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GRASSLAND BIRDS AND HABITAT STRUCTURE IN SANDHILLS PRAIRIE MANAGED USING CATTLE OR BISON PLUS FIRE

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ABSTRACT—Grassland birds are known to respond to specific changes in habitat structure, such as plant height and density. However, the response of grassland bird communities to management induced changes in the regional habitat mosaic are less well understood. Grazing by ungulates and fire regimes play an important role in defining the habitat mosaic in the Great Plains. We provide information on bird abundance, distribution, and habitat structure from similar sandhill prairie landscapes managed traditionally with grazing by cattle (*Bos taurus*) and by a dynamic bison (*Bos bison*)-plus-fire regime. Although the two management regimes are dissimilar, only a few differences were recorded in bird abundance, distribution, and habitat structure at the landscape scale. Our result may reflect either the inherent variability of sandhills prairie compared to the scale at which grassland birds perceive habitat, or the short time frame over which the dynamic bison-plus-fire regime has been in place. The specific habitat patches produced by fire and by intensive bison grazing do appear to have different bird communities and habitat structure at the local scale.

Introduction

Conservationists are increasingly aware of declines in many prairie bird species (Knopf 1996). However, the degree to which these declines are due to conversion of native grassland to other land uses, or to incompatible management of existing habitat, needs continued exploration. Grazing and prescribed burning are management tools used on Great Plains ranchland, prairie preserves, and wildlife management areas. Both of these management tools alter grassland structure and function and, so, they may influence the abundance and distribution of bird species within the landscape. The effects of grazing on upland bird nesting was reviewed by Kirsch et al. (1978). The effects of grazing on non-game bird communities in northern mixed-grass prairie have been reported by Bowen and Kruse (1993), Kantrud (1981) and Kantrud and Higgins (1992). Huber and Steuter (1984), Johnson (1996), and Kirsch and Higgins (1976) reported the effects of fire on non-game bird communities in northern mixed-grass prairie. These studies and others (Kantrud and Kologiski 1983; Messmer 1990; Sedivec 1989; Zimmerman 1996) have demonstrated that local conditions and habitat requirements of individual species determine bird response to the season and intensity of grazing by cattle (*Bos taurus*) and of fire occurrence.

Bison (*Bos bison*) represent an alternative to cattle, both as an economic enterprise and as a management tool in the Great Plains (Plumb and Dodd 1993). In the Nebraska Sandhills, interactive effects of bison grazing and fire may cause plant community dynamics to differ from those produced by traditional cattle grazing management. The comparative ecology of bison and cattle has been discussed by Hartnett et al. (1996a) and Plumb and Dodd (1993). Recently, several authors have examined the interactive effects of bison and fire on plant communities (Biondini et al. 1998; Hartnett et al. 1996b; Pfeiffer and Steuter 1994). However to our knowledge, the research of Zimmerman (1996) in tallgrass prairie is the only instance in which the influence of both bison and cattle, and the interactive effects of fire plus bison, on grassland birds has been examined. Here, we present results of breeding bird censuses and habitat studies conducted on cattle grazed and bison-plus-fire managed sandhill prairie in north-central Nebraska.

Study Area and Methods

Our studies took place on The Nature Conservancy's Niobrara Valley Preserve in north-central Nebraska (Fig. 1). Data were collected in a large pasture managed with bison (Fig. 2) and prescribed burning (referred to as

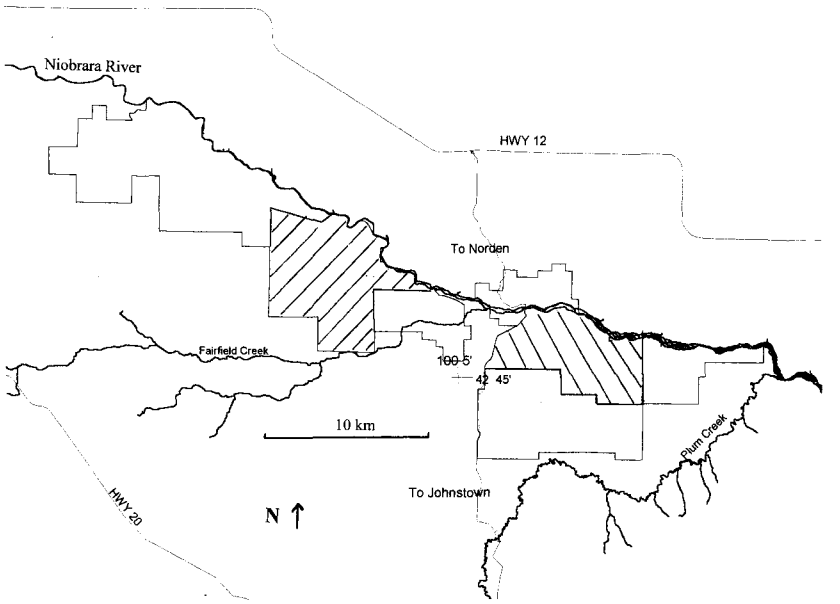

Figure 1. The cattle grazed (///) and bison-plus-fire (\\\) study areas on the sandhill portion of the Niobrara Valley Preserve (——) south-side of the Niobrara River, north of Johnstown, NE.

the bison-plus-fire enclosure), and a four-pasture cattle management unit (referred to as the cattle enclosures). Sandhill prairie occupies the majority of both the bison+fire and the cattle enclosures. A description of the flora of the Nebraska Sandhills can be found in Weaver (1965) while a classification of the herbaceous and woody plant communities at the Niobrara Valley Preserve is provided by Kantak (1995). The primary topo-edaphic units within the bison+fire and cattle enclosures are sands, choppy sands, and shallow-to-gravel range sites (USDA 1992). Sands and choppy sands occupy similar proportions (40%) of the bison+fire and cattle enclosures. Sands range sites have the highest primary production, followed by choppy sands (USDA 1992). Shallow-to-gravel range sites occupy the least amount of area in the bison+fire and cattle enclosures (about 15%), and they are characterized by the lowest primary production.

The bison+fire enclosure is a 3,000 ha unit that is grazed 12 months per year at approximately 1.2 AUM/ha/yr. An AUM is the amount of forage consumed by a 454 kg bison or domestic cow in one month. Areas within the

Figure 2. A bison herd actively grazing through sandhills prairie. Note the structure of the dense, grass-dominated area where grazing is occurring compared to the forb dominated patch in the foreground with higher levels of bare ground. Photo courtesy of Al Steuter.

bison+fire enclosure with the highest fuel accumulations are selected for prescribed burning during dormant (80%) and growing (20%) seasons; and, burn area varies from 40 to 160 ha (Steuter et al. 1990). The cattle enclosures consist of approximately 3,200 ha in four adjacent pastures that are grazed from approximately 15 May to 15 November at about 1.0 AUM/ha/yr.

Twenty-four transects, 250 m long, were randomly located in the bison+fire enclosure (n=12 transects) and in the four cattle enclosures (n=12 transects) in each year of the study. Data were collected 14-29 June 1995 and 10-19 June 1996. Bird data were collected between sunrise and 10:00 am when temperatures were greater than 10 CE, wind speeds were less than 25 kilometers per hour, and it was not raining. Birds were recorded as the observer proceeded along the transect and at 10 points on the transect, 25 m

apart, where the observer paused for three minutes. All birds detected by sight or sound that were either flushed, landing, perched on the ground or perched on vegetation out to a distance of 250 m were recorded. Only birds in front of or perpendicular to the observer were recorded. An effort was made not to record individual birds more than once.

Vegetation structure was determined during the same periods as bird distribution and abundance, and along the same transects. A visual obstruction pole, modified from Robel et al. (1970), was used for measurement of vegetation. Vegetation density was determined by the lowest height at which the entire pole was visible. Vegetation height was determined by the highest point at which vegetation crossed between the observer and the pole. The observer recorded vegetation density and height in four cardinal directions at each of the 10 points, 25 m apart, on every transect.

One-way analysis of variance and Kruskal-Wallace non-parametric tests were used to test for significant differences between the means of each study area for the following variables: species richness, relative abundance of all birds, relative abundance of mourning dove (*Zenaida macroura*), horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), grasshopper sparrow (*Ammodramus savannarum*), lark sparrow (*Chondestes grammacus*) and field sparrow (*Spizella pusilla*), and vegetation density and vegetation height. We accepted type I error at 0.05 probability. When there were no significant differences between years for a variable, the data from 1995 and 1996 were combined to compare means between study areas.

Results

In 1995, fifteen bird species were encountered in the bison+fire enclosure and 11 bird species were encountered in the cattle enclosures. However, there were no significant differences in bird species richness or abundance nor in vegetation density or height in the bison+fire enclosure compared to the cattle enclosures (Table 1).

In 1996, fourteen bird species were encountered in the bison+fire enclosure and 10 bird species were encountered in the cattle enclosures. Species richness and the relative abundance of horned lark and lark sparrow were significantly higher in the bison+fire enclosure, and the relative abundance of western meadowlark was significantly higher in the cattle enclosures in 1996 (Table 2). As in 1995, there were no differences in vegetation density or height between the bison+fire and cattle grazed enclosures.

TABLE 1

MEAN (STANDARD ERROR) BIRD SPECIES RICHNESS AND RELATIVE ABUNDANCE, AND VEGETATION DENSITY AND HEIGHT IN 1995. P-VALUES ARE PROVIDED FOR COMPARISONS, WHERE SAMPLE SIZES WERE ADEQUATE. BOLD P-VALUES INDICATE SIGNIFICANT DIFFERENCES.

	Bison+Fire		Cattle		P-value
	$\bar{X}$	SE	$\bar{X}$	SE	
Species Richness (species/transect)	3.7	0.60	4.0	0.56	0.69
Relative Abundance (birds/transect)					
All Birds	11.2	1.35	11.1	1.79	0.94
Upland Sandpiper (*Bartramia longicauda*)	0		0.2	0.25	-
Mourning Dove	0.2	0.13	0.5	0.34	0.91
Eastern Kingbird (*Tyrannus tyrannus*)	0.1	0.08	0		-
Horned Lark	2.2	1.40	0.9	0.53	0.89
Brown Thrasher (*Toxostoma rufum*)	0.1	0.08	0.2	0.13	-
Yellow-breasted Chat (*Icteria virens*)	0.1	0.08	0		-
Indigo Bunting (*Passerina cyanea*)	0.2	0.13	0		-
Eastern Towhee (*Pipilo erythropthalmus*)	0.5	0.29	0.5	0.23	-
Field Sparrow	0.9	0.54	1.1	0.56	0.69
Lark Sparrow	0.9	0.31	1.4	0.65	0.95
Lark Bunting	0.2	0.17	0		-
Grasshopper Sparrow	4.4	0.93	4.0	0.80	0.55
Western Meadowlark	0.5	0.20	1.2	0.44	0.28
Brown-headed Cowbird (*Molothrus ater*)	0.2	0.25	0.7	0.31	-
American Goldfinch (*Carduelis tristis*)	0.1	0.08	0.2	0.25	-
Vegetation Structure (cm)					
Vegetation Density	4.8	1.21	4.3	1.05	0.76
Vegetation Height	32.1	4.01	34.3	3.23	0.67

TABLE 2

MEAN (STANDARD ERROR) OF BIRD SPECIES RICHNESS AND RELATIVE ABUNDANCE, AND VEGETATION DENSITY AND HEIGHT IN 1996. P-VALUES ARE PROVIDED FOR COMPARISONS, WHERE SAMPLE SIZES WERE ADEQUATE. BOLD P-VALUES INDICATE SIGNIFICANT DIFFERENCE.

	Bison+fire		Cattle		P-value
	$\bar{X}$	SE	$\bar{X}$	SE	
Species Richness (species/transect)	5.2	0.37	3.8	0.32	**0.02**
Relative Abundance (birds/transect)					
All Birds	11.8	1.72	9.8	0.97	0.30
Sharp-tailed Grouse (*Tympanuchus phasianellus*)	0.3	0.26	0		-
Killdeer (*Charadrius vociferus*)	0		0.1	0.08	-
Upland Sandpiper	0.4	0.23	0.5	0.23	-
Mourning Dove	0.4	0.15	0.8	0.37	0.92
Eastern Kingbird	0		0.2	0.17	-
Horned Lark	2.0	0.60	0.5	0.36	**0.03**
American Crow (*Corvus brachyrhynchos*)	0.1	0.08	0		-
Brown Thrasher	0.2	0.11	0		-
Indigo Bunting	0.1	0.08	0		-
Eastern Towhee	0.2	0.18	0		-
Field Sparrow	1.4	0.57	0.8	0.30	0.54
Lark Sparrow	2.2	0.55	0.4	0.23	**0.01**
Grasshopper Sparrow	2.4	0.50	3.2	0.69	0.34
Western Meadowlark	1.3	0.47	2.4	0.36	**0.04**
Brown-headed Cowbird	0.5	0.42	0.8	0.51	-
American Goldfinch	0.2	0.17	0		-
Vegetation Structure (cm)					
Vegetation Density	6.37	0.52	6.4	0.86	0.93
Vegetation Height	27.17	1.57	29.1	1.62	0.40

TABLE 3

MEAN (STANDARD ERROR) FOR APPROPRIATE COMPARISONS BETWEEN THE BISON-FIRE ENCLOSURE AND THE CATTLE ENCLOSURES WITH 1995 AND 1996 DATA COMBINED. BOLD P-VALUES INDICATE SIGNIFICANT DIFFERENCE.

	Bison+fire		Cattle		P-value
	$\bar{X}$	SE	$\bar{X}$	SE	
Relative Abundance (birds/transect)					
All Birds	11.5	1.07	0.4	1.01	0.51
Mourning Dove	0.3	0.01	0.6	0.25	0.92
Horned Lark	2.1	0.75	0.7	0.32	0.10
Grasshopper Sparrow	3.4	0.56	3.5	0.53	0.85
Field Sparrow	1.2	0.40	1.0	0.31	0.89
Lark Sparrow	1.5	0.34	0.9	0.35	**0.05**

A comparison of the variables within the bison+fire enclosure, but between years, revealed that average species richness was significantly higher in 1996 (3.7, S.E. 0.60) than in 1995 (5.2, S.E. 0.37; $P<0.05$). Similarly, comparison within the cattle enclosures between years revealed that the relative abundance of western meadowlark averaged significantly higher in 1996 (2.4, S.E. 0.36) than 1995 (1.2, S.E. 0.44; $P<0.02$). Vegetation density was significantly higher in 1996 (6.4, S.E. 0.86) than 1995 (4.32, S.E.1.05; $P<0.03$).

To facilitate pattern analysis, we combined similar data from 1995 and 1996 and compared the bison+fire enclosure and the cattle enclosures. Relative abundance of the lark sparrow was significantly higher in the bison+fire enclosure than in the cattle enclosures (Table 3). Species richness, relative abundance of western meadowlark and vegetation density could not be included in this analysis because of the significant differences between years (above).

We also compared selected variables between burned ($n = 7$) and unburned ($n = 5$) transects in the bison+fire enclosure in 1995. We found that grasshopper sparrows (Figure 3) were significantly more abundant on unburned transects (6.6, S.E. 1.44) than the burned transects (2.9, S.E. 0.88; $P<0.05$). A comparison between years for the burned transects within the

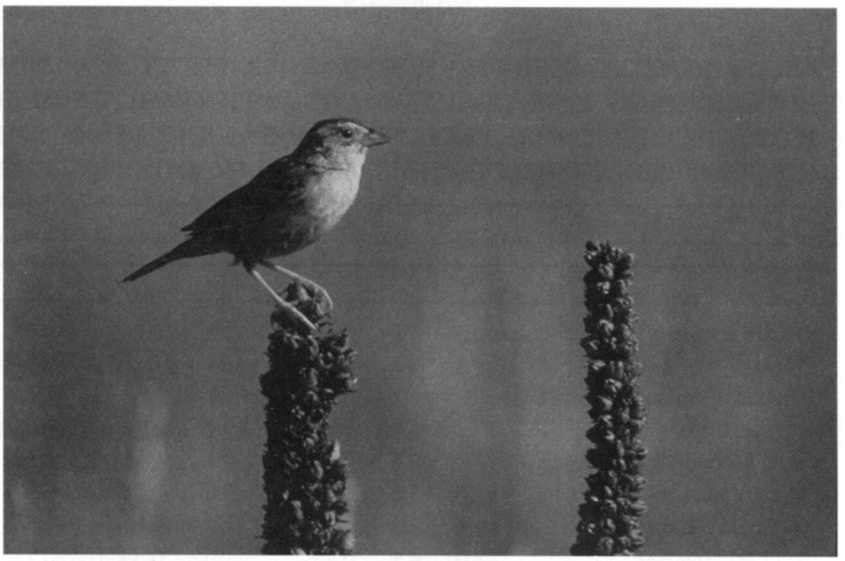

Figure 3. The grasshopper sparrow is a common grassland obligate species in sandhills prairie. Photo courtesy of the Nebraska Game and Parks Commission.

bison+fire enclosure (n = 7 in 1995, n = 8 in 1996), showed no significant differences for any of the variables. However, in a comparison between years for the unburned transects in the bison+fire enclosure (n=5 in 1995, n=4 in 1996), the average number of grasshopper sparrows was significantly higher in 1995 (6.6, S.E. 1.44) than in 1996 (1.8, S.E. 0.48; $P<0.03$). When the data from 1995 and 1996 were combined, except for the grasshopper sparrow, and compared between burned and unburned transects within the bison+fire enclosure, we found that species richness was significantly higher ($P < 0.05$), and the relative abundance of all birds, mourning dove, and horned lark trended higher ($0.05 < P < 0.10$), on the burned transects (Table 4).

We also compared burned transects within the bison+fire enclosure between years, omitting shallow to gravel range sites (n=6 in 1995, n=4 in 1996). In this comparison, we found no significant differences among the means for any of the variables. A similar comparison between years for the unburned transects within the bison+fire enclosure, omitting the shallow to

TABLE 4

MEAN (STANDARD ERROR) FOR APPROPRIATE COMPARISONS BETWEEN THE BURNED (N = 15) AND UNBURNED (N = 9) TRANSECTS WITHIN THE BISON-FIRE ENCLOSURE, 1995 AND 1996 DATA WERE COMBINED. BOLD P-VALUES INDICATE SIGNIFICANT DIFFERENCE.

	Burned		Unburned		P-value
	X	SE	X	SE	
Species Richness (species/transect)	5.2	0.47	3.6	0.26	**0.05**
Relative Abundance (birds/transect)					
All Birds	13.0	1.46	9.1	1.16	0.08
Mourning Dove	0.5	0.13	0.1	0.11	0.08
Horned Lark	3.1	1.12	0.6	0.38	0.07
Field Sparrow	1.3	0.49	1.0	0.67	0.50
Lark Sparrow	1.9	0.49	1.0	0.33	0.23

gravel range sites (n=4 in 1995, n=2 in 1996) also identified no significant differences. When the data from 1995 and 1996 were combined and compared between burned and unburned transects within the bison enclosure (without those on shallow to gravel range sites), we found that both species richness and the relative abundance of horned lark and mourning dove were significantly higher on the burned transects (Table 5).

Discussion

In this study, bird species richness was higher in a bison+fire enclosure than in cattle enclosures in one of the two years. Horned lark, lark sparrow, and mourning dove tended to be more abundant on burned and bison grazed areas. In contrast, grasshopper sparrow and meadowlark tended to be more abundant on unburned and cattle grazed areas, respectively. These results are consistent with other published information on species' preferences for uniformly short stature and for more structurally diverse grasslands, respectively (Huber and Steuter 1984; Kantrud 1981; Kirsch et al. 1978; Zimmerman 1997).

Bird species richness was also higher on burned than on unburned transects in the main vegetation types within the bison+fire enclosure, i.e.,

TABLE 5

MEAN (STANDARD ERROR) FOR APPROPRIATE COMPARISONS BETWEEN BURNED (N = 14) AND UNBURNED (N = 6) TRANSECTS IN SANDS AND CHOPPY SANDS RANGE SITES IN THE BISON-FIRE ENCLOSURE, 1995 AND 1996 DATA WERE COMBINED. BOLD P-VALUES INDICATE SIGNIFICANT DIFFERENCE.

	Burned		Unburned		P-value
	$\bar{X}$	SE	$\bar{X}$	SE	
Species Richness (species/transect)	5.4	0.48	3.3	0.67	**0.03**
Relative Abundance (birds/transect)					
All Birds	13.0	1.57	9.3	1.71	0.19
Mourning Dove	0.5	0.14	0		**0.04**
Horned Lark	2.5	1.04	0		**0.02**
Grasshopper Sparrow	2.9	0.56	4.7	1.65	0.22
Field Sparrow	1.4	0.52	1.5	0.96	0.93
Lark Sparrow	1.9	0.52	1.3	0.42	0.50

when the shallow-to-gravel range sites were excluded from the analysis. The vegetation on shallow to gravel ranges sites has a shorter stature than other sandhill prairie range sites, even in the absence of fire or grazing. Also, these shallow to gravel range sites have distinctly different plant composition (*Grama,* sedges, and forbs), than burned sands or choppy sands ranges sites (*Andropogon, Calamovilfa, Panicum*) (USDA 1992). There is some evidence that the interactive effects of bison grazing and fire create landscape patches with a novel plant structure and function, patches not present within the cattle enclosures (Pfeiffer and Steuter 1994). Such fire+grazing patches were large areas with short vegetation, like shallow to gravel range sites, but composed of the more productive plant species associated with sands and choppy sands range sites. Zimmerman (1997) hypothesized that an increase in energy availability for higher trophic levels on burned prairie could result in higher bird productivity. This would help explain the higher bird species richness that characterized both the entire bison+fire enclosure in 1996 and the burned transects within the bison+fire enclosure in both years.

Our study suggests that the differences in grassland bird abundance and distribution, as well as habitat structure, between traditional cattle and bison+fire managed sandhill prairie are relatively small, and largely confined

to recently burned and intensively grazed patches. In our study, the recently burned and intensively grazed sandhill prairie patches had higher bird species richness and relative abundance of several characteristic grassland bird species. In contrast Zimmerman (1997), working in tallgrass prairie, reported lower species richness and relative abundance for grass/forb dependent birds on comparably burned and grazed patches. The Nebraska sandhill midgrass prairie may have a larger number of bird species preferences for the shortgrass habitat than does Flinthills tallgrass prairie.

The visual obstruction method we used to characterize habitat structure at points along our bird census transects was not sensitive to differences in the horizontal, and possibly vertical, structure of sandhill prairie at the scale observed in livestock enclosures. Grassland birds may perceive habitat structure at a coarser scale than our sampling design measured.

Selective grazing on the dominant grasses results in competitive release of subdominant plants, increasing (equitability) of species in both bison-grazed (Fahnestock and Knapp 1994; Hartnett et al. 1996b) and cattle-grazed systems (Collins and Barber 1985; Hickman et al. 1996). However, plant selectivity and dietary niche breadth of grazers, and non-grazing activities such as pawing, wallowing, and fecal and urine deposition differ between bison and cattle (reviewed by Hartnett et al. 1996a). These contribute to differences in the vegetation mosaic at a small scale. At larger scales, preferential use of burned areas by bison results in larger, more intensively grazed patches than occur in non-burned prairie (Biondini et al. 1998; Vinton et al. 1993). However, cattle also selectively use burned areas when given a choice (Duvall and Whitaker 1964).

Both cattle and bison modify local plant community structure to create complex spatial mosaics. The larger patches of both short and tall vegetation in the bison+fire enclosure resulted in a more coarse-grained mosaic than in the cattle grazing only enclosure. The cattle enclosures used in this study had a consistent stocking rate and season of use applied for at least 15 years. We expect that the large and mid-scale vegetation mosaics were relatively stable during this study. In contrast, the bison+fire enclosure had only a four year history, and it was preceded by an extended period of management similar to the cattle enclosures. In a parallel study (Biondini et al. 1998), we concluded that 1996 was the first year that the pattern of bison use of the fire-induced mosaic stabilized, due to a sufficient number and area of past burn patches. Such differences in management history may partially explain the difference between 1995 and 1996 in our results. Further study will allow us to assess longterm trends in bird species diversity in relation to grazing and fire management strategies.

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