

Conservation reserve enhancement program fields: Benefits for grassland and shrub-scrub species

K.L. Wentworth, M.C. Brittingham, and A.M. Wilson

Abstract: Almost 30,000 ha (74,100 ac) of grassland were created in south-central Pennsylvania through the USDA Conservation Reserve Enhancement Program (CREP) from 2000 to 2004. To assess the use of these fields by grassland and other birds and to develop region-specific management guidelines, we conducted transect counts of singing birds in 103 CREP fields during 2002 to 2004 and measured within-field vegetation and landscape characteristics. Thirty-two bird species were found on fields during the breeding season. Red-winged blackbirds (*Agelaius phoeniceus*) were most numerous, followed by three shrub-scrub species. Grassland obligate species were rare and were most abundant on larger fields with a lower density of vegetation and a predominance of cool-season grasses. Abundances of shrub-scrub species were highest on smaller fields with a higher density of vegetation and a higher proportion of warm-season grasses. Avian use of CREP fields in Pennsylvania differs from Midwestern Conservation Reserve Program fields in a number of important ways. Shrub-scrub species were more common, which may be due to the small mean field size and the more forested landscape. In addition, grassland obligates were found in greater densities on fields of cool-season grasses than in fields of warm-season or mixed grasses. Targeted enrollment and management of large fields or those adjoining other grasslands for grassland birds and small fields or those adjoining woodlands for shrub-scrub species may be the best approach to maximize the benefits of CREP for a range of bird species.

Key words: Conservation Reserve Enhancement Program (CREP)—cool-season grass—grassland birds—Pennsylvania—shrub-scrub birds—warm-season grass

Assessing the effects of the Conservation Reserve Enhancement Program (CREP) on grassland and shrubland birds nationally is critical to understanding regional differences in program benefits and developing region-specific guidelines.

The Conservation Reserve Enhancement Program is a federally funded program of the USDA that offers farmers the opportunity to take highly erodible and environmentally sensitive land out of production, with the aim of improving water quality and reducing soil erosion. An additional goal is to restore and enhance wildlife populations by providing quality habitat for grassland and other farmland wildlife (USDA FSA 2008).

Species associated with grassland and old field and early successional shrub-scrub habitats are among the Partners in Flight priority species for the Ridge and Valley and Mid-

Atlantic Piedmont physiographic regions in which south-central Pennsylvania is located (Rich et al. 2004). Grassland birds have experienced widespread declines throughout the midwestern (Midwest) and eastern United States (Robbins et al. 1986; Askins 1993) and have declined more rapidly since the mid-1960s than any other group of birds (Knopf 1994; Herkert 1995). In Pennsylvania, species such as grasshopper sparrow (*Ammodramus saviannarum*), vesper sparrow (*Pooecetes gramineus*), eastern meadowlark (*Sturnella magna*), northern bobwhite (*Colinus virginianus*), and ring necked pheasant (*Phasianus colchicus*) have declined by 80% or more since the mid-1960s (Sauer et al. 2005). Other species associated with farmland, scrub, and old fields have also suffered significant declines over the same period, including field sparrow (*Spiza pusilla*), song sparrow (*Melospiza*

melodia) and indigo bunting (*Passerina cyanea*) (Sauer et al. 2008). Declines have been attributed to habitat loss and changes on both breeding grounds (Samson and Knopf 1994) and wintering grounds (Fretwell 1986).

Between 2000 and 2004, almost 30,000 ha (74,100 ac) of grassland were created in 20 counties of south-central Pennsylvania through CREP (USDA 2006). Although similar to the Conservation Reserve Program (CRP) in terms of habitat created, the incentives for farmers to participate are greater in the CREP program. Consequently, CREP has provided new habitat in many parts of Pennsylvania where enrollment in the original CRP was low (Lubowski et al. 2006). To maximize the wildlife conservation potential of CREP, it is important to identify the within-field vegetation and surrounding landscape characteristics that are most likely to result in CREP fields being used by targeted groups of birds, particularly those showing population declines. Studies of birds in both grassland and forested habitats have shown that avian use varies with both local and landscape features (Askins 1993; McGarigal and Marks 1995; Donovan et al. 1997; Best et al. 2001).

The majority of research on the effects of CRP practices on bird populations has been conducted in the Midwest (e.g., King and Savidge 1995; Best et al. 1997; Horn 2000), and may not be directly applicable to the eastern United States where field size is smaller and the primary land cover is forest. Consequently, it is important to understand how birds respond to new grassland habitats in a primarily forested state such as Pennsylvania. The objectives of this study were to identify bird species that regularly use CREP fields within Pennsylvania and the local and landscape features that affect bird abundance.

Materials and Methods

Study Area. In 2000, 20 Pennsylvania counties within the Chesapeake Bay Watershed (the Lower Susquehanna River Basin CREP) were identified for the initial enrollment period. Surveys were conducted in 10 of the 20 counties (figure 1). The 10

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counties were selected to provide a representative cross-section of landscapes, from low (<33%), through medium (34% to 66%) to high (≥67%) forest cover, as estimated from vegetation cover maps produced from satellite and aerial photographs (Myers et al. 2000). In 2002 to 2003, we selected fields from six counties (some counties were used more than one year). Within each county, we randomly selected three fields from each of three size categories: <5.0 ha (<12.35 ac) (small), 7.5 to 12 ha (18.52 to 29.64 ac) (medium), and ≥16 ha (≥39.52 ac) (large). This potentially gave us a total of nine fields per county and 18 fields per size category per year. However, we lost some fields because of changes in the status of fields (e.g., some dropped out of CREP), incorrect information (e.g., fields not actually being of the area indicated), inability to get permission, and logistical constraints. In 2004, we resurveyed 23 fields surveyed in either 2002 or 2003 and randomly selected an additional 18 fields (six from each size category). For fields that were surveyed more than once, we randomly selected one year of survey data to include in the analyses. For all years combined, we sampled 103 fields ranging in size from 1.9 to 43.3 ha (4.7 to 106.9 ac) (mean 10.8 ha ± 0.82 standard error [26.7 ± 2.03 ac]) (table 1). We selected fields based on the size category to ensure coverage across the range of available field sizes. However, we used the actual field size and not the size category in our analyses.

We limited CREP fields selected for inclusion to conservation practices that were grass dominated: CP1 (cool-season grass), CP2 (warm-season grass), CP10 (grass cover already established), or a mixture of the three. Grass filter strips (CP21) were included when they were combined in the same field with one of the other grass-dominated conservation practices. Fields that were not already under permanent grass cover were sown with a grass, either warm-season, such as big bluestem (*Andropogon gerardi*) or switchgrass (*Panicum virgatum*), or cool-season, such as tall fescue (*Festuca arundinacea*), orchard grass (*Dactylis glomerata*), or smooth brome (*Bromus inermis*), and a legume, for example red clover (*Trifolium pretense*), or a wildflower mixture. Other vegetation that commonly invaded the fields included goldenrod (*Solidago spp.*), milkweed (*Asclepias spp.*), thistle (*Cirsium spp.*), daisy fleabane (*Erigeron annuus*), sweet clover (*Melilotus spp.*), multiflora rose (*Rosa*

Figure 1
Number and location of Conservation Reserve Enhancement Program (CREP) fields surveyed within 10 counties of south-central Pennsylvania, 2002 to 2004.

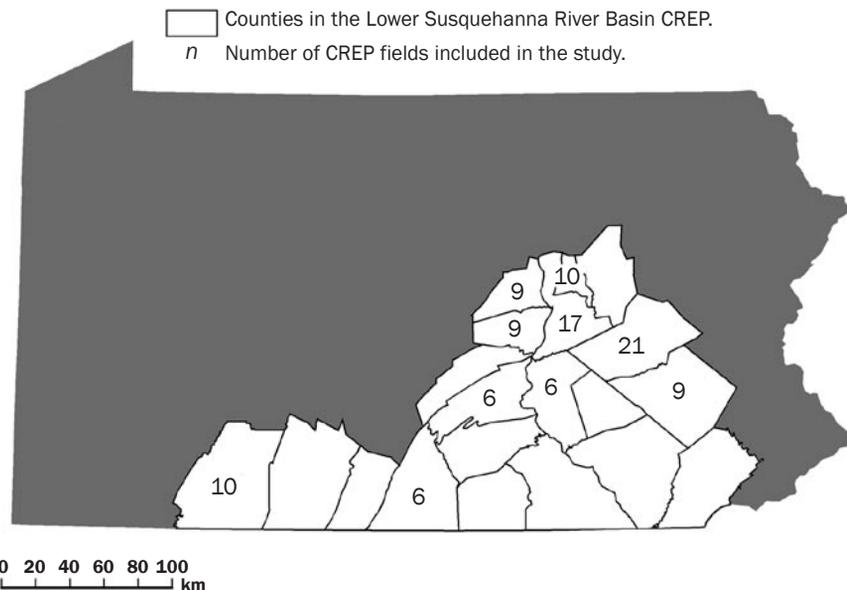


Table 1
Conservation Reserve Enhancement Program fields in which bird surveys were conducted in south-central Pennsylvania, 2002 to 2004, by survey year and field size.

Year	Field size			Total
	Small (<5.0 ha)	Medium (7.5 to 12.0 ha)	Large (16.0 to 43.3 ha)	
2002	14	14	14	42
2003	15	15	9	39
2004	8	7	7	22
Total	37	36	30	103

multiflora), and blackberry (*Rubus spp.*). Many of the CREP fields were surveyed just one or two years after being seeded with grass/legume mixes, and as such were still in the grassland-establishment phase. Indeed, we found that some fields sown with CP2 warm-season grasses were dominated by cool-season grass or other vegetation cover types. Comparison between vegetation types reflects what was in the field at the time of the surveys, not what was sown.

Bird Surveys. We surveyed birds from late May through mid-July in 2002 to 2004. We estimated the number of singing or territorial males within each field. Females and unsexed birds were not counted. Two observers conducted the bird surveys each year. We established transects 100 m (32.8 ft) from an edge and then repeated at intervals of 250 m (820 ft) until the field was covered. A total

of 49,760 m (163,213 ft) of transects were surveyed within the sample of 103 CREP fields, with a mean of 483 m (1,584 ft) per field (range 75 to 1,586 m [246 to 5,202 ft]). To include both early breeders and late-breeding neotropical migrants, each field was surveyed twice, first from late May to mid-June and second from late June to mid-July. Some resident species were likely to have been under-detected by our surveys, notably the ring-necked pheasant, which is much less vocal in late spring than in early spring. The distance from the observer to each singing male was recorded, along with the bearing in respect to the transect line. Surveys were conducted from sunrise to three hours after sunrise and not when it was raining, foggy, or when the winds were greater than 16 km h⁻¹ (9.9 mi h⁻¹). We used distance-sampling techniques to correct for different detection

Table 2

Within-field and surrounding landscape characteristics of 103 Conservation Reserve Enhancement Program fields surveyed in south-central Pennsylvania, 2002 to 2004. Fields were sampled twice (May to early June, and June to early July) at six equally spaced points along the bird survey transects (one to four transects per field).

Measurement	Description	Mean	se
Year	Year of survey 2002 to 2004		
Within-field characteristics			
Area	Field size (ha)	10.8	0.82
Field age	Growing seasons between planting and bird surveys	1.83	0.18
Height (mean)		56.8	2.67
First survey	Vegetation height (cm) during late May to early June	51.0	2.75
Second survey	Vegetation height (cm) during late June to mid-early July	62.6	3.09
Density (mean)	Vegetation density (cm)	47.1	2.10
Density (CV)	Variation in vegetation density	0.52	0.032
Percent cover of			
Forbs	Broad-leaved plants	45.1	2.34
Cool grass	Cool-season grasses	28.8	1.94
Warm grass	Warm-season grasses	4.3	1.10
All grasses	Cool and warm-season grasses	33.1	1.80
Downed litter	Decaying litter on ground	11.6	0.82
Standing litter	Dead stems still standing	1.9	0.43
Woody	Woody vegetation	1.4	0.37
Bare ground	Bare ground	6.8	0.69
Vegetation heterogeneity	Shannon equitability index of the seven vegetation cover types (all grasses is excluded) listed above	0.631	0.019
Grass type	Proportion of grasses that are cool season (0 to 1)	0.877	0.029
Landscape characteristics within 0.5 km radius			
Forest area	Percent land cover forested	29.6	2.13
Grassland area	Percent land cover in grass fields	20.5	1.03
Row crop area	Percent land cover in row crops	47.6	1.84
Landscape characteristics within 5 km radius			
Forest area	Percent land cover forested	41.5	1.71
Grassland area	Percent land cover in grass fields	16.3	0.60
Row crop area	Percent land cover in row crops	37.1	1.30

Notes: se = standard error. CV = coefficient of variation.

probabilities among species (Buckland et al. 2001).

Field Vegetation Measurement. We sampled field vegetation (table 2) at six equally spaced points along the already established bird survey transects on each field. Vegetation sampling was conducted following each field bird survey; hence vegetation was measured during late May to early June and again in late June to mid-July. A cut-off date of May 31 was used to define the number of growing seasons since planting; there was sufficient time after that date to vegetate new plantings before the following calendar year. All fields had one or more growing seasons by the time the bird surveys were conducted.

At each point, we measured vegetation density using a Robel pole (Robel et al. 1970). We used a 0.5 m² (1.6 ft²) Daubenmire

frame (Daubenmire 1959) to measure vegetation cover centered on the point. We estimated the percent cover (nonoverlapping) of warm-season grass, cool-season grass, downed litter (decaying litter on the ground), standing litter (dead stems that are still standing), woody vegetation, forbs, and bare ground. Woody vegetation consisted of low shrubs only; there were no shrubs higher than 2 m (6.6 ft) in our study fields. We measured the height of vegetation and litter depth in the center of the Daubenmire frame to the nearest 1 cm (0.39 in). We used the coefficient of variation for vegetation density as a measure of structural heterogeneity of within-field vegetation. We used the Shannon equitability index (Peet 1974) as a measurement of heterogeneity of the seven vegetation cover types. Field measurements (with the exception of vegetation

height) were averaged over the two surveys and across all points for each field.

Vegetation height in centimeters (0 ± se) differed significantly (paired *t*-test; *t* = 4.81, *p* < 0.0001) between the first (51.0 ± 2.75 [20.1 ± 1.1 in]) and second (62.6 ± 3.09 [24.7 ± 1.2 in]) surveys and thus was kept as separate variables within our models. No other vegetation variable differed significantly (paired *t*-test) between the two surveys.

Measurement of Landscape Characteristics. We calculated land cover characteristics from the GAP analysis (a landscape level analysis of habitat for wildlife) of Pennsylvania (Myers et al. 2000). We established radii at distances of 0.5 km (0.31 mi) and 5 km (3.1 mi) around each field using ARCVIEW 3.4 (Environmental Systems Research Institute) to calculate the landscape statistics (table 2).

The radii were established from the edge of the field to remove the field from the analysis because field area and within-field vegetation characteristics were already measured. The total area included within the radii was different for each field area, but all landscape statistics were calculated as proportions of the total area to allow comparisons. In order to simplify our interpretation, we restricted our analysis to percent land cover in grassland, forest, and row crops.

Analytical Methods. We used Program DISTANCE 3.5 (Thomas et al. 1998) to calculate the density of each bird species for which we had ≥ 25 observations of singing males across the whole sample of 103 fields. We right-truncated data at 100 m (328 ft) from the transect to reduce the likelihood of double-counting birds between transects and to ensure that birds outside of the CREP fields were excluded. We calculated densities for seven species: common yellowthroat (*Geothlypis trichas*), field sparrow, grasshopper sparrow, song sparrow, indigo bunting, bobolink, and red-winged blackbird (*Agelaius phoeniceus*). Note that the number of detections for common yellowthroat and bobolink were lower than the suggested minimum of 60 (Buckland et al. 2001) so some caution should be used when interpreting these results. Additionally, we calculated species guild densities for grassland obligates (eight species) and shrub-scrub (seven species) (table 3) (Sauer et al. 2008). The red-winged blackbird was not included in either of these species guilds.

To select the most parsimonious model of detection probabilities generated in DISTANCE 3.5 (Thomas et al. 1998), we used Akaike's Information Criterion (AIC) (Akaike 1973; Buckland et al. 2001). We then used the resulting estimate of detection probability (p) for each species to estimate densities per field as follows:

$$\frac{n \times (1/p)}{(L \times 200)/10,000} = \text{singing males ha}^{-1}, (1)$$

where n is the maximum number of birds seen in the field during either survey and L is the total length of transects in the field in meters (Buckland et al. 2001).

We used Generalized Linear Models (GLMs) to assess the influence of within-field vegetation characteristics and landscape characteristics at two scales (within 0.5 km [0.311

Table 3
Total bird counts* and field occupancy in 103 Conservation Reserve Enhancement Program fields in south-central Pennsylvania. Each field was surveyed on two occasions between late May and mid-July of 2002, 2003, or 2004.

Species	Scientific name	Total count*	CREP fields occupied (%)	Species guild†
Mallard	<i>Anas platyrhynchos</i>	1	1.0	
Ring-necked pheasant	<i>Phasianus colchicus</i>	1	1.0	G
Wild turkey	<i>Meleagris gallopavo</i>	4	1.9	
Red-tailed hawk	<i>Buteo jamaicensis</i>	1	1.0	
American kestrel	<i>Falco sparverius</i>	1	1.0	
Wilson's snipe	<i>Gallinago delicata</i>	1	1.0	
Northern flicker	<i>Colaptes auratus</i>	1	1.0	
Willow flycatcher	<i>Empidonax traillii</i>	1	1.0	
Eastern phoebe	<i>Sayornis phoebe</i>	1	1.0	
Eastern kingbird	<i>Tyrannus tyrannus</i>	2	1.9	
Gray catbird	<i>Dumetella carolinensis</i>	1	1.0	S
Northern mockingbird	<i>Mimus polyglottos</i>	1	1.0	
Yellow warbler	<i>Dendroica petechia</i>	4	3.9	S
Common yellowthroat	<i>Geothlypis trichas</i>	27	17.5	S
Scarlet tanager	<i>Piranga olivacea</i>	1	1.0	
Chipping sparrow	<i>Spizella passerina</i>	8	4.9	
Field sparrow	<i>Spizella pusilla</i>	62	35.0	S
Vesper sparrow	<i>Poocetes gramineus</i>	8	5.8	G
Savannah sparrow	<i>Passerculus sandwichensis</i>	14	7.8	G
Henslow's sparrow	<i>Ammodramus henslowii</i>	1	1.0	G
Grasshopper sparrow	<i>Ammodramus savannarum</i>	56	27.2	G
Song sparrow	<i>Melospiza melodia</i>	205	77.7	S
Blue grosbeak	<i>Passerina caerulea</i>	2	1.0	
Indigo bunting	<i>Passerina cyanea</i>	79	45.6	S
Dickcissel	<i>Spiza americana</i>	2	1.9	G
Bobolink	<i>Dolichonyx oryzivorus</i>	25	3.9	G
Red-winged blackbird	<i>Agelaius phoeniceus</i>	522	71.8	
Eastern meadowlark	<i>Sturnella magna</i>	21	16.5	G
Common grackle	<i>Quiscalus quiscula</i>	1	1.0	
Brown-headed cowbird	<i>Molothrus ater</i>	4	3.9	
Baltimore oriole	<i>Icterus galbula</i>	1	1.0	
American goldfinch	<i>Carduelis tristis</i>	5	4.9	S

* The total count is the sum of the greater of the two counts for each field.

† S = shrub-scrub species guild. G = grassland obligates species guild (Sauer et al. 2008). These were the only guilds relevant to this study. A blank indicates that the species was not in either of these guilds.

mi] and within 5 km [3.11 mi]) on bird density and species richness. We included survey year as a variable in the models to account for potential differences due to annual variation. Percentage forb cover was omitted from the models because its inclusion would violate the unit-sum constraint; that is, the percentage of the vegetation cover types would always sum to 100%, and therefore, would not be independent of each other. Percentage forb was chosen as the category to omit because it showed the least overall

variation (as measured by the coefficient of variation) among fields.

We modeled density per CREP field using an estimate of the population of singing males per field (estimated by multiplying the density estimate by field area for each CREP field) with field area as an offset, to correct for field size. We used the step AIC function of the MASS library in Program R 1.8.1 (R Development Core Team) to identify the most parsimonious model (lowest AIC). The step AIC procedure uses forwards and backwards elimination to reduce the "full" model

Table 4

Estimated densities of singing male birds in Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2002 to 2004. Mean density is the weighted mean across all fields. Density per field is not weighted by field size.

Species or guild*	n†	Mean density (singing males ha ⁻¹)	Density per field (singing males ha ⁻¹)		Detection probability‡ (95% CI)
			Mean (se)	Maximum	
Common yellowthroat	27	0.06	0.09 (0.03)	2.72	0.33 (0.20 to 0.54)
Field sparrow	77	0.11	0.10 (0.02)	0.94	0.51 (0.44 to 0.61)
Grasshopper sparrow	71	0.12	0.12 (0.03)	1.29	0.46 (0.34 to 0.62)
Song sparrow	275	0.43	0.48 (0.05)	2.84	0.47 (0.40 to 0.54)
Indigo bunting	84	0.12	0.13 (0.02)	1.34	0.68 (0.43 to 0.88)
Bobolink	39	0.06	0.09 (0.05)	4.27	0.56 (0.48 to 0.66)
Red-winged blackbird	747	0.73	0.67 (0.07)	2.75	0.65 (0.61 to 0.69)
Grassland obligates*	149	0.25	0.28 (0.07)	4.98	0.48 (0.39 to 0.59)
Shrub-scrub species guild*	471	0.67	0.73 (0.07)	3.87	0.52 (0.46 to 0.59)

Notes: se = standard error. CI = confidence interval.

* See table 3 for a list of species within each guild.

† Sample size (n) is the sum of all detections of singing males across both survey visits within 100 m of the transect lines.

‡ Detection probabilities with 95% confidence intervals estimated using Program DISTANCE.

to a final model, with only key parameters retained. This stepwise method is particularly useful for analyzing data such as ours where variables show a high degree of collinearity (Chiulli 1999). We fitted multivariate models with both Poisson and negative binomial error distributions. The model with the lowest AIC of the two was chosen as our final model. Choosing the error distribution that best fit our data gave more confidence in the validity of the final model. We based our assessment of model goodness-of-fit on the dispersion parameter (\hat{c}), which is the model residual deviance (D) divided by the degrees of freedom (df), which should be close to 1 (McCullagh and Nelder 1989).

Post-Hoc Analysis. The GLMs suggested some interesting associations between bird species guilds and grassland types. To further elucidate why these patterns emerged, differences between vegetation structure and composition between cool-season (>98% of grass cool-season) and warm-season/mixed grass CREP fields were examined using *t*-tests with a False Discovery Rate to control for multiple comparisons (BenJamini and Hochberg 1995). We used a Wilcoxon paired-sample test to test whether species within the grassland obligate guild were more likely to be present on cool-season than warm-season mixed fields (Zar 1984).

Results and Discussion

Bird Community in Conservation Reserve Enhancement Program Fields. A total of 32 species was observed using the 103 CREP fields (table 3). The red-winged blackbird

was the most numerous species, accounting for 49% of all bird encounters, with an overall mean density of 0.73 singing males ha⁻¹ (0.29 ac⁻¹) (table 4). Three of the next four most-abundant species were shrub-scrub species: song sparrow, indigo bunting, and field sparrow. The song sparrow was the most widespread species, found in 77.7% of fields surveyed. Grassland obligates were not numerous, but vesper sparrows, savannah sparrows, grasshopper sparrows, bobolinks, and eastern meadowlarks were all found in several CREP fields (table 3). The grasshopper sparrow was the most numerous and widespread of these, with an estimated mean density of 0.12 singing males ha⁻¹ (0.048 ac⁻¹) (table 4) and an occupancy of 27.2% of fields (table 3). The overall density of shrub-scrub species was 0.67 singing males ha⁻¹ (0.27 ac⁻¹) compared with 0.25 singing male grassland obligates ha⁻¹ (0.10 ac⁻¹) (table 4).

Correlatives of Bird Species Richness and Density. The chosen models of species richness had Poisson error terms and were found to be a good fit for the data, with residual deviance/residual dispersion factor close to 1, indicating no over- or under-dispersion (table 5). All final models of bird density had negative binomial error terms, with dispersion factors between 0.76 and 1.21, indicative of good model fit (tables 5, 6).

Species richness of grassland obligates was negatively associated with year. Density of birds in the grassland guild was negatively associated with vegetation height at the time of the first survey, vegetation density, the variation in density, and the amount of downed

litter; it was positively associated with field area and the proportions of grasses in the field that were cool-season grasses (table 5). At a landscape scale, density was positively associated with forest area at the immediate (0.5 km [0.311 mi]) landscape scale (table 5). The only grassland obligate for which sample sizes were sufficient to produce a GLM of population density with habitat and landscape characteristics was the grasshopper sparrow (table 6). Density of this species was positively associated with field area, amount of bare ground, and the proportion of cool-season grass; it was negatively associated with year, vegetation density, and variation in density. In the immediate landscape (≤ 0.5 km [≤ 0.311 mi]), densities of grasshopper sparrows were positively associated with forest area. At the larger landscape scale (≤ 5 km [≤ 3.11 mi]), there was a positive association with grassland area (table 6).

Species richness of the shrub-scrub species guild was negatively associated with field size and the proportion of cool- to warm-season grasses and was positively associated with the density of vegetation and the amount of woody vegetation (table 5). Densities were positively associated with amount of woody vegetation and were negatively associated with amount of bare ground and proportion of grasses that were cool-season grasses. No variables were significant at the landscape scale.

Because song sparrow, field sparrow, and indigo bunting were the three most numerous species in the shrub-scrub species guild, it is not surprising that the significant param-

Table 5
Generalized linear models of the effects of field vegetation and landscape characteristics on species richness and density of singing male grassland obligates and scrub/edge species in Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2002 to 2004.

Parameter	Grassland obligates		Shrub-scrub species	
	Species richness	Density	Species richness	Density
Dispersion factor (\hat{c})	1.07†	0.84‡	0.77†	1.19‡
Intercept	-5.83***	-7.82***	-5.00**	-3.35***
Year	-0.512**			
Within field				
Area		0.085**	-0.024**	
Mean height—first survey		-0.029*	-0.006	
Mean height—second survey		0.020		
Density (mean)		-0.046*	0.009*	
Density (CV)		-2.297*		0.522
Downed litter		-0.058*		
Standing litter		0.136		
Woody			0.037*	0.052*
Bare ground				-0.069***
Vegetation heterogeneity			-0.759	
Grass type (percent cool)		0.046***	-0.004*	-0.012**
Landscape \leq 0.5 km				
Forest area		0.030**		0.007
Landscape \leq 5 km				
Forest area			0.008	

Notes: Only estimates for those parameters included in the final (reduced) model are presented. A blank indicates a parameter that was not included in the final model.

† Poisson error distribution.

‡ Negative binomial error distribution.

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

eters for those species (table 6) were similar to those for the guild as a whole (table 5). Exceptions for the indigo bunting were a positive association with year and with the amount of grass cover. At a landscape scale, there was a positive association with the amount of forest within 0.5 km (0.311 mi) and a negative association with forest cover within 5 km (3.11 mi), reflecting the indigo bunting's association with forest edge.

The red-winged blackbird was not included in either the grassland obligate or shrub-scrub species guild. The GLM of densities of this species (table 6) showed a positive association with field area and a negative association with bare ground. At the landscape scale, no parameters were included in the final model.

Bird Associations with Grassland Types.

Abundance and species richness of grassland obligates and shrub-scrub species differed in relation to the proportion of cool-season to warm-season grasses within a field (table 5). Univariate analysis indicated that the density of singing male grassland obligates was 0.359 singing males ha⁻¹ (0.1453 ac⁻¹)

(se = 0.093) on fields with only cool-season grasses (>98% of grass cool-season) but was only 0.044 singing males ha⁻¹ (0.018 ac⁻¹) (se = 0.023) on fields with warm-season/mixed grasses (figure 2). Furthermore, all grassland obligate species had higher occupancy rates in cool-season grass fields than warm-season/mixed fields ($T = 15$, $p = 0.05$) (table 7). In contrast, there was no significant difference in densities of red-winged blackbird or shrub-scrub species between the grassland types (figure 2). The CREP fields with cool-season grasses had shorter vegetation, less standing litter, and less heterogeneity in vegetation cover types than fields of warm-season grasses (table 8). The difference in vegetation height was most pronounced later in the season at the time of the second survey when mean vegetation height between the two groups differed by >20 cm (>7.9 in). Grassland bird densities were significantly associated with more forest cover at the immediate (0.5 km [0.311 mi]) landscape scale, but there was no significant difference in this metric between warm-sea-

son and cool-season grass fields (unpaired t -test; $t = 1.21$, $p > 0.20$).

Discussion. The CREP fields in south-central Pennsylvania are within an agricultural matrix in a forest-dominated landscape. Because of the physical constraints of farming within the ridge and valley landscape, fields tend to be small and irregularly shaped, and are often interspersed with other habitats. Partly as a result of this, the bird community is different from that present in the Midwest, where most studies of avian responses to the Conservation Reserve Program (CRP) have been conducted. Red-winged blackbirds, field sparrows, song sparrows, and indigo buntings dominated the avian community in CREP fields in south-central Pennsylvania. Grassland obligates such as bobolinks, grasshopper sparrows, and eastern meadowlarks were less common. In contrast, grasshopper sparrows and dickcissels are the most common species in similar habitats further west (Johnson and Schwartz 1993; Best et al. 1997; Delisle and Savidge 1997; Klute et al. 1997). Some Midwestern CRP fields supported similar communities

Table 6

Generalized linear models of the effects of field vegetation and landscape characteristics on density of singing males for the five most common species in Conservation Reserve Enhancement Program fields in south-central Pennsylvania, 2002 to 2004.

Parameter†	Grasshopper sparrow	Song sparrow	Field sparrow	Indigo bunting	Red-winged blackbird
Dispersion factor (\hat{c})‡	1.06	1.21	0.76	0.89	1.14
Intercept	-1.24	-3.23***	-5.30***	-5.34***	-4.16***
Year	-2.48*			0.842**	
Within field					
Area	0.077*				0.038*
Mean height—first survey				-0.018	
Mean height—second survey		-0.009		-0.012	
Density (mean)	0.050*	0.020*		0.025	0.832
Density (CV)	-3.63**	1.030		1.508	
Grass				0.030**	-0.014
Downed litter		0.024			
Standing litter	0.182	-0.060			
Woody	-0.115		0.096*	0.068	
Bare ground	0.105*	-0.066**		-0.064	-0.072**
Vegetation heterogeneity	-2.60			-2.669*	
Grass type (percent cool)	0.080**	-0.018***	-0.013*	-0.017**	
Landscape ≤ 0.5 km					
Forest area	0.076***			0.029**	
Landscape ≤ 5 km					
Forest area		-0.014		-0.031**	
Grassland area	0.202***				

Note: CV = coefficient of variation.

† Only parameter estimates for those parameters included in the final (reduced) model are presented. A blank indicates a parameter that was not included in the final model.

‡ All models had a Poisson error distribution.

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

to those in south-central Pennsylvania with red-winged blackbirds being dominant, but grasshopper sparrows, dickcissels, and eastern meadowlarks were the next most common, and few had song sparrows, field sparrows, and indigo buntings as common species (McCoy et al. 2001; DeVault et al. 2002; Horn et al. 2002).

Studies of grassland bird species have used a wide variety of methods to estimate bird density and rarely use detection probabilities, which confound comparisons of densities among studies (Diefenbach et al. 2003). However, even acknowledging some discrepancy because of different methods of density estimation, it is evident that red-winged blackbird and field sparrow densities were greater, whereas grasshopper sparrow density was lower, than those found in Midwest studies (Johnson and Schwartz 1993; Winter and Faaborg 1999). Densities of red-winged blackbird, field sparrow, and grasshopper sparrow were similar to those found in CRP fields in Ohio, and indigo buntings were more numerous (Swanson et

Table 7

Presence of grassland birds was higher on cool-season ($n = 77$) than warm-season/mixed ($n = 26$) Conservation Reserve Enhancement Program fields in south-central Pennsylvania during 2002 to 2004.

	Cool-season only		Warm-season/mixed	
	Percent of fields	Number of fields	Percent of fields	Number of fields
Vesper sparrow	6.5	5	3.8	1
Savannah sparrow	9.1	7	3.8	1
Grasshopper sparrow	35.1	27	3.8	1
Bobolink	5.2	4	0.0	0
Eastern meadowlark	19.5	15	7.7	2

al. 1999). Based on field occupancy rates and estimated densities, ring-necked pheasants, bobolinks, and eastern meadowlarks were all notably scarcer in our study.

Lower densities of some grassland species in our study may simply reflect lower regional densities for most grassland species; regional abundance is greater within the Midwest than the East (Sauer et al. 2008).

Within the Ridge and Valley and Piedmont physiographic provinces, which encompass most of the 20 counties within the Lower Susquehanna River Basin CREP, some grassland obligates such as Henslow's sparrow are scarce (Brauning 1992). Others such as bobolink, grasshopper sparrows, and eastern meadowlarks are more widespread but are not abundant (Brauning 1992; Sauer et

al. 2008). In contrast, scrub and edge species are very widespread (Brauning 1992). The relative scarcity of grassland obligates within our study area may explain why so few of them were found in CREP fields. Colonization of new grassland habitat may be severely hindered by a lack of source populations in some areas. In contrast, red-winged blackbirds and most of the shrub-scrub bird species are already numerous and widespread in the area and are therefore better placed to colonize the new habitat created by CREP.

Densities of two species differed with year of the study. Grasshopper sparrows were less abundant during the third year of the study, and indigo buntings were more abundant. Because grasshopper sparrows were the most common grassland species on our fields, species richness of grassland obligates also varied with year. Annual differences in abundance may be an artifact of the specific fields included each year in the study or may be due to other factors outside the scope of this study.

We found that field size and within-field vegetation type and structure had strong effects on bird usage of CREP fields. Grassland obligates were most abundant on larger fields with a lower density of vegetation and a predominance of cool-season grasses, whereas birds in the shrub-scrub guild were associated with smaller fields with a higher density of

Figure 2

Mean densities (error bars are 95% confidence intervals) of grassland obligates, shrub-scrub species and red-winged blackbirds on CREP fields with warm-season/mixed grasses ($n = 26$) and cool-season grasses ($n = 77$) in south-central Pennsylvania, 2002 to 2004. Nonoverlapping error bars indicate statistically significant difference ($p < 0.05$).

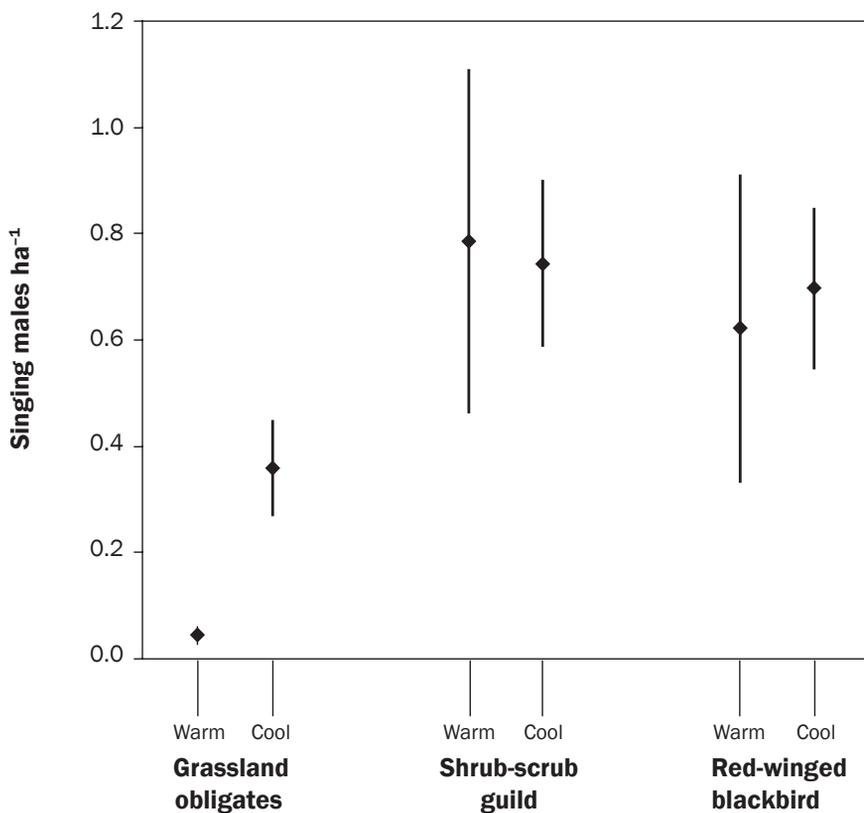


Table 8

Comparison of vegetation composition and structure of Conservation Reserve Enhancement Program fields with warm-season/mixed grasses ($n = 26$) with those with cool-season grasses only ($n = 77$) in south-central Pennsylvania, 2002 to 2004.

	Warm-season/mixed grasses	Cool-season grasses (>98% cool season)	t	p*
	Mean (se)	Mean (se)		
Field size	11.71 (1.60)	10.47 (0.95)	1.30	0.481
Growing seasons since planted	1.81 (0.25)	1.84 (0.22)	0.86	0.528
Vegetation height (cm)—first survey	54.93 (5.09)	49.73 (3.26)	0.83	0.497
Vegetation height (cm)—second survey	78.52 (6.46)	57.24 (3.32)	2.26	0.029
Vegetation density (cm)	50.52 (4.54)	45.94 (2.35)	0.95	0.592
Percent cover of forbs	39.92 (5.00)	46.85 (2.62)	1.30	0.600
Percent cover of grasses	35.31 (3.38)	32.42 (2.13)	0.70	0.534
Percent cover of dead litter	11.93 (1.74)	11.43 (0.94)	0.26	0.796
Percent cover of standing litter	3.91 (1.45)	1.22 (0.27)	2.19	0.034
Percent cover of woody vegetation	0.78 (1.57)	0.37 (0.47)	0.64	0.525
Percent cover of bare ground	8.16 (4.54)	6.32 (0.69)	1.17	0.247
Vegetation cover heterogeneity (Shannon equitability index)	0.72 (0.04)	0.60 (0.02)	2.36	0.024

* Based on False Discovery Rate corrections (Benjamini and Hochberg 1995).

vegetation and a higher proportion of warm-season grasses. As a group, grassland obligates exhibited area-sensitivity, being more abundant on larger fields, which is consistent with other studies (e.g., Herkert 1994; Winter and Faaborg 1999; Johnson and Igle 2001; Horn et al. 2002; Balent and Norment 2003). In some cases, small fields in close proximity to one another may function as large fields. For example, a contiguous block of 12 CREP fields totaling 92.4 ha (228.2 ac) in Maryland sustained a population of approximately 120 singing male grasshopper sparrows (Gill et al. 2006).

That grassland obligates were generally not found in warm-season or mixed grass fields is in agreement with some studies that have shown, for example, that grasshopper sparrows prefer cool-season grass fields (McCoy et al. 2001) but is in disagreement with others that indicate little overall difference in grassland bird densities between grassland types (Delisle and Savidge 1997; Hull 2002) or even a preference for warm-season grasses (Giuliano and Daves 2002). One confounding variable in the comparison between avian use of cool-season and warm-season grass fields is the level of mowing and disturbance occurring during the breeding season. In our study and other studies conducted on CRP and CREP fields (Delisle and Savidge 1997), neither field type was mowed or grazed during the breeding season, and mowing was restricted to minimal weed control occurring primarily after the breeding season. This contrasts with studies, such as the one by Giuliano and Daves (2002), which were conducted on fields being actively managed as pastures and hayfields. In this situation, the level of disturbance was very different between cool- and warm-season fields, with cool-season fields undergoing a much higher level of disturbance during the breeding season (Giuliano and Daves 2002). Consequently, the apparent preference for warm-season grass fields may have been a preference for less disturbance.

Variation in use of warm-season fields may also depend on the species mix, sowing density, and management regime. For example, dense stands of switchgrass in New York were found to support almost no grassland birds (Norment et al. 1999). In the Northeast, without management, warm-season grasses tend to form tall, dense grassland stands, a structure that may not be suitable for grassland birds (Norment

2002). However, with appropriate management, warm-season grass CRP/CREP fields have been shown to be highly suitable for grassland birds (Murray and Best 2003; Gill et al. 2006). For example, Gill et al. (2006) showed that managed (burned) warm-season CRP/CREP fields in Maryland supported high densities of grasshopper sparrows but that fields left unmanaged for two to three years were avoided. Their conclusion, that habitat associations of grasshopper sparrows were attributable to differences in vegetation structure due to management rather than to plant species composition, is very important in regards to the long-term management of CREP fields. Management of these grasses for grassland birds must be mindful of the likely response of warm-season grasses to the wet climate of the eastern United States, where yields on well-drained soils are much greater than those for cool-season grasses (Hall 1994). In contrast, with rather little management, cool-season grass-dominated grasslands do provide suitable habitat for grassland species in the region (Mattice et al. 2005).

Our results show initial responses of birds to these new grasslands. In our study, the average number of growing seasons since the fields were planted was less than two. The relative homogeneity of field ages in our study may explain why field age (time since planting) was not a significant predictor for species richness or population density. As CREP fields mature, bird abundance and community composition will change due to successional changes in the vegetation (McCoy et al. 2001). These changes can lead to a reduction in the suitability of conservation grasslands for some species, while becoming more suitable for others. Some species may not colonize these fields until long after establishment. For example, Bollinger (1995) found that grassland specialists increased as hayfields matured over a 15-year period. The increase in grassland specialists in hayfields occurred because the vegetation became more heterogeneous in structure and more diverse in plant species. In our study, grassland birds are localized within the region and may take several years to find and colonize new habitats created under CREP. There are, therefore, good reasons to expect grassland bird numbers to increase in CREP fields over time, although a positive response would be dependent

upon appropriate grassland management practices being in place.

Responses of birds to landscape variables have been studied far less than responses to field vegetation but were found to be important predictors in some of our models. However, the relationships detected were not always in the direction expected. Densities of grassland obligates as a group and grasshopper sparrows were positively correlated with forest area at the local (<0.5 km [<0.311 mi]) scale. Although these results appear counterintuitive, we believe they are artifacts of Pennsylvania's ridge and valley topography and farming practices. The interiors of the valleys are farmed most intensively, and land close to forest land is generally more marginal farmland and tends to be better for birds and other wildlife. Other landscape results were as predicted, such as the positive association between indigo buntings and local forest cover or the density of grasshopper sparrows and grassland area within 5 km (3.11 mi).

Summary and Conclusions

The CREP fields in Pennsylvania provide habitat for two guilds of birds (grassland, shrub-scrub) that have declined in Pennsylvania and the Northeast in recent decades. The guild that is the primary beneficiary of the new habitat will depend on field size and within-field characteristics. Smaller fields with dense vegetation will benefit shrub-scrub species while larger fields with less dense vegetation and a preponderance of cool-season grasses will benefit grassland obligates. Our results suggest that, in contrast to some sites in the Midwest, warm-season grasses may not be suitable for grassland obligates in the East unless they are actively managed to keep them from becoming dense monotypic stands.

Because grassland birds are the most rapidly declining guild of bird species within North America, implementation and management of CRP and CREP should prioritize providing habitat for these species whenever possible. However, in many instances, the enrollment of fields into CREP is constrained by the availability of suitable fields and the wishes of landowners. It is not always possible to target enrollment of large fields. In cases where this is not possible or feasible, management should be directed towards shrub-scrub species. Although this guild of birds has not been as great a focus of man-

agement concern as the guild of grassland species, many have undergone population declines. Because many shrub-scrub species are still relatively common in Pennsylvania and the Northeast, there are large source populations available to colonize new habitat created through CREP. Consequently, the potential to benefit this guild is great. Targeted management of large fields or those adjoining other grasslands for grassland birds and small fields or those adjoining woodlands for shrub-scrub species may be a pragmatic way of maximizing the potential of all CREP fields to provide habitat for a range of bird species.

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