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Research Article

Bird Community Response to Filter Strips in Maryland

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ABSTRACT Filter strips are strips of herbaceous vegetation planted along agricultural field margins adjacent to streams or wetlands and are designed to intercept sediment, nutrients, and agrichemicals. Roughly 16,000 ha of filter strips have been established in Maryland through the United States Department of Agriculture's Conservation Reserve Enhancement Program. Filter strips often represent the only uncultivated herbaceous areas on farmland in Maryland and therefore may be important habitat for early-successional bird species. Most filter strips in Maryland are planted to either native warm-season grasses or cool-season grasses and range in width from 10.7 m to 91.4 m. From 2004 to 2007 we studied the breeding and wintering bird communities in filter strips adjacent to wooded edges and non-buffered field edges and the effect that grass type and width of filter strips had on bird community composition. We used 5 bird community metrics (total bird density, species richness, scrub-shrub bird density, grassland bird density, and total avian conservation value), species-specific densities, nest densities, and nest survival estimates to assess the habitat value of filter strips for birds. Breeding and wintering bird community metrics were greater in filter strips than in non-buffered field edges but did not differ between cool-season and warm-season grass filter strips. Most breeding bird community metrics were negatively related to the percent cover of orchardgrass (*Dactylis glomerata*) in $\geq$1 yr. Breeding bird density was greater in narrow ($<$30 m) compared to wide ($>$60 m) filter strips. Our results suggest that narrow filter strips adjacent to wooded edges can provide habitat for many bird species but that wide filter strips provide better habitat for grassland birds, particularly obligate grassland species. If bird conservation is an objective, avoid planting orchardgrass in filter strips and reduce or eliminate orchardgrass from filter strips through management practices.

KEY WORDS agriculture, birds, buffer, Conservation Reserve Enhancement Program (CREP), filter strip, Maryland.

The United States Department of Agriculture's (USDA) Conservation Reserve Program (CRP) offers economic incentives to encourage conversion of highly erodible and other environmentally sensitive agricultural land to approved, perennial, vegetative cover. Goals of the CRP are to improve water quality, reduce soil erosion, and establish wildlife habitat. The 1996 Farm Bill (Federal Agricultural Improvement and Reform Act) established the Conservation Reserve Enhancement Program (CREP) provision within the CRP to enable states to enter into partnerships with the USDA to target specific resource concerns by offering enhanced incentives for landowner enrollment. In 1997, the State of Maryland and the USDA established Maryland's CREP initiative to implement conservation practices on private agricultural lands designed to reduce sediment and nutrient inputs to the Chesapeake Bay and to improve wildlife habitat.

Filter strips are strips of herbaceous vegetation planted along agricultural field margins adjacent to streams or wetlands and are designed to intercept sediment, nutrients, and agrichemicals. Roughly 16,000 ha of filter strips (USDA Practice CP21) are enrolled in Maryland's CREP, which comprises 47% of the total CRP acreage (USDA 2009*b*) and 1.9% of the total farmland in Maryland (USDA 2009*a*). Filter strips are usually planted either to native warm-season grasses or cool-season grasses, with the addition of native wildflowers or introduced legumes (usually clovers). Native warm-season grasses begin growth in late spring, set seed near the end of summer, and then go dormant in early fall. Common warm-season grasses in Maryland filter strips include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and indiangrass (*Sorghastrum nutans*). Cool-season grasses begin growth in early spring, set seed in early summer, and then go dormant until they start growing again in fall. The most commonly planted cool-season grass in Maryland filter strips is orchardgrass (*Dactylis glomerata*; S. Strano, Natural Resources Conservation Service [NRCS], Maryland, personal communication), but other cool-season grasses such as red fescue (*Festuca rubra*) and sheep fescue (*Festuca ovina*) are also planted. Orchardgrass and most other cool-season grasses in Maryland filter strips are non-native.

Filter strips often represent the only uncultivated herbaceous areas on farmland in Maryland and therefore may be important habitat for early-successional bird species. Warm-season grasses are known to provide nesting, foraging, and brood-rearing habitat for northern bobwhite (*Colinus virginianus*) and other ground-nesting birds (Whitmore 1981, Burger et al. 1990, Harper et al. 2007). However, there is no consensus in the literature regarding whether cool-season or warm-season grasses are preferable to most early-successional bird species (McCoy et al. 2001). For example, Henningsen and Best (2005) found that breeding bird abundance and relative nest abundance were similar between cool-season and warm-season grass filter strips in Iowa.

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Filter strips in Maryland range from 10.7 m to 91.4 m wide. Bird communities are affected by the width of strip-cover habitats (i.e., narrow or linear habitats; Best 2000, Clark and Reeder 2005). Wider strip-cover habitats are often associated with greater bird abundance or species richness (e.g., Stauffer and Best 1980; Davros 2005; Conover et al. 2007, 2009). However, few studies have evaluated the bird response to herbaceous strip-cover habitat >40 m such as filter strips created through Maryland's CREP (Clark and Reeder 2005).

We conducted this study in response to the needs of land managers and conservation planners seeking to improve the habitat quality of filter strips for birds on agricultural land in the Mid-Atlantic region. Our primary objectives were to determine the composition of breeding and wintering bird communities in CREP filter strips and non-buffered field edges and to determine how bird use is affected by filter strip grass type (cool-season vs. warm-season) and width. We chose a community-based approach because although some individual species require specific conservation attention (Hunter et al. 2001, Wiens et al. 2008), effective conservation efforts should be focused on entire communities (Hunter et al. 2001). We focused particular attention on the response of grassland and scrub-shrub species because these guilds are experiencing substantial population declines (Askins 1993, Hunter et al. 2001) and because they include early-successional species that are likely to benefit from the installation of filter strips.

STUDY AREA

We conducted our study on the Eastern Shore of Maryland (the area of the state east of the Chesapeake Bay) which had approximately 46% of land in farms (USDA 2009*a*) and approximately 77% of the CREP filter strips in the state (USDA 2007). Maryland's Eastern Shore is in the Atlantic Coastal Plain Province and has flat topography. Study sites were located in CREP filter strips and non-buffered field edges (controls) on farms in 3 counties: Caroline, Queen Anne's, and Talbot. Most farms in these counties contained row-crop agriculture interspersed by upland forest blocks or forested wetlands. All filter strips were between corn or soybean fields and a deciduous wooded edge and were originally planted between 1997 and 2004. Non-buffered field edges were cultivated areas on the margins of row-crop fields (corn or soybean) adjacent to a deciduous wooded edge.

METHODS

Study Site Selection and Classification

Our goal was to select a representative sample of CREP filter strips that included cool-season and warm-season grass filter strips across a range of widths. We classified the grass type of each filter strip as either cool-season or warm-season based on the original conservation plan of operation indicated by local NRCS county office records, and we verified the grass type through vegetation surveys or visual inspections. We attempted to select roughly equal numbers of cool-season and warm-season grass filter strips but were granted access to more warm-season grass sites (Table 1). We established study sites in CREP filter strips and non-buffered field edges based on the following criteria: study sites were 1) on separate fields, 2) $\geq$100 m apart, 3) and $\geq$50 m from the end of the field or from an edge where there was a distinct habitat change (e.g., roads or houses).

Table 1. Mean length and width (m) of study sites on the Eastern Shore of Maryland, USA, in which we conducted bird surveys from 2004 to 2007.

Season / Habitat type / Width class	*n*	Length $\bar{x}$[a]	Length SD	Width $\bar{x}$[a]	Width SD
Breeding season[b]					
Non-buffered field edges	15	369.3	206.5	45.0	0.0
Cool-season grass filter strips					
Narrow	12	452.3	243.3	16.7	5.9
Medium	3	576.2	427.7	38.2	8.4
Wide	7	511.6	287.9	82.1	14.2
Warm-season grass filter strips					
Narrow	23	415.8	160.4	18.9	3.6
Medium	11	394.5	126.1	34.2	4.8
Wide	11	317.0	78.3	91.0	5.3
Winter[c]					
Non-buffered field edges	16	313.2	96.8	40.0	0.0
Cool-season grass filter strips					
Narrow	11	230.0	76.0	17.5	5.3
Medium	1	119.0		31.2	
Wide	1	210.0		91.4	
Warm-season grass filter strips					
Narrow	14	370.2	72.0	19.8	2.7
Medium	7	417.0	76.7	35.6	5.3
Wide	6	299.4	72.9	93.1	2.5

[a] Mean across all years.
[b] No. of study sites during the breeding season by yr: 2004: $n = 32$; 2005: $n = 51$; 2006: $n = 22$.
[c] No. of study sites during winter by yr: 2005: $n = 35$; 2006: $n = 21$; 2007: $n = 20$.

We defined filter strip width as the distance from the crop edge to the wooded edge and calculated filter strip width by averaging width measurements taken every 50 m over the length of the filter strip. We classified filter strips as either narrow (<30 m), medium width (30–60 m), or wide (>60 m). Study site widths in filter strips coincided with the width of each filter strip. Non-buffered field edge study sites were 45 m wide in the breeding season and 40 m wide in winter, to approximate the average width of filter strip sites in each season.

We measured study site length from aerial photographs in a Geographic Information System. In 2004 and 2005, study sites spanned as much of the length of the filter strip or non-buffered field edge as possible (breeding season: $\bar{x} = 446$ m, SD = 225 m; winter: $\bar{x} = 444$ m, SD = 182 m). In 2006 and 2007, to increase efficiency and allow for more time to survey other sites, we established shorter study sites (breeding season: $\bar{x} = 301$ m, SD = 21; winter: $\bar{x} = 269$ m, SD = 73 m) that we randomly placed along the length of filter strip or non-buffered field edge. We calculated the area of each site by multiplying the site width times the site length.

Surveys

During the breeding seasons of 2004–2006 we surveyed birds in 67 filter strips and 15 non-buffered field edges (Table 1). We surveyed 19 of these filter strips in 2 yr and 2 of them in all 3 yr. We conducted breeding bird surveys in non-buffered field edges only in 2005. During winters of 2005–2007 we surveyed birds in 40 filter strips and 16 non-buffered field edges. We surveyed 11 of these filter strips in 2 yr and 2 of them in all 3 yr. We surveyed wintering birds in non-buffered field edges in 2005 and 2007 and surveyed 4 sites in both years.

We surveyed breeding birds in filter strips twice between 19 May and 22 July (once from mid-May to mid-Jun and a second time from mid-Jun to mid-Jul) and once in non-buffered field edges between 25 May and 30 June in 2005. We did not survey twice in non-buffered field edges because corn crops were too tall by July for observers to conduct a second round of surveys. We conducted all breeding bird surveys between sunrise and 3.5 hr after sunrise. We surveyed wintering birds between 4 January and 10 March, twice in filter strips in 2005 and 2006, 3 times in filter strips in 2007, and twice in non-buffered field edges in 2005 and 2007. We conducted all winter surveys between 1 hr after sunrise and 1 hr before sunset. We did not conduct surveys in rain, fog, falling snow, or wind >16 km/hr.

We conducted bird surveys at each study site by using a strip-transect method with multiple observers. Width of the strip-transect coincided with the width of the filter strip or non-buffered field edge. During breeding bird surveys in filter strips ≤60 m, and wintering bird surveys in filter strips ≤40 m wide, 2 observers spread out evenly along the width of the filter strip and walked parallel to the wooded edge. During breeding bird surveys in filter strips >60 m wide, we added a third observer and used the same technique. In filter strips >40 m wide in winter, observers walked ≤20 m apart, turning around at the end of the study site to survey the remainder. Observers counted all birds within the filter strip area and communicated regularly to reduce the risk of double-counting. We surveyed birds in non-buffered field edges by using the same techniques as in filter strips. Using these methods, average distance from an observer to all points in strip-transects was approximately 8 m in both seasons (breeding season: SD = 4.2 m, max. = 16.2 m; winter: SD = 2.4 m, max. = 10 m), which is sufficient to determine bird densities in fixed areas of herbaceous habitat (Diefenbach et al. 2003, Roberts and Schnell 2006). We identified the species of all birds seen or heard, except in rare events when we did not observe birds clearly enough to identify them. We counted birds observed foraging in the air above study sites and breeding birds observed in branches overhanging study sites because many birds used the wooded edges as perches.

To estimate detection probability during the primary bird surveys we conducted an additional double-observer (Nichols et al. 2000) strip-transect method in 21 of the filter strips surveyed in winter 2006 and in 8 of the filter strips surveyed in the breeding season of 2006. We established one 300-m long strip-transect in each filter strip, with a half-strip width of 10 m in winter and 15 m in the breeding season. One observer walked down the center line of the strip-transect while a second dependent observer walked 5–10 m behind the first observer recording any birds the first observer missed. We conducted double-observer surveys on separate days from primary surveys or several hours after primary surveys.

We searched for nests in 31 filter strips in the breeding seasons of 2005 and 2006. We searched 14 cool-season grass filter strips (8 narrow, 2 medium, and 4 wide) and 17 warm-season grass filter strips (7 narrow, 3 medium, and 7 wide). We searched 28 filter strips in only 1 yr and 3 in 2 yr. In 2005, we randomly chose a 300-m long section of each filter strip to search for nests regardless of its width (Henningsen and Best 2005). In 2006 we searched a 6,000-m^2 section to standardize the area searched at each site (due to the wide range of areas among filter strips). We conducted nest searches twice each year, once in late June to early July and again in early July to late July, with 2–8 people spaced approximately 2 m apart. Searchers parted vegetation with poles to scan for nests and flushed birds. We checked active nests every 3–4 days and considered nests successful if ≥1 of the host young fledged (Henningsen and Best 2005). We also measured the distance from each nest to the crop edge and the wooded edge.

We estimated percent cover of all cool-season and warm-season grasses in 36 filter strips in 2005 (16 cool-season and 20 warm-season) and in 22 filter strips in 2006 (9 cool-season and 13 warm-season) during the breeding season. We surveyed vegetation once each year within 5 days of the second bird survey at each site. In filter strips <45 m wide we established 1 transect line down the center of the strip. In filter strips >45 m wide we divided the strip into 2 sections and established a transect line down the center of each section. We visually estimated percent cover (non-overlapping) of all cool-season and warm-season grass species within a 1-m^2 frame located at random distances perpendicular to points spaced 50 m apart along each transect line.

Statistical Analyses

Bird community metrics and species' densities.—We calculated detection probabilities from the double-observer strip-transects in Program DOBSERV (Nichols et al. 2000). The data allowed for detection estimations when observers were the maximum distance apart during primary strip-transect surveys. Detection probability was ≥ 0.95 during the breeding season and ≥ 0.89 in winter. Given these high rates of detection we made no adjustments for detection to the counts.

We omitted 20 surveys from winter 2005 (29% of the surveys from that year) due to the presence of snow on the ground during those surveys that we felt prohibited foraging by wintering birds and reduced available cover. We omitted 2 observations of large flocks ($\geq$300 individuals) of red-winged blackbirds (*Agelaius phoeniceus*) and common grackles (*Quiscalus quiscula*), respectively, to improve normality. We omitted observations of eastern bluebirds (*Sialia sialis*) because we most often observed them near bluebird houses that were not evenly distributed among study sites.

We categorized early-successional bird species as either grassland or scrub-shrub birds based on the Birds of North America species accounts (Poole 2010), the North American Breeding Bird Survey Results and Analysis (Sauer et al. 2008), literature on grassland birds (McCoy et al. 1999, Vickery et al. 1999, Hunter et al. 2001, Kammin 2003) and scrub-shrub birds (Askins 1993, Schlossberg and King 2008), and personal observations. We combined obligate grassland birds and facultative grassland birds into a general grassland bird category due to the low abundance of obligate grassland birds we observed in filter strips. Scrub-shrub communities include species associated with scrub-shrub, early-successional, and forest edge conditions (Hunter et al. 2001). We included common yellowthroat (*Geothlypis trichas*), field sparrow (*Spizella pusilla*), mourning dove (*Zenaida macroura*), and northern bobwhite in both the grassland guild and the scrub-shrub guild because they cannot easily be classified into one or the other.

We used 5 bird community metrics in the analyses: total bird density, species richness, grassland bird density, scrub-shrub bird density, and total avian conservation value (TACV). We calculated density estimates by dividing the number of birds counted by the area of the site. Species richness is a measure of the number of species recorded at each site, and TACV is an index that incorporates demographic information about each species and has been used effectively to assess the relative conservation value of different habitat types (Nuttle et al. 2003). We calculated TACV for each site by multiplying each species' density by its Partners in Flight conservation priority rank (Carter et al. 2000, Nuttle et al. 2003) for the Mid-Atlantic Bird Conservation Region (Partners in Flight 2008) and then summing the TACV scores of all species within the site (Conover et al. 2007).

We analyzed differences in bird community metrics and species-specific densities among treatments with mixed model analyses of variance (ANOVAs) by using PROC MIXED in SAS (SAS Institute, Cary, NC). For comparisons of filter strips with non-buffered field edges during the breeding season we used a 1-way ANOVA, only included data from the first round of surveys in 2005 (because we surveyed non-buffered field edges only once in 2005), and included wooded edge length as a covariate because it significantly differed among treatments. For all other analyses, we averaged bird community metrics and species' densities from surveys at the same site within a season and used the means for subsequent analyses. We used a 2-way ANOVA to compare filter strip treatments in the breeding season, with grass type (cool-season or warm-season), filter strip width class (narrow, medium, or wide), and their interaction included as fixed effects, and year and site (nested within treatment) as random terms. For analyses of species richness, we used site area as a covariate to account for species-area effects. The interaction between grass type and filter strip width class was not significant for any breeding season models, therefore we evaluated main effects individually. We tested differences between levels of fixed factors by using pair-wise contrasts. Due to the difficulty of finding replicates of medium width and wide, un-mowed, cool-season grass filter strips in winter, we tested grass type and filter strip width in winter in separate 1-way models. We also analyzed responses for species with average densities >20 birds/100 ha (Table 2) and for grasshopper sparrow (*Ammodramus savannarum*) and savannah sparrow (*Passerculus sandwichensis*) because they are obligate grassland bird species of high conservation concern in Maryland (Maryland Department of Natural Resources 2004). When necessary, we log or square-root transformed response variables to improve normality. When transformations did not improve normality we conducted a 1-way, non-parametric, Kruskal–Wallis test with PROC NPAR1WAY in SAS, using the mean across all years as the response variable. For the non-parametric test of grassland bird density in filter strips compared to non-buffered field edges in winter, we standardized bird density by length of the wooded edge. We tested relationships between bird community metrics and percent cover of 4 common grass species with simple linear regressions. We set statistical significance at $P \leq 0.05$.

Nest densities and nest survival.—We tested for differences in nest densities among filter strip types by using the same mixed model method as for comparing breeding bird community metrics among filter strips. The interaction between filter strip grass type and filter strip width was significant for grassland bird nest density, therefore we examined differences among simple effect means. We did not find enough grassland bird nests in medium width filter strips to reliably estimate nest densities in that width class so we only compared differences between narrow and wide filter strips.

We used the logistic-exposure method (Shaffer 2004, Shaffer and Thompson 2007), by using PROC GENMOD in SAS, to estimate daily survival rate of nests in filter strips and to model nest survival as a function of multiple explanatory variables. We analyzed all nests combined due to the few nests we found for each species. We considered all possible candidate models including filter strip grass type, filter strip width, the interaction of filter strip grass type and width, distance from the nest to the wooded edge, and year. We only included the interaction of grass type

Table 2. Grassland and scrub-shrub bird species (mean density/100 ha) in filter strips on the Eastern Shore of Maryland, USA, during the breeding seasons (May to Jul) of 2004–2006 and winters (Jan to Mar) of 2005–2007.

Common name	Bird community guild	Season observed in filter strips	Breeding season		Winter	
			$\bar{x}$[a]	SE	$\bar{x}$[a]	SE
Northern bobwhite	FG[b] and SS[c]	Year-round	8.7	5.7	21.7	15.6
American kestrel (*Falco sparverius*)	FG	Winter	0.0	0.0	0.2	0.2
Mourning dove	FG and SS	Year-round	5.5	3.0	21.9	18.0
Eastern bluebird	FG	Year-round	2.2	1.1	2.7	2.1
Eastern kingbird (*Tyrannus tyrannus*)	FG	Breeding	11.6	4.0	0.0	0.0
White-eyed vireo (*Vireo griseus*)	SS	Breeding	2.2	1.2	0.0	0.0
Warbling vireo (*Vireo gilvus*)	SS	Breeding	2.1	1.8	0.0	0.0
Gray catbird (*Dumetella carolinensis*)	SS	Breeding	12.6	5.4	0.0	0.0
Brown thrasher (*Toxostoma rufum*)	SS	Breeding	3.1	1.5	0.0	0.0
Common yellowthroat	FG and SS	Breeding	102.4	14.9	0.0	0.0
Yellow-breasted chat (*Icteria virens*)	SS	Breeding	2.7	1.7	0.0	0.0
Eastern towhee (*Pipilo erythrophthalmus*)	SS	Year-round	3.2	1.5	4.4	4.4
Field sparrow	FG and SS	Year-round	81.6	18.8	71.9	42.7
Savannah sparrow	OG[d]	Winter	0.0	0.0	36.6	19.2
Grasshopper sparrow	OG	Breeding	3.5	1.2	0.0	0.0
Song sparrow	SS	Year-round	4.2	2.6	455.0	94.5
Swamp sparrow	SS	Winter	0.0	0.0	35.1	13.0
White-throated sparrow	SS	Winter	0.0	0.0	160.9	87.5
Dark-eyed junco	SS	Winter	0.0	0.0	154.7	137.1
Northern cardinal	SS	Year-round	19.1	5.6	11.9	9.2
Blue grosbeak	SS	Breeding	38.6	8.1	0.0	0.0
Indigo bunting	SS	Breeding	251.6	32.1	0.0	0.0
Red-winged blackbird	FG	Breeding	110.9	24.9	0.0	0.0
Brown-headed cowbird (*Molothrus ater*)	FG	Breeding	9.6	3.0	0.0	0.0
Orchard oriole	SS	Breeding	33.9	9.3	0.0	0.0
American goldfinch (*Spinus tristis*)	SS	Year-round	46.8	12.5	2.1	2.1

[a] Mean across all years.
[b] FG, facultative grassland;
[c] OG, obligate grassland;
[d] SS, scrub-shrub.

and width in models that included both terms in the interaction. We also considered a constant survival model with no parameters other than the intercept. We evaluated models by using Akaike's Information Criterion adjusted for small sample sizes (AIC*c*), ΔAIC*c* values, and Akaike weights (Burnham and Anderson 2002). We estimated model parameter uncertainty by using model averaged parameter estimates and evaluated the relative importance of predictor variables by summing the Akaike weights across all models in which the variable occurred (Burnham and Anderson 2002). We did not include nests from 1 warm-season grass filter strip in 2005 ($n = 21$ nests) in the analysis because we found a disproportionate number of nests in that filter strip, which had a high influence on model selection results. We calculated nest survival over the entire nesting period (laying, incubation, and nestling stages combined), assuming constant daily survival, by raising the daily survival rate to the power of days in the nesting period (Shaffer and Thompson 2007). We assumed a 24-day nesting period based on estimates of the lengths of the nesting periods for the suite of species we found nesting in filter strips (Poole 2010).

RESULTS

Bird Community and Species' Response

We recorded 64 bird species (53 in the breeding season and 23 in winter) in filter strips, including 26 grassland or scrub-shrub species (Table 2). Red-winged blackbirds, indigo buntings (*Passerina cyanea*), and common yellowthroats had the highest breeding bird densities in filter strips, and song sparrows (*Melospiza melodia*), white-throated sparrows (*Zonotrichia albicollis*), and dark-eyed juncos (*Junco hyemalis*) had the highest wintering bird densities in filter strips. Every breeding and wintering bird community metric was greater in filter strips than in non-buffered field edges (Table 3). Scrub-shrub bird density and TACV in the breeding season were 5.6 and 5.4 times greater in filter strips than in non-buffered field edges, respectively.

We found no differences among the 5 bird community metrics between cool-season and warm-season grass filter strips in either season. Common yellowthroat density was 2.9 times greater in warm-season grass filter strips ($\bar{x} = 0.9$ birds/ha, CL = 0.5–1.4 birds/ha) than in cool-season grass filter strips ($\bar{x} = 0.3$ birds/ha, CL = 0.0–0.8 birds/ha; $F_{1,61} = 8.21$, $P = 0.006$) in the breeding season, but we detected no other differences in species' densities between cool-season and warm-season grass filter strips.

We analyzed the relationship between breeding bird community metrics and percent cover of 4 commonly planted and relatively abundant grass species in 2005 and 2006. These included 2 cool-season grasses (fescue spp. [2005: $\bar{x} = 7.4\%$, SD = 10.6%; 2006: $\bar{x} = 6.5\%$, SD = 10.9%] and orchardgrass [2005: $\bar{x} = 13.0\%$, SD = 21.4%; 2006: $\bar{x} = 9.2\%$, SD = 19.7%]) and 2 warm-season grasses (big bluestem [2005: $\bar{x} = 6.9\%$, SD = 13.1%; 2006: $\bar{x} = 13.3\%$, SD = 22.4%] and switchgrass [2005: $\bar{x} = 6.0\%$, SD = 17.1%; 2006: $\bar{x} = 0.5\%$, SD = 1.7%]).

Table 3. Least squares means and 95% confidence limits of bird community metrics in filter strips and non-buffered field edges on the Eastern Shore of Maryland, USA, in the breeding season of 2005 and winters of 2005 and 2007.[a]

Season	Filter strips		Non-buffered field edges		
Bird community metric	$\bar{x}$	CL	$\bar{x}$	CL	F
Breeding season[b]					
Total bird density[c]	6.4	4.8–8.5	1.2	0.5–2.3	27.39***
Species richness[d]	4.6	3.9–5.3	1.9	0.8–3.0	17.89***
Grassland bird density[c]	1.9	1.3–2.7	0.2	−0.2–0.7	17.14***
Scrub-shrub bird density	3.9	2.8–5.3	0.7	0.2–1.5	19.94***
Total avian conservation value[c]	13.5	10.5–17.2	2.5	0.7–5.0	28.25***
Winter[e]					
Total bird density[c]	3.6	1.9–6.3	0.6	−0.1–2.0	8.9**
Species richness[d]	1.6	1.2–2.0	0.2	−0.2–0.7	21.47***
Grassland bird density[f]					
Scrub-shrub bird density[c]	2.9	1.6–4.7	0.2	−0.3–1.1	14.73***
Total avian conservation value[c]	6.0	3.1–10.8	0.8	−0.1–2.8	10.06**

** $P < 0.01$.
*** $P < 0.001$.
[a] All density metrics are in units of birds/ha. We used length of edge as a covariate in all analyses because edge length was significantly different between treatments.
[b] Analysis of variance (df = 1, 48) with treatment type as a fixed effect.
[c] We present geometric means and CLs after back-transformation.
[d] We used site area as a covariate in the analysis to account for species-area effects.
[e] Mixed-model analysis of variance (ANOVA; df = 1, 46) with treatment type as a fixed effect and yr and site (nested within treatment) as random effects.
[f] We could not transform data to meet ANOVA assumptions. A Kruskal–Wallis test indicated that grassland bird density was greater in filter strips compared to non-buffered field edges ($\chi^2_1 = 3.98$, $P = 0.046$).

Percent cover of orchardgrass was negatively related to total bird density, species richness, grassland bird density, and TACV in 2005 and was negatively related to grassland bird density in 2006 (Table 4).

Breeding bird density was greater closer to the wooded edge of filter strips (Fig. 1), resulting in total bird density being greater in narrow filter strips than in wide filter strips (Table 5). Total avian conservation value was 1.8 times greater in narrow filter strips than in wide filter strips. Density of indigo buntings was 6.0 times greater in narrow filter strips ($\bar{x} = 4.1$ birds/ha, CL = 3.3–4.9 birds/ha) than in wide filter strips ($\bar{x} = 0.7$ birds/ha, CL = −0.3–1.7 birds/ha; $t_{61} = 5.31$, $P \leq 0.001$). Grasshopper sparrow and red-winged blackbird densities were greater in wide filter strips than in narrow filter strips (grasshopper sparrow: $\chi^2_1 = 16.6$, $P \leq 0.001$; red-winged blackbird [narrow: $\bar{x} = 0.2$ birds/ha, CL = 0.0–0.6 birds/ha; wide: $\bar{x} = 1.0$ birds/ha, CL = 0.5–1.7 birds/ha; $t_{61} = 2.64$; $P = 0.010$]). We observed 90% of grasshopper sparrows in wide filter strips and >60 m away from the wooded edge.

In winter, several bird community metrics were greater in wide filter strips compared to narrower filter strips (Table 5). Total bird density and species richness were 7.1 and 3.5 times greater in wide filter strips than in medium width filter strips, respectively. Densities of field sparrow, savannah sparrow, and swamp sparrow (*Melospiza georgiana*) were greater in wide filter strips than in narrow filter strips (field sparrow: $\chi^2_1 = 12.23$, $P \leq 0.001$; savannah sparrow: $\chi^2_1 = 15.33$, $P \leq 0.001$; swamp sparrow: $\chi^2_1 = 4.15$, $P = 0.042$) and medium width filter strips (field sparrow: $\chi^2_1 = 7.59$,

Table 4. Test statistics from simple linear regressions of breeding bird community metrics on the percent cover of 4 commonly planted grass species in filter strips on the Eastern Shore of Maryland, USA, from 2005 to 2006.

	Cool-season grasses				Warm-season grasses			
Yr	Fescue spp.		Orchardgrass		Big bluestem		Switchgrass	
Bird community metric	t	P	t	P	t	P	t	P
2005[a]								
Total bird density	−0.02	0.938	−2.61	0.013	−0.15	0.878	0.13	0.896
Species richness[b]	0.20	0.842	−2.3	0.028	0.61	0.543	−0.61	0.544
Grassland bird density	−0.27	0.792	−3.26	0.003	0.35	0.728	0.24	0.812
Scrub-shrub bird density	−0.88	0.386	−1.8	0.081	−0.29	0.776	0.51	0.614
Total avian conservation value	0.01	0.992	−2.87	0.007	−0.16	0.872	0.12	0.908
2006[a]								
Total bird density	0.92	0.370	−1.48	0.154	−0.43	0.674	−0.43	0.674
Species richness[b]	1.62	0.122	−2.08	0.051	−0.65	0.524	0.27	0.789
Grassland bird density	1.36	0.190	−2.22	0.038	−0.48	0.636	0.58	0.571
Scrub-shrub bird density	1.09	0.289	−1.16	0.259	−1.09	0.287	−0.28	0.783
Total avian conservation value	0.99	0.336	−1.93	0.067	−0.44	0.667	−0.21	0.840

[a] Df = 1, 34 in 2005; df = 1, 20 in 2006.
[b] We used study site area as a covariate in the regression analysis of species richness.

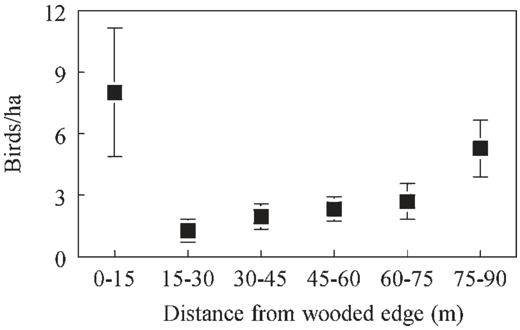

Figure 1. Total breeding bird density (mean across years ± SE), by distance from the wooded edge, in filter strips >90 m wide on the Eastern Shore of Maryland, USA, from 2004 to 2006. The 0–15 m distance category includes birds we observed in branches overhanging filter strips because many birds used the wooded edges as perches.

$P = 0.006$; savannah sparrow: $\chi^2_1 = 7.59$, $P = 0.006$; swamp sparrow: $\chi^2_1 = 3.99$, $P = 0.046$). Song sparrow density was greater in wide compared to medium filter strips ($\chi^2_1 = 5.95$, $P = 0.014$). We observed 76% of savannah sparrows in wide filter strips and >60 m away from the wooded edge.

Nest Density and Nest Survival

We found 82 nests in filter strips in 2005 and 2006, of which 67 were within designated nest searching areas and of 9 different species: common yellowthroat ($n = 8$), field sparrow ($n = 8$), grasshopper sparrow ($n = 1$), song sparrow ($n = 1$), northern cardinal (*Cardinalis cardinalis*; $n = 1$), blue grosbeak (*Passerina caerulea*; $n = 3$), indigo bunting ($n = 22$), red-winged blackbird ($n = 21$), orchard oriole (*Icterus spurious*; $n = 2$). We found no differences in total nest density or scrub-shrub nest density between filter strip grass types or filter strip width classes. Grassland bird nest density was higher in wide, warm-season grass filter strips ($\bar{x} = 2.7$ nests/ha, CL = 1.2–4.8 nests/ha) than in narrow, warm-season grass filter strips ($\bar{x} = 0.1$ nests/ha, CL = −0.1–0.8 nests/ha, $t_{22} = 3.17$, $P = 0.005$), and in narrow ($\bar{x} = 0.2$ nests/ha, CL = −0.1–0.8 nests/ha; $t_{22} = 3.32$, $P = 0.003$) and wide ($\bar{x} = 0.2$ nests/ha, CL = −0.1–1.1 nests/ha, $t_{22} = 3.1$, $P = 0.005$) cool-season grass filter strips.

We evaluated daily nest survival rates in filter strips for 61 nests. None of the candidate models had high Akaike weights (>0.20). The constant survival model was the top ranked model. Four models had only one explanatory variable (filter strip grass type, filter strip width, distance from the nest to the wooded edge, and year) and had ΔAIC_c values <2.0. No explanatory variable was consistently included in the top ranked models. All variables we considered had low relative importance (range: 0.27–0.40). Given these model selection results, we assumed a constant survival model to estimate daily nest survival rate and nest survival over the entire nesting period, for all nesting species combined. Daily nest survival rate was 0.91 (CL = 0.88–0.93) and nest survival for the entire nesting period was 10.7% (CL = 5.1–18.8%).

DISCUSSION

Every bird community metric was substantively greater in filter strips than in non-buffered field edges, indicating that establishment of filter strips has achieved some of the wildlife benefits intended by Maryland's CREP. Our results agree with findings of other studies that compared bird community metrics in herbaceous strip-cover habitats to non-buffered field edges (e.g., Smith et al. 2005; Conover et al. 2007, 2009). In Mississippi, species richness was greater in agricultural fields with herbaceous field borders than in those

Table 5. Least squares means and 95% confidence limits of bird community metrics, by filter strip width class, in filter strips on the Eastern Shore of Maryland, USA, during the breeding seasons of 2004–2006 and the winters of 2005–2007.[a]

Season	Narrow (<30 m)		Medium (30–60 m)		Wide (>60 m)		Narrow vs. medium	Narrow vs. wide	Medium vs. wide
Bird community metric	$\bar{x}$	CL	$\bar{x}$	CL	$\bar{x}$	CL	P	P	P
Breeding season[b]									
Total bird density	11.2	6.5–15.8	7.6	2.0–13.2	5.6	0.5–10.6	0.099	0.002	0.377
Species richness[c]	4.5	2.4–6.5	4.4	2.1–6.8	3.2	0.9–5.5	0.971	0.226	0.250
Grassland bird density[d]	1.8	0.9–3.1	2.4	1.0–4.8	2.0	0.9–3.6	0.471	0.781	0.648
Scrub-shrub bird density[d]	5.9	3.5–9.7	4.0	1.9–7.7	2.0	0.9–3.8	0.162	<0.001	0.039
Total avian conservation value	21.8	12.8–30.9	15.6	4.5–26.7	11.6	1.8–21.4	0.165	0.007	0.413
Winter[e]									
Total bird density[d]	4.9	2.4–9.2	1.3	−0.1–4.5	9.1	3.0–24.5	0.051	0.292	0.019
Species richness[c]	1.5	1.0–2.0	0.8	0.0–1.6	2.8	1.9–3.7	0.126	0.023	0.002
Grassland bird density[f]									
Scrub-shrub bird density[d]	3.4	1.6–6.4	1.1	−0.1–3.9	3.8	1.0–10.3	0.104	0.854	0.153
Total avian conservation value[d]	8.7	3.8–16.9	2.0	0.0–7.5	18.7	5.6–58.1	0.050	0.208	0.012

[a] All density metrics are in units of birds/ha.
[b] Mixed-model analysis of variance (ANOVA; df = 2, 61) with grass type and filter strip width class as fixed factors and yr and site (nested within treatment factors) as random effects.
[c] We used site area as a covariate in the analysis to account for species-area effects.
[d] We present geometric means and CLs after back-transformation.
[e] Mixed-model ANOVA (df = 2, 37) with filter strip width class as a fixed factor and yr and site (nested within filter strip width class) as random effects.
[f] We could not transform data to meet ANOVA assumptions. Kruskal–Wallis tests indicated that grassland bird density in winter was not different between narrow and medium width filter strips ($\chi^2_1 = 0.73$, $P = 0.394$) but was greater in wide compared to narrow ($\chi^2_1 = 10.56$, $P = 0.001$) and medium width ($\chi^2_1 = 8.70$, $P = 0.003$) filter strips.

without field borders during the breeding season (Smith et al. 2005). In the Mississippi Alluvial Valley, total bird abundance, species richness, and TACV were greater in field borders than in non-bordered field margins in winter, particularly in field borders >30 m wide (Conover et al. 2007).

We recorded 53 breeding bird species using filter strips in Maryland, which is more than other studies of breeding bird use in herbaceous strip-cover habitats (Best 2000, Kammin 2003, Davros 2005). We counted birds in overhanging tree branches along the wooded edge because many species use tree branches as perches. In most other studies birds were recorded only if they were seen in the strip. Furthermore, some studies of birds in herbaceous strip-cover habitat were conducted in more open agricultural landscapes containing fewer bird species associated with forested and transitional habitats.

Our finding that most bird community metrics did not differ between cool-season and warm-season grass filter strips is similar to other studies conducted in grassland habitats. In a study of CRP fields in Nebraska, Delisle and Savidge (1997) did not find differences in total bird abundance between cool-season grass fields and warm-season grass fields. Henningsen and Best (2005) found relative bird abundance and relative nest abundance to be similar between cool-season and warm-season grass filter strips in Iowa. Both cool-season and warm-season grasses can provide habitat for breeding and wintering birds, and bird response varies depending on vegetative diversity and habitat structure (McCoy et al. 2001).

We found a negative relationship with most bird community metrics and the percent cover of orchardgrass. Orchardgrass is non-native, is highly competitive and can often dominate other grasses and forbs (Grime 1973), and its wildlife value is very low (Harper et al. 2007). Some grassland birds prefer less dense and more diverse grassland plantings over single-species monocultures (e.g., Whitmore 1981, McCoy et al. 2001, Gill et al. 2006). Filter strips dominated by orchardgrass may lack the openness and plant diversity necessary to attract early-successional birds. Light discing could improve habitat for early-successional birds, such as northern bobwhite, by encouraging more bare ground and forbs and decreasing litter and grass cover (Greenfield et al. 2002). However, because a primary purpose of filter strips is to remove non-point source pollutants from agricultural runoff, opening filter strip vegetation to increase bird habitat value must be balanced with the need for maintaining the ability of filter strip vegetation to filter runoff from agricultural fields.

We used bird densities as measures of habitat quality because although abundance will tend to increase as the area of habitat increases (Stauffer and Best 1980, Davros 2005), bird density measures the relative number of birds in areas of different size. We found that total bird density, scrub-shrub bird density, and TACV in the breeding season decreased with increasing filter strip width because most breeding birds were near the wooded edge regardless of the filter strip width. In contrast, several bird community metrics and species-specific densities in winter were greater in wide filter strips compared to narrower filter strips.

Grasshopper sparrows and savannah sparrows were the only obligate grassland bird species observed in filter strips. Densities of grasshopper sparrows in the breeding season and savannah sparrows in winter were greater in wide filter strips, and most individuals were >60 m from the wooded edge, which is not surprising considering that obligate grassland birds exhibit area sensitivity (Ribic et al. 2009) and prefer large areas farther from wooded edges (Helzer and Jelinski 1999). Grassland bird nest density was also greater in wide, warm-season grass filter strips, suggesting that filter strips adjacent to wooded edges and >60 m wide provide better habitat for grassland birds, particularly obligate grassland species, than filter strips <60 m wide. However, wide filter strips adjacent to wooded edges may still be too narrow to provide adequate habitat for a diverse community of grassland birds that require abundant grassland interior areas (Helzer and Jelinski 1999). Although some small grassland patches are important for grassland birds (Ribic et al. 2009), large blocks of early-successional habitat may be necessary to maintain populations of grassland and shrubland birds adversely affected by fragmentation (Askins 1993).

High bird density and species richness does not necessarily indicate high-quality habitat for birds (Van Horne 1983). Although bird abundance and nest densities in herbaceous strip-cover habitats are generally much greater than in CRP fields, nest survival is generally lower in strip-cover habitats than in CRP fields with comparable vegetation (Best 2000). We estimate that for the suite of species we found nesting in filter strips, nest survival over the entire nesting period was 10.7%. Other studies have found similarly low nest survival in herbaceous strip-cover habitats (Bryan and Best 1994, Kammin 2003, Knoot 2004, Henningsen and Best 2005) compared to CRP fields (e.g., McCoy et al. 1999, 2001). For example, Henningsen and Best (2005) reported that nest survival of common yellowthroats and song sparrows in filter strips adjacent to woody vegetation was 5.4% and 7.5%, respectively. Bryan and Best (1994) reported that nest survival of red-winged blackbirds was 8.4% in grassed waterways. Predation is the most significant reason for nest failure in herbaceous strip-cover habitats (Bryan and Best 1994, Kammin 2003, Davros 2005, Henningsen and Best 2005). These results have raised concern that filter strips act as reproductive sinks for birds. We did not attempt to determine if filter strips were sources or sinks but rather sought to understand how nest survival was related to filter strip characteristics. None of the variables we included in our candidate models were strongly related to daily nest survival, which may be due to the lower number of nests we found compared to other studies of nest survival in filter strips (Kammin 2003, Davros 2005, Henningsen and Best 2005).

MANAGEMENT IMPLICATIONS

State and federal conservation agencies should continue to encourage landowners to install filter strips to provide better bird habitat than non-buffered field edges in agricultural landscapes. Wide filter strips >60 m along wooded edges will likely be better habitat for grassland birds, particularly obligate grassland species. Increasing filter strip length can provide additional habitat for many bird species and may be more feasible in working agricultural landscapes. We found a negative relationship between the percent cover of orchardgrass and most bird community metrics. Given that orchardgrass is non-native, highly competitive, and of low value to wildlife, we recommend against planting orchardgrass in filter strips and reducing or eliminating orchardgrass from filter strips through management practices.

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