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Effects of Field Size and Landscape Composition on Grassland Birds in South-Central Iowa

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Many species of grassland birds have been shown to avoid smaller fields. The avoidance of smaller fields, however, has not been consistently reported; avoidance may occur in one study, but not in another. To examine one possible reason for these inconsistencies, we examined how landscape composition influenced the relations between occurrence or abundance and field size. The study took place during the 1998 breeding season on 44 Conservation Reserve Program (CRP) fields located in Adair, Ringgold, and Union counties. The relations between occurrence, abundance, and field size were not influenced by landscape composition for any species. Grasshopper Sparrow, *Ammodramus savannarum,* Bobolink, *Dolichonyx oryzivorus,* and Eastern Meadowlark, *Sturnella magna,* were more likely to occur or were more abundant in larger fields. Field Sparrow, *Spizella pusilla,* Western Meadowlark, *Sturnella neglecta,* Brown-headed Cowbird, *Molothrus ater,* and American Goldfinch, *Carduelis tristis,* were less likely to occur or were less abundant in larger fields. Field size is an important factor influencing the occurrence and/or abundance of grassland songbirds in fields. Future studies that investigate the effects of landscape composition on area sensitivity should use landscapes that have similar habitat compositions other than the habitat being varied, and use similar sized fields in each landscape.

INDEX DESCRIPTORS: abundance, area sensitive, field size, grassland birds, habitat fragmentation, Iowa, landscape composition, occurrence.

Several grassland bird species found in the United States have experienced declines in population size in recent decades (Askins 1993, Knopf 1994, Igl and Johnson 1997). On the breeding grounds, population declines have been attributed to factors such as loss or fragmentation of grassland habitats (Herkert 1994a, Vickery et al. 1994, Warner 1994), changes in land use (Bernstein et al. 1990, Knopf 1994), and mowing of grassland fields during the breeding season (Bollinger et al. 1990, Frawley and Best 1991).

Loss or fragmentation of grassland habitat results in a landscape of smaller habitat patches surrounded by larger amounts of unsuitable habitat (Meffe and Carroll 1994). Many grassland bird species are more likely to occur in larger habitat patches than smaller ones (Herkert 1994a, Vickery et al. 1994). Bird species that exhibit non-random avoidance of small patches that are larger than their territory size are referred to as area-sensitive species (Askins et al. 1990, Horn et al. 2000). Many species of grassland songbirds found in Iowa are considered to be area sensitive including Sedge Wren (scientific names listed in Table 1), Dickcissel, Grasshopper Sparrow, Henslow's Sparrow, Bobolink, Eastern Meadowlark, and Western Meadowlark (Herkert 1994a and b, Vickery et al. 1994, Best et al. 1996, Helzer and Jelinski 1999, Winter and Faaborg 1999, Johnson and Igl 2001).

Area-sensitivity, however, has not been consistently shown for a given grassland bird species (Johnson and Igl 2001). For example, in Illinois, Herkert (1994a) found a positive relationship between the occurrence of Eastern Meadowlark and field size. Winter and Faaborg (1999), however, did not detect a relation between density and field size for Eastern Meadowlarks in Missouri, and Walk and Warner (1999) observed the species in all of their fields in Illinois. Another determinant of species composition in a field may be the landscape that surrounds the field (Wiens 1989, Freemark et al. 1995, Herkert et al. 1996, Herkert et al. 1999). For example, McCoy (1996) found a positive relationship between the occurrence of the Song Sparrow and the amount of core grassland area within 1 km in Missouri. Horn (2000) reported that Savannah Sparrow (*Passerculus sandwichensis*), Bobolink, and American Goldfinch were more abundant in fields in landscapes with 51–55% perennial grassland compared to 15–20% grassland.

To investigate why species might display area sensitivity in one study but not in another, we compared the relations between species' probabilities of occurrence or relative abundances and field size between study-area types that differed in their grassland composition. Specifically, we compared the relations between study-area types that differed in the amount of reseeded cropland enrolled in the Conservation Reserve Program (CRP) in south-central Iowa.

METHODS

The research took place in south-central Iowa in Adair, Ringgold, and Union counties during the summer of 1998. Two types of 6.4 × 6.4 km study areas were selected based on the amount of CRP land they contained: moderate-grassland cover and high-grassland cover. Our three moderate-grassland cover study areas contained 4–6% CRP land. The remainder of the study-area type was hayland (7%), pastureland (9–19%), cropland (mostly corn and soybeans) (57–61%), and other (e.g., forest and buildings) (11–19%). The NW corner of the first study area was the NW corner of section 18 of Union Township in Adair county. The NW corners of the second and third study areas were the NW corner of section 17 of Douglas Township and section 8 of Spaulding Township in Union County. Our two high-grassland cover study areas contained 18–28% CRP land. The remainder of the study-area type was hayland (7–11%), pastureland (12–15%), cropland (22–30%), and other (19–38%). The NW corners of the study areas were the NW corner of section 1 of Middle Fork Township and section 19 of Monroe Township in Ringgold County. The major differences between the moderate- and high-grassland cover study areas were the greater amounts of CRP and forest land and lesser amounts of cropland in high-grassland cover study areas. To reduce the effect of variation of vegetation type on the bird communities, we restricted our surveys to CRP fields.

To determine field size, a field was defined as a distinct unit of hayland or reseeded grassland enrolled in the CRP that was surrounded by roads or other habitat classes such as pastureland, cropland, and forest. For example, 20 ha of CRP land that was adjacent to 5 ha of hayland was considered a single field of 25 ha. Parcels of CRP land and hayland were considered single fields if they were on both sides of a treeline, telephone line, fencerow, or field border (i.e., a telephone line running through a parcel of CRP does not divide the CRP into two separate fields). Two parcels of CRP land and hayland that were separated by a road were considered to be two fields due to the decreased densities of grassland birds near roadsides (Clark and Karr 1979, Reijnen et al. 1996, Sutter et al. 2000). Pastureland was considered to be a distinct habitat from CRP and hayland fields because many grassland bird species have considerable differences in abundance in pastures compared to CRP and hayland (Kantrud 1981, Renken and Dinsmore 1987, Best et al. 1995). Moreover, because of variation in factors such as vegetation height and density among pastures in our study areas, it would be difficult to assess if and how much pasture served as grassland bird habitat when calculating field size. Similarly, although small grains may be used by grassland birds during the breeding season (Best et al. 1995, Patterson and Best 1996), the quality of these crops varies, and, at the time of bird settlement, these habitats may have no vegetation. Thus, small grains were not included in measurements of field size.

In the five study areas in Iowa, we sampled 44 fields comprising 1,238 ha. Field sizes ranged from 4–208 ha, with a median size of 19 ha. Twenty-three fields comprising 463 ha were sampled in moderate-grassland cover study areas (median = 15 ha, range = 5–48 ha). In the high-grassland cover study areas, 21 fields comprising 775 ha were sampled (median = 26 ha, range = 4–208 ha). Fields < 4 ha were not used to avoid confounding territory size requirements of grassland songbirds with area sensitivity.

We used 5-min, 100-m radius point counts to estimate the probability of occurrence and relative abundance of upland-nesting grassland birds. During each count, we recorded the number of individuals of each species seen or heard. Counts were conducted between 0630–1000 CST from 19 May to 23 June 1998. Point counts were not conducted during unfavorable weather conditions such as precipitation, high wind, and dense fog. All point counts were performed by the same individual (M. L. Braland). The location and number of counts in the CRP portion of each field was predetermined and based on two criteria: 1) count locations were ≥ 100 m from any field edge (with the exception of fields that had a diameter < 200 m), and 2) counts were placed at least 250 m from other count points. The number of counts in the CRP portion of each field was the maximum number of points in a grid-like pattern that could fit within a field and meet these criteria. Thus, the number of point counts conducted on a field was proportional to field size. One hundred sixty-seven point counts were conducted; 70 counts were conducted in fields within moderate-grassland cover study areas, and 97 in high-grassland cover study areas.

We used logistic regression to determine if a species' occurrence (binary response) in a field was influenced by the following explanatory variables: study-area type (categorical variable), field size (continuous variable), and the interaction between study-area type and field size. For species exhibiting a significant relationship between occurrence and field size, we determined minimum area requirements. Minimum area requirements were defined as the area at which a species' probability of occurrence is 50% of its maximum (Robbins et al. 1989, Herkert 1994a). Because sampling fields proportional to size can result in a positive relationship between probability of occurrence and field size that is a sampling artifact (Connor and McCoy 1979, Coleman et al. 1982, Horn et al. 2000), we randomly selected a single point count from each field, regardless of size, to be used in occurrence analyses (e.g., Vickery et al. 1994).

We used linear regression to determine if a species' relative abundance in a field was influenced by the following explanatory variables: study-area type, field size, and the interaction between study-area type and field size. Relative abundance was determined by calculating the mean number of birds per point count within a field. To stabilize the variance in the regressions, means were weighted by the number of point counts conducted in a field, such that each field's contribution in the analysis was equal to the number of point counts conducted in that field divided by the total number of point counts conducted in all fields. Although occurrence and abundance data are correlated (Wright 1991), our occurrence analysis used a single point count per field, whereas the abundance analysis used all point counts per field. Moreover, both occurrence and abundance data are used for determining if a species is area sensitive. We selected logistic and linear regression models with the fewest variables that fit the data based on Akaike's information criterion values (Akaike 1973, 1985). Data were analyzed using the Logistic and Reg Procedures of the SAS statistical package (Version 6.12) (DiIorio 1991, Stokes et al. 1995). Results were considered significant if $P \leq 0.10$.

RESULTS

Thirteen species of grassland songbirds were examined (Table 1). Grasshopper Sparrow occurrence was positively related to field size (Table 2). Its probability of occurrence ranged from 0.25 in 4 ha fields to 0.97 in 208 ha fields, and reached 50% of maximum at a field size of 49 ha (Fig. 1). Field Sparrow and Brown-headed Cowbird had negative relationships between occurrence and field size (Table 2). Field Sparrow probability of occurrence ranged from 0.30 in 4 ha fields to 0.00 in 208 ha fields (Fig. 1), whereas Brown-headed Cowbird probability of occurrence ranged from 0.45 in 4 ha fields to 0.00 in 208 ha fields (Fig. 1).

Dickcissel and Grasshopper Sparrow had greater probabilities of occurrence in the moderate-grassland cover study-area type (0.65 and 0.48 probability of occurrence, respectively, in moderate-grassland cover study areas versus 0.29 and 0.23 in high-grassland cover study areas) (Table 2). Field Sparrow, Song Sparrow, and Brown-headed Cowbird had greater probabilities of occurrence in the high-grassland cover study-area type (0.19, 0.19, and 0.19 probability of occurrence, respectively, in high-grassland cover study areas versus 0.04, 0.04, and 0.09 in moderate-grassland cover study areas) (Table 2). In the analysis of probability of occurrence, no species had an interaction between field size and study-area type.

Grasshopper Sparrow (Fig. 2), Bobolink, and Eastern Meadowlark abundance were positively related to field size, whereas Field Sparrow, Western Meadowlark, and American Goldfinch (Fig. 2) showed negative relationships (Table 3). Relations between relative abundances of Field Sparrow, Bobolink, Eastern Meadowlark, and Western Meadowlark and field size should be viewed with caution. When the largest sampled field was removed from the regression analysis, none of the relationships were significant (thus, we did not include figures of the relationships).

Field Sparrow, Song Sparrow, and American Goldfinch were more abundant in the high-grassland cover study areas, whereas Sedge

Table 1. Relative abundance (mean number of birds per point count) of grassland bird species observed in CRP fields in 1998 in south-central Iowa.

Species	Mean[a]	Variance
Sedge Wren, *Cistothorus platensis*	0.17	0.28
Common Yellowthroat, *Geothlypis trichas*	0.47	0.39
Dickcissel, *Spiza americana*	0.85	1.16
Field Sparrow, *Spizella pusilla*	0.09	0.13
Grasshopper Sparrow, *Ammodramus savannarum*	0.73	0.82
Henslow's Sparrow, *Ammodramus henslowii*	0.07	0.09
Song Sparrow, *Melospiza melodia*	0.10	0.15
Bobolink, *Dolichonyx oryzivorus*	1.07	1.46
Red-winged Blackbird, *Agelaius phoeniceus*	2.90	4.81
Eastern Meadowlark, *Sturnella magna*	0.41	0.42
Western Meadowlark, *Sturnella neglecta*	0.32	0.31
Brown-headed Cowbird, *Molothrus ater*	0.15	0.42
American Goldfinch, *Carduelis tristis*	0.08	0.14

[a]n = 167 point counts

Table 2. Parameters of logistic regression models of the probability of occurrence of grassland bird species observed in CRP fields in 1998 in south-central Iowa and the explanatory variables: study-area type, field size, and the interaction between study-area type and field size. Only species models with a statistically significant explanatory variable are shown.

Species and Variable	Parameter Estimate	SE	P	R^2 [a]
Dickcissel				
Intercept	0.6286	0.4378	0.1510	0.13
Study-area type	−1.5449	0.6519	0.0178	
Field Sparrow				
Intercept	−1.3569	1.2675	0.2844	0.18
Study-area type	2.5224	1.3020	0.0527	
Field size	−0.1311	0.0752	0.0814	
Grasshopper Sparrow				
Intercept	−0.8125	0.5812	0.1621	0.18
Study-area type	−1.7372	0.7956	0.0290	
Field size	0.0361	0.0197	0.0669	
Song Sparrow				
Intercept	−4.4547	2.4065	0.0642	0.15
Study-area type	5.0518	2.7270	0.0639	
Field size	0.0542	0.0715	0.4490	
Interaction	−0.1498	0.0985	0.1283	
Brown-headed Cowbird				
Intercept	0.0193	1.1345	0.9864	0.23
Study-area type	2.0960	1.1744	0.0743	
Field size	−0.1951	0.0934	0.0367	

[a]R^2 is derived from Stokes et al. (1995)

Wren and Bobolink were more abundant in the moderate-grassland cover study areas (Tables 3 and 4). In the analysis of relative abundance, no species had an interaction between field size and study-area type (Table 3). Thus, the area sensitivity of no species was influenced by landscape composition.

DISCUSSION

The amount of CRP land in the landscape did not influence relationships between occurrence or abundance of grassland songbirds and field size in south-central Iowa. Differences in a species' area sensitivity based on landscape composition, however, have been shown in previous studies (Robbins et al. 1989, Freemark and Collins 1992, Rosenberg et al. 1999, Horn 2000). For example, in North Dakota, Horn (2000) reported that the amount of perennial grassland in the landscape influenced the area sensitivity of Grasshopper Sparrow, Bobolink, and Red-winged Blackbird. In study areas with 15–20% grassland, Bobolink and Red-winged Blackbird had positive relationships between relative abundance and field size. In study areas with 51–55% grassland, the occurrence or abundance of Bobolink and Red-winged Blackbird was greater, and no relationship between relative abundance and field size was detected.

Not all studies have reported an effect of landscape composition on a species' area-sensitivity (e.g., Edenius and Sjöberg 1997, Bender et al. 1998, Trzcinski et al. 1999). Bender et al. (1998) found no influence of landscape composition on the relation between patch size and density of birds using meta-analysis of studies from multiple habitat types including forest, grassland, and wetland. Edenius and Sjöberg (1997) examined how habitat area and landscape context influenced the abundance of birds in old-growth forests of northern Sweden. They found no effect of the proportion of forest within a 1 × 1 km grid on the relation between a species' abundance and patch size. Trzcinski et al. (1999) examined whether the distribution of forest birds was influenced by the amount of forest cover, the extent of fragmentation, and the interaction. Of the 31 species examined, only two species showed a significant interaction.

There are several considerations that may have made it difficult to detect an influence of landscape composition on relations between occurrence or abundance and field size in south-central Iowa. First, landscape composition did not affect relative abundance as we expected it to. Three species (Field Sparrow, Song Sparrow, and American Goldfinch) were more abundant in high-grassland cover landscapes, but the species that have been reported to be area sensitive (Sedge Wren and Bobolink) were not. In fact, Bobolink and Sedge Wren had greater relative abundances in fields in moderate-grassland cover landscapes. We expected that landscapes with large amounts of grassland would have greater relative abundances of birds, and consequently, higher occupancy of patches (Wright 1991). Both em-

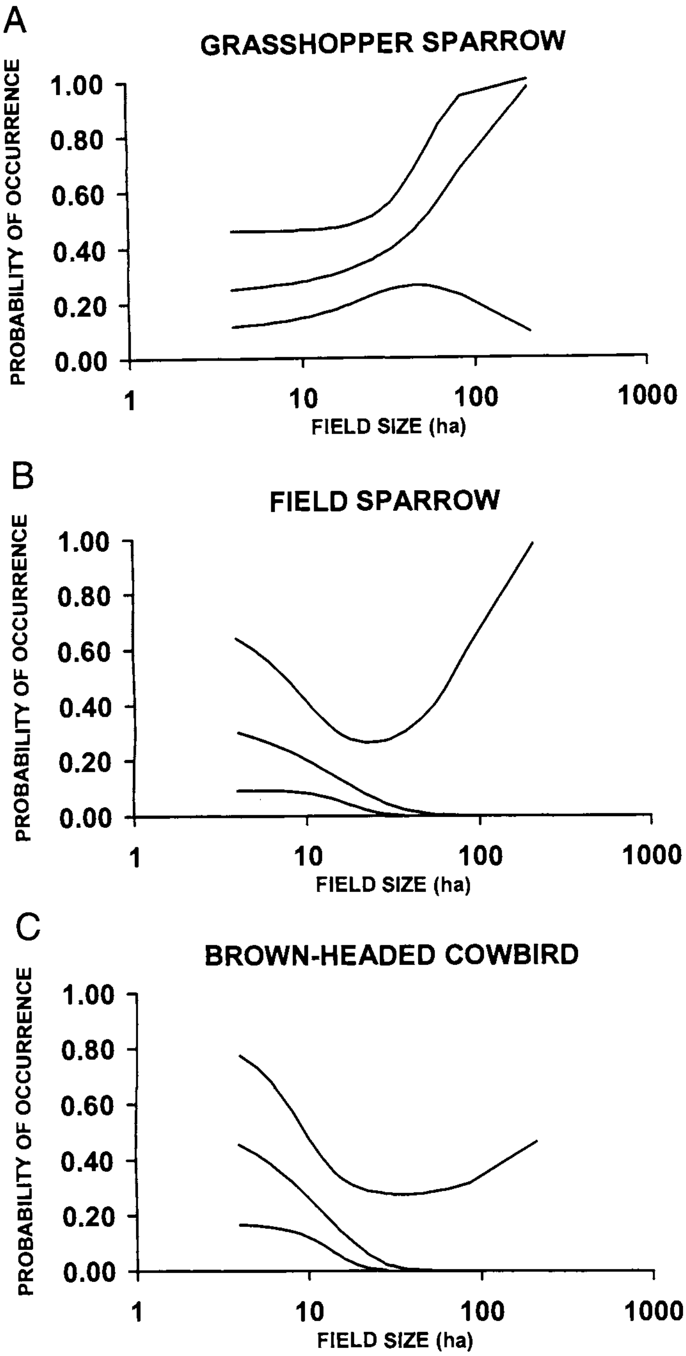

Fig. 1. Relationship between probability of occurrence in fields and field size for Grasshopper Sparrow (a), Field Sparrow (b), and Brown-headed Cowbird (c) in CRP fields in 1998 in south-central Iowa. Top and bottom lines are the 95% confidence limits of expected values of the mean for each field.

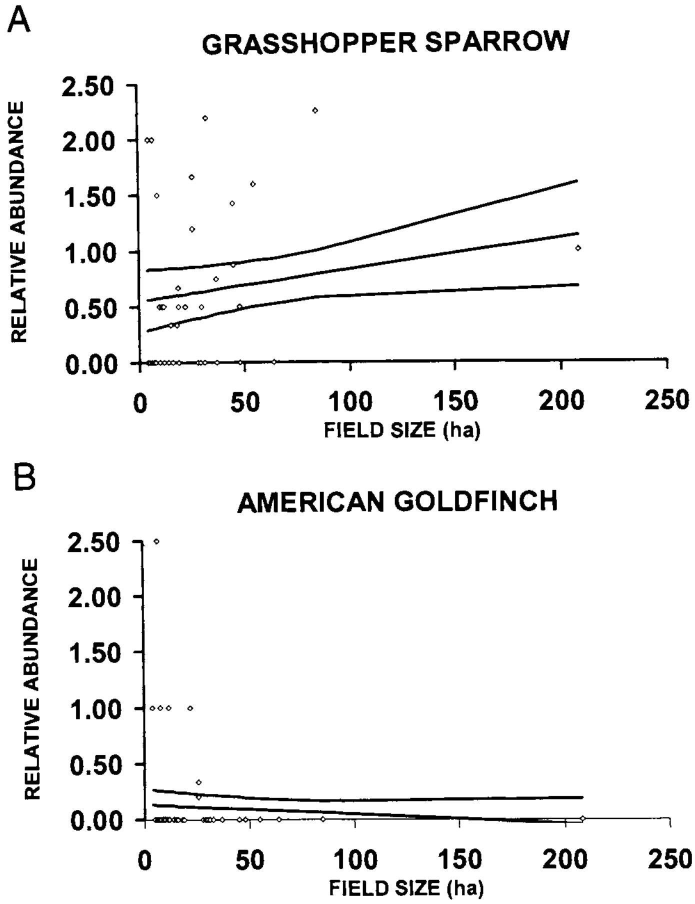

Fig. 2. Relationship between relative abundance in fields and field size for Grasshopper Sparrow (a) and American Goldfinch (b) in CRP fields in 1998 in south-central Iowa. Top and bottom lines are the 95% confidence limits of expected values of the mean for each field.

pirical studies and simulations have found that in landscapes with more suitable habitat, more patches are occupied, and abundance is greater in occupied patches (Andrén 1996, Bellamy et al. 1996, Herkert et al. *1996*, *Venier* and Fahrig 1996, Venier and Fahrig 1998). In the case of Dickcissel and Grasshopper Sparrow, exactly the opposite happened; their probabilities of occurrence were lower in fields within study-area types with more grassland. Horn (pers. obs.) noticed that many of the smaller fields in one of the high-grassland cover study areas were surrounded by woodland. Perhaps these fields were less likely to be colonized by Sedge Wren, Dickcissel, Grasshopper Sparrow, and Bobolink because of increased isolation, and edge effects associated with trees (Johnson and Temple 1990), thereby leading to a lower probability of occurrence and abundance overall in fields within study-area types with high amounts of CRP land. Hughes et al. (1999) observed a decrease in Dickcissel abundance as the amount of wooded field perimeter and wooded area surrounding a field increased, and Winter et al. (2000) found nest success of both Dickcissel and Henslow's Sparrow to be lower at distances < 50 m from a shrubby edge. Johnson and Temple (1990) observed increased rates of nest predation, and parasitism by Brown-headed Cowbirds, in grassland bird nests closer to woody edges.

The two high-grassland cover study areas had greater amounts of other habitats (19–38%) including forest compared to the three moderate-grassland cover study areas (11–19%). McCoy (1996) found a negative relationship between the occurrence of Sedge Wren and the amount of forest within 1 km of a grassland field. Coppedge et al. (2001) reported decreasing abundance of several grassland bird species with increasing amounts of woody vegetation.

Another reason for not detecting an effect of landscape composition on a species' area sensitivity is that the range of field sizes was

Table 3. Parameters of linear regression models of the relative abundance of grassland bird species observed in CRP fields in 1998 in south-central Iowa and the explanatory variables: study-area type, field size, and the interaction between study-area type and field size. Only species models with a statistically significant explanatory variable are shown.

Species and Variable	Parameter Estimate	SE	P	F	R^2
Sedge Wren					
Intercept	0.2857	0.0789	0.0008	3.47	0.08
Study-area type	−0.1929	0.1035	0.0693		
Field Sparrow					
Intercept	0.0638	0.0698	0.3666	2.27	0.10
Study-area type	0.1824	0.0981	0.0701		
Field size	−0.0012	0.0007	0.0861		
Grasshopper Sparrow					
Intercept	0.5474	0.1380	0.0003	3.76	0.08
Field size	0.0028	0.0015	0.0594		
Song Sparrow					
Intercept	0.0143	0.0608	0.8154	3.57	0.08
Study-area type	0.1507	0.0798	0.0659		
Bobolink					
Intercept	1.1332	0.1905	0.0001	3.52	0.15
Study-area type	−0.6004	0.2677	0.0304		
Field size	0.0043	0.0019	0.0286		
Eastern Meadowlark					
Intercept	0.2500	0.0731	0.0014	9.86	0.19
Field size	0.0024	0.0008	0.0031		
Western Meadowlark					
Intercept	0.4249	0.0627	0.0001	6.28	0.13
Field size	−0.0017	0.0007	0.0162		
American Goldfinch					
Intercept	0.0570	0.0782	0.4701	2.44	0.11
Study-area type	0.2029	0.1098	0.7019		
Field size	−0.0015	0.0008	0.0636		

Table 4. Relative abundance (mean number of birds per point count) in fields of five grassland bird species observed in CRP fields in 1998 in south-central Iowa that exhibited a significant relationship between relative abundance in fields and study-area type.

Species	Moderate Grassland		High Grassland	
	Mean[a]	Variance	Mean	Variance
Sedge Wren	0.29	0.71	0.09	0.13
Field Sparrow	0.03	0.04	0.13	0.65
Song Sparrow	0.01	0.01	0.16	0.53
Bobolink	1.26	3.12	0.93	1.95
American Goldfinch	0.01	0.04	0.12	0.83

[a]n = 23 and 21 fields, respectively, in the moderate- and high-grassland cover study areas

not equivalent in the two study-area types. Field sizes ranged from 5–48 ha in moderate-grassland cover study areas and 4–208 ha in high-grassland cover study areas. Several studies have reported minimum area requirements of species to be > 48 ha (Herkert 1994a, Vickery et al. 1994); thus our largest field in the moderate-grassland cover study areas may have been too small to document whether a species' probability of occurrence or relative abundance increased in larger fields. Differences in vegetation composition among fields also may have confounded our results. While we only sampled birds in CRP land, the forb and shrub coverages among CRP fields may have varied both within and between study areas influencing species occurrence and abundance.

All of the species for which we detected area sensitivity have been found to be area sensitive in previous studies. Grasshopper Sparrow has been reported to be area sensitive in Maine (Vickery et al. 1994), Illinois (Herkert 1994a), Nebraska (Helzer and Jelinski 1999), Iowa (this study), and North Dakota (Horn 2000, Johnson and Igl 2001). Minimum area requirements for the species have varied between 8 (Helzer and Jelinski 1999) and 100 ha (Vickery et al. 1994). In Iowa, probability of occurrence was 50% of its maximum at a field size of 49 ha, and a positive relationship between relative abundance and field size was detected.

For Bobolinks, area sensitivity has been detected in Maine (Vickery et al. 1994), Illinois (Herkert 1994a), Nebraska (Helzer and Jelinski 1999), Iowa (this study), and North Dakota (Horn 2000, Johnson and Igl 2001). Minimum area requirements for the species have varied from 46 (Helzer and Jelinski 1999) to 59 ha (Horn

2000). In Iowa, we found a positive relationship between relative abundance and field size, but no relationship was detected between occurrence and field size.

Area sensitivity of Eastern Meadowlark has been detected in Maine (Vickery et al. 1994), Illinois (Herkert 1994a) and Iowa (this study). In Illinois, the minimum area requirement of Eastern Meadowlarks was 5 ha (Herkert 1994a). In Iowa, we did not detect a relation between occurrence and field size for the Eastern Meadowlark; however, a positive relationship between relative abundance and field size was found. Western Meadowlark had a negative relationship between relative abundance and field size. Johnson and Igl (2001) did not observe a consistent pattern of area sensitivity for Western Meadowlark in North Dakota.

Previous studies have found Henslow's Sparrows and Sedge Wrens to be area sensitive (Herkert 1994a and b, Walk and Warner 1999, Winter and Faaborg 1999, Johnson and Igl 2001). We found no evidence of area sensitivity for these species.

Field Sparrow was less likely to occur in larger fields, and Field Sparrow and American Goldfinch had negative relationships between relative abundance and field size. Similarly, Herkert (1994a) found a negative relationship between American Goldfinch occurrence and field size in Illinois.

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