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Evaluation of the Ohio Rapid Assessment Method for Wetlands in the Western Great Lakes: An Analysis Using Bird Communities

Anna C. Peterson and Gerald J. Niemi*

Natural Resources Research Institute
University of Minnesota Duluth
5013 Miller Trunk Highway
Duluth, Minnesota 55811-1442

ABSTRACT. *Rapid assessments are used as qualitative approaches to evaluate wetland quality in the absence of quantitative data and adequate time to assess wetland structure and function. To examine how rapid assessment methods assess bird assemblages in wetlands, we compared bird communities with both the Ohio Rapid Assessment Method (ORAM) and detailed data gathered from 51 coastal riverine wetlands in the western Great Lakes region. We found that birds did not choose wetlands at random but responded to vegetative structure and the degree of anthropogenic disturbance within and surrounding the wetland. ORAM scores adequately reflected the degree of anthropogenic disturbance affecting the wetlands but were insufficient to explain bird species richness or the abundance of several bird species that were obligates of these wetlands. Bird assemblages in the western Great Lakes region spanned a wider range of wetland conditions than were reflected in the ORAM scores. Modification of ORAM scores with a focus on submetrics related to anthropogenic disturbance and vegetative structure improved the ability of ORAM to reflect conditions important to wetland birds. ORAM could be improved for use in the western Great Lakes with a greater emphasis on the landscape context and anthropogenic disturbance of the wetland.*

INDEX WORDS: *Bird community, coastal wetland, Great Lakes, Ohio Rapid Assessment Method (ORAM), rapid assessment method, wetland assessment.*

INTRODUCTION

Coastal wetlands of the United States Great Lakes basin are among the most threatened ecosystems in the region (Government of Canada and U.S. EPA 1995). The U.S. Environmental Protection Agency's Wetlands Program (U.S. EPA 2005) and the U.S. Clean Water Act (Section 404b, U.S. EPA 2003) have established the need to monitor and evaluate anthropogenic impacts to wetland ecosystems. Several Great Lakes state agencies have developed state-specific wetland assessments, yet methods vary in type, procedure, and inter-state coordination (WIDNR 1992, Merkey and Seelbach 2002, MBWSR 2003). Rapid assessment methods for wetlands are used as qualitative approaches to evaluate wetland quality in the absence of quantitative data and adequate time to assess wetland structure and function (Cole 2006). Fennessy *et al.* (2004) reviewed commonly used rapid assessment methods suitable for wetland monitoring and assessment. Of these, we selected the Ohio Rapid Assessment Method (ORAM) for wetlands Version 5.0 (Mack 2001) because of its similarity with many other rapid assessment methods (Collins *et al.* 2004, Fennessy *et al.* 2004) and its potential for broad applications (Mack 2001).

Although not intended to replace more biologically detailed wetland assessments, rapid assessment methods are constructed to provide a measure of wetland quality and to incorporate anthropogenic disturbance to wetlands (Van Dam *et al.* 1998). Biological communities also incorporate information on the habitat condition and degree of disturbance in many different systems, including wetlands (Findlay and Houlahan 1997, Innis *et al.* 2000). Rapid assessment methods should, therefore, not only provide information on the condition of a wetland, but also on the condition of its biota. Two recent studies support this generalization with

*Corresponding author. E-mail: gniemi@d.umn.edu

ORAM. Mack (2004) and Micacchion (2004) found ORAM scores to be positively associated with the diversity of plants and amphibians in wetlands.

Birds have been used as indicators of environmental condition (O'Connell *et al.* 2000, Niemi and McDonald 2004). Birds are sensitive to habitat structure (Stauffer and Best 1980, Murkin *et al.* 1997, Whitt *et al.* 1999), environmental and anthropogenic changes (Finch 1991, Blair 1996, Mensing *et al.* 1998), and wetland integrity (Croonquist and Brooks 1991, Galatowitsch *et al.* 1999, Bryce and Hughes 2002). Birds may also be used as indicators of condition because they are relatively easy to count (Weeber and Vallianatos 2000). Therefore, one goal of rapid assessment methods for wetlands should be to reflect the condition of wetlands for breeding bird communities. Stapanian *et al.* (2004) focused specifically on the ability of ORAM to predict bird species richness in Ohio wetlands and found that ORAM reliably predicted total species richness and species richness of wetland birds of special concern.

Our goals were to evaluate the use of rapid assessment methods for determining the condition of breeding bird communities in the western Great Lakes region and, if necessary, suggest modifications for improvement. We focused on the use of ORAM because: 1) it is the best-developed rapid assessment method in the Great Lakes region, 2) it has potential for broader geographic application (Mack 2001), and 3) it is the basic template for other rapid assessment methods being developed. To evaluate the usefulness of ORAM we also used data from a larger project in the U.S. Great Lakes coastal region in which data on anthropogenic stress, habitat, and landscape context were also gathered (Niemi *et al.* 2004, Danz *et al.* 2005).

METHODS

Study Area

For thousands of years glaciers repeatedly carved into the land of the Great Lakes region leaving behind the Great Lakes we know today. The Great Lakes basin, over 90,000 square miles in size, is the largest fresh surface water system in the world. The hydrology, soils, vegetation, and usage of the basin are highly variable and contribute to the unique wetland characteristics along the Great Lake coasts (Government of Canada and U.S. EPA 1995). The western Great Lakes region lies in a transition zone between boreal forest and broadleaf deciduous forest zones. The soils of this region vary greatly, from peat to clay to sand to combinations of soil types (Keys *et al.* 1995). Coastal wetlands also vary in hydrologic type and dominant vegetation.

We selected a subset of wetland sites identified as part of the Great Lakes Environmental Indicators (GLEI) project (Danz *et al.* 2005). The GLEI sample sites were generated using a random selection of wetlands along an anthropogenic gradient. We focused on riverine wetlands, which were defined by Keough *et al.* (1999) as having a direct water connection to a river and a Great Lake. Wetland selection was also limited to the Laurentian Mixed Forest Ecoprovince (Keys *et al.* 1995) in which riverine wetlands were the most abundant coastal wetland type. We selected all wetlands that met these criteria, excluding wetlands not directly accessible by road or wetlands without granted accessibility. This resulted in 51 wetland sites that occurred along the south coast of Lake Superior and both the east and west coasts of Lake Michigan (Fig. 1).

Field Methods

We used standardized point counts that were similar to those recommended by the National Marsh Bird Monitoring Program (Conway 2005). Wetland sites were sampled once during Jun 03 by a single observer (AP), 1/2 hour before sunrise to 4 hours after sunrise. All male breeding birds detected (visually and audibly) within a 100-m semi-circle established at the perimeter of the wetland were recorded. Semi-circle sample areas were randomly placed along wetland access routes (e.g., roads or trails) for the GLEI project (Danz *et al.* 2005). Point counts consisted of three continuous 5-minute intervals. The first 5-minute period was a passive listening period. The second 5-minute interval was a playback period in which vocalizations from five elusive and wetland-dependent bird species were played on a portable compact disc player. The species included the pied-billed grebe (*Podiceps nigricollis*), least bittern (*Ixobrychus exilis*), common moorhen (*Gallinula chloropus*), sora (*Porzana carolina*), and Virginia rail (*Rallus limicola).* The last 5-minute period was also a passive listening period.

We focused our analysis on breeding birds that were associated with wetlands and eliminated those species that were associated with adjacent upland habitats (Hanowski *et al.* 2003). Breeding birds of these wetlands were further split into two groups: wetland obligates and wetland ubiquitous species.

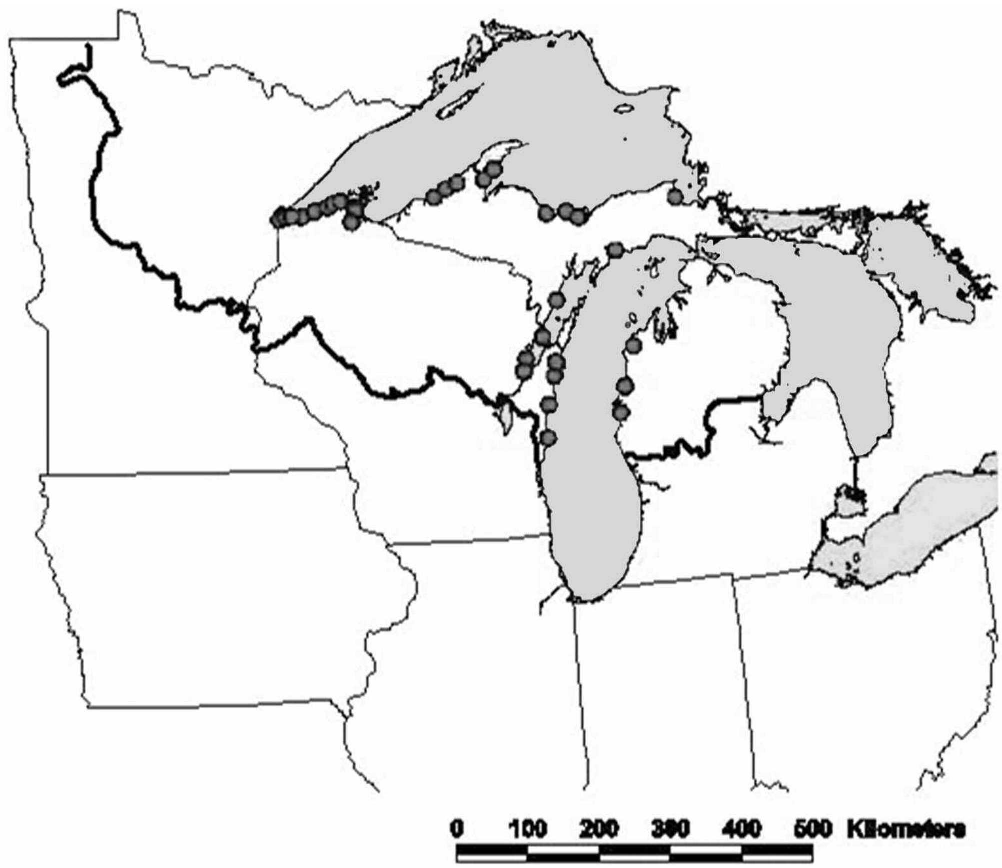

FIG. 1. Coastal riverine wetland study sites on the coasts of Lake Superior and Lake Michigan (n = 51). Dark line indicates the Laurentian mixed forest type boundary (Keys et al. *1995).*

We 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). We defined wetland ubiquitous species as birds that may be found in wetlands but which are not entirely dependent on wetlands and use many other habitats as well. Wetland ubiquitous birds also lacked high regional PIF scores in the western Great Lakes region (Rich *et al.* 2004). Three bird community parameters were calculated: 1) bird species richness—the total number of wetland-associated species recorded at each site, 2) wetland obligate abundance—the total number of individuals of obligate bird species counted at each site, and 3) wetland ubiquitous abundance—total number of individuals of ubiquitous bird species counted at each site. At the species level, we also analyzed the number of individuals of each common wetland bird species with a frequency of occurrence of > 5% of the 51 study sites.

For consistency and accuracy, the primary author attended training in wetland delineation (Environmental Laboratory, U.S. Army Corps of Engineers 1987), in the use of the Ohio Rapid Assessment Method (ORAM; Mack 2001), and conducted all of the ORAM assessments during Jul 03. The ORAM user's manual and evaluation methods are described in Mack (2001). Although ORAM consists of two portions, narrative and quantitative, we only used the quantitative portion of ORAM because the narrative portion was specific to Ohio.

The quantitative portion of ORAM consisted of six metrics that represent attributes of wetland function and condition (Table 1). Each ORAM metric was comprised of one to six submetrics designed to evaluate wetland quality and condition. A submetric received a higher score if the element of wetland condition being evaluated was higher with respect to overall condition and quality. The total ORAM score was the sum of all the submetric scores. We evaluated wetland quality according to

TABLE 1. The Ohio Rapid Assessment Method quantitative portion metrics and submetrics (Mack 2001).

Metric 1. Wetland area (ha)*
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 (not used in analysis)
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

*The metric wetland area was used in the data analysis analogous to an individual submetric.

ORAM at the submetric level and the total ORAM score.

The vegetation submetrics Vegetative Communities and Coverage of Invasive Plants, the landscape submetric Intensity of Surrounding Land Use, and the submetric Habitat Development were important to wetland bird assemblages so are described in more detail here. The submetric Vegetative Communities asked that the evaluator identify and rate six wetland communities including aquatic bed, emergents, shrubs, forests, mudflats, and open water. As each community quality evaluation and coverage area increased, this submetric received higher points. The submetric Coverage of Invasive Plants measured the aerial coverage of invasive plant species present in the wetland, decreasing in score as coverage increased. The submetric Intensity of Surrounding Land Use measured the predominant anthropogenic land use beyond the determined wetland buffer area. As the intensity of land use increased, the submetric score decreased. The submetric Habitat Development asked that the evaluator 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.

Data Analysis

Danz *et al*. (2005, 2007) developed an anthropogenic stress gradient for all wetlands sampled in the U.S.Great Lakes coastal region as part of the GLEI project. The stress gradient was summarized in five different principal components (PCs) that were derived from over 200 original variables related with stress in the coastal region. The principal component scores for each of the five PCs were calculated for each of the 51 wetlands sampled and the interpretations of the five PCs (Danz *et al*. 2005) were as follows. An agricultural PC was related with an increase in agricultural practices such as pesticide and fertilizer applications within the watershed of a wetland. An atmospheric deposition PC was related with an increase in the amount of chemical deposition such as mercury, nitrogen, and acid within the watershed of a wetland. A land cover PC was positively related with an increase in agricultural, industrial, and residential land cover classes and negatively related with forest land cover within the watershed of a wetland. A human population PC reflected an increase in human population density within the watershed of a wetland. Finally, a point source pollution PC reflected an increase in the number of point sources such as sewage treatment plants and industrial activity within the watershed of a wetland.

We compared bird community parameters and the number of individuals of each common wetland bird species to the total ORAM score and ORAM submetric scores using linear regression. All linear regressions in this study used a confidence level of 0.99 ($\alpha = 0.01$) and the Proc Reg procedure in SAS (SAS Institute 1999). Regression analyses were also used to examine relationships between bird community parameters and individual species with the PCs for each of the five major stressors.

RESULTS

Total ORAM scores ranged from 29 to 78 (theoretical range 0 – 90, with an elimination of metric 5 which was a narrative value specific to Ohio wetlands) for the 51 wetlands sampled. During wetland bird surveys we recorded a total of 55 bird species, of which 15 were wetland-associated (12 obligate and 3 ubiquitous, Table 2). A total of four obligate bird species (alder flycatcher [*Empidonax alno-*

TABLE 2. All bird species recorded at wetland sampling sites.

	Species retained in analysis	Present > 5% of sites
Alder Flycatcher (*Empidonax alnorum*)	*	**
American Bittern (*Botaurus lentiginosus*)	*	
American Crow (*Corvus brachyrhynchos*)		
American Goldfinch (*Carduelis tristis*)		
American Redstart (*Setophaga ruticilla*)		
American Robin (*Turdus migratorius*)		
Bank Swallow (*Riparia riparia*)		
Barn Swallow (*Hirundo rustica*)		
Black-and-white Warbler (*Mniotilta varia*)		
Black-capped Chickadee (*Poecile atricapillus*)		
Belted Kingfisher (*Ceryle alcyon*)	*	
Blackburnian Warbler (*Dendrioca fusca*)		
Blue Jay (*Cyanocitta cristata*)		
Brewer's Blackbird (*Euphagus cyanocephalus*)		
Canada Goose (*Branta canadensis*)		
Cedar Waxwing (*Bombycilla cedrorum*)		
Chipping Sparrow (*Spizella passerina*)		
Clay-colored Sparrow (*Spizella pallida*)		
Common Grackle (*Quiscalus quiscula*)		
Common Merganser (*Mergus merganser*)		
Common Tern (*Sterna hirundo*)	*	
Common Yellowthroat (*Geothlypis trichas*)	*	**
Downy Woodpecker (*Picoides pubescen*s)		
Eastern Kingbird (*Tyrannus tyrannus*)		
Eastern Wood-pewee (*Contopus virens*)		
Gray Catbird (*Dumetella carolinensis*)		
Killdeer (*Charadrius vociferus*)		
Mallard (*Anas platyrhynchos*)	*	
Mourning Dove (*Zenaida macroura*)		
Mourning Warbler (*Oporornis philadelphia*)		
Mute Swan (*Cygnus olor*)		
Nashville Warbler (*Vermivora ruficapilla*)		
Northern Cardinal (*Cardinalis cardinalis*)		
Northern Flicker (*Colaptes auratus*)		
Northern Parula (*Parula americana*)		
Northern Waterthrush (*Seiurus noveboracensis*)	*	
Olive-sided Flycatcher (*Contopus cooperi*)		
Rose-breasted Grosbeak (*Pheuctuicus ludovicianus*)		
Ring-billed Gull (*Larus delawarensis*)		
Red-breasted Nuthatch (*Sitta canadensis*)		
Red-eyed Vireo (*Vireo olivaceus*)		
Red-winged Blackbird (*Agelaius phoeniceus*)	*	**
Sandhill Crane (*Grus canadensis*)	*	
Sedge Wren (*Cistothorus platensis*)	*	**
Sora Sora (*Porzana carolina*)	*	
Song Sparrow (*Melospiza melodia*)		
Swamp Sparrow (*Melospiza georgiana*)	*	**
Tennessee Warbler (*Vernivora peregrina*)		
Tree Swallow (*Tachycineta bicolor*)		
Turkey Vulture (*Cathartes aura*)		
Veery (*Catharus fuscescens*)		
Virginia Rail (*Rallus limicola*)	*	**
Wood Duck (*Aix sponsa*)	*	
Yellow-bellied Flycatcher (*Empidonax flaviventris*)		
Yellow Warbler (Dendroica petechia)	*	**

TABLE 3. Linear regression analysis results relating ORAM score, bird community parameters, and common wetland bird species abundance with anthropogenic stress PCs (Danz* et al. *2007). 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
ORAM score with			
Agriculture (-)	4.11	0.26	0.00**
Atmospheric deposition (-)	3.82	0.23	0.00**
Land cover (-)	3.20	0.17	0.00*
Human population (-)	2.73	0.13	0.01*
Pollution	1.52	0.05	0.13
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

rum], sedge wren [*Cistothorus palestris*], swamp sparrow [*Melospiza Georgiana*], and Virginia rail) and three ubiquitous bird species (common yellowthroat [*Geothlypis trichas*], red-winged blackbird [*Agelaius phoeniceus*], and yellow warbler [*Dendroica petechia*]) were common at study sites (> 5% occurrence). Only wetland-associated bird species were retained in analyses. All 15 species were retained in the species richness bird metric while only common species (> 5% occurrence) were included in the bird metrics ubiquitous bird abundance and obligate bird abundance. Dominant bird species in these two metrics were red-winged blackbirds and alder flycatcher, respectively.

Anthropogenic Stress, ORAM, and Birds

ORAM scores, bird community parameters, and common wetland bird abundances reflected anthropogenic disturbance (Table 3). A list of wetland sites with associated ORAM scores, anthropogenic stress PC scores, and bird metric scores is located in Appendix 1. Linear regression results showed as anthropogenic stress PC scores (PCs) increased, ORAM scores decreased in all relationships except pollution. In addition, wetland breeding bird species richness, obligate bird abundance, and alder flycatcher abundance decreased as anthropogenic stress PCs increased except in the case of atmospheric deposition. Ubiquitous bird abundance and red-winged blackbird abundance increased as the agriculture PC, atmospheric deposition PC, and landscape PC scores increased.

Bird Parameters and Common Bird Abundance with ORAM

As ORAM scores increased, ubiquitous bird abundance decreased (Fig. 2, $r^2 = 0.18$, $P < 0.01$), but neither obligate bird abundance nor species richness had significant relationships with total ORAM score (Figs. 3 and 4, Table 4). Of the common wetland birds, only red-winged blackbird (negative) and alder flycatcher (positive) abundances were related to total ORAM score ($r^2 = 0.17$ $P < 0.01$, $r^2 = 0.13$ $P < 0.01$ respectively).

Species richness and obligate species abundances were related to the submetric Wetland Vegetation Communities ($r^2 = 0.15$, $P < 0.01$ and $r^2 = 0.14$, $P < 0.01$ respectively). Ubiquitous species abundance was related to the submetrics Intensity of Surrounding Land Use ($r^2 = 0.20$, $P < 0.01$), 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)).

When 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," associations be-

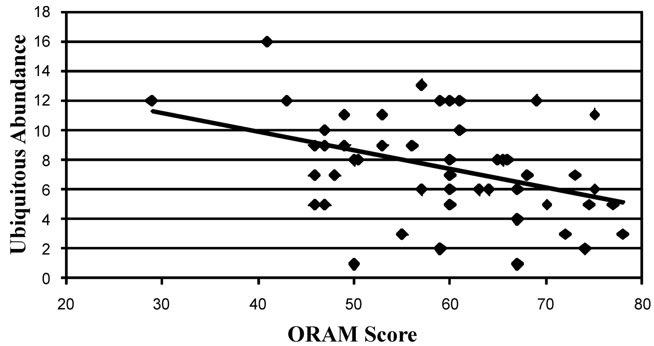

FIG. 2. Scatter plot of the relationship between ubiquitous bird abundance and total ORAM score ($r^2 = 0.08$, $P < 0.01$).

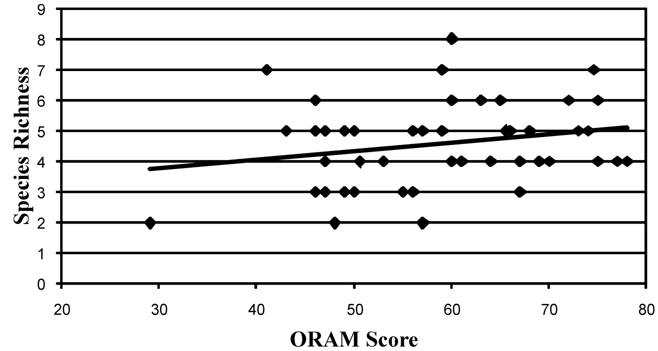

FIG. 4. Scatter plot of the relationship between wetland bird species richness and total ORAM score ($r^2 = 0.05$, $P = 0.13$).

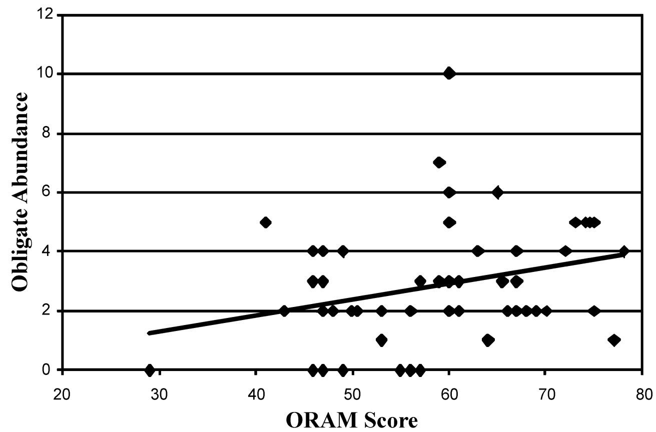

FIG. 3. Scatter plot of the relationship between obligate bird abundance and total ORAM score ($r^2 = 0.08$, $P = 0.05$).

tween the score and bird assemblages improve (Table 4). All bird community parameters as well as the abundance of alder flycatchers and red-winged blackbirds had significant relationships with the new ORAM score.

To attempt a comparison between our study and the study conducted by Stapanian *et al.* (2004) we duplicated one of the comparisons conducted by Stapanian *et al.* 2004 using their new ORAM score that consisted of the sum of the four submetrics with the highest possible contribution to total ORAM score. These four submetrics (Sources of Water, Modifications to Hydrologic Regime, Wetland Vegetation Communities, and Microtopography) contribute to 25% of the total ORAM score. Stapanian *et al.* (2004) found this new ORAM score to be correlated with total and mean species richness. We found that of our three bird parameters

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	< 0.01
Obligate abundance (+)	0.08	0.05	0.12	< 0.01
Ubiquitous abundance (-)	0.18	< 0.01	0.26	< 0.001
Red-winged Blackbird abundance (-)	0.17	< 0.01	0.25	< 0.001
Alder Flycatcher abundance (+)	0.13	< 0.01	0.18	< 0.01

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**

only ubiquitous bird abundance had a significant (negative) relationship with this score ($r^2 = 0.17$, $p < 0.01$), as ORAM score increased, ubiquitous abundance decreased.

DISCUSSION

ORAM was designed to assess wetland quality and integrity with an emphasis on anthropogenic disturbance. We indeed found that ORAM was related to anthropogenic stress. We also found that wetland bird assemblages were affected by anthropogenic stress. However, ORAM scores did not consistently reflect the effect of stress on wetland breeding bird assemblages.

ORAM reflected poor wetland conditions to birds; primarily through the positive relationship with the abundance of ubiquitous wetland bird species and red-winged blackbirds, which comprised a large portion (59%) of the ubiquitous bird parameter. Although in the western Great Lakes red-winged blackbirds are ubiquitous, they are associated with habitats of high emergent stem density (Yasukawa and Searcy 1995, Turner and

McCarty 1998), characteristic of narrow-leaved cattail *(Typha angustifolia)* stands (Eggers and Reed 1997). The most abundant emergent plant species present in this study was *Typha angustifolia,* an invasive species in this region (Johnston *et al.* 2007 this issue). When this species is present, its invasiveness and monotypic nature resulted in lower scores for the following submetrics: Habitat Development, Wetland Vegetation Communities, Horizontal Interspersion, and Coverage of Invasive Plants. The decrease of red-winged blackbird abundance and ubiquitous bird abundance as total ORAM score increased is explained by the presence of *Typha angustifolia*.

In our study, ORAM did not reflect: 1) wetland conditions important to the majority of wetland dependent bird species, 2) wetland obligate bird abundance, or 3) wetland bird species richness. These results challenge the indication that ORAM can be useful for making floral and faunal quality predictions in certain regions (Mack 2001, Micacchion 2004). Our results for this region do not agree with the results found by Stapanian *et al.* (2004) that ORAM can predict avian diversity. 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. We did not find similar results in the western Great Lakes region. Our measurement of obligate bird abundance is similar to Stapanian's special concern species richness measurement. 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 [*Nycticorax nycticorax*], yellow-crowned night-heron [*Nyctanassa violacea*], marsh wren [*Cistothorus palustris]*, and king rail [*Rallus elegans*]). 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. The difference in species composition among these measurements in the two regions is likely an explanation for the lack of consistency between the two regions. We suggest two reasons why our results do not agree with results from the Ohio study by Stapanian *et al.* (2004). First, field methods varied between the two studies. For instance, Stapanian *et al.* (2004) sampled wetlands over a variable area and among different years. Secondly and more important, Stapanian *et al.* (2004) sampled forested wetlands inland from the Great Lakes coast. This would contribute to differences in bird community composition as well as differences in vegetative structure, hydrology, and landscape context between the two studies.

When vegetation and landscape submetrics were included to create a new ORAM score, the associations with the obligate wetland bird species used here were greatly improved. These submetrics, Intensity of Surrounding Land Use, Habitat Development, Vegetative Communities, and Coverage of Invasive Plants, have relatively low contributions to the overall ORAM score.

We note that many of the correlations in this study are relatively low, but this is not unusual for many bird and habitat relationship studies. For instance, there are many additional variables that contribute to population variation in breeding birds including variation in censusing, over-winter survival, and a variety of other external factors.

Suggested Improvements

To improve ORAM or other rapid assessment methods for use in the western Great Lakes basin, we suggest the following changes. First, regional adjustments in the measurements of ORAM should be made, especially if they relate better with the biota (flora or fauna) of the region. Wetland managers should consider the addition of a rapid animal survey technique (e.g., Marsh Monitoring program or its modifications, see Howe *et al.* 2007 and Hanowski *et al.* 2007, both this issue). We also suggest that consideration be given to habitats with the potential for restoration of declining or extirpated species from these wetlands. For example, king rail, Forster's tern, and black tern have been greatly reduced in populations or extirpated from many of the wetlands in the western Great Lakes (Evers 1997), and a wetland assessment offers an opportunity to identify critical habitat for these species. Second, a greater emphasis should be placed on the landscape context in the measurement of wetland quality. With the advent of geographic information systems and improvements in the availability of remote sensing scenes, the inclusion of landscape context (e.g., proportion of native wetland or forest surrounding the wetland) has become much easier. Lastly, ORAM and bird metrics were both associated with independent measures of anthropogenic stress. Managers could incorporate an anthropogenic stress component using a multivariate approach similar to work done by Danz *et al.* (2005, 2007) to better reflect stress within a watershed. The anthropogenic stress database is now available for the entire U.S.Great Lakes coastal region (Danz *et al.* 2005, 2007) and is being developed for the Canadian portion as well. Hence, the degree of anthropogenic influence on a wetland could also be included in the ORAM-type wetland assessments.

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APPENDIX 1. Wetland site names, ORAM scores, bird metrics, and stress PCA scores.

		Bird community parameters			Anthropogenic stress PCA scores				
Wetland site name	ORAM score	Richness	Obligate abund.	Ubiqu. abund.	Ag	Atm depos	Landcover	Pop density	Pollution
St. Louis River—A	57	5	3	6	0.2268	0.1748	0.4666	0.5538	0.5039
St. Louis River—B	64	4	1	6	0.2268	0.1748	0.4666	0.5538	0.5039
St. Louis River—C	66	5	2	8	0.2437	0.1726	0.4566	0.5524	0.1668
St. Louis River—D	75	4	2	11	0.2664	0.1834	0.4039	0.4660	0.3965
St. Louis River—E	69	4	2	12	0.2664	0.1834	0.4039	0.4660	0.3965
Nemadji River—A	60	6	6	12	0.3306	0.1849	0.4383	0.4225	0.3190
Nemadji River—B	47	4	2	9	0.3306	0.1849	0.4383	0.4225	0.3190
Amnicon River	73	5	5	7	0.3030	0.2087	0.4003	0.4316	0.1939
Middle River	77	4	1	5	0.3043	0.2129	0.4437	0.4594	0.0317
Brule River	68	5	2	7	0.3145	0.2209	0.3104	0.4081	0.2660
Flag River—A	59	5	3	12	0.2698	0.1654	0.4762	0.3748	0.2657
Flag River—B	56	5	2	9	0.2698	0.1654	0.4762	0.3748	0.2657
Lenawee Creek	50.5	4	2	8	0.2699	0.1620	0.3299	0.3718	0.0092
Lost Creek	60	8	10	6	0.2695	0.1254	0.3406	0.3953	0.0092
Pikes Creek	65.5	5	3	8	0.2697	0.1373	0.4874	0.4188	0.3131
Sioux River—A	46	6	4	9	0.2699	0.1799	0.3870	0.3708	0.0092
Sioux River—B	47	5	4	5	0.2699	0.1799	0.3870	0.3708	0.0092
Wittlesey Creek	46	5	3	5	0.2699	0.2026	0.5249	0.4081	0.0092
South Fish Creek—A	60	6	3	7	0.2693	0.2090	0.6473	0.4826	0.0092
South Fish Creek—B	60	6	5	8	0.2915	0.2182	0.4680	0.3877	0.0092
Unnamed Creek	53	4	2	11	0.2693	0.2143	0.6712	0.6107	0.0092
Cranberry River	61	4	3	10	0.0898	0.2122	0.2808	0.2492	0.0078
Firesteel River	67	3	4	1	0.1225	0.1568	0.2891	0.3143	0.0086
Misery River	70	4	2	5	0.1308	0.1254	0.2527	0.2857	0.0085
Mud Lake Creek—A	59	7	7	2	0.1259	0.1010	0.1918	0.3169	0.0085
Mud Lake Creek—B	63	6	4	6	0.1259	0.1010	0.1918	0.3169	0.0085
Portage River	60	4	2	5	0.1979	0.1662	0.2527	0.4220	0.3282
Huron River	78	4	4	3	0.1097	0.1447	0.1503	0.2500	0.0118
Carp River	50	3	2	1	0.1722	0.2344	0.1965	0.5358	0.7116
Laughing Whitefish River	74	5	5	2	0.2464	0.2594	0.2458	0.3388	0.0062
Au Train River	72	6	4	3	0.1886	0.2608	0.2858	0.3801	0.2067
Tahquamenon River	75	6	5	6	0.2150	0.1938	0.1213	0.1905	0.0895
Manistique River	67	4	3	4	0.2212	0.2695	0.0557	0.3718	0.1070
Walton River	55	3	0	3	0.4680	0.3989	0.3142	0.3616	0.0087
Peshtigo River—A	61	4	2	12	0.4628	0.3954	0.3137	0.4647	0.3048
Peshtigo River—B	65	6	6	8	0.4628	0.3954	0.3137	0.4647	0.3048
Peshtigo River—C	56	3	0	9	0.4628	0.3954	0.3137	0.4647	0.3048
Tibbet Creek	53	4	1	9	0.7862	0.4714	0.6061	0.5824	0.0430
Duck Creek	47	3	0	10	0.8445	0.4850	0.7324	0.6229	0.4029
Ahnapee River—A	49	3	0	11	0.8067	0.4538	0.7177	0.5130	0.3909
Ahnapee River—B	67	4	2	6	0.8067	0.4538	0.7177	0.5130	0.3909
Ahnapee River—C	46	3	0	7	0.8067	0.4538	0.7177	0.5130	0.3909
Kewaunee River	57	2	0	13	0.8294	0.4587	0.7524	0.5290	0.3920
Little Manitowoc River	29	2	0	12	0.9368	0.5201	0.8570	0.6477	0.3153
Black River	48	2	2	7	0.9285	0.5547	0.7505	0.6987	0.4837
Pere Marquette River—A	50	5	2	8	0.6028	0.6117	0.3606	0.3966	0.3575
Pere Marquette River—B	49	5	4	9	0.6028	0.6117	0.3606	0.3966	0.3575
Manistee River—A	41	7	5	16	0.4225	0.6066	0.2451	0.3659	0.1962
Manistee River—B	47	5	3	9	0.4225	0.6066	0.2451	0.3659	0.1962
Manistee River—C	43	5	2	12	0.4225	0.6066	0.2451	0.3659	0.1962
Platte River	74.5	7	5	5	0.3907	0.5477	0.2330	0.4120	0.0659