

Relationship of Obligate Grassland Birds to Landscape Structure in Wisconsin

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ABSTRACT Conservation plans for grassland birds have included recommendations at the landscape level, but species' responses to landscape structure are variable. We studied the relationships between grassland bird abundances and landscape structure in 800-ha landscapes in Wisconsin, USA, using roadside surveys. Of 9 species considered, abundances of only 4 species differed among landscapes with varying amounts of grassland and forest. Landscape variables explained <20% of variation in abundances for 4 of the 5 rarest species in our study. Our results suggest landscape-based management plans for grassland birds might not benefit the rarest species and, thus, plans should incorporate species-specific habitat preferences for these species. (JOURNAL OF WILDLIFE MANAGEMENT 72(2):463–467; 2008)

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Grassland birds have declined across North America and most species are considered to be of conservation concern in the Midwest (Knopf 1994, Herkert 1995, Peterjohn and Sauer 1999, Knutson et al. 2001). Loss and degradation of grassland habitat has been cited as a major factor contributing to the decline of grassland birds (Martin and Finch 1995). Thus, much research has been conducted on the relationship of grassland birds to habitat characteristics.

Research has provided a good understanding of the influence of vegetation structure and composition on grassland birds within grassland patches (e.g., Wiens 1969, Sample 1989, Madden et al. 2000). In addition, research on grassland birds has suggested abundances are related to grassland patch size (e.g., Herkert 1994, Vickery et al. 1994, Winter and Faaborg 1999) and the surrounding landscape (Ribic and Sample 2001, Bakker et al. 2002, Fletcher and Koford 2002). Relationships of grassland bird abundances to patch size and landscape context, however, are variable among years, sites, and regions (Johnson and Igl 2001, Bakker et al. 2002, Winter et al. 2006).

Despite the variability and lack of biological understanding of relationships of birds and landscape attributes, landscape context has been included as part of the selection criteria for potential management areas (Sample and Mossman 1997, Fitzgerald et al. 1998). Areas with high amounts of grassland and little forest are thought to be good areas for grassland birds relative to areas with less grassland or more forest. Landscape attributes also have been used to predict regional abundances of grassland birds (Thogmartin et al. 2006).

We examined the relationship between landscape structure and grassland bird abundances and the ability to use

landscape variables to predict grassland bird abundances in southwest Wisconsin, USA. First, we compared abundances in 800-ha landscapes classified into 6 landscape types based on the amounts of grassland and forest in the areas. Second, we examined the amount of variation in grassland bird abundances explained by landscape variables measured at 2 scales.

STUDY AREA

Our study took place in Dane, Grant, Greene, Iowa, and Lafayette counties in southwest Wisconsin. The approximately 620,000-ha area was contained in the rolling hills of the southwestern uplands in the Driftless Area of Wisconsin (Martin 1965). Historically the area was composed of a mixture of oak savanna, tallgrass prairie, southern oak forests, and lowland hardwood forests. The area currently is composed mostly of grassland–herbaceous land covers (e.g., pasture, hay, Conservation Reserve Program fields; 57%), row crops (22%), and deciduous forest (18%; 1992 National Land Cover Dataset [NLCD]; Vogelmann et al. 2001).

METHODS

We overlaid a grid of 800-ha cells on the 1992 NLCD. We used a cell size of 800 ha to match the smallest spatial extent used to predict grassland bird abundances by Thogmartin et al. (2006). We combined the grassland–herbaceous and pasture–hay categories of the NLCD into a general grassland category because of high error rates in classification of these cover types (Thogmartin et al. 2004, Environmental Protection Agency 2006). We then calculated percent composition of grassland and forest for each 800-ha cell. We then categorized landscapes based on proportions of grassland and forest. We classified proportion grassland into low (0.30–0.45), high (0.60–0.80), and very

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high (>0.80) categories. Proportional forest cover categories were low (<0.05), medium ($0.05\text{--}0.20$), and high (>0.20).

We classified cells into 6 landscape types that represented most of the landscapes in our study area. The 6 landscape types were 1) very high grassland, 2) high grassland:low forest, 3) high grassland:medium forest, 4) high grassland:high forest, 5) low grassland:low forest, and 6) low grassland:high forest. We randomly selected 5 cells of each landscape type to be surveyed in 2003–2005 and we surveyed an additional cell of each type in 2004 and 2005. We restricted selected cells within each landscape type to be >5 km apart and considered them independent within a landscape type. For very high grassland landscapes, forest cover classification was medium for 5 landscapes and low for one landscape.

To further assess the relationship of landscape structure and bird abundances, we estimated bird abundances in an additional 108 800-ha cells. We selected additional cells by randomly choosing 3 cells adjacent to each of the originally selected 36 cells. We selected cells to be adjacent to the 36 original cells to allow for estimation of bird abundances at the scale containing the 4 associated cells (approx. 11,000 ha), if appropriate for other analyses. Thus, we surveyed 144 800-ha cells for birds.

Within each cell, we placed 3 survey points along secondary roads. We determined the starting point of each route by randomly selecting a road that intersected the cell boundary and placing the first point approximately 0.4 km from the cell boundary. We placed proceeding stops 0.8 km from the previous stop. If the distance to an intersection of secondary roads was <0.8 km from a survey point then we randomly chose the direction of travel at the intersection (right, left, or straight) to the next point.

We conducted surveys along survey routes twice between 15 May and 15 July in 2003–2005. Trained observers (10 individuals) conducted surveys between 0.5 hour before sunrise and 4.5 hours after sunrise. We did not conduct surveys during rain, fog, or high winds (>19 km/hr). At each stop, observers recorded number of birds seen or heard within 400 m during a 5-minute period. Each originally selected cell and associated adjacent cells were surveyed on the same morning by the same observer. An individual surveyed a route only once within a year. We recorded detections of a limited number of species (21 grassland-associated species and 5 species of interest for other research efforts) to allow observers to focus efforts on detecting these species rather than counting abundant species not of interest to our study (e.g., red-winged blackbirds [*Agelaius phoeniceus*]).

We used the maximum number of birds seen per route within a year averaged across years for analyses. We chose to use the maximum number of birds because territorial birds are assumed to maintain the same territory for most of the breeding season and, thus, variation of bird counts within seasons are assumed to be related to detection of individuals and not changes in the number of birds present. Therefore maximum number of birds gave a more accurate estimate of

number of breeding birds than mean number observed. We conducted analyses for 9 species of obligate grassland birds that are of management concern in the region: bobolink (*Dolichonyx oryzivorus*), dickcissel (*Spiza americana*), eastern meadowlark (*Sturnella magna*), grasshopper sparrow (*Ammodramus savannarum*), Henslow's sparrow (*Ammodramus henslowii*), sedge wren (*Cistothorus platensis*), upland sandpiper (*Bartramia longicauda*), vesper sparrow (*Pooecetes gramineus*), and western meadowlark (*Sturnella neglecta*; Sample and Mossman 1997, de Szalay et al. 2000, Partners in Flight Species Assessment Database 2005).

We related abundance data for the 36 classified cells to grassland and forest classifications by using analysis of variance to test for differences in abundance between grassland categories, forest categories, and their interaction. We log-transformed abundances prior to analyses.

For each 800-ha cell, we estimated the following landscape variables using the NLCD in FRAGSTATS 3.1: proportion grassland, proportion forest, proportion row-crop, total grassland edge (m), area-weighted mean patch size for grasslands (ha), and land-cover diversity using Shannon's Diversity Index (McGarigal et al. 2002). We did not include mean grassland patch size in models because it was highly correlated with proportion grassland ($\rho = 0.88$).

We also expected habitat availability around survey points, however, to be related to bird abundances. Therefore we related bird abundances to landscape composition within 400-m radii areas surrounding survey points. We estimated proportions of land cover around survey points on the ground by recording land uses for each 400-m radii survey area based on field and parcel boundaries visible from orthophotos. We then digitized the land cover using digital orthophotos in ArcGIS 9.1. We used ground-truthed land cover along survey routes instead of the NLCD because it allowed classification of habitat into more detailed categories. We then calculated proportion hay (alfalfa [*Medicago sativa*] hay, grass hay, mixed hay), idle grasslands (grasslands that were not recently mowed, plowed, or grazed), pasture, row-crop, and forest along each survey route in ArcGIS.

We related abundances in all 144 cells to landscape variables using multiple regression. We used stepwise selection of linear models in R to select the final model to explain variation in bird abundance for the route and 800-ha levels (R Development Core Team 2004). We did not include variables measured at different scales in the same models because they were confounded. We centered around zero and standardized landscape variables to allow direct comparison of estimated slopes among landscape variables. We calculated coefficient of determination (R^2) for both models to measure amount of variation in abundance explained.

Because not accounting for potential spatial autocorrelation in data can lead to inflated significance levels, we then used generalized-least-squares regressions in the nlme package in R to accommodate possible spatial autocorrelation and calculate significance levels from t -tests for all variables in the final stepwise models at both scales (Cressie

1993, Pinheiro et al. 2005). We used a spherical semi-variogram model with initial values set at 3.1 km (1.1 times the min. distance between cells) for the range and 0.1 for the relative nugget. We report all variables included in the final stepwise model, but we considered only variables with $P < 0.05$ to be significantly related to abundances.

RESULTS

Eastern meadowlark was the most abundant grassland species in the study area with a mean of 3.09 birds per route (SE = 0.17). Bobolink was the second most abundant species ($\bar{x} = 1.39 \pm 0.14$) followed by dickcissel (0.69 ± 0.08) and western meadowlark (0.62 ± 0.10). The 3 rarest species were upland sandpiper (0.14 ± 0.03), vesper sparrow (0.08 ± 0.17), and Henslow's sparrow (0.07 ± 0.02). Abundances for grasshopper sparrow (0.42 ± 0.06) and sedge wren (0.37 ± 0.05) were intermediate relative to the other species.

We observed significant differences in abundances among different landscape classifications for only 4 species. Dickcissel ($F = 4.69$, $P = 0.017$) and eastern meadowlark ($F = 15.78$, $P < 0.001$) abundances were different among grassland classifications; both species had higher abundances in landscapes with more grassland (Table 1). There were 0.22 dickcissels per route (± 0.17) in low grass landscapes increasing to 0.54 ± 0.28 in high and 1.72 ± 0.59 in very high grass landscapes. Eastern meadowlarks abundances were 1.58 ± 0.43 in low grass landscapes increasing to 3.86 ± 0.35 in high and 5.11 ± 0.62 in very high grass landscapes. Upland sandpiper and western meadowlark had significant grassland-by-forest interaction terms ($F = 3.65$, $P = 0.039$; $F = 11.22$, $P < 0.001$, respectively). Abundances for both upland sandpiper and western meadowlark were higher in the very high grassland and high grassland:low forest landscapes compared to the other landscape types (Table 1). Grassland and forest classification did not explain variation in bird abundances of the other 5 species ($P > 0.10$; Table 1).

The final landscape models at both scales for dickcissel, eastern meadowlark, and western meadowlark explained 18–50% of the variance in abundances. For bobolink, grasshopper sparrow, and sedge wren, the route-level models explained between 15–26% of the variation, and <10% of the variation was explained by the 800-ha-level models. For Henslow's sparrow, upland sandpiper, and vesper sparrow, neither model explained >10% of variation in abundance.

At the route level, dickcissels were positively related to proportion of hay ($\beta = 0.10$, $t = 2.61$, $P = 0.010$) and idle grass ($\beta = 0.10$, $t = 2.60$, $P = 0.011$) and negatively related to forest ($\beta = -0.16$, $t = 4.13$, $P < 0.001$; $R^2 = 0.18$). At the 800-ha scale, the final dickcissel model included proportion row-crop ($\beta = -0.57$, $t = 1.96$, $P = 0.052$) and a grassland-by-forest interaction ($\beta = -0.09$, $t = 2.05$, $P = 0.043$; $R^2 = 0.19$). Dickcissel abundance was positively related to proportion of grassland in landscapes with little to moderate forest ($\beta = 0.36$, $P = 0.014$) but showed no relationship to

proportion grassland in landscapes with higher proportions of forest ($\beta = 0.06$, $P = 0.615$; Fig. 1).

The route- and 800-ha-level models explained 50% and 38%, respectively, of variation in eastern meadowlark abundance. At the route level, eastern meadowlark abundance was positively related to proportion of hay ($\beta = 0.15$, $t = 4.32$, $P < 0.001$), idle grass ($\beta = 0.17$, $t = 4.82$, $P < 0.001$), pasture ($\beta = 0.15$, $t = 4.35$, $P < 0.001$), and strip-crop ($\beta = 0.11$, $t = 3.29$, $P = 0.001$) and negatively related to proportion of forest ($\beta = -0.25$, $t = 6.57$, $P < 0.001$). At the 800-ha level, eastern meadowlark abundance was positively related to proportion of grassland ($\beta = 1.00$, $t = 2.28$, $P = 0.024$) and land-cover diversity ($\beta = 0.21$, $t = 2.57$, $P = 0.011$). The proportions of row-crop ($\beta = 0.66$, $t = 1.59$, $P = 0.113$) and forest ($\beta = 0.55$, $t = 1.28$, $P = 0.203$), amount of grassland edge ($\beta = -0.10$, $t = -1.89$, $P = 0.062$), and a grassland edge-by-forest interaction ($\beta = -0.07$, $t = 1.39$, $P = 0.167$) also were included in the final model but were not significantly related to abundance.

For western meadowlark, the route- and 800-ha-level models explained 39% and 33%, respectively, of variation in abundance. At the route level, western meadowlark abundance was positively related to proportion of hay ($\beta = 0.11$, $t = 3.33$, $P = 0.001$), row-crop ($\beta = 0.28$, $t = 7.24$, $P < 0.001$), and strip-crop ($\beta = 0.09$, $t = 2.68$, $P = 0.008$) with proportion of pasture ($\beta = -0.05$, $t = 1.43$, $P = 0.156$) also included in the final model. At the 800-ha level, western meadowlark abundance was negatively related to proportions of grassland ($\beta = -0.22$, $t = 4.24$, $P < 0.001$) and forest ($\beta = -0.38$, $t = 5.31$, $P < 0.001$) and to land-cover diversity ($\beta = -0.10$, $t = 2.04$, $P = 0.043$). The grassland-by-forest interaction term also was included in the final model ($\beta = -0.09$, $t = 1.86$, $P = 0.066$).

Bobolink abundance along a route was positively correlated to proportions of hay ($\beta = 0.30$, $t = 4.84$, $P < 0.001$), idle grass ($\beta = 0.27$, $t = 3.32$, $P = 0.001$), pasture ($\beta = 0.27$, $t = 4.13$, $P < 0.001$), strip-crop ($\beta = 0.18$, $t = 2.64$, $P = 0.009$), and row-crop ($\beta = 0.29$, $t = 2.09$, $P = 0.038$; $R^2 = 0.26$). Proportion of forest ($\beta = 0.20$, $t = 1.83$, $P = 0.070$) also was included in the final bobolink model. Route-level variables explained 17% of variation in grasshopper sparrow abundance with amounts of hay ($\beta = 0.14$, $t = 4.43$, $P < 0.001$), idle grass ($\beta = 0.15$, $t = 4.02$, $P < 0.001$), pasture ($\beta = 0.07$, $t = 2.34$, $P = 0.021$), and row-crop ($\beta = 0.11$, $t = 2.93$, $P = 0.004$) being positively related to abundance. Amount of idle grassland along survey routes was positively related to sedge wren abundance ($\beta = 0.14$, $t = 5.01$, $P < 0.001$) and explained 15% of variation in abundance.

DISCUSSION

Of the 9 grassland bird species, 4 demonstrated expected relationships to landscape composition with higher abundances in areas with more grassland and less forest. However, abundances of the other species were not related to amounts of grassland and forest in the landscape. In particular, 4 of the 5 rarest species in our study (grasshopper sparrow, sedge wren, vesper sparrow, Henslow's sparrow)

Table 1. Mean maximum abundances of grasslands birds per year and standard errors from roadside surveys in 2003–2005 in 800-ha landscapes in southwest Wisconsin, USA classified into 6 landscape types based on land cover from 1992 National Land Cover Data.

| Species | Landscape types ^a | | | | | | | | | | | |
|---------------------|------------------------------|------|------------------------|------|---------------------------|------|-------------------------|------|-----------------------|------|------------------------|------|
| | Very high grass ^b | | High grass: low forest | | High grass: medium forest | | High grass: high forest | | Low grass: low forest | | Low grass: high forest | |
| | \bar{x} | SE | \bar{x} | SE | \bar{x} | SE | \bar{x} | SE | \bar{x} | SE | \bar{x} | SE |
| Bobolink | 2.45 | 1.15 | 0.61 | 0.35 | 3.11 | 1.02 | 1.81 | 0.81 | 0.33 | 0.23 | 1.00 | 0.47 |
| Dickcissel | 1.72 | 0.59 | 1.05 | 0.79 | 0.39 | 0.18 | 0.17 | 0.17 | 0.33 | 0.33 | 0.11 | 0.11 |
| Eastern meadowlark | 5.11 | 0.62 | 4.53 | 0.80 | 3.95 | 0.46 | 3.11 | 0.44 | 2.17 | 0.62 | 1.00 | 0.53 |
| Grasshopper sparrow | 0.83 | 0.48 | 1.33 | 0.59 | 1.28 | 0.61 | 0.28 | 0.16 | 0.28 | 0.22 | 0.28 | 0.22 |
| Henslow's sparrow | 0.06 | 0.06 | 0.00 | 0.00 | 0.11 | 0.11 | 0.22 | 0.11 | 0.14 | 0.09 | 0.17 | 0.17 |
| Sedge wren | 0.31 | 0.16 | 0.56 | 0.22 | 0.47 | 0.20 | 0.56 | 0.31 | 0.17 | 0.07 | 0.28 | 0.18 |
| Upland sandpiper | 0.22 | 0.11 | 0.78 | 0.32 | 0.00 | 0.00 | 0.11 | 0.07 | 0.00 | 0.00 | 0.06 | 0.06 |
| Vesper sparrow | 0.06 | 0.06 | 0.08 | 0.08 | 0.00 | 0.00 | 0.11 | 0.11 | 0.36 | 0.15 | 0.06 | 0.06 |
| Western meadowlark | 1.08 | 0.92 | 0.83 | 0.28 | 0.17 | 0.11 | 0.00 | 0.00 | 0.44 | 0.24 | 0.00 | 0.00 |

^a Very high grass (>80% grassland; $n = 6$), high grass (60–80%; $n = 18$), low grass (30–45%; $n = 12$), low forest (<5% forest; $n = 13$), medium forest (5–20%; $n = 11$), and high forest (>20%; $n = 12$).

^b Forest cover for very high grass landscapes ranged from 1% to 12%.

did not show strong relationships to proportions of grassland and forest. Murray (2006) also found that predictions of grassland bird abundances based on landscape variables were more accurate for more abundant species. The lack of relationships between landscape composition and bird abundances could be due to the inability to differentiate between grassland types in the 800-ha landscapes using the NLCD. Accounting for other sources of variation in abundance not well-described by landscape variables also may have increased our power to detect landscape effects.

More route-level models explained >10% of variation in abundance relative to 800-ha models. Other studies also found that variables measured at smaller extents and within grassland patches better explained abundance for some grassland species than did variables at larger extents (Ribic and Sample 2001, Bakker et al. 2002). Ribic and Sample (2001) found that landscape variables were important for

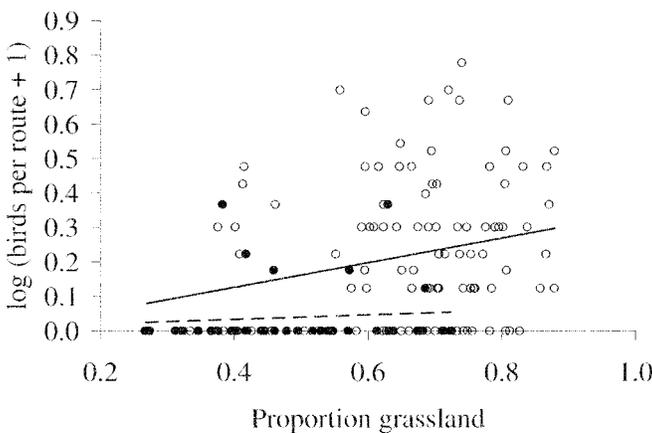


Figure 1. Dickcissel abundance along roadside survey routes in southwest Wisconsin, USA, during the breeding seasons of 2003–2005 related to the proportion of grassland in 800-ha landscapes at different levels of forest in the landscape. Abundance was positively related to proportion of grassland in landscapes within the first 3 quartiles of proportion forest (open circles, solid line) but showed no relationship to proportion grassland for landscapes in the fourth quartile (closed circles, dashed line).

explaining abundances, but landscape variables were measured at smaller extents (≤ 246 ha) than in our study.

At the route level, proportion of hay and idle grass were common across models with consistent relationships across species. Other studies in the same area have found relationships between grassland bird abundance and landscape variables at extents similar to the route-level scale we used (Ribic and Sample 2001; R. B. Renfrew and C. A. Ribic, University of Wisconsin, unpublished data). Results from these studies, though variable among species and years, indicate the importance of amounts of grassland in the landscape to grassland birds in southwest Wisconsin.

The lack of relationships of 800-ha landscape variables and grassland birds in our study could be because we did not examine landscapes containing very little grassland. Andren (1994) suggested that fragmentation did not strongly affect bird populations until the area was composed of <30% suitable habitat. In our study area, most 800-ha landscapes were composed of >30% grassland and, thus, may be above the threshold where a large effect from habitat fragmentation would be expected.

In addition, population status and social structure might bias habitat models (Hepinstall et al. 2002). If populations are limited by factors other than availability of breeding habitat (e.g., reproductive success, winter survival) then suitable habitat areas might not be occupied (Newton 1998). Presence of unoccupied suitable habitat could lessen the statistical importance of biologically significant landscape attributes by relating low abundances to suitable landscape characteristics.

Future research should test potential mechanisms of landscape effects on grassland bird populations and determine the scale at which landscape effects are biologically significant, especially for species of highest conservation priority. Our study examined the relationship of abundance to landscape variables, but demographic parameters (i.e., nest success, juv survival) might be influenced by landscape context (e.g., Herkert et al. 2003) and these relationships also should be further studied.

Management Implications

Our results suggest 800-ha landscapes with high amounts of grassland and low amounts of forest characterize areas of high relative abundances for some grassland species. Other grassland species, however, might not benefit from management in these selected landscapes because they are more common in landscapes with less grassland or more forest or show no relationship to landscape variables. In particular, our results show that the rarest grassland species might not benefit from management decisions based on landscape attributes at large extents. Conservation efforts for grassland birds based on landscape structure at large extents should consider local habitat variables and species-specific habitat preferences.

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