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BREEDING BIRD RESPONSE TO FIELD BORDER PRESENCE AND WIDTH

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ABSTRACT.—Avian communities can benefit from reconstructed herbaceous, strip habitats among agriculture; however, any benefits may be limited by width-dependent factors such as edge effects. We used 2 years of strip-transect surveys to evaluate avian density, richness, and conservation value between non-, narrow (mean width = 8.2 m), and wide (mean width = 40.7 m) field borders on intensive row-cropped field margins in the agriculture-dominated Mississippi Alluvial Valley. Wide field borders supported two times more birds (7.0 birds/0.2 ha) than narrow borders (3.6 birds/0.2 ha), which supported six times more birds than no border (0.6 birds/0.2 ha). Mean bird species richness was over five times greater in bordered (0.80–1.10 species/0.2 ha) than non-bordered margins (0.14 species/0.2 ha), but was largely uninfluenced by border width. We documented more bird use of agricultural fields and wooded fencerows adjacent to bordered than non-bordered margins. Red-winged Blackbirds (*Agelaius phoeniceus*) and Dickcissels (*Spiza americana*) had the strongest positive response to field border presence and width. Wide borders attracted high densities (2.0 birds/0.2 ha) of Dickcissels, an edge-sensitive species, suggesting the conservation potential of herbaceous vegetation patches <50 m of wooded edges for grassland birds. Extensive implementation of field borders, particularly of enhanced width, may contribute substantially to grassland bird conservation strategies in intensive, agricultural landscapes, although confirmation of these benefits requires additional demographic information. *Received 20 June 2008. Accepted 27 February 2009.*

Grassland birds have exhibited more significant and consistent population declines than any other avian guild highlighting the urgency for conservation action (Peterjohn and Sauer 1999, Brennan and Kuvlesky 2005). These declines in the United States have largely resulted from extensive degradation of midwestern native grasslands (Johnson and Schwartz 1993, Samson and Knopf 1994, Warner 1994, Noss et al. 1995) and conversion of native habitats to row-crop agriculture (Herkert 1994). Grassland birds in agricultural landscapes are largely reliant on non-crop, strip habitats for food, nest sites, song perches, and escape cover (Rodenhouse et al. 1993, Best 2000). However, the diversified farming techniques and small farm fields that historically facilitated strip habitat on farmlands (Warner 1994) have been largely replaced with modern techniques that promote crop intensification to maximize yield. These land-use alterations have contributed to declines in grassland bird populations through reduced presence of weedy, strip-habitats (Herkert 1995).

The Conservation Reserve Program (CRP) helped stabilize many avian populations by providing suitable wildlife habitat on private lands, although some species have continued to decline (Ryan et al. 1998). The Dickcissel (scientific names in Table 1) was of particular concern having endured population sinks in some CRP habitats (McCoy et al. 1999). Conservation buffers are an effort to increase habitat options and enhance wildlife benefits through federal Farm Bill programs such as CRP. Conservation buffers are non-crop strips of vegetation that enhance soil and water quality, and provide suitable wildlife habitat (Best 2000). Whereas most conservation buffers are restricted to riparian zones, CP33-Habitat Buffers for Upland Birds (hereafter, field borders) are non-crop, linear strips of herbaceous vegetation that target grassland birds in upland habitats (Burger et al. 2006). Field borders benefit the avian community year-round by providing nesting habitat, foraging habitat, roosting sites, movement corridors, and escape cover (Marcus et al. 2000, Conover 2005, Smith et al. 2005, Conover et al. 2007). The contribution of herbaceous strips to adjacent plant communities may also enhance avian benefits on agriculture-wooded field ecotones, where avian abundances are typically elevated (Best et al. 1990). The vegetative diversity in strip habitats can provide other environmental benefits, including increased avian diversity (Rotenberry 1985, Bryan and Best 1994), greater

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TABLE 1. Mean bird densities[a] (no. birds/0.2 ha ± SE) in descending order of overall relative abundance (RA) and taxonomically for species of equal RA in the field border zone for non-, narrow, and wide-bordered field margin treatments during 2003–2004 in the Mississippi Alluvial Valley.

		Field margin treatment		
Species	RA	Non	Narrow	Wide
Red-winged Blackbird, *Agelaius phoeniceus*	0.500	0.119 ± 0.061	1.686 ± 0.345	4.278 ± 0.925
Dickcissel, *Spiza americana*	0.128	0	0.137 ± 0.069	2.000 ± 0.763
Northern Cardinal, *Cardinalis cardinalis*	0.113	0.143 ± 0.087	0.569 ± 0.132	0.167 ± 0.121
Indigo Bunting, *Passerina cyanea*	0.080	0.048 ± 0.033	0.392 ± 0.119	0.278 ± 0.135
Mourning Dove, *Zenaida macroura*	0.048	0.143 ± 0.073	0.157 ± 0.071	0.111 ± 0.076
Common Grackle, *Quiscalus quiscula*	0.021	0.024 ± 0.024	0.078 ± 0.055	0.111 ± 0.076
Blue Jay, *Cyanocitta cristata*	0.018	0.071 ± 0.053	0.059 ± 0.033	0
Yellow-billed Cuckoo, *Coccyzus americanus*	0.012	0	0.059 ± 0.044	0.056 ± 0.056
Brown-headed Cowbird, *Molothrus ater*	0.012	0	0.078 ± 0.047	0
Ruby-throated Hummingbird, *Archilochus colubris*	0.009	0	0.039 ± 0.039	0.056 ± 0.056
Eastern Meadowlark, *Sturnella magna*	0.009	0	0.039 ± 0.028	0.056 ± 0.056
Northern Bobwhite, *Colinus virginianus*	0.006	0	0.020 ± 0.020	0.056 ± 0.056
Northern Mockingbird, *Mimus polyglottus*	0.006	0	0.039 ± 0.028	0
Red-tailed Hawk, *Buteo jamaicensis*	0.003	0	0.020 ± 0.020	0
Wild Turkey, *Meleagris gallopavo*	0.003	0	0.020 ± 0.020	0
Killdeer, *Charadrius vociferus*	0.003	0	0.020 ± 0.020	0
Great-crested Flycatcher, *Myiarchus crinitus*	0.003	0	0.020 ± 0.020	0
Horned Lark, *Eremophila alpestris*	0.003	0	0.020 ± 0.020	0
Carolina Chickadee, *Poecile carolinensis*	0.003	0.024 ± 0.024	0	0
Carolina Wren, *Thryothorus ludovicianus*	0.003	0	0	0.056 ± 0.056
American Robin, *Turdus migratorius*	0.003	0	0.020 ± 0.020	0
Brown Thrasher, *Toxostoma rufum*	0.003	0	0.020 ± 0.020	0
Blue Grosbeak, *Guiraca caerulea*	0.003	0	0	0.056 ± 0.056
Painted Bunting, *Passerina ciris*	0.003	0	0.020 ± 0.020	0
Eastern Towhee, *Pipilo erythrophthalmus*	0.003	0	0	0.056 ± 0.056
Orchard Oriole, *Icterus spurius*	0.003	0	0.020 ± 0.020	0

[a] Bird density and relative abundance estimates include all data, including line-transects surveyed during only 1 year, which were excluded from the repeated measures ANOVA.

abundance of agronomically-beneficial insects (Marshall and Moonen 2002), and suppression of agronomic weeds (Davison 1941, Marshall and Moonen 2002).

The high rate of field border acceptance by landowners in 35 states (80% of an available 101,174 ha enrolled in first 2 years) heightens our need to understand the interactions among field borders, farmland wildlife, and crop production. Width is a particularly important factor for bird use of linear habitats, as it may mitigate their vulnerability to edge effects (Gates and Gysel 1978, Ratti and Reese 1988, Paton 1994). Wider borders provide habitat farther from the wooded edge, which can benefit birds that use edges (Paton 1994) and those that avoid them (Johnson and Temple 1986, Herkert 1994, Vickery et al. 1994). However, previous studies of grassland bird responses to woody edges commonly focused on 50 m thresholds (Paton 1994, O'Leary and Nyberg 2000, Jensen and Finck 2004) and provide tenuous predictions for these field borders, as all except one are <50 m wide. The augmented field border area that results from increased width can also result in enhanced vegetative heterogeneity (Rodenhouse and Best 1983) and subsequently, increased avifaunal density and diversity (Warner 1992).

Our primary study objectives investigated the hypotheses that: (1) field margins with borders would have greater density and richness than without, and (2) wide-bordered margins would have greater avian density and richness than narrow-bordered margins.

METHODS

Study Area.—We conducted fieldwork on six farms in the lower Mississippi Alluvial Valley (MAV; Bird Conservation Region 26; Sunflower County, MS, USA) over two consecutive breeding seasons (May–Jun; 2003–2004). This region was historically bottomland-hardwood forest, and field borders do not constitute native habitat restoration, but semi-natural vegetation in a landscape largely devoid of non-crop vegetation. All farms were within 12 km and representative of the MAV landscape, which has nominal topographic relief dominated by large (171.14 ± 34.20 ha) row-crop fields of soybeans (58%), cotton (16%), milo (10%), and other crops (16%, e.g., corn, wheat, etc.), and fragmented by wooded fencerows and linear riparian zones (e.g., drainage ditches, rivers, and streams). Agricultural fields had varied tillage (till and minimal-till) regimes, although this should not influence avian community patterns on field margins (Castrale 1985). Soil associations were primarily Dundee silt loam or Forestdale silt loam, which are stratified alluvium soils of fine to coarse texture with poor to moderate drainage and varying acidity levels (Powell et al. 1952). Average precipitation over 3 years was highest during June (20.1 cm) and lowest in May (8.7 cm), and July (10.1 cm). Total precipitation was somewhat lower during 2003 (39.2 cm) than 2004 (58.5 cm; USDA-NRCS Beasley Lake, MS weather station).

Field Borders.—Field borders were established between a wooded field margin (typically an old fencerow) that enclosed a drainage ditch, and an agricultural row-crop field. Borders were planted in spring 2002, although adequate vegetative cover did not emerge until late June. Field borders were 400 m in length and established at either a narrow (10 m) or enhanced (≥30 m) width. Our sample of field border segments was randomly drawn from the population of pre-existing 400-m border segments on the properties of participating landowners. Control segments were similarly drawn from the population of non-bordered segments on these farms and represented ditch-to-ditch, row-crop practices that typically lacked non-crop, herbaceous vegetation. We randomly placed control (non-bordered) plots on field margins with predetermined similarity of landscape context (e.g., adjacent to a wood line with drainage ditch and crop field) and in similar proportions of field border samples per farm. Farm operators were instructed not to disturb (mow, burn, treat with chemicals, drive on, or disk) field borders during the study. This failed to prevent some border destruction, which resulted in slightly altered border widths and sample sizes between years, of which we supplemented for the wide treatment in 2004. Field margin ($\bar{x}$ ± SE width) treatments included non-bordered (2003: $n = 21$; 2004: $n = 21$), narrow-bordered (2003: 8.5 ± 0.4 m, $n = 27$; 2004: 7.3 ± 0.5 m, $n = 24$), and wide-bordered (2003: 38.9 ± 2.7 m, $n = 7$; 2004: 44.3 ± 1.4 m, $n = 11$) margins. Individual border widths were averaged using five independent measurements at equidistant intervals. Narrow border widths ($\bar{x}$ ± SE) (8.2 ± 0.3 m) ranged from 5.8 to 11.7 m (mean CV = 0.22) and wide border widths (40.7 ± 3.0 m) ranged from 19.7 to 56 m (mean CV = 0.18).

Experimental field borders were planted with a mixture of Indian grass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), partridge pea (*Chamaecrista fasciculata*), and kobe lespedeza (*Lespedeza striata*). The floral composition of field borders was more diverse than planting mixtures, and included horsetail (*Conyza canadensis*), vervain (*Verbena* sp.), Bermuda grass (*Cynodon dactylon*), johnsongrass (*Sorghum halepense*), goldenrod (*Solidago* spp.), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*A. trifida*), poison ivy (*Toxicodendron radicans*), curly dock (*Rumex crispus*), and *Rubus* spp. Field borders with substantive annual grass competition (primarily johnsongrass) during the establishment year were treated with the selective herbicide Imazapic (Plateau, ® 0.29 l/ha) to control competition and promote growth of planted native warm-season grasses. Herbicide applications had relatively minor effects, aside from competition control, on total vegetative composition or structure and tended to reduce heterogeneity among planted borders (Conover 2005).

Community Assessment.—The avian community was surveyed during two breeding seasons (May–Jun, 2003–2004) using line-transect surveys (Buckland et al. 2001). Transects were paced evenly for 10 min over a 200-m length with ≥100 m buffer between transects to reduce repeat counts. Two individuals, pre-trained to visually and acoustically detect all birds in the study region, conducted transect surveys with one observer executing >95% of transects to reduce observer bias. Both observers spent a minimum of 15 days confirming bird identifications and detection distances at field sites prior to survey initiation. Distance estimation was practiced with pre-measured field tape placed throughout the survey zone and using a rangefinder. We surveyed transects within 3 hrs post-sunrise (CST) on days with no precipitation and wind <12 km/hr.

Surveys were conducted on the same field borders twice each breeding season, once during the latter half of each month (May and Jun) over 2 years. Flyover observations were not included, as their detection was not likely associated with field border presence. We recorded all birds within 30 m of both sides of the transect line, which included three habitat-delineated, field margin zones: field border (FBZ), agriculture, and wooded zones. The FBZ represented both the treatment and control, and was a 10-m wide strip between the wooded edge and crop field that included herbaceous vegetation for narrow and wide-bordered margins, or ditch-to-ditch farming practices (i.e., control) for non-bordered margins. The agriculture (30-m wide strip of row-crop) and wooded (20-m wide strip of wooded fencerow) zones were adjacent surrounding the FBZ (Conover et al. 2007: fig. 1). Bird observations were pooled in each field margin zone. We restricted our analyses to include maximum counts for each species' per field margin during May and June with most observations being single detections of singing males. All observations were ≤30 m of the observer permitting a reasonable assumption of a 100% detection probability in herbaceous habitat (Diefenbach et al. 2003); it is likely we did not count every individual and report conservative density estimates.

Statistical Analyses.—Avian community measurements included species richness, density (# birds/0.2 ha), and total avian conservation value (TACV; Nuttle et al. 2003). TACV was calculated by multiplying the species' abundance by their respective Partners in Flight (PIF) priority rank (http://www.rmbo.org/pif/scores/scores.html). Priority ranks are calculated based on breeding and wintering distribution, relative abundance, potential threats to breeding and wintering habitat, population trend, and physiographic-specific area importance value (Carter et al. 2000). These estimates were summed across species to produce a TACV score for the treatment-habitat zone combination of interest (Nuttle et al. 2003). We applied PIF ranks reported for birds in the MAV during the breeding season. Unidentified birds (<1%) were not assigned a PIF rank and were excluded from subsequent analyses.

We analyzed the avian community using a repeated measures analysis of variance with PROC MIXED (Littell et al. 1996). Fixed main effects were field border treatments (non-, narrow, and wide) with year as the repeated time effect, and line transects as the random subject effect. Variance-covariance structure was first-order auto-regressive, which was selected based on lowest AIC value. Mean species-specific densities are reported for combined years to include borders eliminated from repeated measures tests from between-year sample size differences. We report species-specific densities for only the FBZ to partition effects from the influence of surrounding vegetation zones (Arnold 1983). Crop type varied in agriculture zones, and we conducted preliminary analyses to test the influence of adjacent crop type on avian densities within field margin treatments (Shalaway 1985). These analyses indicated no significant differences in bird density among crop types (soybean, corn, milo, cotton; $F_{6,491} = 1.64$, $P = 0.135$) with the exception of wheat (other crop = 14.43, SE = 0.74, wheat = 36.17, SE = 6.73; $F_{1,502} = 10.30$, $P = 0.001$), which was the only food-producing crop during the breeding season.

RESULTS

We documented 78 bird species and detected >15,000 birds throughout this study. The most commonly detected species across all field margin zones were Red-winged Blackbird (30%), Northern Cardinal (10%), Common Grackle (8%), Mourning Dove (5%), Indigo Bunting (5%), Blue Jay (5%), Dickcissel (5%), and Carolina Wren (4%). The FBZ attracted a total of 26 bird species with the most common including Red-winged Blackbird (50%, $F_{2,47} = 14.600$, $P < 0.001$), Dickcissel (13%, $F_{2,47} = 8.070$, $P = 0.001$), Northern Cardinal (11%, $F_{2,47} = 5.010$, $P = 0.011$), Indigo Bunting (8%, $F_{2,47} = 3.330$, $P = 0.045$), and Mourning Dove (5%, $F_{2,47} = 0.030$, $P = 0.972$) of which all were significantly more abundant in bordered than non-bordered margins except Mourning Dove (Table 1).

Avian density ($F_{2,47} = 14.66$, $P < 0.001$), species richness ($F_{2,47} = 10.09$, $P < 0.001$), and TACV ($F_{2,47} = 14.96$, $P < 0.001$) differed in the FBZ among narrow, wide, and non-bordered margins. We observed nearly twice the density and TACV in wide borders than narrow (Fig. 1). Greater avian density ($F_{2,47} = 7.85$, $P < 0.001$; $F_{2,47} = 5.83$, $P = 0.004$), species richness ($F_{2,47} = 5.78$, $P = 0.004$; $F_{2,47} = 5.41$, $P = 0.008$), and TACV ($F_{2,47} = 5.99$, $P = 0.005$; $F_{2,47} = 4.27$, $P = 0.020$) was observed in bordered agriculture and wooded zones compared to non-bordered, respectively (Fig. 1). Wide borders also had

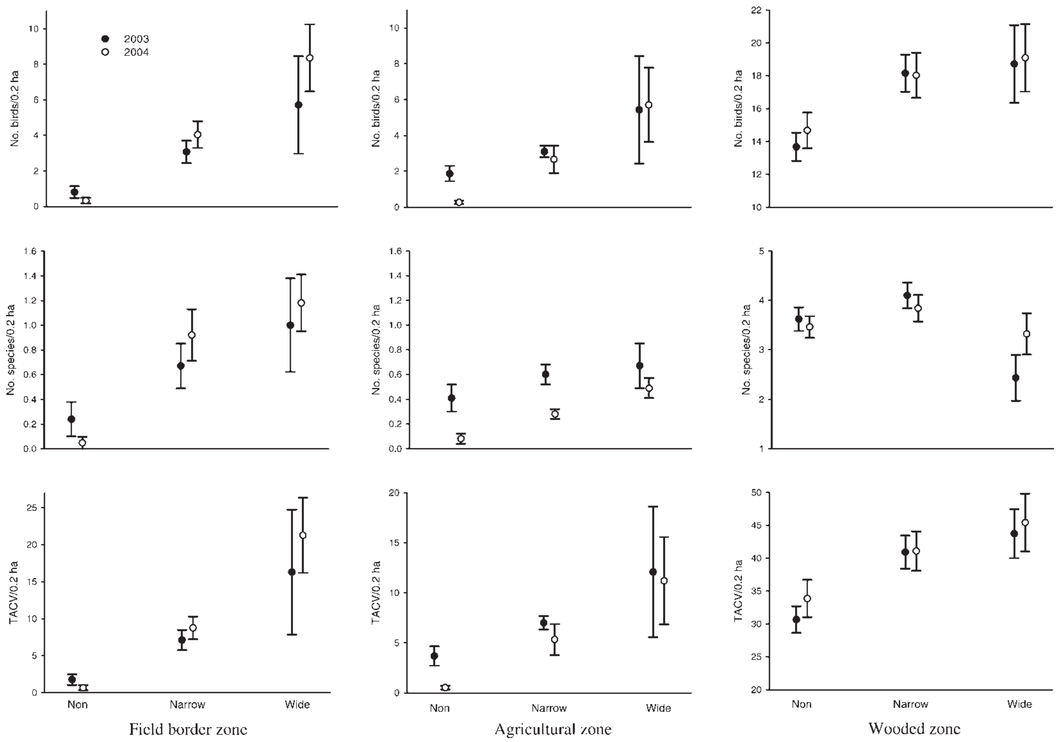

FIG. 1. Mean bird density, richness, and TACV (Total Avian Conservation Value; ± SE) for field margin treatments (non-, narrow, and wide-bordered) and zones (field border, agriculture, and wooded) in the Mississippi Alluvial Valley during May–June 2003 (closed-circle) and 2004 (open-circle).

nearly two times greater avian density and TACV than narrow borders in the agriculture zone (Fig. 1). Repeated measures ANOVA revealed a year effect for density ($F_{1,47} = 4.36$, $P = 0.042$), richness ($F_{1,47} = 4.36$, $P = 0.042$), and TACV ($F_{1,47} = 12.91$, $P = 0.002$) in the agriculture zone. However, year had less influence on density ($F_{1,47} = 4.03$, $P = 0.050$; $F_{1,47} = 0.36$, $P = 0.547$), richness ($F_{1,47} = 0.82$, $P = 0.371$; $F_{1,47} = 0.51$, $P = 0.479$), or TACV ($F_{1,47} = 38$, $P = 0.072$; $F_{1,47} = 0.10$, $P = 0.757$) in the field border and wooded zones, respectively. Year*treatment interaction effects were non-significant ($P > 0.05$) for community metrics.

DISCUSSION

Species-specific Response.—All birds commonly observed in agricultural field margins in the MAV were positively influenced by field border presence. Red-winged Blackbird, Dickcissel, Northern Cardinal, and Indigo Bunting were over two times more abundant in narrow than non-bordered field margins (Table 1). Red-winged Blackbird and Dickcissel were, respectively, 2.5 and 14.5 times more abundant in wide-bordered margins than narrow. Enhanced use of wide borders by these species may correspond with their ability to exploit forage and nest-site resources from the greater area at farther proximity to the wooded edge in wider borders. Dickcissel densities in Mississippi field borders (1000.0 birds/100 ha) exceeded those found elsewhere, including grass/forb dominated Illinois grasslands (4.0 birds/100 ha; Kobal et al. 1999), Iowa CRP fields (58.4 birds/100 ha; Patterson and Best 1996), central Iowa grass waterways (333.0–390.0 birds/100 ha; Bryan and Best 1991), Kansas CRP fields (107.6–199.6 birds/100 ha; Hughes et al. 1999), mixed-grass prairie in South Dakota (6.1 birds/100 ha; Fritcher et al. 2004), and Iowa warm-season grass filter strips adjacent to non-wooded (103.3 birds/100 ha) and wooded edges (8.0 birds/100 ha; Henningsen and Best 2005). Others have reported high Dickcissel densities in herbaceous strip habitats (Bryan and Best 1991, Henningsen and Best 2005), but our study documented unprecedented densities in strip habitats directly adjacent to wooded edges. We speculate the elevated Dickcissel densities in field borders in the MAV may result from the isolation of these strip habitats in a landscape nearly devoid of non-crop vegetation. This finding contrasts to previous research, which has shown that Dickcissels avoid vegetation patches $\leq$50 m of wooded edges (Jensen and Finck 2004), as do many grassland birds (O'Leary and Nyberg 2000). The rapid colonization and intensive use of field borders by Dickcissels and Red-winged Blackbirds is encouraging for their indication of potential conservation benefits, as both species have continued (1980–2005) to have population declines $>$2%/year throughout Mississippi (Sauer et al. 2007). The Dickcissel is of even greater concern given the loss of native grasslands in their core range (Samson and Knopf 1994) and precarious over-winter conservation status (Basili and Temple 1999). Great densities highlight the need for demographic information to examine the possibility of a population sink (Pulliam 1988). This is particularly important for the Dickcissel, a species previously found with lower nest survival near wooded and shrubby edges (Hughes et al. 1999, Winter et al. 2000). We recommend future research to increase the understanding of Dickcissel ecology in field borders $>$10 m and $<$50 m from wooded edges to differentiate their spatial use of vegetation patches closer to wooded edges than the typical 50 m threshold.

Field borders also provide complementary benefits to birds in adjacent wooded fencerows. Northern Cardinal and Indigo Bunting, albeit primarily forest species, were more abundant in bordered margins and were frequently observed foraging in field borders. These two species responded similarly to wide and narrow field borders, and likely benefited most from field border vegetation nearest the wooded edge. Early-succession birds considered of regional conservation concern in the MAV by PIF that were not observed using field borders include Eastern Kingbird (*Tyrannus tyrannus*), Loggerhead Shrike (*Lanius ludovicianus*), and Common Yellowthroat (*Geothlypis trichas*). Other species we had anticipated to use these borders but which were not recorded include Grasshopper Sparrow (*Ammodramus savannarum*), American Kestrel (*Falco sparverius*), and Eastern Bluebird (*Sialia sialis*). We speculate the failure of field borders to attract these species may relate to landscape composition, area-sensitivity, food availability, or local vegetation structure.

Community Response.—Farmland avian communities in the MAV responded positively to addition of field borders on agriculture-wooded field margins. Avian richness, density, and TACV were significantly greater in narrow than non-bordered margins within both the field border and agriculture zones. Community metrics in wooded zones were less influenced by field border presence. However, wooded zones had greater TACV and bird densities when adjacent to narrow field borders than at abrupt agriculture-wooded edges. The increase of avian density and richness likely relates to enhanced vegetative structure, cover, and floral diversity in field borders. The conservation benefits indicated by elevated TACV scores highlight the potential of field borders to contribute to the sustainability of farmland bird populations; however, reproductive information in these relative to alternative habitats is necessary to understand their contribution to recruitment and population trajectories (Van Horne 1983).

We found convincing support for our hypothesis of enhanced benefits from increased border width relative to avian density and TACV in field border and agriculture zones. Greater avian densities in and adjacent to wide field borders may be attributed to increased vegetative diversity (Rotenberry 1985), lower perimeter to area ratio (Helzer and Jelinski 1999), or larger overall patch area in wide borders (Winter et al. 2006). We detected no effect of field border width on avian richness during either year, which contradicted our prediction. We speculate the lack of a positive relationship between border width and avian richness corresponds with decreased avian diversity at the landscape scale from overall scarcity of non-crop, herbaceous habitat.

The continuing decline of North American grassland bird populations is of primary conservation concern regarding agricultural land-use practices (Peterjohn and Sauer 1999, Brennan and Kuvlesky 2005). Widespread restoration and retention of permanent, managed grassland blocks is the appropriate prescription to stem these declines, but the majority of agricultural land is not conducive to large unfarmed blocks, as they are privately owned and managed for commodity production and economic return. Farmland-integrated habitats with minimal economic drawbacks, such as field borders (Barbour 2006), are more amenable to producer objectives and of increasing importance given the elevated strain on natural resources from worldwide food demands and expanding human populations (Tilman et al. 2002, Robertson and Swinton 2005). Field borders seemingly provide attractive avian habitat, thereby representing an effective tradeoff between wildlife and landowner needs in agricultural landscapes. This study demonstrates that field borders provide habitat to enhance bird populations in agriculture-dominated landscapes. Consequently, we advocate integrating field borders, especially of enhanced width, as a standard conservation practice to mitigate effects of agricultural intensity on bird populations.

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