Table 5).

Of the common wetland bird species, only the abundances of Red-winged Blackbirds and Alder Flycatchers had significant relationships with at least one ORAM submetric ($p < 0.01$, Table 5). Alder Flycatcher abundance had a positive relationship with the submetric Intensity of Surrounding Land Use ($r^2 = 0.28$, $p < 0.001$). Red-winged Blackbird abundance had a negative relationship with the submetrics Intensity of Surrounding Land Use ($r^2 = 0.14$, $p = 0.01$), Habitat Development ($r^2 = 0.19$, $p < 0.001$), Wetland Vegetative Communities ($r^2 = 0.17$, $p = 0.00$), and Coverage of Invasive Plants ($r^2 = 0.20$, $p < 0.001$).

It is important to note that the submetric scores for Intensity of Surrounding Land Use and Coverage of Invasive Plants decreased as the particular measurement for these submetrics increased with respect to quality. For example, as the intensity of anthropogenic related land use surrounding the wetland increased, the Intensity of Surrounding Land Use submetric score decreased. Therefore, Red-winged Blackbird abundance was positively associated with high surrounding land use intensity. Coverage of Invasive Plant submetric scores increased as invasive aerial coverage decreased. Therefore Red-winged Blackbird abundance was positively associated with a high coverage of invasive plants as measured by ORAM (Table 5).

When the submetrics most important to wetland bird assemblages (Intensity of Surrounding Land Use, Habitat Development, Vegetative Communities, Coverage of Invasive Plants) were added together to create a new ORAM “score” (hereafter referred to as the New ORAM score), associations between the New ORAM score and bird assemblages improve (Table 4). All

three bird metrics as well as the abundance of Alder Flycatchers and Red-winged Blackbirds had significant relationships with the New ORAM score.

Comparisons of Birds and Habitat Proportions

Linear regression results comparing habitat proportions and bird metrics indicated that vegetation was important in the structure of wetland breeding bird communities (Figure 5, Table 6). For example, there was a significant relationship between common wetland bird CA axis one scores and habitat proportion CA axis one scores ($r^2 = 0.32$, $p < 0.001$; Figure 5). When recording emergent vegetation proportion, I also recorded emergent vegetation type. It is important to note that when the proportion of emergent vegetation made up a majority of the wetland sample site (> 50%), narrow-leaved cattail *(Typha angustafolia*) was the prominent emergent vegetation type. Obligate bird abundance had a significantly positive relationship with the proportion of shrub vegetation ($r^2 = 0.17$, $p = 0.00$) and ubiquitous bird abundance was significantly related to both emergent (positive) and shrub (negative) vegetation ($r^2 = 0.24$, $p < 0.001$ and $r^2 = 0.21$, $p < 0.001$, respectively). Proportions of emergent vegetation and shrub vegetation were also significantly related to Red-winged Blackbird abundance ($r^2 = 0.25$, $p < 0.001$ and $r^2 = 0.20$, $p < 0.001$, respectively) and Alder Flycatcher abundance ($r^2 = 0.16$ $p = 0.00$ and $r^2 = 0.21$, $p < 0.001$, respectively). Red-winged Blackbird abundance had a positive relationship with emergent vegetation and a negative relationship with shrub vegetation. The opposite relationship existed between Alder Flycatchers and these vegetation types. The

habitat associations of Red-winged Blackbirds (dense emergent vegetation) and Alder Flycatchers (shrub vegetation) in this study are in agreement with other studies (Lowther 1999, Yasukawa and Searcy 1995). Wetland breeding bird species richness was not related to any habitat proportion type.

Comparisons of Anthropogenic Stressors, ORAM, and Birds

Linear regression results showed all but one (pollution) of the measured anthropogenic stress categories represented by GLEI principal component one scores (Danz, 2005) had significantly negative relationships with total ORAM score (Table 7).

Wetland breeding bird species richness, obligate bird abundance, and Alder Flycatcher abundance all had significantly negative relationships with all GLEI anthropogenic stressors except atmospheric deposition (Table 8). Ubiquitous bird abundance and Red-winged Blackbird abundance had significantly positive relationships with agriculture, atmospheric deposition, and a landscape with a high amount of agriculture cover classes.

Discussion

ORAM, Vegetation and Ubiquitous Birds

Many of the significant relationships in this study reflect the importance of wetland vegetation to the structure of wetland bird assemblages. In western Great Lakes coastal wetlands, wetland birds were associated with some element(s) of wetland habitat and were therefore not choosing wetlands at

random. The natural ordering of wetland birds among wetlands sampled had a more significant relationship with habitat proportion measurements than total ORAM score.

The most abundant emergent plant species present in this study was narrow-leaved cattail (*Typha angustifolia*) which forms large monotypic stands of dense vegetation (Eggers and Reed 1997). Turner and McCarty (1998) showed that breeding Red-winged Blackbirds, a ubiquitous species, more readily chose wetlands with high emergent stem density, reflectant of *Typha angustifolia* stands. In the western Great Lakes region *Typha angustifolia* is an invasive species and when present, the invasiveness and monotypic nature of this emergent plant resulted in lower scores for the following submetrics: Habitat Development, Wetland Vegetation Communities, Horizontal Interspersion and Coverage of Invasive Plants. It is the presence of *Typha angustifolia* that helped to explain the significant negative relationship between ubiquitous bird abundance, Red-winged Blackbird abundance and total ORAM score. Although these relationships show that ORAM does reflect wetland conditions utilized by Red-winged Blackbirds, it is important to note that these wetlands were also occupied by the obligate species Virginia Rail, although no significant relationships between this species and ORAM exist.

ORAM and Birds

Although ORAM was not intended to predict quality characteristics of flora and fauna present in a wetland (Mack 2001), studies have indicated that the

structure of this rapid assessment method allowed for such predictions (Mack 2001, Micacchion 2002). In particular, Stapanian et al. (2004) found a direct correlation between ORAM score and two bird variables: total bird species richness and wetland bird species richness of special concern species in Ohio wetlands. In general I did not find similar results to Stapanian's study. Bird species richness in riverine coastal wetlands of the western Great Lakes did not have a significant relationship with total ORAM score. Obligate bird abundance, which is similar to Stapanian's special concern species richness measurement, also did not have a significant relationship with total ORAM score. Because of geographical differences, several of the bird species in Stapanian's study were not recorded in the coastal wetlands sampled in this study (e.g., Black-crowned Night-heron, Yellow-crowned Night-heron, Marsh Wren, and King Rail). Birds of special concern in the study by Stapanian et al. (2004) that did occur in the wetlands sampled in this study include the American Bittern, Virginia Rail, Sora, Alder Flycatcher, Sedge Wren, and Northern Waterthrush.

ORAM, Anthropogenic Stressors, and Birds

Western Great Lakes coastal riverine wetlands varied most widely in anthropogenic disturbance submetrics including Buffer Width and Modifications to Hydrologic Regime. The ability of ORAM to reflect the independent stress measurements developed by Danz et al. (2005) support this relationship. Although birds have been shown to be sensitive to anthropogenic stressors (Findlay and Houlahan 1996, Mensing et al. 1998) and the bird metrics in this

study were associated with anthropogenic stress in wetland watersheds (Danz et. al 2005), total ORAM scores did not consistently reflect the impact and affect of these stressors on wetland breeding bird assemblages.

Submetrics and Birds.

Vegetation and landscape related submetrics were associated with wetland bird variables. The submetric Vegetative Communities was associated with all three bird metrics reflecting the importance of plant species composition to birds. The submetric Coverage of Invasive Plants was also associated with several wetland bird variables exemplifying the importance of vegetative structure. Landscape related submetrics such as Intensity of Surrounding Land Use and Habitat Development were associated with the bird metric ubiquitous bird abundance. These relationships which reflect the importance of landscape to the abundance of ubiquitous wetland birds were also found in another other by Riffell et al. (2003). When the vegetation and landscape related submetrics important to wetland birds were combined to generate the New ORAM score, associations greatly improved between the New ORAM score and wetland bird metrics. Although these submetrics were associated with bird assemblages, they have been calibrated to have a low amount of contribution or weight in computing the overall ORAM score and hence do not reflect changes in wetland bird communities.

Suggested Improvements

To improve ORAM or other rapid assessment methods for use as a Great Lakes rapid assessment method, I suggest the following changes. First, the wetland animal community should be more thoroughly considered. Species that are common in one geographic region may be rare or unique in another, so regional adjustments are essential. Although this study focused on birds, animals such as amphibians that also reflect wetland condition (Micacchion 2004) may be a necessary addition to a Great Lakes rapid assessment method. Wetland managers developing this method need to explore the use of rapid animal survey techniques so as to keep the assessment timely. I suggest the addition of a bird or amphibian component to a Great Lakes rapid assessment method because little training and time is needed to conduct obligate bird surveys using playbacks or to conduct frog calling surveys. I also suggest a focus on historical and regional bird abundances to aid in the reflection of present bird community condition and to identify regionally extirpated bird species or those with historically low abundances. Managers need to note that using birds or amphibians will require conducting a wetland assessment during the appropriate breeding season. Second, as shown by Riffell et al. (2003) and in this study, more emphasis should be placed on landscape context. In western Great Lakes wetlands, the intensity of land use surrounding a wetland was shown to be important for wetland bird assemblage structure. Developing submetrics that properly reflect landscape context such as the proportion of native wetland or forest surrounding the wetland could improve a rapid

assessment method's ability to better reflect bird assemblages. Lastly, ORAM and bird metrics were associated with independent measures of anthropogenic stress but ORAM did not consistently reflect stress conditions important to wetland bird assemblages. Although ORAM did reflect poor conditions for birds, a Great Lakes rapid assessment method would need to further address this issue and incorporate specific stress variables that would help the rapid assessment method to better reflect all conditions for wetland bird assemblages.

Conclusions

Rapid assessment methods for wetlands are becoming the most broadly used measurement of wetland quality and condition (Thiesing 1998). ORAM reflects the structure of many other assessments and has the potential for broad applications (Fennessy et al. 2004, Mack 2001). ORAM did reflect anthropogenic stress and poor wetland conditions for birds, but bird assemblages at western Great Lakes coastal riverine wetlands spanned a wider range of wetland condition than the ORAM scores reflected. The results of this study suggest that ORAM and rapid assessment methods with similar structure need to be regionally specific. Through incorporation of regionally important fauna and habitat types, rapid assessment scores will better reflect regional condition. ORAM and other rapid assessment methods also need to better incorporate landscape and anthropogenic measurements important to birds and other biota to best reflect the biotic integrity of a wetland system. Overall, the use of a general rapid assessment method such as ORAM in the western Great Lakes

region would result in the inconsistent reflection of wetland biota condition such as birds, and a misinterpretation of wetland quality and condition. However, with the addition of regionally specific landscape and biotic components, and placing more weight on anthropogenic stress, a rapid assessment method such as ORAM could prove to be very useful in western Great Lakes coastal wetland management.

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Table 1. The Ohio Rapid Assessment Method quantitative portion metrics and submetrics.

- Metric 1. Wetland Area (hectares)*
- Metric 2. Upland Buffers and Surrounding Land Use
  - Submetric 2a. Average Buffer Width
  - Submetric 2b. Intensity Surrounding Land Use
- Metric 3. Hydrology
  - Submetric 3a. Sources of Water
  - Submetric 3b. Connectivity
  - Submetric 3c. Maximum Water Depth
  - Submetric 3d. Duration Inundation/Saturation
  - Submetric 3e. Modifications to Natural Hydrologic Regime
- Metric 4. Habitat Alteration and Development
  - Submetric 4a. Substrate Disturbance
  - Submetric 4b. Habitat Development
  - Submetric 4c. Habitat Alteration
- Metric 5. Special Wetlands **
- Metric 6. Plant Communities, Interspersion, and Microtopography
  - Submetric 6a. Wetland Vegetation Communities
  - Submetric 6b. Horizontal Interspersion
  - Submetric 6c. Coverage of Invasive Plants
  - Submetric 6d. Microtopography

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* The metric Wetland Area was used in the data analysis analogous to an individual submetric

** Metric 5 not used in analysis

(Mack 2001)

Table 2. Riverine wetland associated birds recorded in 51 wetlands and the assigned bird status in the western Great Lakes region.

Species	**Status**
Alder Flycatcher (*Empidonax alnorum*)*	Obligate
Belted Kingfisher (*Ceryle alcyon*)	Obligate
Canada Goose (*Branta canadensis*)	Obligate
Mallard (*Anas platyrhynchos*)	Obligate
Northern Waterthrush (*Seiurus motacella*)	Obligate
Sandhill Crane (*Grus canadensis*)	Obligate
Sedge Wren (*Sterna hirundo*)*	Obligate
Sora (*Porzana Carolina*)	Obligate
Swamp Sparrow (*Melospiza georgiana*)*	Obligate
Virginia Rail (*Rallus limicola*)*	Obligate
American Bittern (*Botaurus lentiginosus*)	Obligate
Common Tern (*Sterna hirundo*)	Obligate
Wood Duck (*Aix sponsa*)	Obligate
Common Yellowthroat (*Geothlypis trichas*)*	Ubiquitous
Red-winged Blackbird (*Agelaius phoeniceus*)*	Ubiquitous
Yellow Warbler (*Dendroica petechia*)*	Ubiquitous

* Common bird species present in > 5% of wetlands surveyed.

Table 3. Principal component one (PC1) and principal component two (PC 2) eigenvector loadings derived from ORAM submetric scores for 51 coastal riverine wetlands sampled in the western Great Lakes region. The highest loading values, indicating the most influential submetrics in ORAM submetric variation, are in bold face type. Only PC1 is retained for further analyses because of the minimal variation explained by PC 2.

Submetric	PC1	PC 2
Wetland Area	-.02	-.31
Buffer Width	**.52**	-.50
Intensity of Surrounding Land Use	.27	.07
Sources of Water	.01	.03
Maximum Water Depth	.02	-.03
Connectivity	.02	.03
Duration Inundation/Saturation	.04	.00
Modifications to Hydrologic Regime	**.42**	-.04
Substrate Disturbance	.04	.02
Habitat Development	**.34**	.05
Habitat Alteration	.25	-.40
Vegetation Communities	**.30**	.59
Horizontal Interspersion	.22	.23
Coverage of Invasive Plants	**.37**	.28
Microtopography	.17	-.02
% Explained variation	46.9	14.6
% Cumulative variation	46.9	61.5

Table 4. Linear regression analysis results relating total ORAM score and a New ORAM score to bird metrics. For individual bird species, only relationships with a p-value < 0.05 are listed. Significant relationships are defined by p < 0.01. (+) or (-) indicates the direction of the relationship between the bird metrics and ORAM score. The New ORAM Score was calculated from the score addition of the submetrics Intensity of Surrounding Land Use, Habitat Development, Vegetative Communities, and Coverage of Invasive Plants.

	ORAM Score		**New ORAM Score**	
Bird Metric	r^2	p-value	r^2	p-value
Species Richness (+)	0.05	0.13	0.16	0.00
Obligate Abundance (+)	0.08	0.05	0.12	0.01
Ubiquitous Abundance (-)	0.18	0.00	0.26	< 0.001
Red-winged Blackbird Abundance (-)	0.17	0.00	0.25	< 0.001
Alder Flycatcher Abundance (+)	0.13	0.01	0.18	0.00

Table 5. Linear regression results relating wetland bird metrics and ORAM submetrics. Only relationships with a p-value < 0.05 are listed. * p < 0.01, ** p ≤ 0.001 before rounding. The symbols (+) and (-) indicate the direction of the relationship between the dependent (bold) and independent variables. *** As the submetric scores for Intensity of Surrounding Land Use and Coverage of Invasive Plants increase, the land use intensity and the aerial coverage of invasive plants decrease, respectively.

	t-value	r^2	p-value
Species Richness with			
Habitat Alteration (-)	2.12	0.08	0.04
Vegetative Communities (+)	2.96	0.15	0.01*
Coverage Invasive Plants (+)***	2.34	0.10	0.02
Obligate Abundance with			
Intensity Surrounding Land Use (+)***	2.57	0.12	0.01
Vegetative Communities (+)	2.86	0.14	0.01*
Coverage Invasive Plants (+)***	2.60	0.12	0.01
Ubiquitous Abundance with			
Intensity Surrounding Land Use (-)***	3.46	0.20	0.00**
Modifications to Hydro. Regime (-)	2.04	0.08	0.05
Habitat Development (-)	3.74	0.22	0.00**
Habitat Alteration (-)	2.28	0.10	0.03
Vegetative Communities (-)	2.95	0.15	0.01*
Coverage Invasive Plants (-)***	3.51	0.20	0.00**
Microtopography (-)	2.10	0.08	0.04
ALFL with			
Intensity Surrounding Land Use (+) ***	4.31	0.28	0.00**
Modifications to Hydro. Regime (+)	2.03	0.08	0.05
Habitat Development (+)	2.23	0.09	0.03
Vegetative Communities (+)	2.23	0.09	0.03
Coverage Invasive Plants (+)***	2.42	0.11	0.02
Microtopography (+)	2.02	0.08	0.05
RWBL with			
Wetland Area (+)	2.02	0.08	0.05
Intensity Surrounding Land Use (-)***	2.80	0.14	0.01*
Modifications to Hydro. Regime (+)	4.30	0.08	0.05
Habitat Development (-)	3.38	0.19	0.00**
Habitat Alteration (-)	2.30	0.10	0.03
Vegetative Communities (-)	3.16	0.17	0.00*
Interspersion (-)	2.17	0.09	0.03
Coverage Invasive Plants (-)***	3.46	0.20	0.00**
SEWR with			
Habitat Alteration (-)	2.08	0.08	0.04
Vegetative Communities (+)	2.19	0.09	0.03
Interspersion (+)	2.21	0.09	0.03
SWSP with			
Wetland Area (+)	2.16	0.09	0.04
YWAR with			
Wetland Area (-)	2.07	0.08	0.04

Table 6. Linear regression analysis results relating habitat proportions and bird metrics. Dependent variables in bold. Only relationships with a p-value < 0.05 listed. * p < 0.01, ** p ≤ 0.001 before rounding. The symbols (+) or (-) indicate the direction of the relationship between the bird metrics and habitat proportion variables.

	t-value	r^2	p-value
Obligate Abundance with			
Emergent Vegetation (-)	2.42	0.11	0.02
Shrub Vegetation (+)	3.15	0.17	0.00*
Ubiquitous Abundance with			
Emergent Vegetation (+)	3.95	0.24	0.00**
Shrub Vegetation (-)	3.60	0.21	0.00**
Red-winged Blackbird Abundance with			
Emergent Vegetation (+)	4.03	0.25	0.00**
Shrub Vegetation (-)	3.52	0.20	0.00**
Alder Flycatcher Abundance with			
Emergent Vegetation (-)	3.08	0.25	0.00**
Shrub Vegetation (+)	3.66	0.21	0.00**

Table 7. Linear regression analysis results relating GLEI anthropogenic stress measurements (Danz et al. 2005) and total ORAM score. *p < 0.01, **p ≤ 0.001 before rounding. The symbols (+) and (-) indicate the direction of the relationship between the dependent and independent variables.

Dependent Variable = ORAM score	t-value	r^2	p-value
Agriculture PC1 (-)	4.11	0.26	0.00**
Atmospheric Deposition PC1 (-)	3.82	0.23	0.00**
Land Cover PC1 (-)	3.20	0.17	0.00*
Human Population PC1 (-)	2.73	0.13	0.01*
Pollution PC1	1.52	0.05	0.13

Table 8. Linear regression analysis results relating bird metrics, common wetland bird species abundance, with anthropogenic stress categories derived from PC1 scores (Danz et al. 2005). Dependent variables are in bold face type. Only relationships with a p-value < 0.05 are listed in the table. * p < 0.01, ** p ≤ 0.001 before rounding. The symbols (+) and (-) indicate the direction of the relationship between the dependent and independent variables.

	t-value	r^2	p-value
Species Richness with			
Agriculture (-)	3.81	0.23	0.00**
Atmospheric Deposition	1.77	0.06	0.08
Land Cover (-)	3.16	0.17	0.00*
Human Population (-)	3.48	0.20	0.00*
Pollution (-)	3.06	0.16	0.00*
Obligate Abundance with			
Agriculture (-)	3.82	0.23	0.00**
Atmospheric Deposition (-)	2.38	0.10	0.02
Land Cover (-)	3.71	0.22	0.00**
Human Population (-)	3.89	0.24	0.00**
Pollution (-)	2.89	0.15	0.01*
Ubiquitous Abundance with			
Agriculture (+)	3.15	0.17	0.00*
Atmospheric Deposition (+)	2.84	0.14	0.00*
Land Cover (+)	3.16	0.17	0.00*
Human Population (+)	2.17	0.09	0.03
Pollution	1.92	0.07	0.06
ALFL with			
Agriculture (-)	3.33	0.18	0.00*
Atmospheric Deposition (-)	2.11	0.08	0.04
Land Cover (-)	3.52	0.20	0.00**
Human Population (-)	5.01	0.34	0.00**
Pollution (-)	2.90	0.15	0.01*
RWBL with			
Agriculture (+)	3.67	0.22	0.00**
Atmospheric Deposition (+)	3.40	0.19	0.00*
Land Cover (+)	3.01	0.16	0.00*
Human Population (+)	2.46	0.11	0.02
SEWR with			
Pollution (-)	2.36	0.10	0.02
SWSP with			
Agriculture (-)	2.30	0.10	0.03
Land Cover (-)	3.53	0.20	0.00**
Human Population (-)	3.10	0.16	0.00*

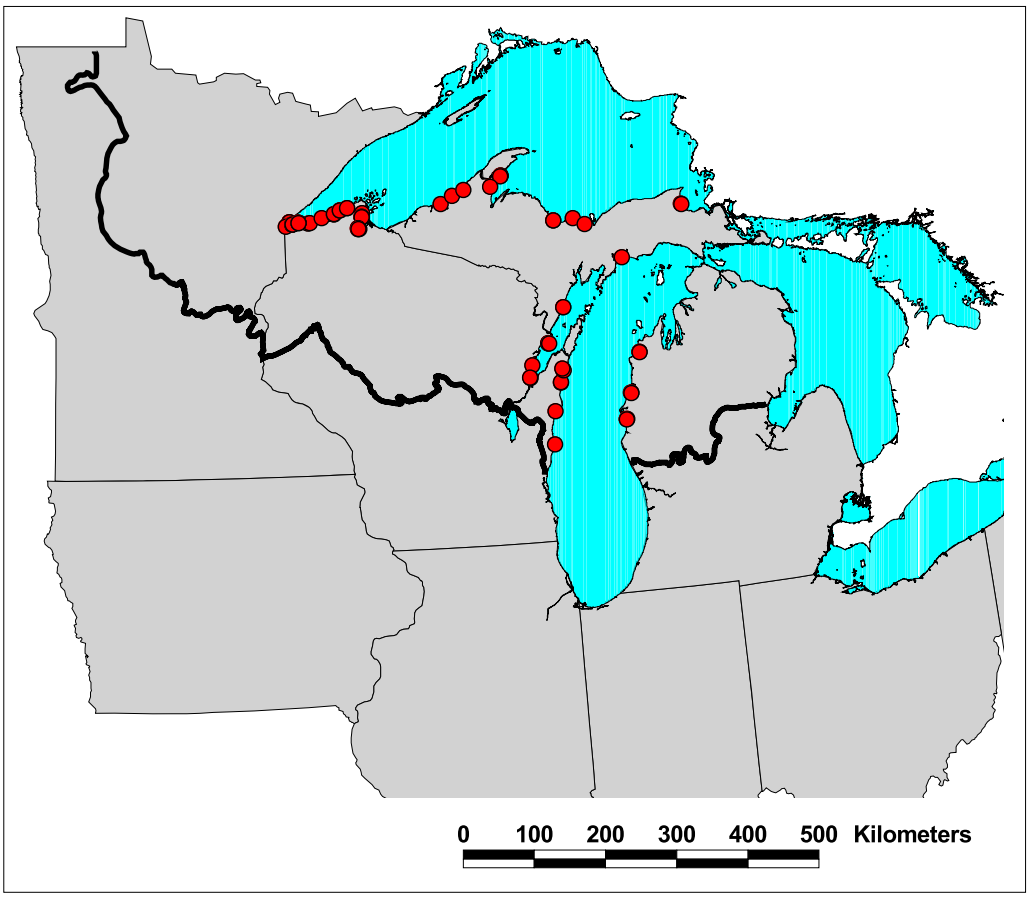

Figure 1. Coastal riverine wetland study sites on the coasts of Lake Superior and Lake Michigan (n = 51). Dark line indicates the Laurentian Mixed forest type boundary (Keys et al. 1995).

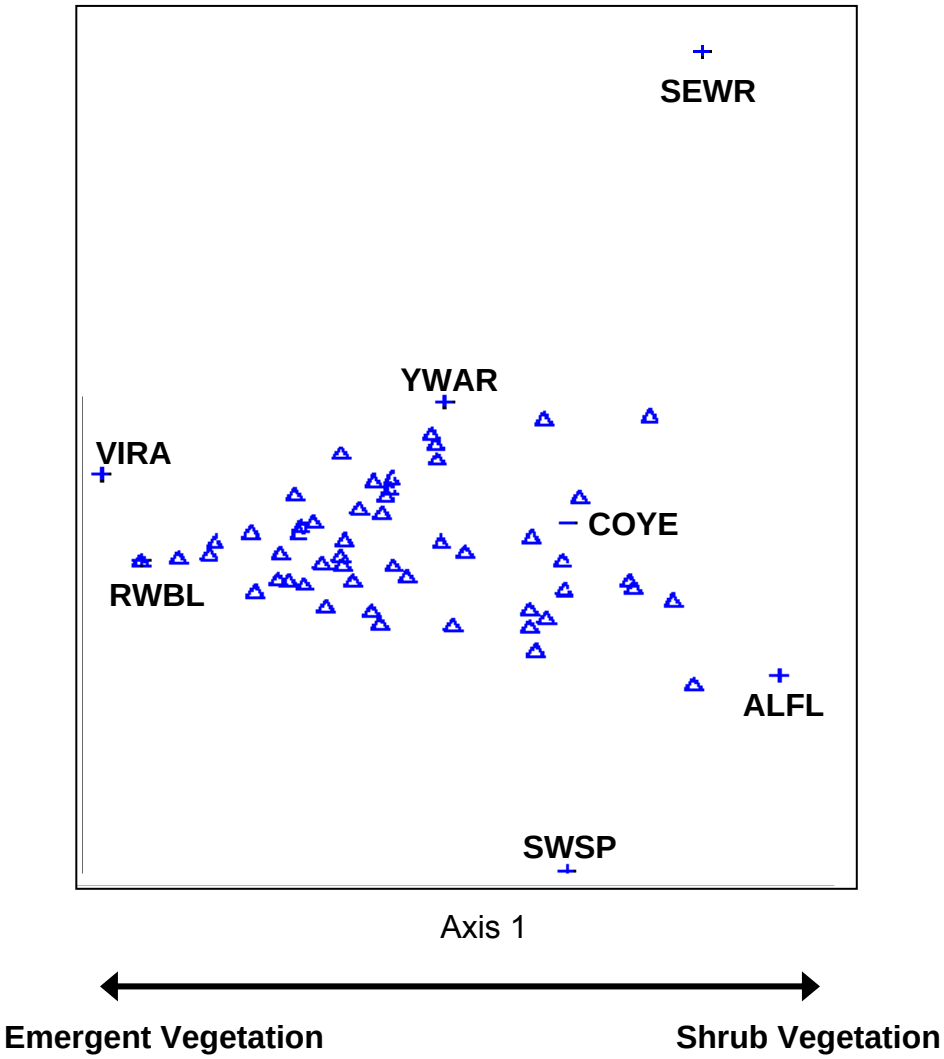

Figure 2. Common wetland bird species distributions among surveyed riverine coastal wetlands according to a correspondence analysis. Wetland sites appear as triangles in ordination space. 54% of the total inertia is explained by axis one (36.6%, λ = 0.26) and axis two (17.9%, λ = 0.13) combined. Axis one is interpreted as a gradient of decreasing emergent vegetation and increasing shrub vegetation as axis one scores increase. Abbreviations: ALFL = Alder Flycatcher, COYE = Common Yellowthroat, RWBL = Red-winged Blackbird, SEWR = Sedge Wren, SWSP = Swamp Sparrow, VIRA = Virginia Rail, YWAR = Yellow Warbler.

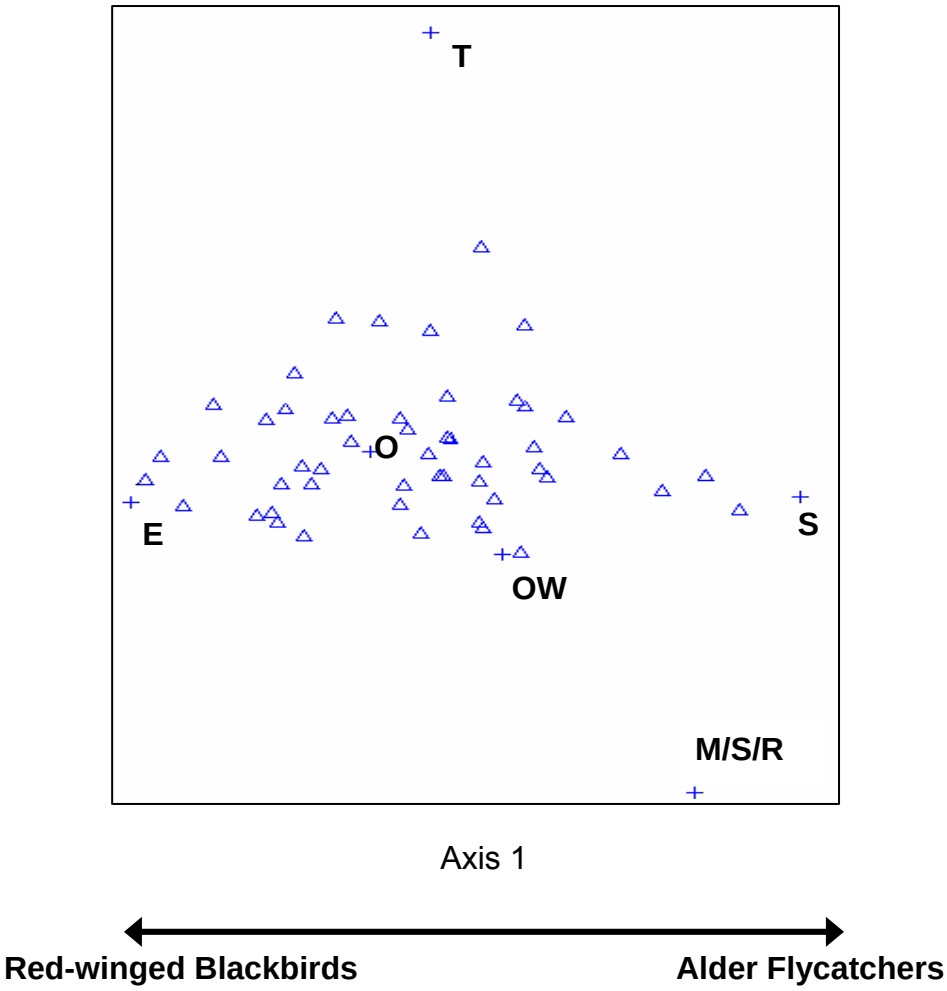

Figure 3. Riverine wetland habitat proportion and type distribution according to a correspondence analysis. Wetland sites appear as triangles in ordination space. 58.5% of the total inertia is explained by axis one (39.6%, λ = 0.27) and axis two (18.9%, λ = 0.13) combined. Axis one is interpreted as a gradient of decreasing Red-winged Blackbird abundance and increasing Alder Flycatcher abundance as axis one scores increase. Axis Abbreviations: E = Emergent Vegetation, M/S/R = Mud Sand and Rock, O = Other, OW = Open Water, S = Shrub Vegetation, T = Trees.

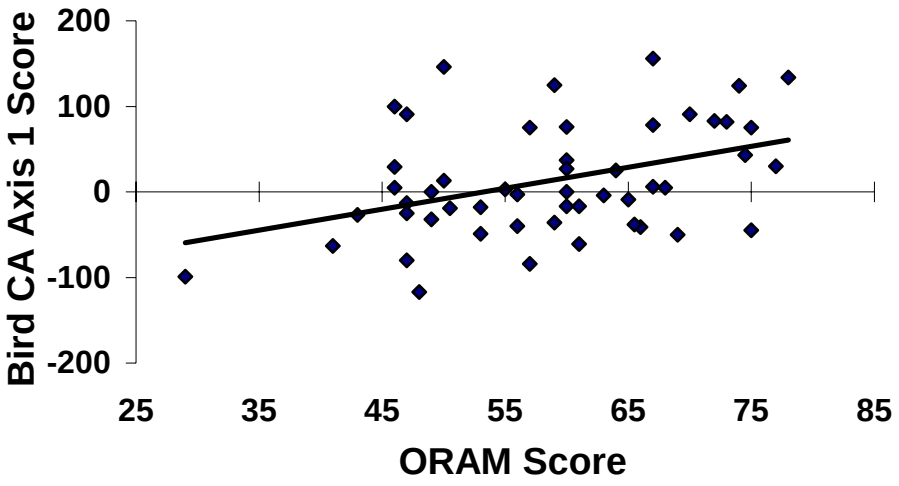

Figure 4. Relationship of common (present in > 5% of sites) riverine wetland bird correspondence analysis (CA) axis 1 and total ORAM score (r^2 = 0.16, p = 0.00).

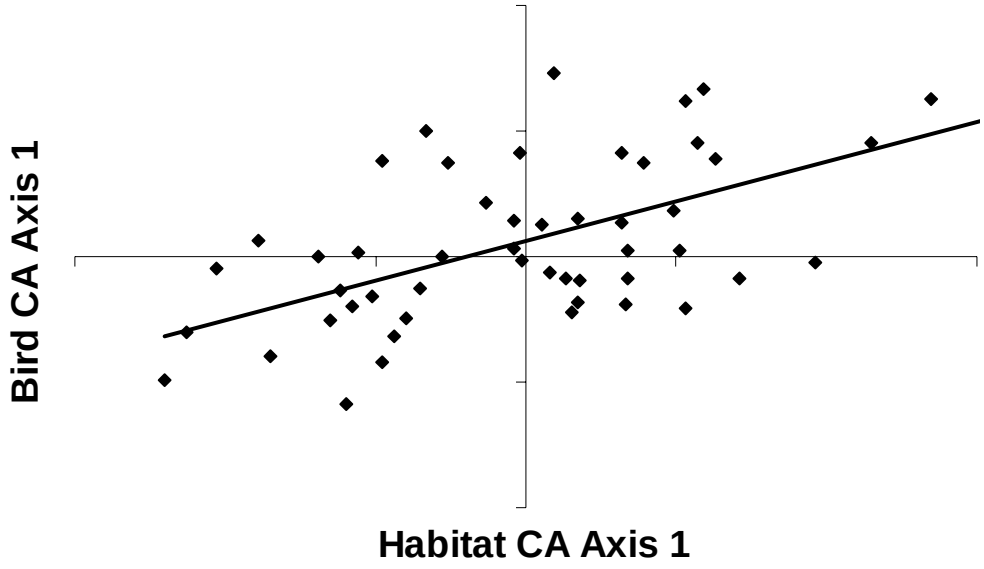

Figure 5. Correlation between common (present in > 5% of sites) riverine wetland bird correspondence analysis (CA) axis one and wetland habitat proportion correspondence analysis (CA) axis one ($r^2 = 0.32$, $p < 0.001$).

Abstract

Rapid assessment methods are qualitative approaches to assessing wetland quality without detailed studies of wetland function and biology. I compared wetland quality data gathered using the Ohio Rapid Assessment Method (ORAM) to quantitative data gathered on bird assemblages. I focused on 51 coastal riverine wetlands of the western Great Lakes region and evaluated ORAM using both total ORAM score and ORAM submetric scores. As expected, riverine wetland birds did not choose wetlands at random and appeared to be sensitive to vegetative structure and anthropogenic disturbance. ORAM reflected anthropogenic disturbance in the wetlands sampled but did not reliably predict wetland bird species richness or the abundance of obligate wetland bird species. Bird assemblages spanned a wider range of wetland condition than the ORAM scores reflected. However, focusing on ORAM submetrics related to anthropogenic disturbance and vegetative structure improved ORAM's ability to reflect conditions important to wetland bird assemblages. Overall, the ORAM evaluation procedure was inconsistent in its ability to reflect responses by wetland bird species composition in this region. ORAM could be improved for use as a Great Lakes rapid assessment method by carefully considering the regional biotic community, placing more emphasis on the affects of landscape changes on the wetland system, and increasing the weight contribution of anthropogenic stress to the total rapid assessment method score.