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Habitat Relations

Overwintering Sparrow Use of Field Borders Planted as Beneficial Insect Habitat

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ABSTRACT Field borders are an effective conservation strategy for providing habitat to overwintering sparrows, and may be a venue through which beneficial insect populations are promoted. However, traditional fallow field borders lack sufficient pollen and nectar sources required to sustain beneficial insect populations; therefore, borders planted to a mix of native prairie flowers and grasses may be needed if increases in beneficial insect populations are desired. Although the value of fallow borders to birds has been established, little is known about bird use of beneficial insect habitats. Using single-observer transect surveys, we compared overwintering sparrow densities among 4 field border treatments (planted native warm season grasses and prairie flowers, planted prairie flowers only, fallow, and mowed) replicated around 9 organic crop fields from November to March 2009–2010 and 2010–2011. Sparrow densities were 5–10 times lower in mowed borders than in other border treatments in 2009–2010 and 2010–2011, but did not differ among planted and fallow borders in either year. Planted field borders may be a useful conservation practice for providing habitat for both overwintering sparrows and beneficial insects.

KEY WORDS beneficial insects, field borders, organic farming, sparrows, winter habitat.

Grassland and shrubland songbirds have declined steadily in North America over the last half-century (Sauer et al. 2011). Populations in the southeastern United States have suffered in particular, experiencing annual declines between 1.1% and 2.3% (Sauer et al. 2011). Species declines are attributed primarily to the loss or degradation of usable early-successional habitat (Vickery and Herkert 1999). Historically, such habitats included farm grasslands and pastures, timber harvests, fallow fields, and fire-adapted forests with well-developed grass and herbaceous understories (Hunter et al. 2001). Yet, over the past half-century, most native grasslands have been converted for other uses, and remaining habitat has been altered or fragmented by urbanization, agricultural intensification, fire suppression, and forest maturation (Brennan and Kuvlesky 2005). Consequently, most grassland birds primarily use agricultural production areas that often lack essential habitat requirements as a result of modern farming practices (Hunter et al. 2001, Murphy 2003).

Declines in shrubland and grassland songbird populations have prompted efforts to conserve and enhance early-successional habitat. Federal and state agencies have initiated programs to develop practical land-management strategies that will provide adequate habitat for songbirds without diminishing agricultural productivity on private lands (Best 2000). A widely accepted practice is to leave areas along crop field margins (hereafter field borders) fallow so they return to natural vegetation (Marcus et al. 2000, Riddle et al. 2008, Smith et al. 2008). Unmowed field borders provide better habitat for birds and other wildlife than the mowed field margins common on many farms and may provide the only non-cultivated herbaceous area on the farm (Marcus et al. 2000, Harper 2007, Blank et al. 2011*a*). The interface between crop and adjacent areas, especially forest, has lower crop productivity (Morris 1998), and a number of programs offer subsidies to compensate for financial losses incurred as a result of establishing the field borders (e.g., Conservation Reserve Program's Upland Bird Habitat Buffer (CP-33), Bobwhite Quail Initiative in Georgia, and North Carolina Wildlife Resource Commission Cooperative Upland Habitat Restoration and Enhancement Program). Field borders are simple and relatively inexpensive to establish, and aside from wildlife habitat, provide erosion control and improved water quality near riparian areas (Osborne and Kovacic 1993, Daniels and Gilliam 1996).

Most research investigating the use of field borders by songbirds has focused on the breeding season, but less is known about use of borders by wintering sparrows (Vickery and Herkert 1999). Although narrow field borders increase

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the density of some avian species, their value as nesting habitat is typically low (Bryan and Best 1994, Riddle and Moorman 2010). Songbirds nesting within narrow habitat strips suffer high rates of nest predation, largely because of increased predator activity and efficiency (Camp and Best 1994, Dijak and Thompson 2000). Although the breeding season benefits of field borders to grassland songbirds are variable, borders may be of value to songbird populations during the winter, particularly resident and short-distance migrant sparrows. Marcus et al. (2000) and Smith et al. (2005) observed greater overwintering sparrow densities along field margins with borders than along margins without borders in North Carolina and Mississippi, respectively. Additionally, Blank et al. (2011*a*) reported greater overwintering songbird density and species richness in planted filter strips than along non-buffered field edges.

However, fallow field borders typically lack the flowering plants required by arthropod species that either prey upon or parasitize insect crop pests (hereafter, beneficial insects; Olson and Wäckers 2007). Traditionally, biological control of pest insects involved the augmentation and release of control species, but a growing interest in developing land management practices that promote and maintain beneficial insect populations is emerging, especially on organic farms (Landis et al. 2005). To meet caloric demands, most adult beneficial insects require habitats with abundant pollen and nectar sources, and without them, are unable to maintain population sizes large enough to control pest populations that are typically large within monoculture crop fields (Heimpel and Jervis 2005, Landis et al. 2005). Therefore, field borders planted in a mix of flowering species may better conserve beneficial insect populations, including ecologically and economically important pollinator species (Allen-Wardell et al. 1998).

The inherent differences in floral characteristics between planted and fallow borders may influence variability in sparrow use of these habitats. Granivorous sparrow species rely heavily on seed food sources during the winter, and seed abundance can influence bird densities within an area, especially after waste grains have been depleted (Robinson and Sutherland 1999). Seed availability also can be a major factor in winter mortality rates for many sparrow species (Watts 1990). Overwintering habitats must contain sufficient percentages of bare ground for seeds to be accessible to sparrows, which otherwise have difficulty scratching through a thick thatch layer. Variability in vegetation structure also can influence differential use of field margin habitats, depending on individual bird species' foraging strategy and reliance on protective cover (Beck and Watts 1997, Douglas et al. 2009).

Field border management strategies that provide habitat for both beneficial insects (e.g., Natural Resources Conservation Service Plant Enhancement Activity PLT08) and songbirds may be a useful tool for maximizing the ecological benefits of conservation practices focused on agricultural lands. We measured overwintering sparrow densities within field borders planted as beneficial insect habitat to determine whether their value as overwintering songbird habitat is comparable to traditional fallow field borders. Although previous studies have investigated winter bird use of planted borders, we believe ours is the first to investigate bird use of borders planted specifically for beneficial insects. Smith et al. (2008) compared bird use between planted and fallow buffers, but their study had no replication and habitat patches were dominated by woody plants established to protect water quality rather than provide habitat. We hypothesized that overwintering sparrow abundance would be similar in planted and fallow borders because of similar plant structure, and that planted and fallow borders would harbor more birds than mowed field margins.

STUDY AREA

We conducted the study in the upper coastal-plain physiographic region at the Center for Environmental Farming System's Organic Research Unit (ORU) near Goldsboro, North Carolina, USA. Within the ORU, 9 organic crop fields ranging from 1.6 to 4.0 ha were planted in soybeans (*Glycine max*), corn (*Zea mays*), or hay crop (red clover [*Trifolium pretense*] and orchardgrass [*Dactylis glomerata*]). Three fields were planted in each of the crop types, and crops followed an annual rotation pattern of hay to corn, corn to soybeans, and soybeans to hay. All agricultural practices followed United States Department of Agriculture (USDA) organic crop production guidelines. In 2008, 4 field border treatments were established randomly around each of the 9 crop fields yielding 36 experimental units. Field borders were established along crop field margins and were bordered by other crop fields, shrubland, forest, railroad, or farm buildings. All field borders were approximately 91.44 m × 9.14 m (0.08 ha), creating 0.33 ha of experimental habitat around each field. The average distance between the edges of adjacent borders within a crop field was 37 m.

The 4 border treatments were 1) planted native warm season grasses (NWSG) and native prairie flowers (hereafter NWSG/flowers); 2) planted native prairie flowers only (hereafter flowers only); 3) fallow, unmanaged vegetation (hereafter fallow); and 4) volunteer grasses and herbaceous vegetation mowed 2–3 times per month (hereafter mowed). The NWSG species planted were indiangrass (*Sorghastrum nutans*) and little bluestem (*Schizachyrium scoparium*). Planted native prairie flower species were lance-leaved coreopsis (*Coreopsis lanceolata*), purple coneflower (*Echinacea purpurea*), black-eyed susan (*Rudbeckia hirta*), butterfly milkweed (*Asclepias tuberosa*), common milkweed (*Asclepias syriaca*), swamp sunflower (*Helianthus angustifolius*), heath aster (*Symphyotrichum pilosum*), and showy goldenrod (*Solidago speciosa*). We chose the mix of native prairie flowers because they are native to the United States, they are adaptable to North Carolina soils and climate, they were readily available for purchase, and they have demonstrated value for beneficial insects (Fiedler and Landis 2007). Additionally, individual species bloomed at various times during the growing season, which provided a continuous source of nectar. The fallow treatment was intended to represent traditional field borders established for wildlife habitat, and we included the mowed treatment as a comparison to the management of cropland margins most commonly implemented on farms across the southeastern United States.

We established planted field borders in the spring of 2008. Treatment areas were disked, and the corresponding seed mix was broadcast over the tilled soil using a manually powered seed spreader. After the seeds were sewn, we ran a culti-packer over the treatment area to ensure good seed-to-soil contact. Once vegetation in the planted borders reached approximately 30 cm in height, we mowed the area at a height of approximately 16 cm. During the 2008 growing season, planted borders were mowed 5–6 times to reduce weed competition. No further management was performed on planted border treatments. Following tillage in the fall of 2007, natural vegetation was permitted to grow in all fallow border treatments for the duration of the study. Fallow field border vegetation consisted of a mix of grasses, such as bermudagrass (*Cynodon dactylon*) and crabgrass (*Digitaria ciliaris*), and commonly occurring herbaceous species, such as horseweed (*Conyza canadensis*), dogfennel (*Eupatorium capillifolium*), heath aster, pigweed (*Amaranthus* spp.), and coffeeweed (*Senna obtusifolia*). *Baccharis halimifolia* also became prevalent within fallow borders 2 years following border establishment. Mowed borders were cut to a height of 16 cm every 2–3 weeks throughout the growing season. Borders were not mowed during winter bird surveys, but the dominant species in the mowed borders were crabgrass and bermudagrass, both warm-season grasses that exhibited limited growth after the final mowing in the fall.

METHODS

We estimated overwintering songbird densities using single observer transect surveys from November to March 2009–2010 (hereafter 2009) and 2010–2011 (hereafter 2010). In 2009 and 2010, the same observer walked the edge of each field border treatment and counted the number of birds within each border. Because many overwintering sparrows move in large flocks, share subtle field markings, and tend to fly into dense cover shortly after flushing, identifying individuals to species is difficult. Therefore, we counted sparrow species collectively, and identified individuals only when easily visible with binoculars. We were careful to note the location of where flushed birds landed so that we did not count individuals more than once in the same border or in adjacent borders. Also, to improve detectability, the observer frequently clapped and talked loudly while conducting surveys. The observer conducted surveys between sunrise and 1000 hours on mornings with no precipitation and winds not exceeding 25 km/hour. The observer surveyed all field borders over the course of the morning, and sampled the borders in a different order on each subsequent survey. In each year, a single observer sampled borders 9 times.

We estimated vegetation composition within each field border at 8 randomly distributed points using a 1-m × 1-m sampling frame from June to August 2009 and 2010. Although vegetation characteristics changed between when we measured vegetation in the summer and when we conducted bird surveys during the winter, most grasses and forbs held their structure throughout the winter. Accordingly, we reported the vegetation measures only as an index of relative differences among border treatments and not as a predictor of bird response. At each sampling point, we estimated the percent cover of forbs, grasses, woody plants, and bare ground. Within NWSG/flowers and flowers only borders, we also estimated the abundance of each planted NWSG and flower species. In 2009, we counted the number of each NWSG and flower species within each sample. In 2010, we estimated the percent cover of all planted NWSGs and planted flowers, as well as the percent cover of each individual NWSG and flower species. We estimated vegetation height and density using a Robel pole to calculate visual obstruction readings (VOR) at 5 random points within each field border (Robel et al. 1970). We classified land adjacent to each field border treatment as crop field, shrubland, forest, or manmade structures.

To quantify overwintering sparrow response to border habitat type, we performed an analysis of variance (ANOVA) using repeated measures models in Proc MIXED (v. 9.1.3, SAS Institute, Inc., Cary, NC). Number of sparrows counted was the dependent variable and border treatment, adjacent habitat, and year were the independent variables. We treated year, adjacent habitat type, and border treatment as fixed effects, and field as a random effect. We also included the interaction between field and border treatment within year as a repeated measures effect in the model, because we surveyed individual borders multiple times within the same year. We did not analyze individual sparrow species response to border treatment because the ability to identify individual birds was confounded by the density of sparrows. Therefore, species traveling in large flocks may have been underestimated in individual species analysis. We reported sparrow densities as the number of sparrows per 0.08 ha. We used a Tukey–Kramer adjustment to compare sparrow density among border treatments.

Because field borders were 10 m wide and consisted primarily of herbaceous vegetation, we assumed detection probability was near 100% (Diefenbach et al. 2003). Additionally, during our initial surveys in 2009, we walked through the middle of border treatments making noise and beating vegetation immediately following a survey to determine if individuals had not been detected. Few birds were undetected (C. Plush, North Carolina State University, unpublished data).

We conducted ANOVAs using Proc MIXED to test for differences in percent cover of forbs, grass, bare ground, and woody vegetation, and mean VOR among border treatments. Because structure of the vegetation in planted and fallow borders changed drastically during the 2 years of the study, we analyzed differences in vegetation structure and composition among border treatments separately for each year. In all models, we treated border treatment as a fixed effect, and included field as a random effect. We used Tukey–Kramer adjustments to compare vegetation parameters among border treatments.

RESULTS

We observed 2,881 birds in the winters of 2009 and 2010. Most birds were sparrows (96.4%), of which we were able to positively identify 1,424 (51%) to species. Sparrow species observed within field borders were savannah sparrow (*Passerculus sandwichensis*; 61.5%), song sparrow (*Melospiza melodia*; 22.8%), swamp sparrow (*Melospiza georgiana*; 6.8%), field sparrow (*Spizella pusilla*; 3.8%), dark-eyed junco (*Junco hyemalis*; 2.9%), white-crowned sparrow (*Zonotrichia leucophrys*; 0.8%), grasshopper sparrow (*Ammodramus savannarum*; 0.7%), and chipping sparrow (*Spizella passerina*; 0.4%). Other birds observed within borders included northern bobwhite (*Colinus virginianus*), eastern bluebird (*Sialia sialis*), and eastern meadowlark (*Sturnella magna*).

We detected no significant difference in total sparrow density between 2009 and 2010 ($F_{1,\ 16} = 1.93$; $P = 0.18$) or an interaction between year and field border treatment ($F_{3,\ 46} = 0.76$; $P = 0.52$). Adjacent habitat type did not affect sparrow density ($F_{3,\ 46} = 0.21$; $P = 0.89$), but sparrow density differed among field border treatments ($F_{3,\ 46} = 6.64$; $P < 0.001$). In 2009, sparrow density was similar among NWSG/flowers, flowers only, and fallow borders, but sparrow density was over 5 times lesser in mowed borders than in other border types (Fig. 1). In 2010, sparrow density again was similar between planted and fallow borders, although density was 42% greater in fallow borders than in flowers only borders and 35% greater in fallow borders than in NWSG/flowers borders. In 2010, mowed borders had 6–10 times lesser sparrow abundance than all other border treatments (Fig. 1).

Percentage of forb cover was not different between planted and fallow borders in 2009, but was at least 21% greater in flowers only borders than in other treatments in 2010 (Table 1). Black-eyed susan and heath aster comprised over 50% of the planted flower species present in NWSG/flowers and flowers only borders. Percentage of grass cover was similar in all treatments in 2009. In 2010, grass cover did not differ between fallow and NWSG/flowers borders, but was nearly 50% less in flowers only borders than in NWSG/flowers borders. The majority of grass species within NWSG/flowers borders were planted NWSGs, whereas bermudagrass and crabgrass were the dominant species in other treatments. Percent bare ground cover was similar among border treatments in both years. Mean VOR was greatest in NWSG/flowers only borders in 2009, but in 2010, VOR was over 23% greater in fallow borders than in other treatments. In 2010, percentage of woody vegetation was nearly 7 times greater in fallow borders than in other border treatments (Table 1).

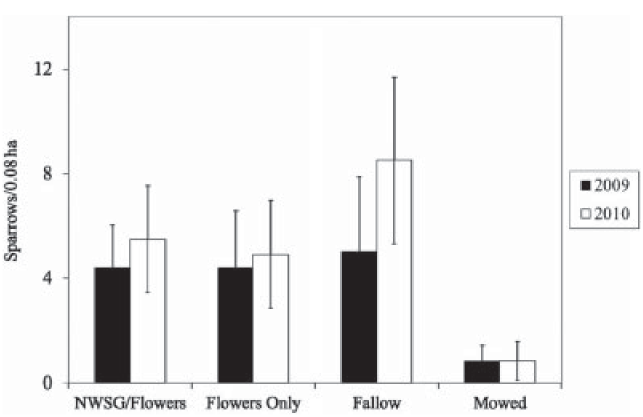

Figure 1. Mean (±SE) sparrow density (sparrows/0.08 ha) in 4 field border treatments in North Carolina (Nov–Mar 2009–2010 and 2010–2011).

DISCUSSION

Beneficial insect habitats provided winter habitat for sparrows equal to that of fallow field borders. Rising demand for food production coupled with increasing economic constraints on conservation programs make it essential that conservation strategies focused on agricultural lands yield the greatest amount of ecological services possible. Therefore, field borders planted as beneficial insect habitat may be a useful tool for maximizing biodiversity on arable lands by providing habitat to both beneficial insects and declining populations of grassland sparrows.

Mowed field margins did not support a great abundance of overwintering sparrows, likely because they lacked overhead cover needed for protection from predators. Also, thatch typically accumulates in frequently mowed areas, and grasses begin to dominate stands over short time periods (McCoy et al. 2001, Harper 2007). Because sparrows are weak scratchers, the combination of a thick litter layer and dense stands of mat-forming grasses could have reduced their ability to identify and access food sources on the ground (Harper 2007). Winter sparrows also were less abundant in mowed cropland margins than in unmowed margins in Maryland and North Carolina (Marcus et al. 2000, Blank et al. 2011*b*). Low sparrow densities observed in mowed field borders implies that wide-spread agricultural practices that leave cultivated lands void of residual cover during the winter may be a factor in the decline of many grassland bird species (Murphy 2003). In Europe, the long-term decline of many granivorous bird species has been linked to increased winter mortality due to the loss of food and cover resources on farmlands (Peach et al. 1999, Robinson and Sutherland 1999). We suspect similar detrimental effects on overwintering sparrows in the United States, given that most crop fields have been cultivated prior to the winter months, and the mowing of field edges, hedgerows, and ditches are commonplace practices.

Although vegetation structure may have the greatest influence on sparrow abundance, differences in plant species composition may also affect abundance indirectly through food availability. Sparrows are primarily granivorous during the winter months, and the abundance of seeds can affect overwintering bird densities and survival (Robinson and Sutherland 1999, Moorcroft et al. 2002). Seed production within field borders may be a critical food resource during later winter months, particularly when waste grain food sources are quickly depleted in crop fields because of efficient harvest. In fallow borders, commonly occurring annual and perennial grasses and forbs, such as crabgrass, heath aster, and pigweed, produce seeds readily eaten by sparrows (Pulliam and Enders 1971); however, no research has been conducted on songbird preference for seeds produced by flower species planted in beneficial insect habitats. More research is needed to determine whether seed availability and

Table 1. Mean and standard error for vegetation parameters within 4 field border treatments in North Carolina (Jun–Aug 2009 and 2010).

	Field border treatment[a]							
	NWSG/flowers[b]		Flowers only		Fallow		Mowed	
Variable	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
2009[c]								
Sorghastrum nutans (no./m^2)	1.2	0.6						
Schizachyrium scoparium (no./m^2)	3.3	1.5						
Asclepias tuberosa (no./m^2)	1.4	1.1	1.6	0.8				
Asclepias syriaca (no./m^2)	1.0	0.5	1.1	0.7				
Rudbeckia hirta (no./m^2)	4.6	2.1	5.1	3.2				
Echinacea purpurea (no./m^2)	1.9	1.1	2.1	1.0				
Coreopsis lanceolata (no./m^2)	1.5	0.8	1.7	0.4				
Helianthus angustifolius (no./m^2)	1.4	1.1	1.3	0.7				
Symphyotrichum pilosum (no./m^2)	2.1	0.7	1.8	0.7				
Solidago speciosa (no./m^2)	1.6	0.9	1.3	0.4				
% all forbs	50.9^{A}	15.9	61.5^{A}	12.9	47.9^{A}	22.3	29.2^{B}	11.0
% all grasses	35.2	20.0	23.9	5.9	24.1	15.2	45.0	23.8
% woody	0.0	0.0	0.0	0.0	4.4	8.1	0.0	0.0
% bare ground	64.7	7.5	67.4	7.5	48.5	15.1	53.3	23.4
VOR[d]	4.5^{A}	0.5	3.7^{AB}	0.5	3.1^{B}	0.7	0.6^{C}	0.1
2010[e]								
All planted NWSG (% cover)	50.5	16.7						
Sorghastrum nutans	12.6	6.0						
Schizachyrium scoparium	70.3	9.8						
All planted flowers (% cover)	38.7	16.1	71.6	19.1				
Asclepias tuberose	0.0	0.0	1.4	1.4				
Asclepias syriaca	0.3	0.8	1.4	2.6				
Rudbeckia hirta	46.1	21.5	29.0	14.4				
Echinacea purpurea	4.2	3.8	7.3	7.8				
Coreopsis lanceolata	1.7	2.1	3.2	3.3				
Helianthus angustifolius	0.4	0.9	7.0	6.9				
Symphyotrichum pilosum	34.7	26.1	36.2	17.7				
Solidago speciosa	0.0	0.0	0.0	0.0				
% all forbs	40.6^{B}	15.0	74.8^{A}	19.2	53.1^{B}	22.8	1.8^{C}	2.6
% all grasses	55.6^{B}	15.6	23.6^{C}	21.3	38.2^{B,C}	23.1	98.3^{A}	3.0
% woody	0.9^{B}	2.7	0.7^{B}	1.0	6.5^{A}	6.2	0.0^{B}	0.0
% bare ground	13.7	12.2	15.1	11.4	14.7	18.5	6.2	16.2
VOR	4.6^{B}	0.4	3.4^{C}	0.3	5.9^{A}	1.3	0.4^{D}	0.2

[a] Within rows, means followed by different letters were statistically different ($P < 0.05$).
[b] NWSG: native warm season grasses.
[c] In 2009, estimates for individual species of planted NWSG and planted forbs are based on the individual plants/m^2.
[d] VOR is visual obstruction reading.
[e] In 2010, estimates for individual species of planted NWSG and planted forbs are based on percent cover/m^2.

vegetation species influence sparrow abundance in beneficial insect habitats.

We observed greater sparrow densities in both planted and fallow field borders than in other studies of sparrow use of field borders (Marcus et al. 2000, Smith et al. 2005, Conover et al. 2007), which may be related to organic farming practices used in adjacent crop fields. Organic farms support greater species richness and abundance of breeding songbirds compared to conventionally managed crop fields (Vickery et al. 2001, Beecher et al. 2002, Belfrage et al. 2005). However, less is known about winter bird use of organic farm fields than conventionally managed agricultural fields. Organically managed fields typically are smaller in size, and contain greater amounts of non-crop vegetation because of restrictions on herbicide use (Beecher et al. 2002). Most sparrow species are less likely to use expansive areas of clean farming, where access to immediate escape cover is not available (Watts 1991). In our study, the smaller fields may have allowed sparrows to exploit greater areas of the crop fields because access to escape cover was maximized by surrounding field borders. Also, residual weed seeds produced by non-crop vegetation may have been more abundant within crop fields, thus providing a larger food source to sparrows. Although we recognize that comparisons between studies can be misleading because of differences in methodology and the species of birds encountered, the high densities of sparrows detected during our study suggests a need for additional research investigating the benefits of organic farming practices to overwintering birds.

We speculate that the increase in woody cover likely contributed to the slight increase in sparrow use of fallow borders in 2010. Song and swamp sparrows, 2 of the most commonly detected species in our study, typically select wintering habitats with substantial shrub and woody cover (Beck and Watts 1997, Baldwin et al. 2007), and savannah sparrows frequently used woody vegetation as perches while feeding in adjacent open habitats (C. J. Plush, personal observation). Early successional habitats containing modest levels of woody vegetation often support more diverse breeding (Riddle and Moorman 2010) and wintering bird communities (Baldwin et al. 2007), likely because the greater amount of structural diversity satisfies the habitat requirements of multiple bird species. Additionally, tall, woody vegetation acts as natural deterrent to aerial predators because it provides a greater over-head screening effect, and increases the distance of vulnerability between the ground and where predators can capture prey efficiently (Watts 1990).

However, expansive woody cover can limit the value of border habitats to many grassland-obligate species (Graves et al. 2010). Whereas song and swamp sparrows generally thrive in areas with substantial shrub or woody cover, savannah sparrows typically are restricted to grassland habitats, and likely would respond negatively if woody vegetation became the dominate vegetation type within border habitats (Arcese et al. 2002, Wheelwright and Rising 2008). Because the management practices used to establish beneficial insect habitats inherently deter woody vegetation encroachment, planted borders may provide suitable habitat over longer time periods for sparrow species strongly associated with strictly herbaceous cover, such as grasshopper sparrows and savannah sparrows.

We did not detect an effect of adjacent habitat type on total sparrow abundance, but we suspect adjacent cover type likely influenced species-specific distributions among field borders (Smith et al. 2005, Conover et al. 2007). Edge-adverse species (e.g., savannah sparrow) may have selected borders established between agricultural fields, whereas other species (e.g., song sparrow and swamp sparrow) used borders adjacent to shrub or forest habitats. Additional research is needed on individual species use of beneficial insect habitats, especially within areas where borders have been planted over larger areas and independent of fallow field borders.

MANAGEMENT IMPLICATIONS

Our results suggest beneficial insect habitats may maximize the biodiversity potential of field border establishment by providing suitable habitat for beneficial insects and overwintering sparrows. Also, field borders planted with a diversity of wildflower species offer greater aesthetic appeal to landowners than fallow borders established in weedy plant species. Although planted borders can be created to provide habitat for overwintering sparrows, structurally complex borders containing a mix of grasses, forbs, and woody shrubs or tree saplings likely provide the highest quality year-round bird habitat (Riddle and Moorman 2010). Although fallow borders in our study contained approximately 50% forb cover, the most common forb species present (e.g., pigweed, horseweed, and dogfennel) are not recognized as offering floral resources for beneficial insects. However, fallow borders in other settings may contain forb species of higher quality for beneficial insects. If beneficial insect habitat is not an objective, the use of fallow borders likely is the best option for bird conservation because they are easier and less expensive to establish than borders planted in a mix of grasses and flowers. In our study, the costs of establishing NWSG/flowers and flowers only borders were approximately $1,928/ha and $1,773/ha, respectively. However, estimates for planting borders in non-experimental settings are substantially less than the costs for establishing our borders. Regardless of the border type, disturbance every 2–3 years is required to limit woody plant and grass dominance over forbs in the borders. Frequent disturbance in planted mixes containing NWSGs can prevent grass monocultures that diminish the border's value to both beneficial insects and overwintering birds (Dively 2008).

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