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RESEARCH ARTICLE

Bird Assemblages in *Phragmites* Dominated and Non-*Phragmites* Habitats in Two Lake Erie Coastal Marshes

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ABSTRACT: A decline in Lake Erie water levels in 2000 from historic high levels of the 1990s has facilitated a shift in coastal wetland vegetation from open-water floating-leaf plant communities to emergent communities often dominated by the invasive perennial grass, *Phragmites australis*. Dense, near monotypic stands of this grass may lead to the loss of native plants and reduce suitable habitat for waterfowl and other wetland birds. To assess avian response to this shift in plant community structure, we conducted bird surveys (June–August, 2007) across four vegetation types in two coastal wetlands in the western basin of Lake Erie. *Phragmites* habitat had higher overall bird abundance but contained the lowest species diversity (H′ = 0.71) of the four habitat types. Of the 35 species observed across habitat types, 4 species: (1) red-winged blackbird (*Agelaius phoeniceus*); (2) tree swallow (*Tachycineta bicolor*); (3) barn swallow (*Hirundo rustica*); and (4) bank swallow (*Riparia riparia*), accounted for 94% of total bird abundance. Ninety-four percent of all birds observed in sampled plots of *Phragmites* were red-winged blackbirds, and 73% of the total bird abundance (all species) across habitats occurred in *Phragmites*. This was mostly attributed to the large roosts (>500 birds/50-m radius plot) of red-winged blackbirds in sampled plots of *Phragmites. Phragmites* community overlap (R_o), represented by Horn's index, varied from a low of 0.30 with floating-leaved vegetation to a high of 0.69 within the *Typha* (cattail) community. Our results suggest that *Phragmites* does influence bird abundance and species diversity, but caution is warranted without additional data on nest success and survival.

Index terms: invasive species, Lake Erie, *Phragmites australis*, wetland birds, wetlands

INTRODUCTION

Coastal wetlands of the Laurentian Great Lakes are dynamic, biologically diverse systems that support extensive floral and faunal communities. These wetlands, however, are increasingly threatened by human intrusion and the introduction and expansion of exotic species that disrupt established food webs, displace native species, and threaten the ecological integrity of these dynamic systems (Fletcher 2003; Zedler and Kercher 2004). Since the early 1800s and the settlement of the region, the Great Lakes have been subjected to invasions of numerous exotic organisms (Ricciardi 2006). Mills et al. (1993) documented the establishment of 139 nonindigenous aquatic species in the Great Lakes, 42% of which are plants. Well-known examples include purple loosestrife (*Lythrum salicaria* L.), narrow-leaf cattail (*Typha angustifolia* L.), reed canary grass (*Phalaris arundinacea* L.), and common reed grass (*Phragmites australis* (Cav.) Trin. Ex Steud.). *Phragmites*, a wetland perennial grass, is of special concern because of its rapid rate of expansion and the apparent resulting decline in habitat heterogeneity (Marks et al. 1994). The expansion of *Phragmites* into the wetlands of the Great Lakes region is largely a recent phenomenon thought to have been triggered by a return to water levels closer to the long-term mean after nearly three decades of unprecedented high water levels (Trexel-Kroll 2002; Wilcox et al. 2003). Beginning in 1999, wetlands along Lakes Erie and Michigan shifted from open water systems to *Phragmites*-emergent dominated plant communities (Wilcox et al. 2003; Tulbure et al. 2007; Whyte et al. 2008). During periods of low water many wetland plant species regenerate from the seed bank, a process vital to maintaining plant diversity (Keddy and Reznicek 1986). However, fluctuating water levels appear to facilitate the colonization of *Phragmites* on exposed substrate and subsequently may minimize the establishment of native species (Trexel-Kroll 2002). *Phragmites*, once established, may also displace established healthy stands of native emergents (Whyte et al. 2008).

Native wetland plant assemblages provide critical habitat for many species of marsh birds (Herdendorf 1992; Prince et al. 1992). An increase of nonindigenous invasive plant species such as *Phragmites,* may contribute to a decline in the quality of wetland habitat for migrating waterfowl and other bird species that use these wetlands (Whitt et al. 1999; Howe et al. 2007). Natural area managers from throughout North America have anecdotally reported declines in avian use of wetlands where *Phragmites* has become the dominant wetland plant. However, *Phragmites* may not always be an ecological disaster, and the presumed negative ecological effects of *Phragmites* have not been clearly demonstrated (Weis and Weis 2003). Regardless, it is certain that nonnative species can bring undesirable ecosystem change and alter the flora and fauna. As more studies are completed, a better understanding of the impacts of these invasive species will be developed. Very few studies have sought to quantitatively document the ecological effects on birds that result from a shift from native to predominantly nonnative wetland vegetation, and fewer still have attempted to document bird use in *Phragmites*-dominated wetlands of the Great Lakes (Howe et al. 2007; Meyer et al. 2010).

Large-scale vegetation control programs are being proposed and implemented in response to the spread of *Phragmites*, yet our understanding of overall system impacts and community dynamics resulting from an increased presence of *Phragmites,* and other invasive plants, remains incomplete (Kulesza et al. 2008). On Pea Patch Island, Delaware, *Phragmites* may provide critical habitat for nesting wading birds, and control measures could prove to be adverse to some species of nesting birds (Parsons 2003). *Phragmites* control measures along Lake Erie's south shore have inadvertently interfered with marsh wren (*Cistothorus palustris* A. Wilson) nesting in adjacent *Typha* patches (Lazaran et al. 2013). As *Phragmites* continues to spread and control efforts proceed, we will need better information to understand the associated ecological impacts. Additional studies examining plant–animal interactions, such as bird use of *Phragmites*, will allow wetland and natural resource managers to better understand vegetation dynamics of *Phragmites* and enable managers to implement more appropriate management and restoration strategies.

The Old Woman Creek National Estuarine Research Reserve (OWC) and the Sheldon Marsh Nature Preserve comprise some of the last remaining undeveloped stretches along the Ohio shoreline of Lake Erie. Their location at the eastern edge of the western Lake Erie basin provides important stopover sites for all groups of migratory birds including waterfowl, shorebirds, raptors, other wetland dependent birds, and associated upland birds. Old Woman Creek and Sheldon Marsh provide critical breeding, nesting, feeding, and protective areas for many species of birds. The Ohio Department of Natural Resources reported 370 bird species in the region surrounding OWC and Sheldon Marsh, with 44 listed as species of concern (Herdendorf et al. 2006). Recognizing the critical need to protect these natural areas and the threat posed by the continued spread of *Phragmites*, we sought to document bird use in OWC and Sheldon Marsh in different wetland vegetation types, and secondarily to test the hypothesis that *Phragmites* has a negative impact on habitat quality and the use of these coastal wetlands by birds. Specifically, we documented habitat use and abundance by wetland birds and assessed whether the composition and diversity of the bird community differs in *Phragmites* dominated patches versus patches consisting of *Typha angustifolia* and native plant assemblages. We consider this research to be the first step in an ongoing effort to assess the overall use and nest success of wetland birds so that wetland managers may more effectively design and implement management measures.

METHODS

Study Site

Birds were observed, identified, and counted in two coastal wetlands (Old Woman Creek National Estuarine Research Reserve and Sheldon Marsh State Nature Preserve) situated along Lake Erie's south shore at the eastern extent of its western basin. Both systems are hydrologically connected to Lake Erie through their respective interceding barrier beaches. Water exchange in these systems is facilitated by wind tides and seiches in Lake Erie, and in OWC to a much greater extent by drainage from its 69-km^2 watershed (Herdendorf et al. 2006). Sheldon Marsh represents the eastern portion of the 10.5-km long Cedar Point sand spit and maintains a permanent ~25 m wide opening at the western end of its 1.8-km long barrier beach. Old Woman Creek is a drowned river mouth that maintains a semipermanent connection to Lake Erie through the opening and closing of a sand-barrier beach. The hydrologic dynamics of both wetlands define the characteristic plant communities that are present. These wetlands are currently characterized by large areas of emergent vegetation dominated by the invasive species *Phragmites* and *Typha angustifolia* as well as native floating-leaved beds of *Nelumbo lutea* L. (American water lotus), *Nymphaea odorata* Aiton (white waterlily), and *Nuphar lutea* (L.) Sm. ssp. Advena (Aiton) Kartesz & Gandhi (yellow waterlily) (Whyte et al. 2008; Back 2010). A decline in water levels in 1999–2000 facilitated a shift in wetland plant communities from open water systems dominated by floating-leaved vegetation, to shallow emergent systems. In OWC, the percent cover of emergent vegetation increased from 10% to almost 50% by 2001, and total vegetation cover rose from 40% to 70% in the same time period (Trexell-Kroll 2002). More significantly, the dramatic decline in water levels facilitated the invasion and spread of *Phragmites* to encompass 40% of the wetland vegetation in OWC (Whyte et al. 2008), and to cover 18% of the emergent vegetation in Sheldon Marsh (Back and Holomuzki 2008).

Field Surveys

All sampling was done in 50-m radius circular plots (0.785 ha) in 10 distinctive vegetation patches across four vegetation types at the two sites (OWC and Sheldon Marsh): *Phragmites* dominant (2 plots), *Typha* dominant (*Typha angustifolia*) (2 plots), floating-leaved (rooted) (3 plots), and mixed-emergent (representative of the emergent native wetland vegetation) (3 plots). Bird plot size was chosen to detect the diversity of species present (Ralph et al. 1993), and plot locations were chosen to achieve independence between plots based on avian territorial behavior. All bird sample plots were located in vegetation patches of a minimum of 2 ha but less than 5 ha. The selection and location of bird plots were limited by the availability of viable *Phragmites* patches in 2007. The study was designed (and funded) in 2006, but an unexpected late summer 2006 aerial herbicide spraying of extensive areas of *Phragmites* at OWC decreased the extent of *Phragmites* in 2007. As a result, sampling was also conducted in nearby Sheldon Marsh (~6.5 km from OWC).

An active *Phragmites* control program in Sheldon Marsh has limited the spread of this invasive plant throughout the marsh, but we were able to locate one of the two *Phragmites* plots and two *Typha* plots at Sheldon Marsh (Figure 1).

Birds were surveyed during a single breeding season (9 June–3 August 2007) in each of the wetlands and their respective plots approximately every 10 days, for a total of seven sample dates per plot. All field counts were conducted between 0600 and 1000 hours. Each plot was passively surveyed from the center of the plot for a 15-minute listening and observing period. This was followed by a walk through the survey plot to flush previously undetected birds. Individual birds that were using the

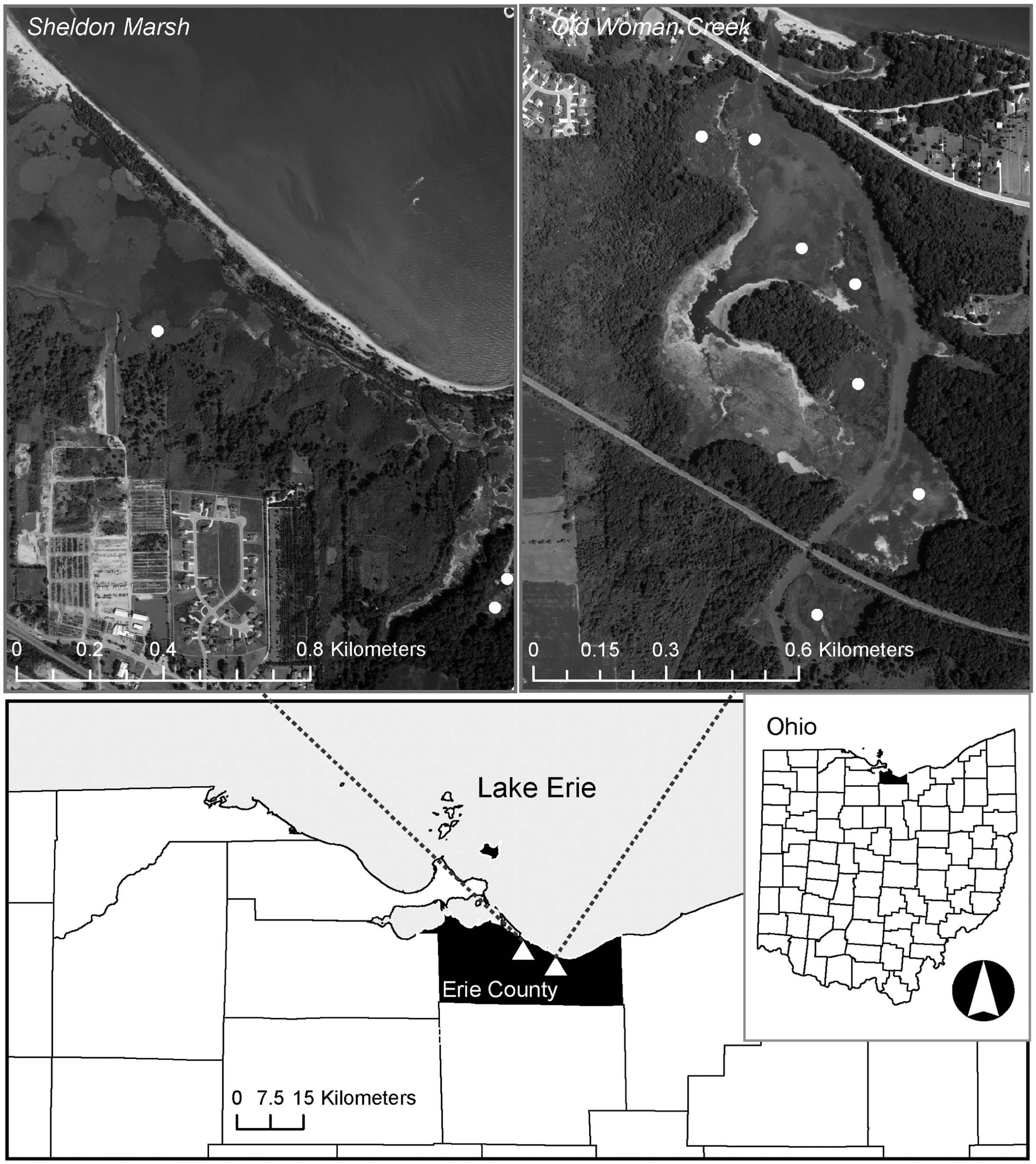

Figure 1. Aerial photographs of the Old Woman Creek National Estuarine Research Reserve and Sheldon Marsh Nature Reserve, indicating study location in Huron, Ohio.

habitat and its resources were counted (i.e., roosting, preening, foraging, singing, nesting), whereas birds not actively engaged at the site (e.g., passing over and not aerially foraging) were not counted. All birds were classified based on habitat descriptions in Peterjohn (2001) and Ehrlich et al. (1988) as either wetland dependent (rely on wetlands for major aspects of life cycle), wetland user (spend a considerable portion of life cycle in wetlands but not exclusively dependent upon wetlands), or nonwetland species (typically not associated with wetlands).

Plant community characterization for each corresponding bird sample plot was initially based on previous vegetation surveys and subsequently adjusted based on follow-up field verification. To verify and characterize the vegetation within each of the sampled bird plots, wetland vegetation was sampled in 1 × 1-m quadrats along randomly placed transects in each of the selected plant community types. A minimum of one transect was placed in each habitat type, with transects running perpendicular to the shore along an elevation gradient. Within quadrats, the percent foliage cover was determined for each plant species and the value converted to a cover class using a modified Braun-Blanquet method (<1%, 1 to <10%, 10 to <25%, 25 to <50%, 50 to >75%, 75 to100%) encompassing six classes (McCune and Grace 2002). The mid-point cover value for each species within each quadrat was then summed and an average cover determined. Plant names generally followed the USDA PLANTS Database (USDA, NRCS 2012). Plant communities were categorized based on the dominance of a single species or group of related species. *Phragmites* and *Typha* dominated communities were characterized by 50% or greater relative cover of *Phragmites australis* and *Typha angustifolia*. The floating-leaved community had a combined cover of greater than 40% *Nelumbo lutea* and *Nymphaea odorata*, although *Nelumbo* was generally the dominant plant. Mixed-emergent communities had no single plant with a cover of greater than 30%. In the mixed-emergent community, vegetation structure was primarily the result of recent herbicide control efforts and, to a lesser extent, remnants of areas not yet invaded by *Phragmites*. Vegetation in these areas included various grasses, sedges, and herbaceous emergents (e.g., *Leersia oryzoides* (L.) Sw., *Echinochloa* spp., *Scirpus* spp., *Schenoplectus* spp., *Cyperus* spp., *Sagittaria latifolia* Willd., *Typha angustifolia*, *Polygonum* spp., and *Sparganium eurycarpum* Engelm.). Water depths were measured in each sampled plant community and correlated to data logger readings at a fixed station that provided continuous water depth readings at each bird study plot for the study period.

Data Analysis

For the 2007 breeding season, data were pooled from like vegetation plots and averaged by date for each of the four dominant vegetation types. The *Phragmites* plots represent the only case where the plots occurred on two different sites (OWC and Sheldon Marsh). The data were pooled in the same manner as the other vegetation types. Although each of the four vegetation types were sampled using a small number of plots (2–3), measurements were replicated in time (across seven sample dates). This approach allowed us to test the effect of the vegetation type on bird community structure.

Bird assemblages were characterized in vegetation plots by the Shannon-Wiener diversity index (H′) (Krebs 1999), species richness, abundance (direct counts), bird species composition by wetland dependency (wetland dependent, wetland user, and nonwetland), and community similarity. The Shannon-Wiener diversity index uses the formula $H' = -\sum(p_i)\ln p_i$, where p_i is the proportion of individuals found in the i^{th} species. H′ increases as the number of species in the community increases. H′ was calculated for each study plot on each sampling date. Evenness (E) was also calculated from the Shannon-Weiner function where $E = H'/\ln S$ with a maximum value of 1.0, indicating all species are equally abundant (Krebs 1999). Community similarity of observed birds was measured from relative abundance values using Horn's index of similarity (Krebs 1999). We believed use of a community similarity index was important to help further assess bird assemblage differences across plant community types (particularly *Phragmites*) in relation to bird species composition.

Total bird counts, species richness, H′-diversity, as well as bird counts and species richness by wetland dependency status (square root transformed x + 1), were compared among plant community types by one-way repeated measures (RM) ANOVA, and pairwise comparisons were done (Tukey test) if a significant difference was found ($P < 0.05$).

RESULTS

Sampled plant community structure was characterized by a summary of vegetation features that included total plant species richness, plant density, and total and relative plant cover. This served to confirm our habitat categories based upon the dominant wetland vegetation or community type. *Phragmites*, *Typha*, and floating-leaved vegetation all contained a single dominant plant species based on mean relative plant cover (*Phragmites australis* 67%, *Typha angustifolia* 75%, and *Nelumbo lutea* 40%, respectively). No other single plant species had a relative cover greater than 20% in these three vegetation types. In contrast, no one plant dominated the mixed-emergent substrate; five plant species comprised 67% of the relative cover (range 10–20%). Mixed-emergent plant density was more than seven times greater than all other vegetation types, reflecting the dominance of several graminoid species. Total cover, density, and number of plant species in the floating-leaved vegetation type was less than the other vegetation types (Figure 2). Within each sampled plant community, water depths were less than 45 cm from May through August and fluctuated directly with changes in Lake Erie water levels. Overall water depths were greatest in the floating-leaved vegetation and least in the mixed-emergent vegetation, which had little to no standing water for the duration of the study period.

Thirty-five species of birds were documented in the four sampled vegetation types across the seven sample dates (Table 1). Mean bird counts were 198, 29, 6, and 31, in *Phragmites*, mixed-emergent, *Ty*-

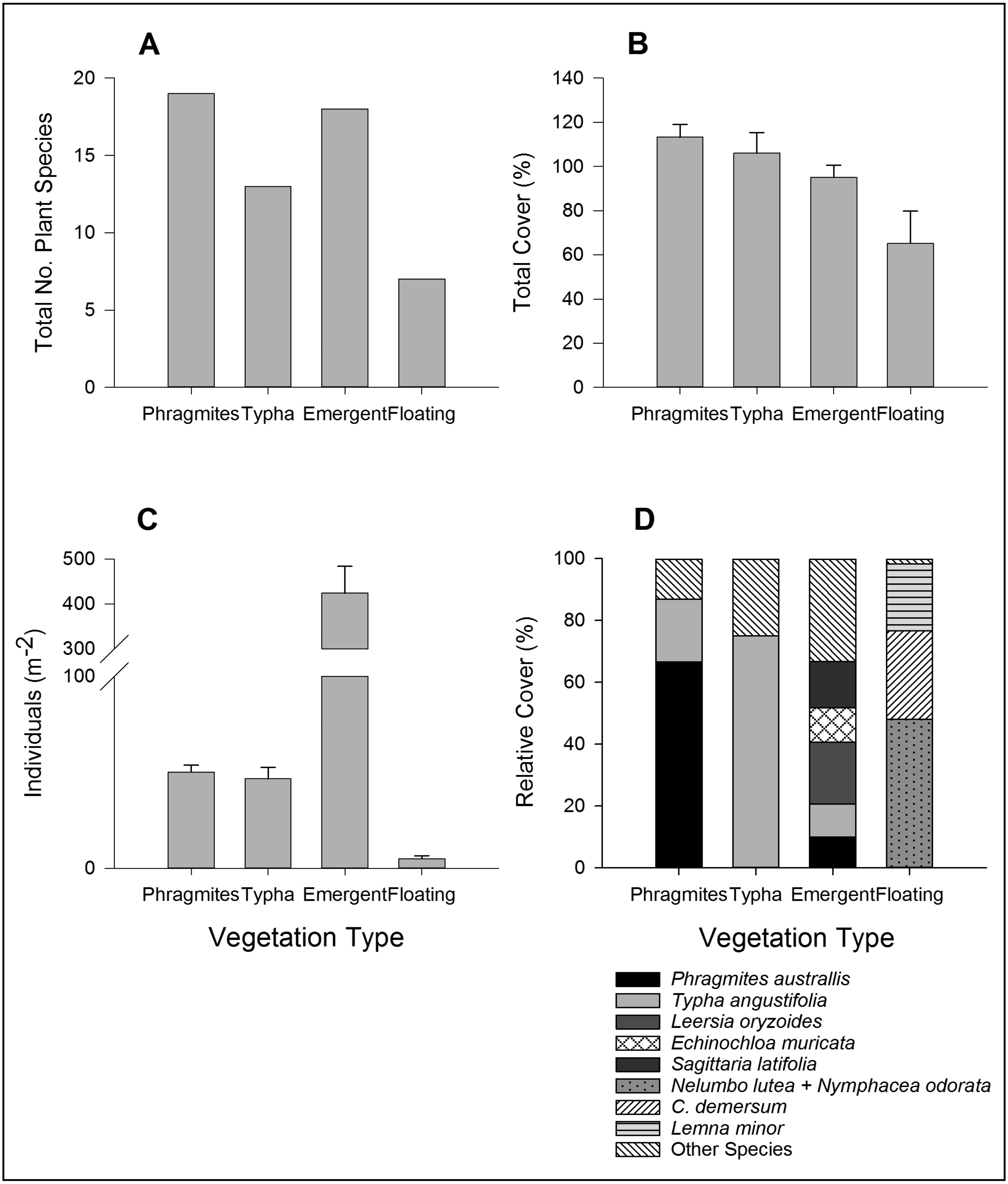

Figure 2. Plant community structure by vegetation type showing: (a) total number of plant species; (b) total plant cover (%) (mean + 1 SE); (c) plant density (mean + 1 SE); and (d) relative cover (%) at Old Woman Creek and Sheldon Marsh in Huron, Ohio, 2007.

Table 1. Mean number of birds (+ 1SE) observed by vegetation type, and total relative abundance during sampling in June–August 2007 in Huron, Ohio. Mean values with different alphabetical letters indicate significant differences among vegetation types by bird species ($P < 0.05$).

	Vegetation Type				
Species (common name)	*Phragmites*	Mixed-emergent	*Typha*	Floating-leaved	Total Relative Abundance
Agelaius phoeniceus (red-winged blackbird)	186.6 (45.5)a	5.9 (2.5)b	2.9 (0.8)b	1.4 (0.4)b	72.8
Tachycineta bicolor (tree swallow)	4.9 (2.3)a	7.4 (4.3)a	0.0a	11.6 (6.7)a	8.8
Hirundo rustica (barn swallow)	5.7 (2.4)a	8.3 (3.7)a	0.0a	4.7 (1.9)a	6.9
Riparia riparia (bank swallow)	0.0 a	5.2 (3.0)a	0.0a	7.3 (4.2)a	4.7
Aix sponsa (wood duck)	0.1 (0.1)	0.0	0.0	2.3 (1.3)	0.9
Cistothorus palustris (marsh wren)	0.0	1.0 (0.1)	0. 5 (0.2)	1.2 (0.8)	0.8
Melospiza georgiana (swamp sparrow)	0.0	1.6 (0.7)	0.0	0.0	0.6
Anas platyrhnynchos (mallard)	0.0	0.1 (0.1)	0.0	1.2 (0.8)	0.5
Carduelis tristis (American goldfinch)	0.1 (0.1)	1.1 (0.4)	0.0	0.0	0.4
Ardea herodias (great blue heron)	0.3 (0.2)	0.0	0.0	0.7 (0.2)	0.4
Quiscalus quiscula (common grackle)	0.9 (0.9)	0.0	0.0	0.0	0.4
Ardea alba (great egret)	0.1 (0.1)	0.0	0.0	0.8 (0.2)	0.3
Melospiza melodia (song sparrow)	0.0	0.8 (0.2)	0.1 (0.1)	0.0	0.3
Cardinalis cardinalis (northern cardinal)	0.0	0.1 (0.1)	0.6 (0.3)	0.0	0.3
Tyrannus tyrannus (eastern kingbird)	0.4 (0.2)	0.2 (0.2)	0.0	0.0	0.3
Charadrius vociferus (killdeer)	0.4 (0.3)	0.0	0.0	0.0	0.2
Turdus migratorius (American robin)	0.0	0.0	0.4 (0.2)	0.0	0.1
Polioptila caerulea (blue-gray gnatcatcher)	0.0	0.0	0.4 (0.4)	0.0	0.1
Passerina cyanea (indigo bunting)	0.0	0.0	0.3 (0.2)	0.0	0.1
Branta canadensis (Canada goose)	0.0	0.0	0.0	0.3 (0.3)	0.1
Geothlypis trichas (common yellow throat)	0.0	0.3 (0.0)	0.0	0.0	0.1
Butorides virescens (green heron)	0.1 (0.1)	0.0	0.0	0.1 (0.1)	0.1
Empidonax traillii (willow flycatcher)	0.1 (0.1)	0.1 (0.1)	0.0	0.0	0.1
Progne subis (purple martin)	0.0	0.2 (0.2)	0.0	0.0	0.1
Nycticorax nycticorax (black-crowned night heron)	0.0	0.0	0.1 (0.1)	0.0	0.1
Megaceryle alcyon (belted kingfisher)	0.0	0.0	0.0	0.1 (0.1)	0.1
Laris delawarensis (ring-billed gull)	0.0	0.0	0.0	0.1 (0.1)	0.1
Scolopax minor (American woodcock)	0.1 (0.1)	0.0	0.0	0.0	0.0
Haliaeetus leucocephalus (bald eagle)	0.0	0.0	0.1 (0.1)	0.0	0.0
Cyanocitta cristata (blue jay)	0.0	0.0	0.1 (0.1)	0.0	0.0
Picoides pubescens (downy woodpecker)	0.0	0.0	0.1 (0.1)	0.0	0.0
Dumetella carolinensis (gray catbird)	0.0	0.0	0.1 (0.1)	0.0	0.0
Archilochus colubris (ruby-throated hummingbird)	0.0	0.0	0.1 (0.1)	0.0	0.0
Setophaga petechia (yellow warbler)	0.0	0.0	0.0	0.0	0.0
Unknown swallow	0.0	0.0	0.1 (0.1)	0.0	0.0
Mean Counts	197.9 (45.7)a	28.6 (7.9)b	5.7 (0.5)b	30.9 (9.5)b	
Relative Abundance	75	11	2	12	
Total Species Richness	14	14	14	13	

pha, and floating-leaved vegetation types, respectively, and differed across plant communities ($F_{3,24}$ = 13.393, P < 0.001). Mean counts were greater in *Phragmites* than all other vegetation types (P < 0.001). Less than 3% of all birds were observed in *Typha*. Four bird species, red-winged blackbird (*Agelaius phoeniceus* L.), tree swallow (*Tachycineta bicolor* Vieillot), barn swallow (*Hirundo rustica* L.), and bank swallow (*Riparia riparia* L.) represented 94% of the total number of observed birds; all other species individually comprised <1%. Red-winged blackbirds were observed in all plant communities and accounted for 73% of all birds recorded. Mean red-winged blackbird counts in *Phragmites* were highly variable (range 5–506/50-m radius plot; Table 1) across sample dates, but were greater than in other vegetation types. The tree, barn, and bank swallows actively fed in the air immediately above the vegetation and were the next greatest in abundance (9, 7, and 5%, respectively), although their occurrence and densities were also variable. The bank swallow was not detected in *Phragmites*, and the bank, tree, and barn swallows were not recorded in *Typha*.

The total number of bird species observed for the duration of the study was similar among plant communities, with 13 species recorded in the *Phragmites* and floating-leaved habitats, and 14 species recorded in each of the other two community types. Mean species richness, however, differed across vegetation types ($F_{3,24}$ = 4.280, P = 0.019; Figure 3), albeit the range was small (3.05–4.43/50-m radius plot), and was greatest in the mixed-emergent vegetation (P < 0.05). Shannon diversity (H′) for bird species differed across vegetation types (RM ANOVA: $F_{3,24}$ = 5.480, P = 0.007; Figure 3;). H′ and evenness (E) were greatest in the mixed-emergent bird community (H′ = 1.52, E = 0.75), and lowest in *Phragmites* (H′ = 0.71, E = 0.38), but only different from mixed-emergent.

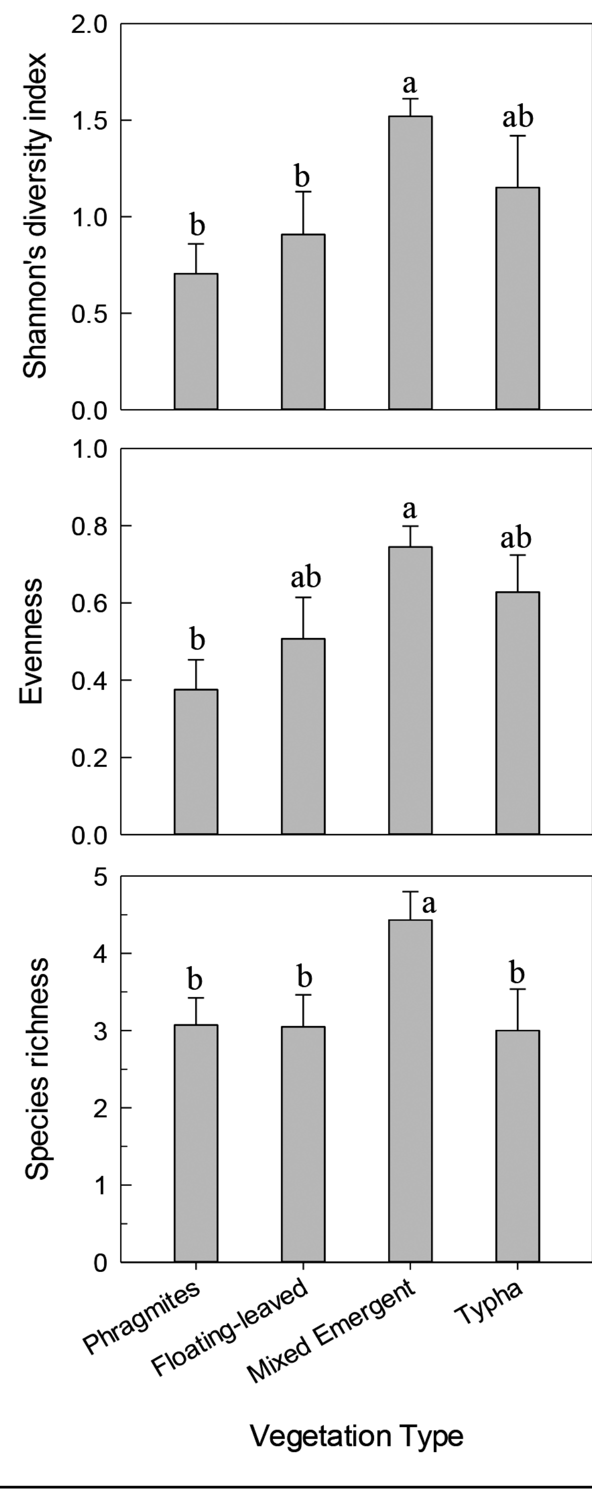

Figure 3. Mean (+1 SE) for Shannon's diversity index, evenness, and species richness of birds in each of the four sampled vegetation types at Old Woman Creek and Sheldon Marsh in Huron, Ohio, 2007. Different letters indicate significant difference (P < 0.05).

Bird species richness by wetland dependency (wetland dependent, wetland user, nonwetland) varied among the plant communities. Of the 34 species identified (one species was not confirmed), 41% were wetland dependent compared to 32% wetland users and 27% nonwetland species. Mean wetland dependent species richness differed among the vegetation types ($F_{3,24}$ = 9.665, P < 0.001), with the mean number of species in *Phragmites* less than that of the floating-leaved habitat (P < 0.05; Table 2), but similar to other vegetation types

($P > 0.05$; Table 2). Species richness of wetland user and nonwetland bird species was similar between *Phragmites* and all other vegetation types ($P > 0.05$).

Wetland users were the predominant bird group in all vegetation types. The number of birds considered wetland users was ~15 to ~57 times greater in *Phragmites* than all other vegetation types ($P < 0.05$; Table 2). There were no differences in the number of wetland dependent individual birds between *Phragmites* habitat and other vegetation types ($P > 0.05$). Overall, nonwetland birds were low in numbers in all vegetation types (range 0.05–1.95/50-m radius plot), with lowest numbers in the floating-leaved vegetation.

Horn's Index of Community Similarity indicated mixed-emergent and floating-leaved vegetation had the greatest community overlap ($R_o = 0.74$), whereas *Typha* and floating-leaved were the least similar ($R_o = 0.16$) (Table 3). *Phragmites* had the greatest community overlap with *Typha* ($R_o = 0.69$), and was the least similar to floating-leaved ($R_o = 0.30$). The community of birds using the mixed-emergent vegetation was the most similar to other vegetation types (mean $R_o = 0.56$), while the floating-leaved bird community was the most dissimilar to birds in other vegetation types (mean $R_o = 0.40$).

DISCUSSION

Bird Abundance and Diversity among Plant Communities

Wetland birds may be particularly vulnerable as native plant assemblages are replaced with dense monocultures of the exotic *Phragmites*, which may not provide suitable habitat for many species of wetland birds (Benoit and Askins 1999). In stands dominated by *Phragmites*, total number of bird species among vegetation types was the same, but bird counts, species composition, diversity, and wetland dependency status of the birds varied among vegetation types. *Phragmites* stands had greater bird abundance than all plant community types (73% of total abundance), but in contrast had a Shannon species diversity value for the observed bird community that was less than the other vegetation types, and an uneven distribution of species ($H' = 0.71 \pm 0.16$, range 0.01–1.19; $E = 0.38 \pm 0.08$, range 0.01–0.61). The low evenness value was affected by roosts of red-winged blackbirds exceeding 500 birds/50-m radius plot on five of seven survey dates in Old Woman Creek. Red-winged blackbirds represented 94% of all birds observed in *Phragmites*, and 78% of all red-winged blackbirds were recorded in *Phragmites*. Red-winged blackbirds were also the most abundant species found in *Typha* (~52%) and were an important component of the mixed-emergent bird community (~22%) at our sites as well. Similarly, Benoit and Askins (1999) working in Connecticut tidal marshes, and Meyer et al. (2010) in Lake Erie (Ontario, Canada), found a greater abundance of red-winged blackbirds in stands of *Phragmites* than in other habitat types. Neither study, however, reported the presence of large roosts as observed in OWC. Meanley (1965) reported large red-winged blackbird roosts (densities were not provided) in the Chesapeake Bay region occurring mainly in *Phragmites* (reported

Table 2. Mean (+ 1 SE) number of individuals and number of species per 50-m radius plot, by vegetation type, from sampling in Huron, Ohio, June–August 2007. Mean values with different alphabetical letters indicate significant differences among vegetation types by wetland dependency ($P < 0.05$).

	Phragmites	Mixed-emergent	*Typha*	Floating-leaved
Number of Individuals				
Wetland dependent	5.50 (2.37)a	16.48 (7.25)a	0.36 (0.20)a	24.33 (10.24)a
Wetland users	228.93 (36.09)a	14.91 (3.41)b	4.14 (1.34)b	6.52 (1.56)b
Nonwetland	0.14 (0.14)a	1.95 (0.46)b	1.21 (0.54)ab	0.05 (0.05)a
Number of Species				
Wetland dependent	1.86 (0.46)b	2.86 (0.40)ab	1.14 (0.34)b	4.43 (0.57)a
Wetland users	2.29 (0.29)ab	2.57 (0.20)a	1.29 (0.36)a	1.43 (0.20)b
Nonwetland	0.14 (0.14)	1.57 (0.37)	1.86 (0.67)	0.14 (0.14)

Table 3. Horn's index of community similarity for the sampled vegetation types.

Vegetation Type	Mixed-emergent	*Phragmites*	Floating-leaved	*Typha*
Mixed-emergent	-----	-----	-----	-----
Phragmites	0.52	-----	-----	-----
Floating-leaved	0.74	0.3	-----	-----
Typha	0.41	0.69	0.16	-----
Mean R_o	0.56	0.5	0.4	0.42

as *Phragmites communis* Trin), *Typha*, and big cordgrass (*Spartina cynosuroides* (L.) Roth), and that they were influenced by food supply, dense cover, and standing water. Contributing factors in OWC may include food supplied by the largely agricultural area immediately surrounding OWC and the depth of standing water, which ranged from 3 to 25 cm in the *Phragmites* survey plot during our study.

Similar to Meyer (2003), we observed two of the three swallow species (tree and barn swallow) in *Phragmites* but, unlike Meyer, all three swallow species were most abundant in mixed-emergent and floating-leaved communities. Meyer (2003) observed swallows (species not specified) roosting in *Phragmites*, and explained this as a function of fewer available insects in *Phragmites*. In our study, however, swallows were observed primarily foraging while flying immediately above the wetland vegetation; only the tree swallow was observed roosting, and then only in the mixed-emergent vegetation. A more recent and local study of benthic structure in several wetlands (including OWC and Sheldon Marsh) along Lake Erie's south shore found that macroinvertebrate densities were similar across stands of *Phragmites*, *Typha*, and native plant assemblages (e.g., mixed-emergent and floating-leaved) (Holomuzki and Klarer 2010). This suggests our sites, unlike Meyer (2003), had the food supply to support swallows in *Phragmites,* as well as other vegetation types.

Habitat selection by swallows and other bird species may also be related to structural differences in the vegetation, such as the tall, denser stands of *Phragmites* with significant litter accumulation and sediment accretion (Rooth 2003). In combination with low water levels and the lack of interior openings, the structure may directly contribute to the presence or absence of particular species. Mean *Phragmites* density was 29 stems/m^2, and mean cover was 67% in our vegetation sample plots. Water depths in *Phragmites* stands ranged from a low of 3 cm on 21 June, to a high of 25 cm on 30 July. The marsh wren, swamp sparrow (*Melospiza georgiana*, Latham), and red-winged blackbird may use *Phragmites* and *Typha* for nesting (Meyer 2003), and, therefore, are looking for tall dense emergent plants to provide support and protection for their nests, whereas the swallows' use of mixed-emergent and floating-leaved vegetation may be more related to feeding. Swamp sparrows and marsh wrens, which are both wetland dependent species, are known to nest in *Typha* and wet meadows, but will occupy all wetland habitat types (Peterjohn 2001; Riffell et al. 2001). The marsh wren is an Ohio state listed species of concern, and its presence and habitat use in these wetlands is of concern to state wetland managers.

Several species of ground birds, waders, and waterfowl were observed in our *Phragmites* study plots, but all with total relative abundance of less than 1%. Great blue herons (*Ardea herodias* L.) and great egrets (*Ardea alba* L.) were observed near the outer edges of plots, nearer to the open water where the emergent vegetation tended to be less dense and the water slightly deeper. The wood duck (*Aix sponsa* L.) was the only duck observed to use the outer margins of *Phragmites*. Canada geese (*Branta canadensis* L.) and mallards (*Anas platyrhynchos* L.) did not use *Phragmites*, and were the only waterfowl observed in the study survey plots. American woodcocks (*Scolopax minor* Gmelin) and green herons (*Butorides virescens* L.), which tend to select woodland edges and moist brushy areas, were detected on the landward edges of *Phragmites* plots. The low number of bird species found in *Phragmites* highlight the well-known ecological principle that within many communities, only a few species may be common with the majority being uncommon or rare (MacArthur and Wilson 1967; Gaston 1994). For nonaerial insectivorous bird species, lack of habitat accessibility may account for the low numbers and frequency of occurrence. Structurally, *Phragmites* culms are very strong and many remain erect well into the next growing season. These culms are slow to decompose, and contribute substantially to the accumulation of litter (Gorham and Pearsall 1956). In OWC, we found dead erect stems (height $\geq$1.5 m) in 65% of all sampled plots at a density of 13.8 stems/m^2 $\pm$ 2.33 (mean + 1SE) (R. Whyte, unpubl. data). This may explain our observations of these birds nearer to stand edges. It is uncertain if water levels may have contributed to accessibility to stand interiors. Water levels in OWC and Sheldon Marsh between May and July were above the mean level of Lake Erie (174.1 m; International Great Lakes Datum, 1985**),** resulting in shallow flooding of most of the vegetated areas. However, the *Phragmites* interior remained closed, limiting access to waterfowl.

Phragmites Stand Structure and Habitat Quality

In evaluating bird use of wetland habitat, greater attention must be given to the structural complexity of wetland plant communities and, ultimately, how community composition, particularly invasive exotic plants such as *Phragmites,* may affect habitat quality. For example, *Phragmites* stands are often described as large, dense, homogeneous stands low in species richness. As Tulbure et al. (2007) suggested, however, such a description may be site specific and temporally dependent. Therefore, it is important that we have adequately described the sampled plant community types. Only through more detailed assessment of the difference in plant community composition and structure can similarities and differences in species diversity and relative abundance among wetland bird species be ascertained. Based on stand density (range 29–49 culms/m^2), cover extent (>65%), and frequency of occurrence (e.g., 96% in Sheldon Marsh), the stands of *Phragmites* at both OWC and Sheldon Marsh, could be described as nearly monotypic. Even though the number of plant species in these stands was surprisingly high (19 and 20 in OWC and Sheldon Marsh, respectively), the abundance of non-*Phragmites* species was low. Overall, the somewhat homogeneous environment and dense structure may be factors contributing to the low bird species diversity found in *Phragmites*.

Caution must be used in drawing conclusions about habitat quality solely based on bird abundance and species diversity. Van Horne (1983) indicated that abundance may be a misleading indicator of habitat quality without examination of nesting success and survival under certain conditions, including environmental disturbances that result in an animal's failure to correctly recognize and select favorable habitats (Bock and Jones 2004). In the Great Lakes, water level change has facilitated the invasion and spread of *Phragmites,* which has displaced native species, including *Typha latifolia* L. Structurally, *Phragmites* seems to be similar to *Typha*, and some species of birds appear to substitute one for the other. The next important question is this; does *Phragmites* provide the same reproductive opportunities for birds as *Typha*? We did not examine this (although a future study will). Few studies on the Great Lakes have examined the relationship between habitat and reproductive success. Our results, however, do suggest that *Phragmites* influences bird abundance and species diversity.

This study is a first step to understanding vegetation type in relation to habitat quality. Bock and Jones (2004) concluded that, in most instances, information on density is a reliable indicator of habitat quality, and can be used as a basis for management decisions. However, they cautioned that disturbance may impair the ability of birds to appropriately select optimum habitat. Results from Meyer et al. (2010), one of the few studies to examine bird use in *Phragmites* in a Great Lakes wetland, were consistent with ours in documenting active use by birds in *Phragmites,* as well as high abundance of red-winged blackbirds. Whitt et al. (1999), working in Saginaw Bay, assessed bird use in purple loosestrife, an aggressive wetland invader, and found high bird densities but low species diversity relative to other wetland vegetation types. Despite the availability of alternate wetland habitats, red-winged blackbirds demonstrated a greater selection for purple loosestrife, including nesting in this habitat, but again, reproductive success was not directly assessed. Although purple loosestrife is structurally dissimilar to *Phragmites*, these results cautiously suggest that invaders, such as *Phragmites,* may reduce the availability of suitable habitat. The effect on bird species, however, varies and resource managers will continue to need more detailed information on habitat preference of a number of wetland dependent species to make more informed management decisions.

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LITERATURE CITED

Back, C.L. 2010. Effects of Common Reed (*Phragmites australis)* Invasion and Glyphosate and Imazapyr Herbicide Application on Gastropod and Epiphyton Communities in Sheldon Marsh Nature Reserve. M.S. thesis, Ohio State University, Columbus.

Back, C.L., and J.R. Holomuzki. 2008. Long-term spread and control of invasive, common reed (*Phragmites australis*) in Sheldon Marsh, Lake Erie. Ohio Journal of Science 108:108-112.

Benoit, L.K., and R.A. Askins. 1999. Impact of the spread of *Phragmites* on the distribution of birds in Connecticut tidal marshes. Wetlands 19:194-208.

Bock, C.E., and Z.F. Jones. 2004. Avian habitat evaluation: should counting birds count? Frontiers in Ecology and the Environment 2:403-410.

Ehrlich, P.R., D.S. Dobkin, and D.D. Wheye. 1988. The Birder's Handbook: A Field Guide to the Natural History of North American Birds. Simon and Schuster, New York.

Fletcher, R.J., and R.R. Koford. 2003. Changes in breeding bird populations with habitat restoration in northern Iowa. *American Midland Naturalist* 150:83-94.

Gaston, K.J. 1994. Rarity. Chapman and Hall, London.

Gorham, E., and W.H. Pearsall. 1956. Production ecology III. Shoot production in *Phragmites* in relation to habitat. Oikos 7:206-214.

Herdendorf, C.E. 1992. Lake Erie coastal wetlands: an overview. Journal of Great Lakes Research 18:533-551.

Herdendorf, C.E., D.M. Klarer, and R.C. Herdendorf. 2006. The ecology of Old Woman Creek: an estuarine and watershed profile. Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Columbus.

Holomuzki, J.R., and D.M. Klarer. 2010. Invasive reed effects on benthic community structure in Lake Erie coastal wetlands. Wetlands Ecology and Management 18:219-231.

Howe, R.W., R.R. Regal, J. Hanowski, G.J. Niemi, N.P. Danz, and C.R. Smith. 2007. An index of ecological condition based on bird assemblages in Great Lakes coastal wetlands. Journal of Great Lakes Research 33:93-105.

Keddy, P.A., and A.A. Reznicek. 1986. Great Lakes vegetation dynamics: the role of fluctuating water levels and buried seeds. Journal of Great Lakes Research 12:25-36.

Krebs, C.J. 1999. Ecological Methodology. University of British Columbia, [Vancouver].

Kulesza, A.E., J.R. Holomuzki, and D.M. Klarer. 2008. Benthic community structure in stands of *Typha angustifolia* and herbicide treated and untreated *Phragmites australis*. Wetlands 28:40-56.

Lazaran, M.A., C.I. Bocetti, and R.S. Whyte. 2013. Impacts of *Phragmites* management on marsh wren nesting behavior. Wilson Journal of Ornithology 125:184-187.

MacArthur, R.H., and E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton, NJ.

Marks, M., B. Lapin, and J. Randall. 1994. *Phragmites australis* (*P. communis*): Threats, management, and monitoring. Natural Areas Journal 14:285-294.

McCune, B., and J.B. Grace. 2002. Analysis of Ecological Communities. MjM Software Design, Gleneden Beach, OR.

Meanley, B. 1965. The roosting behavior of the red-winged blackbird in the southern United States. Wilson Bulletin 77:217-228.

Meyer, S.W. 2003. Comparative use of *Phragmites australis* and Other Habitats by Birds, Amphibians, and Small Mammals at Long

Point, Ontario. M.S. thesis, University of Western Ontario, London.

Meyer, S.W., S.S. Badzinski, S.A. Petrie, and C.D. Ankney. 2010. Seasonal abundance and species richness of birds in common reed habitats in Lake Erie. Journal of Wildlife Management 74:1559-1566.

Mills, E.L., J.H. Leach, J.T. Carlton, and C.L. Secor. 1993. Exotic species in the Great Lakes: a history of biotic crisis and anthropogenic introductions. Journal of Great lakes Research 19:1-54.

Parsons, K.C. 2003. Reproductive success of wading birds using *Phragmites* marsh and upland nesting habitats. Estuaries 26:596-601.

Peterjohn, B.G. 2001. The Birds of Ohio. Wooster Book Company, Wooster, OH.

Prince, H.H., P.I. Padding, and R.W. Knapton. 1992 . Waterfowl use of the Laurentian Great Lakes. Journal of Great Lakes Research 18:673-699.

Ralph, J.C., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. General Technical Report PSW-GTR-144, US Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Ricciardi, A. 2006. Patterns of invasion in the Laurentian Great Lakes in relation to changes in vector activity. Diversity and Distributions 12:425-433.

Riffell, S.K., B.E. Keas, and T.M. Burton. 2001. Area and habitat relationships of birds in Great Lakes wet meadows. Wetlands 21:492-507.

Rooth, J.E., J.C. Stevenson, and J.C. Cornwell. 2003. Increased sediment accretion rates following invasion by *Phragmites australis*: the role of litter. Estuaries 26:475-483.

Trexel-Kroll, D. 2002. Succession of floating-leaf to emergent plant communities following reduced water levels in Old Woman Creek estuary. M.S. Thesis, Miami University, Oxford, OH.

Tulbure, M.G., C.A. Johnston, and D.L. Auger. 2007. Rapid invasion of a Great Lakes coastal wetland by non-native *Phragmites australis* and *Typha*. Journal of Great Lakes Research 33:269-279.

[USDA, NRCS] US Department of Agriculture, Natural Resources Conservation Service. 2012. The PLANTS Database (http://plants.usda.gov). National Plant Data Team, Greensboro, NC.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Weis, J.S., and P. Weiss. 2003. Is the invasion of the common reed, *Phragmites australis*, into tidal marshes of the eastern U.S. an ecological disaster? Marine Pollution Biology 46:816-820.

Whitt, M.B., H.H. Prince, and R.R. Cox. 1999. Avian use of purple loosestrife dominated habitat relative to other vegetation types in a Lake Huron wetland complex. Wilson Bulletin 111:105-114.

Whyte, R.S., D. Trexel-Kroll, D.M. Klarer, R. Shields, and D.A. Francko. 2008. The invasion and spread of *Phragmites australis* during a period of low water in a Lake Erie coastal wetland. Journal of Coastal research 55:111-120.

Wilcox, K.L., S.A. Petrie, L.A. Maynard, and S.W. Meyer. 2003. Historical distribution and abundance of *Phragmites australis* at Long Point, Lake Erie, Ontario. Journal of Great Lakes Research 29:664-680.

Zedler, J.B., and S. Kercher. 2004. Causes and consequences of invasive plants in wetlands: opportunities, opportunists, and outcomes. Critical Reviews in Plant Sciences 23:431-452.