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Grassland vegetation and bird communities in the southern Great Plains of North America

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Abstract

Structure and composition of vegetation and abundance of breeding birds in grasslands seeded to Old World bluestem (*Bothriochloa ischmaeum*) were compared to native mixed prairie in the southern Great Plains of North America. Abundance of birds was determined using fixed-radius point counts. Detrended correspondence analysis was used to compare plant community composition and canonical correspondence analysis was used to examine the relationships between plant species composition and vegetation structure with the bird community. Plant species composition differed distinctly between seeded grassland and native mixed prairie, but the differences were not reflected in habitat structure, bird community composition, or abundance of bird species. Seeded grassland was inferior to native mixed prairie in terms of diversity of plant species, but that difference did not translate into meaningful differences in structure that drove habitat selection by breeding birds. Conservation programs that promote establishment of seeded grassland and do not allow for suitable disturbance regimes will selectively benefit a narrow suite of birds regardless of plant species composition.

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Keywords: Grassland; Grassland birds; Grazing; Habitat management; Plant species composition

1. Introduction

Vegetation structure is critical to habitat selection and productivity of bird species in central USA grassland (Johnson and Schwartz, 1993b; McCoy et al., 2001). Studies in the UK also demonstrate the influence of vegetation structure on abundance and productivity of grassland birds (Pain et al., 1997; Wakeham-Dawson and Aebischer, 1998; Vickery et al., 2001). Seeding mixtures of herbaceous species to benefit grassland breeding birds is encouraged by government policy in the USA (Wildlife Management Institute, 1994; McCoy et al., 2001) because gradients in composition, and therefore structure of vegetation, influence bird assemblages in shrub-steppe and forested ecosystems (Rotenberry and Wiens, 1980). A similar relationship should apply to the grassland of the Great Plains. Because native mixed prairie has greater plant species richness than fields planted to exotic species, native mixed prairie should provide

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complex habitat that attracts a unique assemblage of bird species (Sutter and Brigham, 1998). Bird communities usually (Wilson and Belcher, 1989; Sutter et al., 1995; Davis and Duncan, 1999), but not always (Sutter and Brigham, 1998), differ between grassland types. Recent studies of bird abundance and productivity on fields enrolled in the Conservation Reserve Program (CRP, the equivalent of set-aside or arable reversion in Europe) comparing native plants with exotic plants found that vegetation structure overrides the influence of plant species seeded (Delise and Savidge, 1997; McCoy et al., 2001).

Grassland seeded to a single plant species on land formerly cultivated for annual grain crops comprised one-third of the grassland cover in States of the Great Plains in the mid-1980s (ECOP/ANR Grazing Lands Committee, 1986). Seeded grassland became even more common after the 1985 Food Security Act when highly erodible cropland was seeded preferentially to exotic grasses on millions of hectares in all but a few states with Kansas representing the primary exception (Schenck and Williamson, 1991; Baker, 2000).

Since the original 10-year contracts have been expiring, the fate of CRP grassland includes reenrollment in the CRP under the 1996 Federal Agricultural Improvement and Reform Act, conversion back to cropland, hay, or grazing livestock (Osborn and Heimlich, 1993; Anderson and Magleby, 1997). Most of the CRP grassland has been excluded from active management, including grazing, except during severe drought—a caveat to the hands-off management approach that has been the subject of considerable controversy (Allen et al., 2001). A change in strategy may follow the Farm Security and Rural Investment Act of 2002, which may allow greater flexibility in management prescriptions.

Seeded grassland differs from native mixed prairie in two important ways, i.e. (1) native mixed prairie has never been cultivated and is potentially superior in plant species richness, and (2) seeded grassland (i.e., CRP fields) is rarely if ever grazed whereas native mixed prairie is almost always grazed.

The influence of type of grassland on vegetation structure, bird species assemblages, and bird abundance is examined in this paper. Specifically, the hypothesis that disturbance contributes to complexity and creates gradients in composition and structure of vegetation (Coppedge et al., 1998) and therefore influences abundance of birds in native mixed prairie versus seeded grassland is tested.

2. Methods

This study was conducted in the southern Great Plains of northwestern Oklahoma, USA, which is characterized by gently sloping to steep uplands of silty to moderately sandy soils (Fitzpatrick, 1950). Climate is sub-humid with mean annual temperature of 15.3 °C and mean annual precipitation of 62.7 cm. Mixed prairie is the region's natural vegetation, but shrubs and trees are locally abundant. Land uses include cattle production, wheat, and sorghum. Seeded grassland is common mainly as monocultures of Old World bluestem (*Bothriochloa ischaemum* L.) (McCoy et al., 1992).

Two sites (36°50′N, 99°00′W and 36°58′N, 99°13′W) located in Woods County, Oklahoma were selected (Coppedge et al., 2001), each of 2500 ha along a 39.4 km line. Aerial photographs were used to identify four plots of either seeded grassland or native mixed prairie from each of the two study sites. Eight plots, i.e. two per grassland type and study site, were sampled in 1998 and the remaining eight in 1999. A 10 ha study area was established within each plot. Grazing on each plot was estimated visually and classified as no use, light, moderate, or heavy (Smith, 1998). Three seeded grassland plots were enrolled in the CRP (no grazing or haying), two were grazed heavily, two were hay fields, and one seeded grassland not enrolled in CRP was neither hayed or grazed. Seven of the eight native grassland plots were grazed continuously at light to moderate stocking rates and one was not grazed.

Vegetation data were collected at 50 random sampling points per plot during the last week of May and the first week of June 1998 and 1999. Horizontal structure and vegetation composition were estimated within a 20 cm × 50 cm frame placed at each sample point (Daubenmire, 1959). Species cover could overlap or exceed 100%. Vertical structure of the vegetation at each sample point was indexed by visually estimating obstruction (VOB) of a vertical pole positioned at a distance of 4 m and height of 1 m from the observer (Robel et al., 1970).

Abundance of bird species was estimated within a radius of 50 m (0.79 ha) of each of six permanently marked points spaced at 150 m in each plot (Savard and Hooper, 1995). Counts occurred five times within each of five 10-day intervals during the breeding season from 1 May to 19 June in 1998 and 1999 (Ralph et al., 1993). Counts were not conducted when wind speed exceeded 8 km/h or during heavy rain. Each count was made between 0530 and 1000 a.m. and was 8 min in duration. Counting of birds began as the observer approached the perimeter of a 50 m point. Three observers conducted counts and the same observer did not count each site more than three times (Sauer et al., 1994).

Composition of plant species (COMP) was analyzed using detrended correspondence analysis (DCA) within CANOCO (v4.0; ter Braak and Smilauer, 1998) with year and route as covariables in the DCA. Plant species composition, coefficient of variation of percent cover of grass (CVGRASS; Roth, 1976) and mean height (cm) of visual obstruction (VOB) within a plot (Robel et al., 1970) were compared using the Wilcoxon signed-rank test (PROC NPAR1WAY; SAS, 1989).

Bird abundance by species was averaged over the six points and five periods and expressed as bird density (number of individuals per 40 ha). Interaction between year and grassland type on abundance of individual species of birds was tested using analysis of variance on ranked data (PROC GLM; SAS, 1989) or the Wilcoxon signed-rank test.

Effects of composition and structure of vegetation on the bird community was assessed using canonical correspondence analysis within CANOCO. Monte Carlo permutations ($n = 199$) were used to test for significance. Plot scores of the pCCA were subjected to the Wilcoxon signed-rank test to determine if bird assemblages on seeded grassland differed from bird assemblages in native mixed prairie along habitat gradients in the pCCA.

3. Results

Vegetation of the two grassland types occupied different positions in ordination space (Fig. 1a, Table 1). Plots containing greater canopy cover of exotic grasses had low scores, whereas native grasses and the majority of forb species had high scores on axis 1 of the species scatter plot of the pDCA (Fig. 1b, Table 1). Vertical structure (VOB) ($P = 0.16$) and horizontal structure (CVGRASS) ($P = 0.08$) did not differ between native mixed prairie and seeded grassland plots (Table 1).

The most abundant bird species, eastern meadowlark, western meadowlark, and grasshopper sparrow, were similarly abundant in the two grassland types (Table 2). Data were pooled across years because abundance of individual species of birds was not affected by an interaction between year and grassland type ($P > 0.05$). However, abundance of individual species of birds clearly varied in a predictable manner along gradients in habitat structure (Fig. 2b). For example, northern bobwhite and killdeer were more abundant with greater horizontal patchiness. Western meadowlark and grasshopper sparrow were less abundant with greater horizontal patchiness but more abundant with low levels of vertical structure (Fig. 2b). Northern mockingbirds, brown-headed cowbirds, dickcissels, and eastern meadowlarks were more abundant with high levels of vertical structure and greater richness of plant species (Fig. 2b).

Table 1
Mean (±S.E.) habitat attributes of native mixed prairie ($n = 8$) and seeded grassland ($n = 8$), 1998–1999

Habitat attribute	Abbreviation	Mean		P[a]
		Seeded grassland	Mixed prairie	
Visual obstruction (cm)	VOB	39.6 (±6.4)	48.7 (±4.5)	0.16
CV of % grass cover	CVGRASS	35.2 (±3.6)	48.0 (±6.4)	0.08
Composition of vegetation (%)[b]	COMP	0.2 (±0.1)	2.8 (±0.1)	0.01

[a] Wilcoxon 2-sample signed-rank test.

[b] Importance value derived from axis-1 plot scores ($n = 16$) from a partial detrended correspondence analysis (pDCA) of plant species cover.

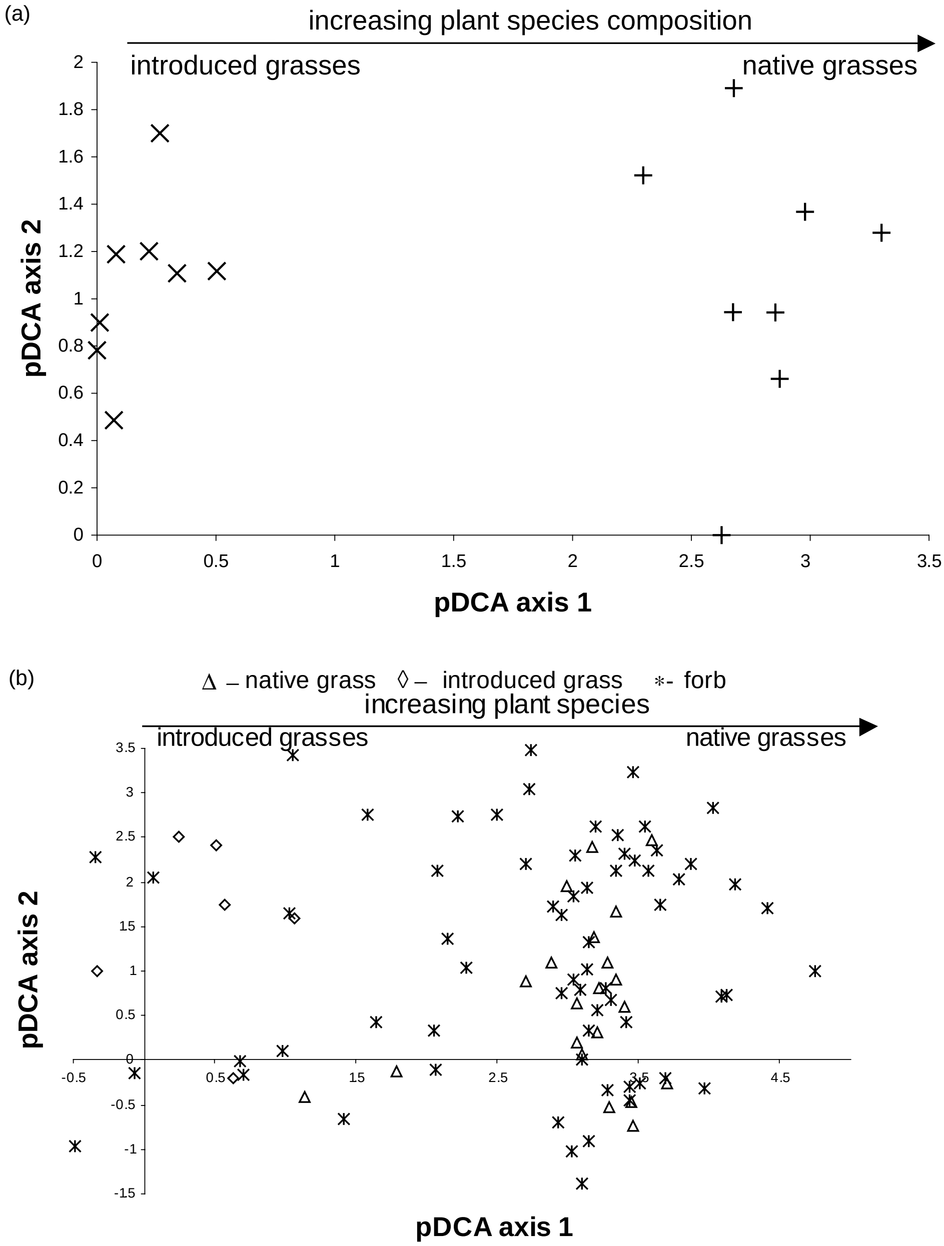

Fig. 1. Scatter plots of (a) plot scores [×: seeded grassland; +: native mixed prairie] and (b) species scores from a partial detrended correspondence analysis (pDCA) of percent cover of plant species on seeded grassland ($n = 8$) and native mixed prairie ($n = 8$).

Bird community and habitat attributes were clearly related, and structural habitat variables were more correlated to the first two axes of the pCCA than was composition of vegetation (Fig. 2). Horizontal heterogeneity of vegetation (CVGRASS) was correlated with the first pCCA axis, vertical structure of vegetation (VOB) with axis 2, and vegetation composition (COMP) with axis 3 (Table 3).

Table 2
Abundance (number of individuals/40 ha) of bird species occupying seeded grassland ($n = 8$) and native mixed prairie ($n = 8$), 1998–1999

Bird species	Seeded grassland		Mixed prairie		P[a]
	Mean	S.E.	Mean	S.E.	
Killdeer, *Charadrius vociferous* (Linnaeus)	4.5	2.6	1.9	0.7	0.86
Upland sandpiper, *Bartramia longicauda* (Bechstein)	0.4	0.4	0.0	0.0	0.38
Wild turkey, *Meleagris gallopavo* (Linnaeus)	0.0	0.0	0.9	0.9	0.38
Ring-necked pheasant, *Phasianus colchicus* (Linnaeus)	0.2	0.2	0.2	0.2	1.00
Northern bobwhite, *Colinus virginianus* (Linnaeus)	0.9	0.6	0.4	0.3	0.84
Mourning dove, *Zenaida macroura* (Linnaeus)	4.0	1.9	9.1	6.8	1.00
Yellow-billed cuckoo, *Coccyzus americanus* (Linnaeus)	0.2	0.2	0.0	0.0	0.38
Red-headed woodpecker, *Melanerpes erythrocephalus* (Linnaeus)	0.0	0.0	0.9	0.9	0.38
Northern flicker, *Colaptes auratus* (Linnaeus)	0.0	0.0	0.4	0.4	0.38
Scissor-tailed flycatcher, *Muscivora forficatus* (Gmelin)	0.9	0.6	3.8	1.7	0.20
Eastern kingbird, *Tyrannus tyrannus* (Linnaeus)	0.2	0.2	0.9	0.5	0.27
Western kingbird, *Tyrannus verticalis* (Say)	0.2	0.2	0.0	0.0	0.40
Great-crested flycatcher, *Myiarchus crinitus* (Linnaeus)	0.2	0.2	1.3	1.3	1.00
Blue jay, *Cyanocitta cristata* (Linnaeus)	0.2	0.2	1.3	1.3	1.00
Northern mockingbird, *Mimus polyglottos* (Linnaeus)	0.0	0.0	1.1	0.6	0.08
American robin, *Turdus migratorius* (Linnaeus)	0.0	0.0	0.2	0.2	0.38
Red-winged blackbird, *Agelaius phoeniceus* (Linnaeus)	0.4	0.4	2.1	1.0	0.13
Brown-headed cowbird, *Molothrus ater* (Boddaert)	3.0	2.1	4.5	2.4	0.78
Common grackle, *Quiscalus quiscula* (Linnaeus)	0.6	0.4	0.0	0.0	0.17
Great-tailed grackle, *Quiscalus mexicanus* (Gmelin)	0.0	0.0	0.9	0.6	0.19
Eastern meadowlark, *Sturnella magna* (Linnaeus)	10.0	4.5	11.5	4.3	0.53
Western meadowlark, *Sturnella neglecta* (Audubon)	14.7	9.0	14.0	6.3	0.92
Northern oriole, *Icterus galbula* (Linnaeus)	0.2	0.2	0.9	0.9	1.00
Dickcissel, *Spiza americana* (Gmelin)	6.0	2.9	15.5	11.1	0.63
Northern cardinal, *Cardinalis cardinalis* (Linnaeus)	0.0	0.0	0.9	0.9	0.38
Indigo bunting, *Passerina cyanea* (Linnaeus)	0.0	0.0	0.2	0.2	0.38
Painted bunting, *Passerina ciris* (Linnaeus)	0.2	0.2	0.2	0.2	1.00
Field sparrow, *Spizella pusilla* (Wilson)	0.6	0.4	2.8	1.6	0.44
Lark sparrow, *Chondestes grammacus* (Say)	3.0	1.6	8.3	2.8	0.09
Grasshopper sparrow, *Ammodrammus savannarum* (Gmelin)	36.7	13.3	37.4	8.0	0.37
Total bird abundance	87.3	20.1	121.7	14.8	0.11
Species richness	7.5	1.0	10.1	0.9	0.14

[a] Wilcoxon 2-sample signed-rank test.

Table 3
Partial canonical correspondence analysis (pCCA; $F = 1.74$, $P = 0.01$) of abundance of breeding birds and habitat attributes on seeded grassland ($n = 8$) and native mixed prairie ($n = 8$) from 1998 to 1999, and comparison of the effect of grassland type

pCCA axis	Results of ordination (pCCA)			Seeded grassland		Mixed prairie		P[c]
	Gradient[a]	Eigenvalue	Variance explained (%)[b]	Mean	S.E.	Mean	S.E.	
Axis 1	CVGRASS (0.90)	0.15	56	−0.3	0.5	0.0	0.3	0.32
Axis 2	VOB (0.84)	0.07	26	−0.2	0.4	0.2	0.4	0.57
Axis 3	COMP (−0.98)	0.05	18	1.0	0.3	−0.8	0.4	0.01

[a] Identified by inter-set correlations. r-Value in parentheses.
[b] Between bird abundance and habitat attributes.
[c] Wilcoxon 2-sample signed-rank test of the effect of grassland type.

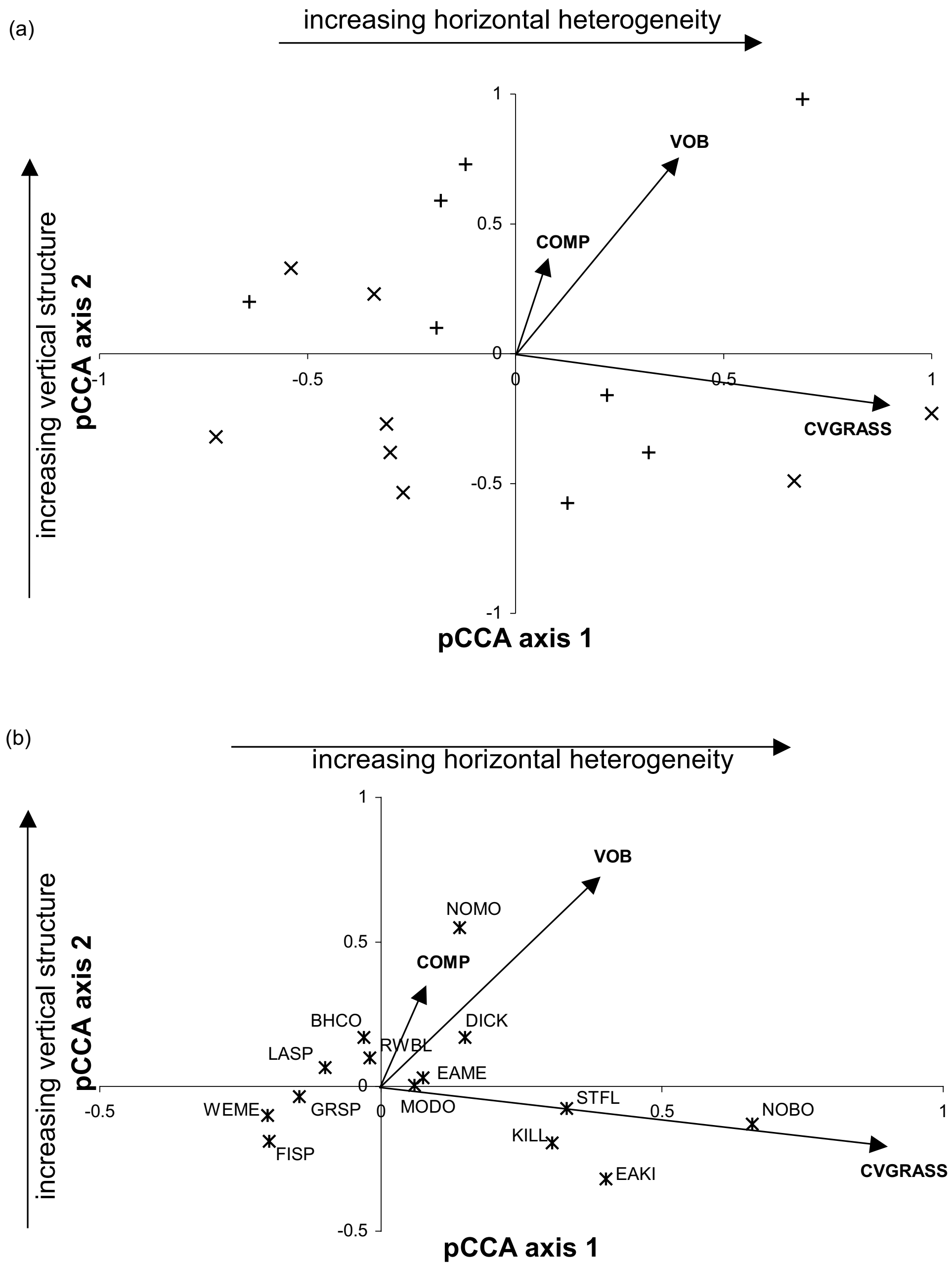

Fig. 2. Biplots for (a) plots [×: seeded grassland; +: native mixed prairie] and (b) species from a partial canonical correspondence analysis (pCCA) of bird abundance and habitat attributes of horizontal heterogeneity (CVGRASS), vertical structure (VOB), and vegetation composition (COMP) on seeded grassland ($n = 8$) and native mixed prairie ($n = 8$) ($F = 1.74$, $P = 0.01$).

Bird abundance differed with respect to the gradient of composition of plant species, but that gradient explained only 18% of the variance between abundance of bird species and habitat attributes (Table 3). Therefore, the two structural attributes (VOB and CVGRASS) represented more important habitat gradients to bird assemblages than composition of plant species (COMP; Fig. 2). Bird abundance did not differ between seeded grassland and native mixed prairie along the gradients of horizontal heterogeneity (CVGRASS) and visual obstruction of vegetation (VOB), but the two gradients explained most of the variance between bird abundance and habitat attributes (Table 3). The two grassland types overlapped considerably in ordination space along environmental gradients with respect to species composition of the bird community (Fig. 2a).

4. Discussion and conclusions

Because cover of each plant species was analyzed in the pDCA, plot scores from axis 1 of the pDCA represented floristic composition of the plant communities studied. As in the northern Great Plains (Wilson and Belcher, 1989; Sutter and Brigham, 1998), native mixed prairie had more species than seeded grassland. However, seeded grassland is managed to maintain a monoculture (McCoy et al., 1992; Engle and Bidwell, 2000). Differences in plant species composition between native mixed prairie and seeded grassland were not reflected in either habitat structure or bird community composition. In other studies, species composition of the bird community differed between native mixed prairie and seeded grassland when differences were large in both plant species composition and habitat structure (Wilson and Belcher, 1989; Sutter et al., 1995; Davis and Duncan, 1999), but did not differ when habitat structural differences were small (Sutter and Brigham, 1998). Grassland birds respond to structural cues during the breeding season (Wiens, 1973; Sutter et al., 1995; Herkert, 1997), and the investigated bird community was ordered largely along structural gradients during the breeding season even with large differences in plant species composition between grassland types. Because structure did not differ between native mixed prairie and seeded grassland, much of the structural gradients were attributed to disturbance created by grazing and haying.

As in the UK (Vickery et al., 2001), herbivory is a major factor influencing horizontal structure of vegetation and therefore bird assemblages. Grassland receiving long-term rest from grazing had greater horizontal patchiness than hay fields, most CRP fields, and heavily grazed pastures. Heavy grazing contributes to homogeneity of horizontal structure because use of forage is more uniform with increasing grazing pressure, whereas grazing at low to moderate intensity results in patches of lightly grazed and heavily grazed vegetation (Holechek et al., 1998). Bird species composition within moderately grazed grasslands varied considerably along the horizontal patchiness gradient. Grasshopper sparrow and western meadowlark require uniform, often short to mid-stature, herbaceous vegetation with high grass cover and moderate litter cover (Lanyon, 1994; Vickery, 1996) and were associated with hay fields and other CRP fields that contained generally uniform stands of Old World bluestem.

Establishment of seeded grasses in croplands influences horizontal heterogeneity, and therefore, bird species composition. In the present study, a CRP field and an ungrazed pasture, both seeded, were the patchiest and had the lowest cover of Old World bluestem. These two plots were associated with birds requiring horizontal patchiness.

Revegetation with exotic plants may provide economic advantages over native plant species (Whisenant, 1999). Habitat conservation programs and federal set-aside programs, including CRP, have relied on introduced species and are reported to provide important habitat for grassland birds in areas of intensive agriculture (Johnson and Schwartz, 1993b; Best et al., 1997). These programs are believed to contribute to recovery of declining species of grassland birds (Johnson and Schwartz, 1993a; Herkert, 1997), despite recommendations for seeding native plants (e.g., Wildlife Management Institute, 1994). Adding native species to seeded grassland in the southern Great Plains, an infrequent practice, would add structural heterogeneity and contribute to greater bird diversity similar to pastures of the northern Great Plains seeded to a grass–legume mixture (Johnson and Schwartz, 1993b; Davis and Duncan, 1999).

Abundance of breeding birds is only one index of habitat suitability, and productivity of birds also must be considered when assessing quality of breeding habitat (Vickery et al., 1992). There are few differences in abundance of various grassland bird species in CRP fields planted to either native or exotic grasses, but productivity can vary according to structural complexity (McCoy et al., 2001). Nest success and productivity could be greater on native mixed prairie than on seeded grassland for a number of reasons. For example, Old World bluestems produce chaffy seeds, which are not preferred by seed-eating birds (Baumgartner et al., 1952) whereas forb species provide an assortment of seed and invertebrate food resources (Blenden et al., 1986).

Seeded grassland was inferior to native mixed prairie in terms of diversity of plant species, an important conservation issue itself, but this was not translated into meaningful differences in herbaceous habitat structure that drove habitat selection by breeding birds. The overlap in bird community composition showed that disturbance rather than plant species composition creates habitat heterogeneity required by a diverse assemblage of bird species. Conservation programs that promote establishment of seeded grassland and do not allow for suitable disturbance regimes will selectively benefit a narrow suite of birds regardless of plant species composition.

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