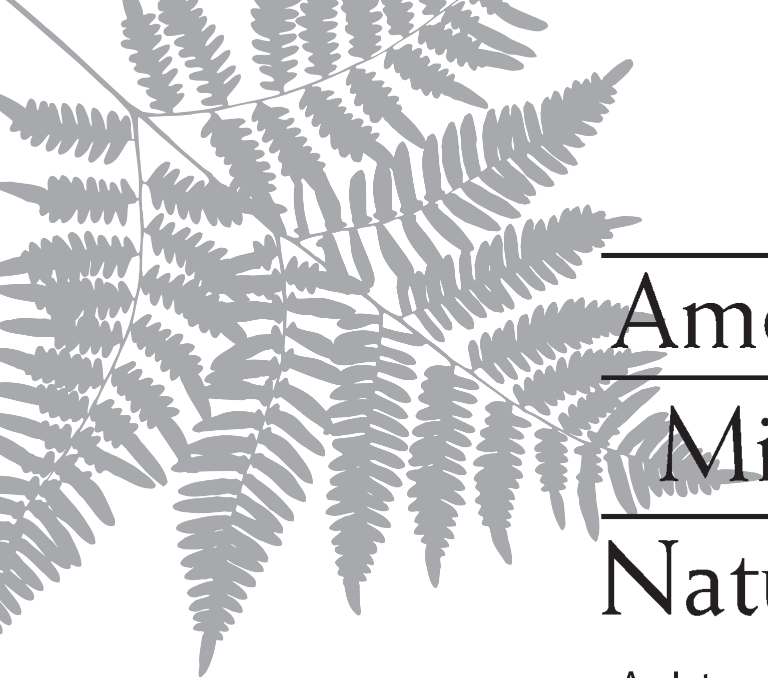

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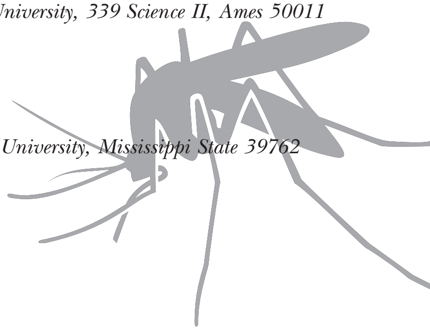

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ABSTRACT.—Creating and restoring patches of noncrop early-succession vegetation within agricultural landscapes may mitigate grassland bird population declines caused by agricultural land use and intensification. Achieving this goal requires an ability to balance avian benefits with agronomics, which may be facilitated by understanding how bird communities respond to various conservation practices. We evaluated bird richness, abundance, Shannon diversity, and Total Avian Conservation Value in 20 replicates of four Conservation Reserve Program practices in an intensive rowcrop agricultural landscape in the Mississippi Alluvial Valley from May–Jul., 2005–2007. Conservation practices included: (1) large blocks of structurally-diverse early-succession vegetation (6–8 y old trees) and three buffer types; (2) 30 m wide monotypic filter strips with tall dense switchgrass (*Panicum virgatum*); (3) 30 m wide diverse filter strips with a forb-native warm season grass mixture; and (4) 60 m wide early-succession riparian forest buffers (1–3 y old trees). The breeding bird community was dominated by red-winged blackbirds (*Agelaius phoeniceus*; 43% of total) and dickcissels (*Spiza americana*; 42% of total) but commonly included eastern meadowlarks (*Sturnella magna*), indigo buntings (*Passerina cyanea*), mourning doves (*Zenaida macroura*), and northern bobwhite (*Colinus virginianus*). We observed $\geq 1.8 \times$ more dickcissels in large blocks and diverse filter strips than other buffers and greater Shannon diversity in large blocks than any buffers ($P < 0.05$). Diverse filter strips had $\geq 1.6 \times$ greater overall bird density (7.2 birds/0.6 ha), on average, than all other practices. Based on these data, we conclude that buffers are attractive to farmland breeding birds and may provide important ecological benefits to supplement a conservation management system founded on large blocks of early-succession vegetation.

INTRODUCTION

The conversion of native ecosystems to agriculture in the U.S. resulted in grassland bird range shifts (Hurley and Franks, 1976) and severe population declines (Herkert, 1991; Peterjohn and Sauer, 1999; Brennan and Kuvlesky, 2005). By the time cropland development stabilized in some regions of the U.S. (*e.g.,* Mississippi; Lubowski *et al.*, 2006), farmland bird assemblages included species that could exploit the remnant grassland, shrub, and forest patches that persisted on field margins (Warner, 1994). Agricultural advances have since facilitated intensification (*e.g.,* larger field size, hedgerow removal) to maximize crop yield and based on European studies, may represent the primary future threat to bird populations on U.S. farmlands (Chamberlain *et al.*, 2000; Donald *et al.*,

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2001; Benton *et al.*, 2002) alongside pesticide toxicity (Mineau and Whiteside, 2013). In the U.S., bird populations have been negatively influenced by intensification practices such as crop field enlargement and 'clean farming', which removes field margin vegetation to maximize arable area (Best, 1983; Best *et al.*, 1990; Herkert, 1991; Herkert 1994; Warner, 1994).

The combination of native grassland degradation throughout the midwest (Noss *et al.*, 1995) and grassland bird range expansions from agriculture (Hurley and Franks, 1976) creates both a need and an opportunity to support these populations by establishing patches of early-succession vegetation on agricultural landscapes outside the midwest. The Mississippi Alluvial Valley (MAV) is such a location, as flood control in the early 1900s helped convert the largest (10 million ha) contiguous, forested wetland system in North America to predominantly agricultural production (Brown *et al.*, 1999). Furthermore, 'clean farming' is heavily implemented in the MAV (R. R. Conover, pers. obs.), where herbaceous buffers on field margins are rare but commonly used by breeding and wintering birds (Smith *et al.*, 2005a; Conover *et al.*, 2007, 2009).

The U.S. Department of Agriculture (USDA) initiated the Conservation Reserve Program (CRP) in 1985 to replace lost noncrop vegetation with various set-aside conservation practices (*i.e.*, types of vegetation cover) in agricultural landscapes, although wildlife conservation was not a program objective until 1996. Despite CRP successes, the need for program improvement was highlighted by the continued declines (Ryan *et al.*, 1998) and limited reproductive potential for some bird species (*e.g.*, Dickcissel, *Spiza americana*; McCoy *et al.*, 1999) that used existing CRP practices. One potential remedy includes the addition of conservation buffers, which are noncrop strips of vegetation intended to reduce soil erosion, improve water quality, and conserve biodiversity (McKenzie, 1997; Best, 2000). Some commonly deployed types of CRP buffer plantings include Conservation Practice (CP) 21 (*i.e.*, filter strips), which is either established using all grasses or grasses/forbs planting regime, and CP 22 (*i.e.*, riparian buffers), which consists of a hardwood tree planting regime. Buffers with herbaceous vegetation are used by birds of conservation concern in all seasons and provide various resources for breeding (*e.g.*, food, nesting sites) and wintering (*e.g.*, food, thermal regulation, escape cover) birds (Marcus *et al.*, 2000; Smith *et al.*, 2005a, b; Conover *et al.*, 2007, 2009, 2011). Furthermore, herbaceous buffers in the MAV are attractive to Dickcissels (Conover *et al.*, 2009) and, as such, managing for vertical cover and forbs may enhance such species-specific benefits (Zimmerman, 1982; Hughes *et al.*, 1999). As conservation buffers are typically located on field margins, they more effectively balance wildlife and agronomic benefits (Barbour *et al.*, 2007) than do large blocks of herbaceous vegetation, which may amplify their future role in agri- environmental sustainability.

A potential drawback to conservation buffers is their high perimeter to area ratio, which may enhance edge effects and confound intended avian benefits by harboring unnaturally high movement of nest predators (Gates and Gysel, 1978; Helzer and Jelinski, 1999; Heske *et al.*, 1999; Woodward *et al.*, 2001). Management protocols that minimize edge effects depend on understanding avian responses based on buffer design, disturbance regimes, and landscape context. Specific mechanisms of increased bird use may relate to increased overall area (Vickery *et al.*, 1994; Winter and Faaborg, 1999), buffer width (Conover *et al.*, 2009), nesting opportunities (Shalaway, 1985; Warner, 1992; Conover *et al.*, 2011), arthropod abundance (DiGiulio *et al.*, 2001), vegetative heterogeneity (Wiens, 1974), and reduced nest predation (Gates and Gysel, 1978). Vegetative composition can influence bird use through resource availability, floral diversity, and structural heterogeneity (Cody, 1968; Willson, 1974; Benton *et al.*, 2003). Herbaceous planting strategies that promote diverse native flora also enhance structural diversity and may indirectly increase bird abundance and diversity (Warner, 1992; Bryan and Best, 1994; Burger, 2000; McCoy *et al.*, 2001). Woody components may enhance bird use via increased vertical structure and heterogeneity (Best, 1983). Buffer establishment techniques entail tradeoffs between sown grass buffers that promote rapid vegetative growth but suppress plant invasion and nonsown grass buffers (*e.g.,* planted to trees), which have less cover immediately postestablishment but higher overall floral diversity (Kleijn *et al.*, 1998). Agricultural producers are also more willing to adopt grass practices over tree practices as crop yield is lower directly adjacent to wooded vegetation compared to herbaceous vegetation (Barbour *et al.*, 2007).

We surveyed avian community structure and species specific abundances to evaluate the effects of four distinct CRP practices, including patch shape (buffer/strip vs. large block) and local physiognomic features. We hypothesized that: (1) large blocks would exhibit higher bird abundance and diversity than buffers because of their greater overall area and woody cover and (2) buffers with increased width or floral heterogeneity would have more diverse and abundant bird communities.

METHODS

STUDY AREA

We studied bird communities within a 2630 ha farm in Coahoma County, Mississippi (34°18′N, 90°34′W), located in the MAV. The MAV landscape is dominated by large fields of ditch to ditch row crop agriculture [primarily cotton (*Gossypium* sp.) and soybean (*Glycine* sp.)] with negligible topographic relief. The study farm was selected for its large size and enrollment in a range of CRP conservation practices (*see* below). The farm, which had recently established several seminatural vegetation patches to benefit wildlife, consisted of 48% row crop, 30% early succession hardwood afforestation plantings, 14% partially forested wetlands, 4% conservation buffers, 2% woodlands, and 2% herbaceous drains. Row crops consisted of soybeans in 2005 and 2007 and wheat (*Triticum* sp.) with a late soybean planting in 2006. There was no variation in growth patterns of crops adjacent to the study plots as spatio-temporal crop emergence was consistent throughout the study area.

CONSERVATION PRACTICES

We monitored breeding bird communities in 80 study plots (20 per conservation practice) that were randomly selected from a farm wide population of 200 m long sections of each practice. Practices included: (1) large, early-succession, afforestation blocks (hereafter, ''blocks'') that were structurally diverse but maintained primarily herbaceous vegetation and three conservation buffers; (2) diverse filter strips (hereafter, ''diverse strips'') that were planted 30 m wide with a forbs native warm season grass mixture; (3) monotypic filter strips (hereafter, ''monotypic strips'') that were 30 m wide and densely planted with only switchgrass (*Panicum virgatum*); and (4) early succession riparian forest buffers (hereafter, ''riparian buffers'') that were 60 m wide and dominated by herbaceous plants that colonized naturally. Sample sizes were lower for diverse strips (n = 14) and monotypic strips (n = 6) from incomplete plot delineation during 2005, the first year of study implementation.

Both filter strip practices were established in spring 2004; diverse strips were planted with partridge pea (*Chamaecrista fasciculata*, 4.5 kg/ha seeding rate), Indian grass (*Sorghastrum nutans*, 1.7 kg/ha seeding rate), little bluestem (*Schizachyrium scoparium*, 5.6 kg/ha seeding rate), and big bluestem (*Andropogon gerardii*, 1.7 kg/ha seeding rate), whereas monotypic strips were planted with a high density (9.0 kg/ha) of switchgrass. Riparian buffers were planted in fall 2004. Conservation buffers were established along a row crop field margin that was adjacent to a riparian zone (*e.g.,* drainage ditch, stream); however, some riparian buffers and diverse strips were adjacent to herbaceous or wooded riparian zones. Blocks were established in fall 1999 and thus had enhanced woody growth but retained primarily herbaceous vegetation. Blocks and riparian buffers were planted with Nuttall's oak (*Quercus nutallii*), water oak (*Quercus nigra*), and willow oak (*Quercus phellos*). Conservation practices were colonized at differing levels with local, nonplanted vegetation that mostly included marestail (*Conyza canadensis*), redvine (*Brunnichia cirrhosa*), vetch (*Vicia* sp.), goldenrod (*Solidago* spp.), giant ragweed (*Ambrosia trifida*), curly dock (*Rumex crispus*), dewberry (*Rubus trivialis*), blackberry (*Rubus oklahomus*), johnsongrass (*Sorghum halepense*), erect poison ivy (*Toxicodendron radicans*), broomsedge (*Andropogon virginicus*), honey locust (*Gleditsia triacanthos*), American elm (*Ulmus americana*), and sugarberry (*Celtis laevigata*).

CONSERVATION PRACTICE ASSESSMENT

We surveyed vegetation structure and cover during the approximate middle of the breeding season in the final year of the study (14 Jun. to 02 Jul., 2007) to obtain representative estimates that permit relative comparisons among conservation practices. USDA-Farm Service Agency administers the CRP program and certifies conservation practices as ''established'' after the second growing season. The goal of our vegetation surveys was to characterize vegetation structure in ''established'' stands of each practice but before midcontract management was implemented (after the 4th growing season). Although the treatments were not considered officially ''established'' by the CRP standards, we noticed fast growth of the planted species in the first year with minimal change across the three years of the study (R. Conover, pers. obs.). Furthermore, the observed annual variation was relatively low compared to the seasonal variation, which changed drastically in these herbaceous communities. Nonetheless, the objective of the vegetation survey data is to offer insight on the relative differences of plant communities between treatments, not from which to interpret annual changes in bird communities. We conducted three vegetation surveys on each of the 20 plots per practice, totaling 60 surveys per practice. Individual survey locations were randomly located within plots and consisted of a 4 m radius circle divided into quadrants to estimate vegetative cover and composition. Measured variables included proportions of live vegetation cover types (*i.e.*, forb, grass, and woody) to quantify structure, vertical cover, horizontal cover, and litter depth. Horizontal cover was visually estimated using the mean proportion of ground cover across 4 quadrants per survey. Vertical cover was estimated as effective vegetative height, which is the height of total visual obscurity from each of the 4 cardinal directions using a modified Robel pole that was observed at a height of 1 m and distance of 4 m (Robel *et al.*, 1970). These data are displayed using box plots to display variability without assumption of statistical distributions. We also statistically analyzed vegetation variables using an analysis of variance (ANOVA, $\alpha = 0.05$) to determine the extent of the variation of plant communities between practices.

BIRD COMMUNITY ASSESSMENT

We conducted strip-transect surveys monthly (May, Jun., and Jul.) in three breeding seasons (2005–2007) to account for seasonal and annual changes in bird use patterns. Transects were paced for 10 min and were 200 m long, with bird detections recorded within a 30 m area perpendicular to the observer. Walking pace and distance estimates of bird detections were assisted by marked plot edges and systematically placed flagging. One expert (3 y bird identification experience in this geographical region) observer conducted all surveys within 3 h post-sunrise (Central Standard Time) on days with no precipitation and wind <12 km/h. Conservation practices were clustered in several farm regions (*i.e.*, management units) and as such, we temporally randomized bird survey per farm region. Buffer transects were located on the buffer-ditch edge and bird counts included unidirectional observations within 30 m into each buffer, whereas blocks transects bisected the plot with 30 m bidirectional observations. To minimize bias through uneven sampling, we used mean values for each side independently in all subsequent block analyses. Flyovers (*e.g.,* observations of aerially foraging swallows) were excluded as they were not directly associated with conservation practices. We did not calculate detection functions for conservation buffers as their ecotonal context violates the uniform distribution assumption, and the transect locations were intentionally situated on the buffer-ditch edge, not spatially randomized (Buckland *et al.*, 2001). We therefore constrained bird observations to ≤30 m of the transect line to permit the reasonable assumption of a 1.0 detection probability (Diefenbach *et al.*, 2003). We assumed constant species-specific detection probabilities across conservation practices to permit community metric estimation (Rotella *et al.*, 1999).

Bird community structure was analyzed using abundance (birds/0.6 ha), species richness (total species/0.6 ha), Total Avian Conservation Value (TACV; TACV/0.6 ha; Nuttle *et al.*, 2003), and Shannon diversity index (H′, H′/0.6 ha; Shannon and Weaver, 1949). TACV measures relative conservation value using Partners' in Flight (PIF) bird conservation priority ranks (Nuttle *et al.*, 2003), which are based on regional (Bird Conservation Region 26) population trends, global population size, regional area importance value, global breeding and wintering distributions, regional threats to breeding habitat, and global threats to wintering habitat (Carter *et al.*, 2000; Panjabi *et al.*, 2005). This is calculated by multiplying species' abundances by their breeding status PIF rank for the MAV (http://www.rmbo.org/pif/scores/scores.html, accessed 15 Mar. 2010) and summing species-specific TACV scores within study plots. The PIF estimation protocol for area importance had been altered since Nuttle *et al.* (2003); our ranks are based on the updated version, which indexes area importance from relative density scores that reflect mean density of a species in the MAV relative to the Bird Conservation Region with the highest breeding season density (Panjabi *et al.*, 2005). Migratory nonbreeding species and unidentified birds were excluded from TACV calculations.

We compared community structure and species-specific abundances between conservation practices using a mixed-model repeated-measures ANOVA with PROC MIXED in SAS® software, Version 9.1.3 (SAS Institute Inc., 2002). This analysis incorporated seasonal and annual variation using month and year as repeated time effects, with conservation practice as the fixed main effect and transects as random subject effects. We applied an unstructured covariance structure, as selected by model fit using lowest AIC scores (Burnham and Anderson, 2002). Denominator degrees of freedom were computed using the Kenward-Roger adjustment, which incorporates variance of the F-value to minimize bias when using an unstructured covariance matrix (Kenward and Roger, 1997). Pair wise comparisons were evaluated with a student's *t*-test and the Tukey-Kramer P-value adjustment to conservatively account for unequal sample sizes in 2005 and minimize chances of type I errors. Estimates are reported as least squares means, which are predicted margins for a balanced population. Results were considered statistically significant at $\alpha \leq 0.05$ for purposes of hypothesis testing.

As the surveyed buffers were a random sample of all buffers within the study farm, some diverse strip and riparian buffer transects were adjacent to wooded (n = 6, n = 8) and nonwooded (n = 14, n = 12) field margins, respectively. Wooded edges were defined as adjacent areas that had predominantly woody (>50%) ground cover and although some monotypic strips had woody edges, their sample sizes were insufficient for statistical testing.

We accounted for this effect separately by testing the relationship between bird abundance and adjacent vegetation types using t-tests, and in our primary analyses this effect represents natural variation that is typical of the MAV landscape.

RESULTS

CONSERVATION PRACTICES

Vegetation structure and cover was distinct among conservation practices in the final year of the study, including vertical cover ($F_{3,76} = 100.08$; $P < 0.01$), horizontal cover ($F_{3,76} = 46.07$; $P < 0.01$), grass cover ($F_{3,76} = 58.43$; $P < 0.01$), forb cover ($F_{3,76} = 39.95$; $P < 0.01$), woody cover ($F_{3,76} = 20.16$; $P < 0.01$), and litter depth ($F_{3,76} = 2.91$; $P = 0.04$; Fig. 1). Filter strips were grass dominated with minimal colonization by forbs or woody vegetation. Monotypic strips had the most horizontal and vertical cover of all practices but the least amount of horizontal or structural heterogeneity. Diverse strips had slightly less dense vegetative cover and more heterogeneity (*e.g.,* higher forb and less grass cover) than monotypic strips. Riparian buffers had the lowest overall cover, being largely composed of forbs and woody plants. Blocks had moderate cover and heterogeneity, and were primarily defined by balanced proportions of forb, grass, and woody cover (Fig. 1).

BIRD COMMUNITY STRUCTURE

We detected 34 bird species across all conservation practices throughout the breeding seasons of 2005–2007. We observed the greatest number of species (n = 25) in blocks, followed by diverse strips (n = 20) and riparian buffers and monotypic strips (n = 17). Red-winged blackbirds (43%) and dickcissels (42%) dominated bird communities across all conservation practices. We also frequently observed eastern meadowlarks (4%), indigo buntings (2%), mourning doves (2%), and northern bobwhite (2%; Table 1). Dickcissel was most dominant in blocks (55%) and least abundant in monotypic strips (30%), whereas red-winged blackbird exhibited the reverse, being the most abundant in monotypic strips (63%) and least abundant in blocks (25%, Table 1).

Conservation practices differed in bird abundance ($F_{3,72} = 12.08$; $P < 0.01$), richness ($F_{3,79.9} = 6.36$; $P < 0.01$), TACV ($F_{3,67.7} = 10.48$; $P < 0.01$), Shannon diversity ($F_{3,71.5} = 13.50$; $P < 0.01$), and Dickcissel abundance ($F_{3,78.9} = 10.77$; $P < 0.01$). Bird abundance was similar across conservation practices except diverse strips, which supported 2.4 to 3.3 more birds/0.6 ha than other practices across years (Table 2) but had similar abundances to blocks in 2006 (Fig. 2). Blocks had consistently higher species richness than other practices in all years combined (Fig. 2). Blocks and diverse strips had significantly greater species richness than riparian buffers but only slightly greater species richness than monotypic strips (Table 2). Diverse strips had greater avian conservation value than other practices within years (Fig. 2) and 4.0–5.8 greater avian conservation values than other practices across years (Table 2), whereas other practices had similar avian conservation values within and across years (Fig. 2). Blocks had significantly greater Shannon diversity than all other practices across years (Table 2), including 1.4 and 1.3 times more than the second most diverse conservation practice in 2005 and 2006, respectively (Fig. 2). Dickcissels were most abundant in diverse strips and blocks, with approximately 1.4 and 1.1 individuals/0.6 ha more in diverse strips and blocks, respectively, than monotypic strips or riparian buffers (Table 2). Our analysis of adjacent vegetation type (wooded vs. nonwooded) indicated greater mean ($\pm$SE) bird abundance for diverse strips (1.63 ± 1.01 birds/0.6 ha; $P = 0.11$) and riparian buffers (2.43 ± 0.93 birds/0.6 ha; $P = 0.01$) that were adjacent to nonwooded margins.

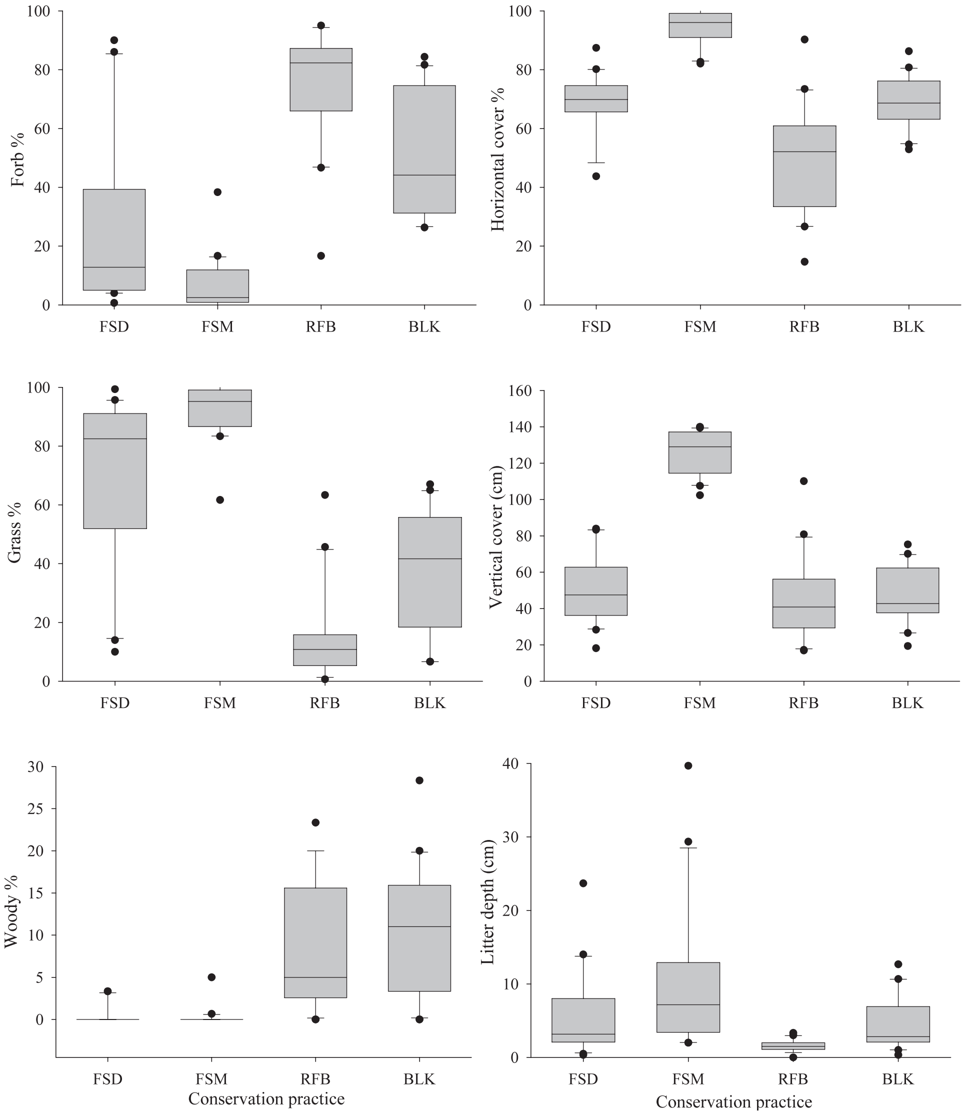

FIG. 1.—Vegetation variables were measured for filter strips with diverse (FSD) and monotypic (FSM) planting regimes, early-succession riparian forest buffers (RFB) and early-succession, hardwood blocks (BLK) during late Jun. 2007 in the Mississippi Alluvial Valley, MS

DISCUSSION

The prompt and extensive bird use that we documented in these conservation practices is promising, and variation in bird response between practices elucidates habitat-use patterns that may assist future conservation protocols. Bird communities were more similar amongst early-succession conservation practices than expected. We attribute this to the relative

TABLE 1.—Bird species are listed in descending order of overall number of detections in 200 × 30 m strips (0.6 ha) in conservation practices in the intensive, rowcrop landscape of the Mississippi Alluvial Valley, MS, 2005–2007

Species	All birds		FSD[b]			FSM			RFB			Block		
	No.	RA[a]	No.	RA	Δ%[c]	No.	RA	Δ%	No.	RA	Δ%	No.	RA	Δ%
Red-winged Blackbird	1330.5	0.428	452	0.444	1.6	393	0.628	20.0	284	0.438	1.1	201.5	0.246	−18.2
Dickcissel	1310	0.421	427	0.419	−0.2	189	0.302	−11.9	241	0.372	−4.9	453	0.553	13.2
Eastern Meadowlark	131	0.042	25	0.025	−1.8	7	0.011	−3.1	39	0.060	1.8	60	0.073	3.1
Indigo Bunting	74.5	0.024	39	0.038	1.4	1	0.002	−2.2	32	0.049	2.5	2.5	0.003	−2.1
Mourning Dove	60.5	0.019	13	0.013	−0.7	10	0.016	−0.3	12	0.019	−0.1	25.5	0.031	1.2
Northern Bobwhite	55	0.018	21	0.021	0.3	4	0.006	−1.1	6	0.009	−0.8	24	0.029	1.2
Common Yellowthroat	27	0.009	10	0.010	0.1	4	0.006	−0.2	6	0.009	0.1	7	0.009	0.0
Grasshopper Sparrow	25.5	0.008	0	0.000	−0.8	1	0.002	−0.7	0	0.000	−0.8	24.5	0.030	2.2
Northern Cardinal	19	0.006	6	0.006	0.0	1	0.002	−0.5	12	0.019	1.2	0	0.000	−0.6
Other species	78.5	0.025	25	0.025		16	0.026		16	0.025		21.5	0.026	
All birds	3111.5		1018			626			648			819.5		

[a] RA = relative abundance of a bird species within a conservation practice

[b] Conservation practices: FSD (filter strip with diverse planting regime), FSM (filter strip with monotypic planting regime), RFB (early-succession, riparian forest buffer), Block (early-succession, hardwood block)

[c] Percentage difference between specific habitat RA and total number of observations for species across habitats

TABLE 2.—Pair wise student's *t*-test results that compare avian abundance, species richness, and total avian conservation value (TACV) amongst four conservation practices in the intensive, rowcrop landscape of the Mississippi Alluvial Valley, MS, 2005–2007

Main effects	Abundance			Richness			TACV			Shannon diversity			Dickcissel abundance		
	Δ mean ± SE[A]	*T*	P[c]	Δ mean ± SE	T	P	Δ mean ± SE	*T*	P	Δ mean ± SE	*T*	P	Δ mean ± SE	*T*	P
2005 2006	2.38 ± 0.51	4.65	***	0.70 ± 0.10	7.39	***	5.04 ± 1.07	4.72	***	−0.076 ± 0.038	−1.99	0.12	0.67 ± 0.22	3.04	**
2005 2007	1.43 ± 0.53	2.37	0.05	0.58 ± 0.10	5.59	***	3.97 ± 1.16	3.43	**	0.063 ± 0.036	1.77	0.19	0.04 ± 0.25	0.17	0.867
2006 2007	−0.94 ± 0.36	−2.65	*	−0.12 ± 0.07	−1.87	0.16	−1.06 ± 0.54	−1.95	0.13	0.139 ± 0.038	3.61	**	−0.63 ± 0.14	−4.58	***
FSD[b] FSM	2.79 ± 0.71	3.96	**	0.22 ± 0.17	1.30	0.57	5.02 ± 1.34	3.75	**	0.091 ± 0.040	2.25	0.12	1.45 ± 0.34	4.18	***
FSD RFB	3.49 ± 0.61	5.72	***	0.47 ± 0.15	3.12	*	5.97 ± 1.11	5.37	***	0.103 ± 0.035	2.93	*	1.43 ± 0.31	4.59	***
FSD BLK	2.64 ± 0.61	4.32	***	−0.14 ± 0.15	−0.90	0.80	4.16 ± 1.11	3.74	**	−0.096 ± 0.035	−2.72	*	0.31 ± 0.31	0.99	0.325
FSM RFB	0.70 ± 0.69	1.02	0.74	0.25 ± 0.16	1.55	0.42	0.95 ± 1.30	0.73	0.89	0.012 ± 0.040	0.30	0.99	−0.02 ± 0.34	−0.05	0.962
FSM BLK	−0.16 ± 0.69	−0.23	1.00	−0.35 ± 0.16	−2.15	0.15	−0.86 ± 1.30	−0.66	0.91	−0.187 ± 0.040	−4.73	***	−1.14 ± 0.34	−3.35	**
RFB BLK	−0.86 ± 0.59	−1.45	0.47	−0.60 ± 0.15	−4.11	***	−1.81 ± 1.06	−1.70	0.33	−0.200 ± 0.034	−5.82	***	−1.12 ± 0.31	−3.68	***

[a] Least squares mean difference ± standard error, with sign denoting positive or negative trend

[b] Conservation practices: FSD (diverse-planted filter strip), FSM (monotypic-planted filter strip), RFB (early-succession, riparian forest buffer), BLK (early-succession, hardwood block)

[c] P-values represent a Tukey-Kramer adjustment

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

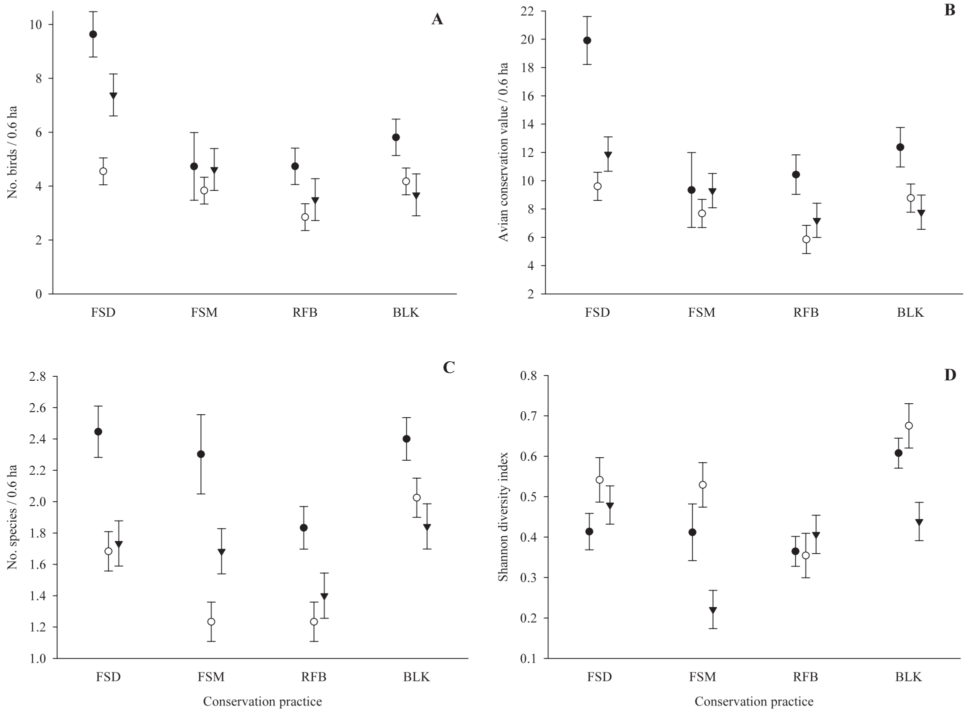

FIG. 2.—Bird abundance (**A**), species richness (**B**), total avian conservation value (**C**), and Shannon diversity (**D**) estimates for filter strips with diverse (FSD) and monotypic (FSM) plantings, early-succession riparian forest buffers (RFB) and early-succession hardwood blocks (BLK) during the summers (May–Jul.) of 2005 (filled circles), 2006 (open circles), and 2007 (filled triangles) in the Mississippi Alluvial Valley, MS

dominance of all conservation practices by just two species (dickcissel and red-winged blackbird) and the scarcity of noncrop vegetation in the surrounding landscape.

CONSERVATION PRACTICES

Large blocks were the most structurally diverse practice and had moderate proportions of forbs, grasses, and woody substrates, and moderate vertical cover. Vegetation in conservation buffers was dominated by either grasses (diverse strips and monotypic strips) or forbs (riparian buffers). The absence of herbaceous plantings in riparian buffers and blocks resulted in an early-succession stage defined by forbs that colonized naturally with relatively low cover.

BIRD COMMUNITY STRUCTURE

Bird use in conservation practices varied annually, as expected from the dynamic nature of early-succession vegetation and annual variation in row crop plantings. Blocks exhibited greater species-specific abundances than buffers for common but nondominant birds, including northern bobwhites, mourning doves, grasshopper sparrows, and eastern meadowlarks. Greater vegetative structure (Willson, 1974) and area (Warner, 1992; Winter and Faaborg, 1999) likely contributed to the elevated bird species richness and diversity in blocks compared to buffers. Blocks also exhibited higher overall bird densities and avian conservation values than all buffers except diverse strips. Greater bird density in diverse strips than blocks may have resulted from their relatively diverse and dense vegetative cover in concert with their ecotonal context (Bryan and Best, 1991). Hence, blocks had a larger suite of birds than buffers but densities between the two patch shapes were more similar. Diverse filter strips had higher bird densities and TACV than all other buffer types, thus supporting our prediction that bird use would be positively correlated with structural diversity, a byproduct of planting regimes. Conversely, monotypic strips and riparian buffers both exhibited relatively low bird use despite their representing opposite ends of the vegetative cover and grass-forb spectrums, suggesting a potential reduction of buffer quality with extremely high or low cover as well as dominance by either grasses (monotypic strips) or forbs (riparian buffers). Plant communities appeared to maintain relative differences between treatments (R. Conover, pers. obs.) however; annual changes in bird community structure cannot be inferred from vegetation data as they were only recorded in the final year of the study. Future research should explore the practicality of incorporating herbaceous plantings in riparian forest buffers to expedite benefits for grassland breeding birds by enhancing vegetative cover and structural diversity prior to sufficient woody emergence.

Although this study was not designed to test specific effects of buffer width, the similarities in bird abundance, richness, and TACV between 30 m and 60 m wide buffers may indicate that early-succession birds on farmlands perceive buffers in this width range more as patches than strips. Some effects of width alone may have been masked by the greater relative effect of vegetation composition and landscape context. The lack of a strong block versus buffer effect could be explained by having few buffers located on wooded edges, where increased buffer width is a factor in grassland bird attraction (Conover *et al.*, 2009), or by higher vegetation cover in the more narrow filter strips. Dickcissel and red-winged blackbird abundances were greater adjacent to nonwooded than wooded field margins in diverse strips (1.8 and 2.2 times greater, respectively) and riparian buffers (2.7 and 4.2 times greater, respectively). These results support previous findings in strips of similar vegetation (Henningsen and Best, 2005). As such, the differential bird benefits between 30 m and 60 m wide early-succession, conservation buffers remain ambiguous.

Conservation practices that supported the greatest bird use had high relative structural diversity and moderate vegetative heterogeneity and cover. Dickcissel was the most abundant community member of blocks but second to red-winged blackbird in all buffers. Lower dickcissel abundances in riparian buffers compared to diverse strips may be attributed to the lack of vertical and grass cover in riparian buffers (Patterson and Best, 1996; Hughes *et al.*, 1999). Dickcissels may exhibit area sensitive reproductive responses (Winter and Faaborg, 1999; Conover *et al.*, 2011) and hence, it is important to understand and incorporate factors related to their reproductive success when targeting buffer management for this species.

The performance of diverse strips highlights the potential benefits provided to farmland birds by buffer practices with mixed forbs/grasses plantings. The low bird diversity yet high TACV in diverse strips suggest the possibility of an abundance driven TACV. As such, we encourage management decisions to incorporate multiple community metrics. Furthermore, an understanding of bird reproductive ecology in these conservation practices will elucidate whether concerns about edge and area effects are justified and permit a more informed comparison of relative benefits amongst conservation buffer and block practices (Van Horne, 1983; Vickery *et al.*, 1992). Increased bird use of conservation practices with enhanced vegetative structural diversity may be explained by a correlative response in food resources, chiefly the arthropod community (DiGiulio *et al.*, 2001).

CONSERVATION IMPLICATIONS

This study highlights the importance of buffer planting regimes to enhance wildlife benefits from conservation buffers. Filter strip plantings should discourage domination by grasses and at a minimum, implement moderate seeding rates to promote vegetative diversity by natural colonization of local plants. The dense vegetative cover and homogeneous structure of monotypic grass buffers planted with a high seed density may decrease bird use and should be avoided if bird conservation is a farmland management objective. The distinction of bird assemblages between buffer types demonstrated the value of incorporating multiple buffer practices to manage for bird communities farm wide (Marshall and Moonen, 2002). Additionally, these data indicate buffer establishment on nonwooded edges will maximize benefits for grassland-breeding birds. Nevertheless, buffers adjacent to wooded edges provide the greatest agronomic opportunities (Barbour *et al.*, 2007) and increase the overall percentage of noncrop vegetation in the landscape while providing suitable vegetation for shrub scrub bird species.

Whereas the functional role of field margin vegetation for agriculture has declined, the environmental role is increasingly important (Marshall, 2002). Reconstructed strips of noncrop vegetation effectively balance landowner and wildlife needs to overcome social challenges associated with biodiversity in agricultural landscapes (Firbank, 2005). With the increasing shift of conservation attention from nature reserve designs to managing vegetation in working landscapes, the potential for conservation buffers to support bird populations amid intensive, row crop agriculture is of keen importance. Given previously confirmed benefits and limitations of CRP practices for grassland birds (Ryan *et al.*, 1998; McCoy *et al.*, 1999), this study enumerates the potential for conservation buffers to expand the breadth of wildlife benefits provided by the program. We recommend the employment of multiple conservation buffer practices using diversified planting regimes as complementary to establishing block practices for mitigating farmland bird population declines from agricultural intensification (Donald *et al.*, 2001; Newton, 2004).

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