RIPARIAN WIDTH AND NEOTROPICAL AVIAN SPECIES RICHNESS IN THE AGRICULTURAL MIDWEST

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ABSTRACT. Neotropical migratory birds have declined in recent decades in the agricultural Midwest and a conservation need is to determine the minimum size of riparian buffer areas needed to support diverse populations of Neotropical migrants during the breeding season. Thirty-six sites were surveyed along the west side of a 17 km stretch of the Mississinewa River in east-central Indiana, each adjacent to an area with agriculture as the primary land use. Sites were divided into three categories based on the width of the riparian buffer (< 25 m, 25–75 m, and > 75 m) and surveyed three times each during the breeding season. In total, 56 species of birds were identified, including 25 species of Neotropical migrants. A positive correlation was noted between Neotropical species richness and riparian buffer width, however no difference in species richness was noted between medium and wide sites suggesting that widening riparian buffers to 75 m in the agricultural Midwest would be a practical conservation target and help protect all but the most area-sensitive species such as Acadian Flycatcher (*Empidonax virescens*) and Wood Thrush (*Hylocichla mustelina*). Vegetative characteristics had little impact on species richness in our study likely because our sites were generally homogeneous and unmanaged.

Keywords: Agriculture, avian conservation, Midwest, Neotropical migrants, riparian width

INTRODUCTION

Many Neotropical migrants utilize riparian areas for nesting during the breeding season, however due to increased agricultural activity, many of these nesting areas have been pushed closer and closer to rivers (Peak & Thompson 2006). These riparian buffer zones are typically areas that are either of too poor quality to be utilized for agricultural purposes or areas that are maintained to reduce nutrient and sediment run-off and stabilize river banks (Frimpong et al. 2006). There are a number of problems associated with narrower riparian buffer zones, particularly for birds. Narrow buffer zones increase the amount of edge habitat, which often increases egg parasitism, especially by species such as Brown-headed Cowbird (*Molothrus ater*; Gates & Giffen 1991; Bohning-Gaese et al. 1993) that utilizes agricultural lands for foraging and nearby wooded habitat for egg-laying (Saab 1999). Narrow riparian buffer areas also increase the risk of predation to songbirds posed by larger predators and competitors (e.g., raccoons, fox, and feral cats, as well as other birds) that prefer edge habitats (Bohning-Gaese et al. 1993; Peak et al. 2004; Shake et al. 2011). In addition, area-sensitive species, such as Wood Thrush (*Hylocichla mustelina*) are often absent in places with narrow riparian areas. Wood Thrush, which prefer mature, interior wooded habitat near water, has experienced an annual population decrease of 2.1% since 1966 (USGS 2012).

Previous studies have indicated that a minimum riparian width is needed to maintain a high degree of avian diversity. Darveau et al. (1995) assessed species richness in riparian buffer strips of the boreal forest that were 20 m, 40 m, 60 m, and > 300 m from recent clear-cuts and concluded that a minimum of 60 m buffer strips were necessary to support the majority of forest-dwelling birds. Hodges & Krementz (1996) surveyed six focal species in different-width corridors in Georgia adjacent to pine plantations and suggested that 100 m was necessary to support the majority of Neotropical

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migrants. Kilgo et al. (1998) conducted a study in the South Carolina hardwoods with three different habitat types (forest, pine forest, and field-scrub) surrounding riparian buffer zones, and suggested that 500 m or more was needed to support the complete avian community. Hagar (1999) studied widths of logged versus unlogged sites in Oregon and suggested that riparian buffer areas $\geq$ 40 m were most beneficial to forest-dwelling species. In Missouri, Peak & Thompson (2006) observed more bird species in wider forested-riparian habitat and suggested that riparian buffers should be $>$ 400 m in width where possible. The broad range of recommendations reported in previous studies are likely related to regional differences in climate and land-use history and illustrate the need for careful regional-level recommendations to be provided in places where studies have not yet been conducted.

Some studies have also assessed the impact of vegetative quality and/or successional stage on the usefulness of riparian buffer areas for birds. Saab (1999) evaluated the impact of vegetation on avian species richness at three spatial scales (i.e., macrohabitat, landscape, and microhabitat) and found that microhabitat variables correlated most with species richness. At this scale, the greatest predictor of species richness was canopy cover; species richness was greater in habitats with a more open canopy. Peak & Thompson (2006) reported that grassland-shrub buffer strips increase avian species richness in narrow habitats. Berges et al. (2010) revealed that avian species richness was dependent on both the successional stage of the riparian buffer strips (2, 9, and 14 year plots) and on the dominant vegetation present (i.e., tree, shrub, or native grass/forb). Studies such as these provide landowners with important recommendations on how to improve the composition of buffer areas for birds in cases where increasing buffer area is not feasible.

Prior to European settlement, much of the agricultural Midwest, including as much as 85% of Indiana, was covered by forest (Tormoehlen et al. 2000). Settlers began clearing the land for agriculture, particularly during the 1950s when technology and farming techniques improved. Subsequently, farms became both larger and more intensively cultivated, leading to increased soil erosion, stream degradation, and a decline in native biodiversity, especially of Neotropical migrant birds (USGS 2012). By 2005, only 20% of the original forest cover remained, and this was scattered and fragmented across the landscape (Hewitt 2005). In response to these changes, Partners in Flight (PIF), a prominent partnership committed to promoting bird conservation, recognized the importance of providing "conservation recommendations regarding minimum patch sizes and landscape attributes that will sustain populations of PIF priority species especially for regions where grasslands, shrublands, savanna, and forest once were naturally interdigitated" (Donovan et al. 2002). Therefore, the objective of this study is to assess Neotropical migrant species richness in relation to riparian buffer width and vegetative quality in an area of Indiana that is representative of much of the agricultural Midwest.

METHODS

Study area.—This study was conducted along an approximately 17 km (10 mi) stretch of the Mississinewa River in Grant and Delaware Counties, Indiana (between 40° 28′ 10.55″ N, 85° 36′ 33.12″ W and 40° 15′ 57.24″ N and 85° 26′ 17.16″ W). The Mississinewa River begins in western Ohio and runs northwest, emptying into the Wabash River near Peru, Indiana. The riparian zone of the Mississinewa River between Jonesboro and Eaton, Indiana, is dominated by bottomland forest (US Fish and Wildlife Service 2014). It mainly consists of a mix of mature tree species often $>$ 6 m in height, including box elder (*Acer negundo*), American elm (*Ulmus americana*), and sycamore (*Platanus occidentalis*) in the lowlands, and hackberry (*Celtis occidentalis*), as well as a number of oak (*Quercus*) and maple (*Acer*) species in the upland habitat. Wood-nettle (*Laportea canadensis*) is often dominant in the floodplain. In the upland habitat mutiflora rose (*Rosa multiflora*) is dominant. The majority of adjacent land-use is agricultural (i.e., row crops such as corn and soybeans), with fragmented forests scattered throughout the watershed, and riparian buffer strips of varying widths. Based on these characteristics, the Mississinewa resembles many of the streams in Indiana, as well as in the broader Midwest.

Site selection.—Potential sites along the west side of the river with agriculture as the adjacent land-use were identified using ArcGIS 10.1 (ESRI 2012 – Redlands, CA). Assessing one side of the river and considering one type of adjacent land-use minimized potential variability associated with avian habitat preferences. Upon identification of potential sites, permission to access sites was requested from landowners by mail. Based on the number of returned permission forms, 45 possible site locations were identified and categorized as ‘small,’ ‘medium’ or ‘large’ based on the width of the riparian buffer. ‘Small’ sites were between 0–25 m in width, ‘medium’ sites were 26–75 m in width, and ‘large’ sites were > 75 m in width; these designations were based on typical buffer sizes found in this region of Indiana. The riparian buffer zone was the distance from the edge of the river to the edge of the forest/agricultural demarcation.

Two feature-class polygons were created (one with a width of 25 m and one with a width of 75 m; each were 100 m in length) and superimposed over base maps of Grant and Delaware Counties that were downloaded from the Geographic Information System (GIS) map database from Indiana University (http://gis.iu.edu/). If the whole width of the site fit within the 25 m polygon, it was considered a small site. If the site was wider than the 25 m polygon, but fit within the 75 m polygon, it was considered a medium site. If the site was wider than 75 m polygon, it was considered a large site. Of the 45 total sites, 18 were classified as small sites, 14 as medium sites, and 13 as large sites. Each potential site was utilized except those that, upon visiting, were found to be inaccessible or too close to the interstate highway, and therefore too noisy, to allow for reliable detection of birds by sound ($n = 9$). This resulted in 12 usable sites in each of our 3 width categories. A poly-line was created to measure the distance between sites to make sure they were ≥ 250 m apart to reduce the likelihood that an observer would count the same bird twice (Ralph et al. 1995). At each of the sites ($n = 36$), flagging was put up at the point of observation, as well as 50 m upstream and downstream to demarcate the observation area. Every bird seen or heard within the flags was identified in each trial.

Point counts.—Each site was visited three times throughout the breeding season to increase the likelihood that all species utilizing the site were recorded. Even though Neotropical migrants were the focus of our study, all birds detected were recorded, including “year-round residents” (i.e., those found in the Midwest throughout the year or those that likely wintered somewhere in the United States; Butler 2003). Surveys were conducted from sunrise until no more than four hours after sunrise (i.e., between 0600–1000 hrs EST), a period of high bird activity. Point counts were conducted from 3 June 2013 to 28 June 2013, a period when most transient migrants had likely passed and most breeding birds were maintaining territories or raising young. Small and medium sites were surveyed from the geometric center of each site and large sites were surveyed at a fixed width of 50 m from the river to increase detection probability (Forcey & Anderson 2002). During each trial, MC waited one min for birds to become acclimated to her presence and then recorded every bird seen or heard for 10 min. Individuals heard or seen outside the site or flying overhead (and obviously not utilizing the site) were not counted.

Vegetation survey.—The vegetative type and structure at each site was assessed during the last point count survey (21 June 2013 to 28 June 2013) by MC when vegetation was at its peak growth and easy to identify. Five random circular plots to sample were selected within each site, by latitude and longitude, using a random number table. The centroid of each circular plot was located using a handheld GPS unit and a 5 m sampling radius was flagged. The percentage aerial cover of canopy, understory, and shrubs in each circular plot was estimated by the observer. The canopy (vegetation > 6 m tall) consisted of the tallest trees as well as vines that reached the same height. The understories were mainly trees that were not yet mature (i.e., between 2 and 6 m tall). The shrub layer was < 2 m tall and usually consisted of brambles and other short growing plants. A site average was calculated by dividing the sum of each variable by five. The number of trees, tree species, and snags in each plot were counted and shrub and groundcover species were identified. Trees were defined as being ≥ 2.54 cm (1 in.) dbh (diameter at breast height) and > 2 m tall (note: most trees were > 6 m in height), snags consisted of standing dead trees, shrubs included species < 2 m in height, and groundcover species included emerging saplings and herbaceous vegetation not included in the shrub layer such as wood nettle (*Laportea canadensis*) which reached 1.5 m in some places. The number of tree, shrub, and groundcover species were added together across the five plots to determine the cumulative number of species at each site. The total number of trees, snags, and shrub and groundcover individuals were also averaged across the five plots to determine a mean density value at each site for each variable and expressed as the number of individuals per 78.5 m^2.

Data analysis.—Analysis of variance (ANOVA) and linear regression were used to analyze the relationship between riparian width and avian species richness for Neotropical migrants, for year-round residents, and for all birds combined (Keller et al. 1993). Each of the analyses met normality assumptions. Multiple regression was then used to identify the impact of each vegetation parameter on avian species richness; since preliminary analyses indicated that riparian width was strongly correlated with avian species richness, it was included in each of the regression equations. Logistic regression was used to analyze the presence/absence probability of each of the 56 species at different riparian widths and significance was assessed at an α-level of 0.05.

RESULTS

Across all sites (n = 36), 56 species of birds were identified, including 25 species of Neotropical migrants (Table 1). Overall species richness at each site ranged from 6 to 33 species. Collectively, 38 species were observed at small sites, and richness ranged from 6–22 species per site ($\bar{x}$ = 8.6 species per visit, SD = 3.3). Medium sites had a total of 50 species and richness ranged from 15–26 species per site ($\bar{x}$ = 14.9 species per visit, SD = 3.1). Large sites had a total of 49 species and richness ranged from 14–33 species per site ($\bar{x}$ = 15.4 species per visit, SD = 5.2). No temporal trends were noted in number of birds observed in subsequent sampling periods. Using width class as a categorical variable, ANOVA indicated differences in Neotropical species richness among riparian buffer widths when plots were averaged ($P < 0.001$; Fig. 1). Post-hoc tests indicated that small and medium sites differed in mean species richness, as well as small and large sites; however no differences were found between medium and large sites (Fig. 1). Comparable results were noted when year-round residents species were analyzed and when Neotropical and year-round residents were combined (Fig. 1). Using width class as a continuous variable, linear regression also showed that as riparian buffer width increased, Neotropical species richness increased (P = 0.033; Fig. 2).

Based on logistic regression, there were positive correlations between buffer width and presence of Wood Thrush and Acadian Flycatcher (*Empidonax virescens*) (P = 0.048, P = 0.045, respectively). Acadian Flycatcher was observed at ten of the thirty-six sites; however, only one individual was observed at a small site and all others were observed at sites that were $\geq$ 50 m wide. Similarly, Wood Thrush was observed at eight of the thirty-six sites, with the narrowest being 75 m wide. There was a 50% probability of observing Acadian Flycatcher and Wood Thrush in areas of buffer width of 370 m and 455 m, respectively (Fig. 3). A positive correlation with width that approached significance ($P < 0.1$) was noted for Cerulean Warbler (*Setophaga cerulea*), Baltimore Oriole (*Icterus galbula*), Blue-gray Gnatcatcher (*Polioptila caerulea*), and Louisiana Waterthrush (*Parkesia motacilla*).

No relationships were detected between species richness and individual vegetation variables when combined with riparian width, although the number of shrub species approached significance (P = 0.094). When comparing each vegetation variable by width class using ANOVA, only the total and average number of shrub species differed between treatments, with smaller sites having a greater mean number of shrub species. In addition, the percent shrub cover approached significance (P = 0.052) with smaller sites tending to have a greater percent shrub cover.

DISCUSSION

Our results indicate that increasing riparian width increases Neotropical bird species richness (Fig. 2). Most notably, however, no difference in species richness were observed between medium and wide sites which suggest that medium sites, with widths of 25–75 m, may be sufficient to support the majority of avian diversity in this region (Fig. 1). While it is possible that medium sites contain both species that prefer edge habitat and species that prefer forest-interior habitat, the overall similarity in species noted between width categories suggest that these potential differences in species richness may be negligible.

In the North-Central region of Indiana, there is limited suitable habitat for bird populations due to intense land use associated with agriculture, making it likely that Neotropical species

Table 1.—All bird encountered during our study along the Mississinewa River (east-central Indiana) in early summer 2013, categorized as Neotropical migrants (*a*) and year-round residents (*b*) according to Butler (2003). Values indicate the percentage of sites in each riparian width class where species were observed. Species arranged taxonomically according the American Ornithologists' Union 7th Checklist of North and Middle American Birds.

a)

Bird species	% of sites occupied per riparian band width category		
Neotropical species:	Small (n = 12)	Medium (n = 12)	Large (n = 12)
Yellow-billed Cuckoo	8	33	25
Ruby-throated Hummingbird	8	8	17
Eastern Wood-Pewee	17	83	92
Acadian Flycatcher	8	33	42
Least Flycatcher	0	8	0
Great Crested Flycatcher	50	67	75
Yellow-throated Vireo	0	25	17
Warbling Vireo	58	50	58
Red-eyed Vireo	8	25	25
House Wren	42	33	42
Blue-gray Gnatcatcher	25	50	83
Wood Thrush	0	8	58
Gray Catbird	58	50	33
Cedar Waxwing	17	42	25
Ovenbird	0	0	17
Louisiana Waterthrush	0	33	33
Common Yellowthroat	25	75	33
Cerulean Warbler	0	0	17
Northern Parula	58	67	75
Yellow-throated Warbler	0	25	25
Yellow-breasted Chat	8	0	8
Scarlet Tanager	0	0	8
Rose-breasted Grosbeak	0	8	0
Indigo Bunting	92	92	67
Baltimore Oriole	17	58	58

b)

Bird species	% of sites occupied per riparian band width category		
Local species	Small (n = 12)	Medium (n = 12)	Large (n = 12)
Wild Turkey	0	8	0
Turkey Vulture	0	8	0
Red-tailed Hawk	0	17	0
Mourning Dove	67	67	67
Barred Owl	0	0	8
Red-bellied Woodpecker	58	92	92
Downy Woodpecker	50	75	92
Northern Flicker	17	42	50
Pileated Woodpecker	8	8	8
Blue Jay	67	58	75
Eastern Phoebe	0	25	8
American Crow	25	42	50
Carolina Chickadee	83	92	100
Tufted Titmouse	58	92	92
White-breasted Nuthatch	50	58	83
Carolina Wren	17	58	58
Eastern Bluebird	17	17	17
American Robin	75	67	75

Table 1.—Continued.

Bird species *Local species*	% of sites occupied per riparian band width category		
	Small (n = 12)	Medium (n = 12)	Large (n = 12)
Brown Thrasher	0	8	8
Northern Mockingbird	0	8	0
Pine Warbler	8	0	0
Eastern Towhee	0	8	25
Chipping Sparrow	42	25	25
Field Sparrow	17	8	33
Song Sparrow	50	75	58
Northern Cardinal	58	83	92
Red-winged Blackbird	17	8	0
Common Grackle	8	25	25
Brown-headed Cowbird	58	58	42
House Finch	0	8	0
American Goldfinch	58	67	50

utilize similar habitats for nesting and food as year-round residents. The similarities between Neotropical species richness and year-round resident species richness (Fig. 1) suggest that year-round species richness could be used as an indicator of Neotropical richness if surveying the entire avian community in an area is not feasible.

As expected, certain birds, such as Acadian Flycatcher and wood thrush, showed correlations with buffer width (Fig. 3), similar to what Keller et al. (1993) reported in Maryland and Delaware. While basing management recommendations on the habitat needs of area sensitive species (i.e., suggesting that the buffer widths should be ≥ 450 m; Fig. 3) may be optimal from a conservation standpoint, this width is not feasible for most private landowners in the agricultural Midwest who use their land for cash crops. Acadian Flycatcher and Wood Thrush, not withstanding, riparian buffers of ≥ 75 m could be a more realistic target if managing for Neotropical migrants in the Midwest is a conservation objective (Figs. 1 & 2).

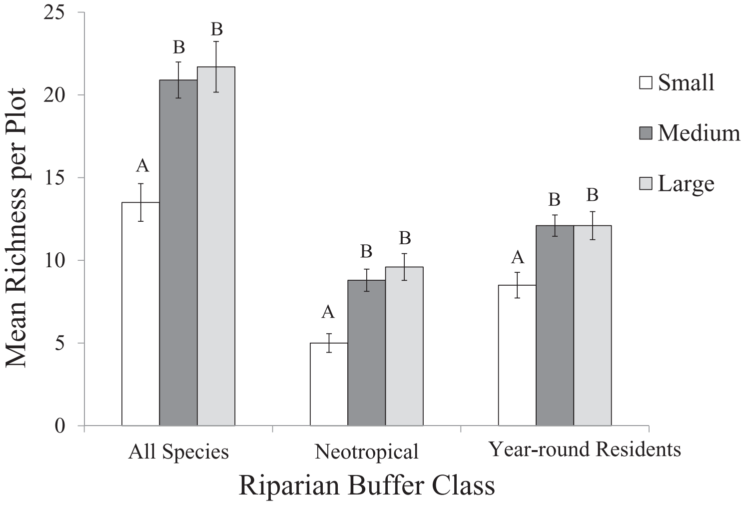

Figure 1.—Mean number of species observed per site during three visits to small, medium, and large sites. Analysis of variance (ANOVA) indicated differences in mean species richness by riparian buffer class for all species combined, Neotropical species, and year-round residents. Inset letters indicate differences between mean species richness at small and medium, and at small and large sites. Error bars represent standard error.

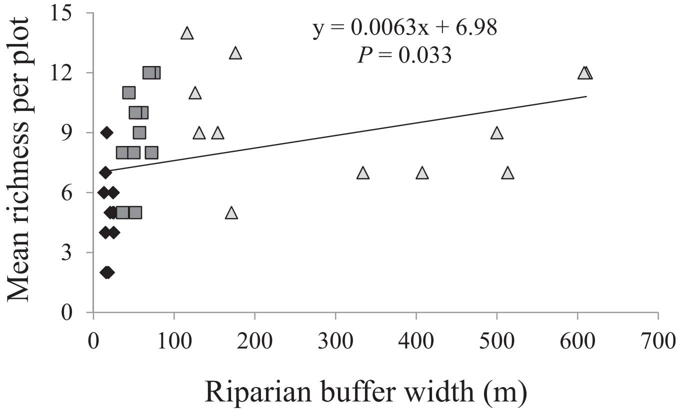

Figure 2.—Linear regression comparing the width of small (diamonds), medium (squares), and large (triangles) sites and mean Neotropical species richness during three visits ($P = 0.033$).

There were no correlations between vegetation variables and Neotropical species richness. There was, however, variability in the number of shrub species among width categories ($P = 0.01$), as well as a weak correlation with the percent shrub cover ($P = 0.052$), which may explain the weak negative correlation between cumulative Neotropical species richness and the number of shrub species ($P = 0.094$). This result is somewhat counterintuitive as it would seem that a greater number of shrub species would provide more nesting habitat and food for Neotropical migrants. It is possible that year-round species may be more aggressive in claiming and occupying territories in shrubby habitats (Kokko 1999), or that Neotropical birds observed in this study simply did not prefer to utilize this specific type of habitat. Taken together, the vegetative characteristics of all field sites were largely homogeneous which is often the case in many areas of the Midwest (Asbjornsen et al. 2014) and may have prevented us from detecting relationships between vegetative variables and avian species richness that have been reported in previous studies (Stauffer & Best 1980; Saab 1999; Schultz et al. 2004; Berges et al. 2010; Bennett et al. 2014; Holoubek & Jensen 2015). In many cases, regional guidelines and incentives are in place (e.g., through the Indiana Department of Natural Resources http://www.in.gov/dnr/fishwild/2352.htm) for landowners who wish to improve riparian buffer composition for wildlife species.

Management implications.—Population sizes of neotropical migrants have declined at a greater rate than non-migrants in recent years, and

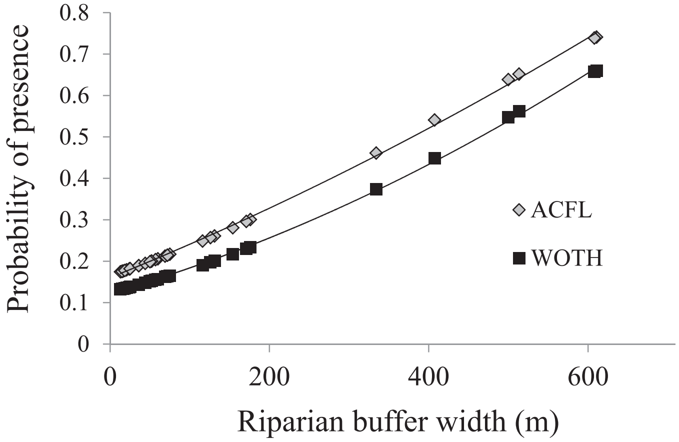

Figure 3.—Logistic regression indicated a positive correlation between the presence of Acadian Flycatcher (ACFL; $P = 0.045$) and Wood Thrush (WOTH; $P = 0.048$) and increasing riparian buffer widths.

while many factors may contribute, habitat loss on the breeding grounds is often a primary contributor (Sillet & Holmes 2002). Based on our results, programs designed to protect habitat for the majority of Neotropical migrants in the agricultural Midwest should encourage landowners to increase the width of riparian buffer areas to a target width of 75 m and follow regional guidelines for improving the quality of existing buffer areas, which may include managing the shrub layer. In addition, larger areas of public land, such as state parks or fish and wildlife areas, may still be needed at the regional level to support the most area-sensitive species.

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