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Species diversity and habitat of grassland passerines during grazing of a prescribe-burned, mixed-grass prairie

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SPECIES DIVERSITY AND HABITAT OF GRASSLAND PASSERINES DURING GRAZING OF A PRESCRIBE-BURNED, MIXED-GRASS PRAIRIE

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ABSTRACT.—No published data exist on responses of grassland passerines and their habitat to combined grazing and burning treatments in northern mixed-grass prairie. At Lostwood National Wildlife Refuge (LNWR) in northwestern North Dakota, we monitored breeding bird occurrence, abundance, and habitat during successive annual grazing treatments (1998–2000) on 5 prescribe-burned, mixed-grass prairie management units (range = 50–534 ha, each burned 3–6 times in the previous 10–20 years). All breeding passerine species characteristic of upland, northern mixed-grass prairie were common (>10% occurrence) during at least 1 of 3 years on burned and grazed units, except Chestnut-collared Longspur (*Calcarius ornatus*), which was uncommon. Vegetation was generally shorter and sparser than that found on 4 nearby units treated by fire only (1999; density, visual obstruction, and height, all $P < 0.01$). Regardless, occurrences of individual bird species resembled those previously documented on prairie units at LNWR with similar fire histories but no grazing; however, Brown-headed Cowbird (*Molothrus ater*) occurred 2.4 times more frequently on burned and grazed units studied. Our data suggest that species diversity of breeding grassland passerines changes little during initial years of rotation grazing at moderate stocking rates in fire-managed, northern mixed-grass prairie at LNWR.

Key words: prescribed fire, rotation grazing, habitat management, grassland passerine, mixed-grass prairie, northern Great Plains, species diversity.

The evolution of Great Plains grasslands was shaped by interacting fire and grazing disturbances (Higgins 1986) along with climatic variability (Bragg 1994). To conserve these grasslands and associated wildlife communities, land managers often use prescribed fire or livestock grazing to mimic historic disturbances. Diversity and abundance of grassland birds can increase after fire is reintroduced to northern mixed-grass prairie (Johnson 1997, Madden et al. 1999). Depending on the grazing system employed, livestock grazing can reduce abundances of some breeding bird species, such as Baird's Sparrow (scientific names of bird species are listed in Table 2; Kantrud 1981). Surprisingly, no published data exist on breeding passerine responses to combined fire and grazing treatment regimes in northern mixed-grass prairie. At Lostwood National Wildlife Refuge (LNWR) in northwestern North Dakota, cattle grazing is used mainly to reduce exotic plants, especially smooth brome (*Bromus inermis*), on northern mixed-grass prairie renovated by fire (U.S. Fish and Wildlife Service 1998).

Our primary objective was to measure species diversity and habitat of breeding grassland passerines at LNWR on prairie units managed by a combination of prescribed fire and livestock grazing. Specifically, we sought to document breeding bird occurrence and abundance, species diversity, and habitat (i.e., vegetation) conditions during rotation grazing of prairie 1–4 years after the last of several prescribed burns. Our secondary objective was to compare breeding bird diversity with that of prairie at LNWR with similar fire histories but no grazing (Madden et al. 1999).

STUDY AREA AND METHODS

LNWR covers 109 km² of rolling to hilly moraine in Burke and Mountrail Counties, northwestern North Dakota (48°37′N, 102°27′W). The refuge is 55% native prairie, 21% previously cropped fields that were revegetated with native and introduced plants, 20% wetlands, 2% trees, and 2% tall shrubs (Murphy 1993). Native prairie is a needlegrass-wheatgrass (*Stipa-Agropyron*) association heavily invaded by western snowberry

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(*Symphoricarpos occidentalis*) and 2 exotic grasses, smooth brome and Kentucky bluegrass (*Poa pratensis*). Soils are mainly gravelly clay-loams that occur as Silty and Thin Upland range sites (Soil Conservation Service 1984). Climate is semiarid with a mean annual precipitation of 42 cm (Madden et al. 1999).

The floral integrity of LNWR's mixed-grass prairie deteriorated during decades of long-term rest or light grazing but began to recover after 3–5 prescribed burns were applied over 10–20 years (U.S. Fish and Wildlife Service 1998, Madden et al. 1999). The burning treatment phase was followed by a mixed grazing and burning phase. Five management units at LNWR entered this mixed treatment phase in 1998 (4 units) and 1999 (1 unit), 1–2 years after last having been burned (Table 1). On each unit we employed a rotation grazing system with 1 cattle herd. Each unit was divided into 3 equal-sized cells, and each cell was grazed by cattle for 14 days. Every year 2 of 3 cells in each unit received a 2nd grazing treatment for another 14 days, with 28 days of rest between grazing treatments. The grazing season was late May through mid-August (about 2.5 months). Stocking rates were 0.6–1.2 ha · AUM^{-1} (Table 1), which we considered moderate compared with roughly 0.8 ha · AUM^{-1} recommended based on area soil types (Soil Conservation Service 1984).

During 1998–2000 we sampled vegetation on all of these prescribe-burned and grazed management units and birds on all or a subset of them (Table 1). In 1999 we also sampled vegetation on 4 other management units at LNWR (36, 45, 61, 755 ha) that had burn histories similar to other burn-graze units studied, but they lacked grazing treatments. We sampled birds on 4 of the burn-graze units in 1998. Two of these were relatively small for bird sampling (only 3–4 survey plots each; Table 1). Therefore, during 1999 and 2000 we substituted a larger unit that entered the mixed treatment phase in 1999, while continuing to sample birds on the other 2 large burn-graze units. We did not sample birds on control (burn-only) units because 3 of the 4 units either had more wetlands or more trees than the 5 burn-graze units or were only about 100 m wide.

We followed methods outlined in Madden (1996) and Madden et al. (1999) for measuring bird occurrence and vegetation attributes. We randomly established 75-m-radius survey plots with centers at least 250 m apart. Roads, trees, unit boundaries, and most wetlands were avoided (Madden et al. 1999). Survey plots remained fixed during the course of our study (3–15 plots per unit; units D through H in Table 1). In June each year we conducted three 10-minute surveys of singing males within each plot (Hutto et al. 1986), during the period from one-half hour before sunrise until 0900 CST. Surveys were not conducted during rain, fog, or winds >16 km · h^{-1}. Abundance of each species was the mean number of singing males per plot (i.e., means derived from 3 survey visits to each plot were averaged). Brown-headed Cowbirds were tallied regardless of sex, and their total number on a survey of a plot was divided by 2 for abundance (Madden et al. 1999).

Each year from late June through mid-July, we recorded vegetation structure and general composition for each plot along 2 perpendicular, 150-m transects that bisected the plot center on a randomly selected bearing (Grant et al. 2004). We identified the dominant plant group (woody or herbaceous [i.e., grasses, sedges, forbs], native or exotic vegetation) at 0.5-m intervals for a total of 300 readings per transect (n = 600 readings per plot). We randomly omitted some transect data to avoid over-representing plot centers (Grant et al. 2004). At 15-, 35-, 55-, and 75-m stops from the center along each transect (n = 16 measures per plot), we used a 7-mm-diameter rod to measure vegetation density (i.e., total contacts on the rod; Rotenberry and Wiens 1980), maximum height (highest dm contacted), and litter depth (to nearest cm). Visual obstruction readings (VORs; Robel et al. 1970) were recorded at each stop in 1999 and 2000 to estimate vegetation height-density. VORs were recorded from 4 m away, in 4 cardinal directions, at a height of 1 m. Structural measures were averaged for each plot. We used 2-sample t tests to assess differences in vegetation structure between treatment (burn-graze) units and control (burn-only) units in 1999.

We compared frequencies of occurrence of common breeding bird species during the post-fire grazing treatments of prairie with those documented in 1994 at LNWR on prairie with similar fire histories but no grazing (based on a subset of data from Madden et al. 1999). To minimize differential observer bias in this

TABLE 1. Prescribed burning and grazing treatment history on management units where breeding passerine species were surveyed, Lostwood National Wildlife Refuge, northwestern North Dakota.

Year	Precipitation (cm)[a]	Units[b]	No. burns[c]	Years since last fire[c]	Fire index ($\bar{x}$)[d]	Stocking rate (AUM · ha^{-1})[c,e]
1994	71.3	A, B, C	4, 4, 4	8, 2, 2	1.5	(no grazing)
1998	51.7	D, E, F, G	5, 6, 3, 4	1, 2, 2, 2	2.9	1.2, 0.8, 1.2, 1.2
1999	71.9	F, G, H	3, 4, 5	3, 3, 2	1.6	0.8, 0.8, 0.6
2000	49.4	F, G, H	3, 4, 5	4, 4, 3	1.1	0.8., 0.8, 0.6

[a]Total rainfall and snowmelt from previous June through May of respective study year (U.S. Fish and Wildlife Service unpublished refuge climatological data).
[b]Area (ha) of and number of point count plots sampled for each unit: A, 89 and 9; B, 372 and 20; C, 494 and 20; D, 102 and 4; E, 50 and 3; F, 271 and 10; G, 534 and 15; H, 313 and 10.
[c]Listed respectively for units for each year.
[d]Fire index is a gauge of fire experience based on total number of prescribed burns divided by number of years since the last burn, with 0 indicating no burns and 6.0 indicating many burns, the last recently (Madden et al. 1999).
[e]AUM = Animal Unit Month.

TABLE 2. Frequency of occurrence (%)[a] and abundance[b] of breeding passerine species during 3 years of rotation grazing following prescribed fire treatments on Lostwood National Wildlife Refuge.

	1998 (n = 32)[d]			1999 (n = 35)			2000 (n = 35)		
		Abundance			Abundance			Abundance	
Species[c]	%	$\bar{x}$	$s_{\bar{x}}$	%	$\bar{x}$	$s_{\bar{x}}$	%	$\bar{x}$	$s_{\bar{x}}$
Eastern Kingbird (*Tyrannus tyrannus*)	37.5	0.16	0.04	25.7	0.12	0.04	17.1	0.07	0.03
Horned Lark (*Eremophila alpestris*)*[e]	15.6	0.05	0.02	0			2.9	0.02	0.02
Sprague's Pipit (*Anthus spragueii*)*	15.6	0.05	0.02	34.3	0.14	0.04	31.4	0.16	0.05
Common Yellowthroat (*Geothlypis trichas*)*	0			11.4	0.05	0.02	8.6	0.03	0.02
Clay-colored Sparrow (*Spizella pallida*)*	87.5	0.92	0.13	80.0	0.57	0.08	85.7	0.78	0.07
Vesper Sparrow (*Pooecetes gramineus*)*	28.1	0.15	0.05	11.4	0.06	0.03	11.4	0.05	0.02
Savannah Sparrow (*Passerculus sandwichensis*)*	100	0.98	0.10	97.1	0.97	0.08	100	1.50	0.09
Baird's Sparrow (*Ammodramus bairdii*)*	18.8	0.08	0.04	60.0	0.41	0.07	51.4	0.30	0.06
Grasshopper Sparrow (*Ammodramus savannarum*)*	34.4	0.20	0.06	48.6	0.29	0.06	60.0	0.59	0.11
LeConte's Sparrow (*Ammodramus leconteii*)	18.8	0.07	0.03	25.7	0.12	0.04	25.7	0.09	0.02
Bobolink (*Dolichonyx oryzivorus*)*	46.9	0.29	0.06	57.1	0.45	0.08	57.1	0.27	0.04
Western Meadowlark (*Sturnella neglecta*)*	40.6	0.18	0.04	22.9	0.10	0.03	22.9	0.10	0.03
Brewer's Blackbird (*Euphagus cyanocephalus*)	50.0	0.28	0.08	17.1	0.07	0.03	0		
Brown-headed Cowbird (*Molothrus ater*)*	68.8	0.69	0.10	60.0	0.69	0.14	77.1	1.07	0.18

[a]Percentage of 75-m-radius plots at which a species was detected.
[b]Mean number of singing males detected per 75-m-radius plot.
[c]Only common species, i.e., those detected at >10% of all plots, are included. Species less frequently detected included Western Kingbird (*Tyrannus verticalis*), Sedge Wren (*Cistothorus platensis*), Gray Catbird (*Dumetella carolinensis*), Yellow Warbler (*Dendroica petechia*), Nelson's Sharp-tailed Sparrow (*Ammodramus nelsoni*), Song Sparrow (*Melospiza melodia*), and Chestnut-collared Longspur (*Calcarius ornatus*).
[d]Number of 75-m-radius plots surveyed.
[e]Asterisks denote breeding bird species characteristic of northern mixed-grass prairie (Stewart 1975:25).

comparison, RFD conducted bird surveys in 1998–2000 with training and instruction from RKM and EMM, who conducted 1994 surveys in Madden et al. (1999). We used fire indices and weather records to identify years of comparable fire and precipitation history (Table 1; 1994 versus 1999). Units in the comparison were reasonably similar in range site and general vegetation makeup (i.e., woody and exotic vegetation).

RESULTS

We detected 21 bird species between 1998 and 2000: 17 species in both 1998 and 1999 and 14 species in 2000. Thirteen species were common (detected at >10% of plots) in 1998 and 1999 and 11 were common in 2000 (Table 2). In all years Savannah Sparrow and Clay-colored Sparrow were nearly ubiquitous (detected at ≥80% of plots) and Brown-headed Cowbird was almost as widespread. Several other species were fairly common, although occurrence of some varied among years. For example, Baird's Sparrow, Grasshopper Sparrow, and Sprague's Pipit occurred about twice as frequently in 1999 and 2000 as in 1998. Vesper Sparrow and Western Meadowlark occurred about one-half as frequently in the 2nd and 3rd study years. Horned Lark was rarely detected after 1998. Abundances of species roughly paralleled their respective frequencies of occurrence (Table 2).

Vegetation density and litter depth on the burn-graze units averaged only about 8–9 contacts and 1 cm in all years (Table 3). All units were dominated by a mix of native herbaceous and native woody vegetation. Vegetation density, VOR, and maximum height were greater on control (burn-only) units than on burn-graze units measured the same year (1999; df = 7; t = 4.17, 4.57, and 7.15, respectively; P = 0.004, 0.003, and <0.001), but we detected no difference in litter depth (Aspin-Welch unequal variance test, df = 7, t = 1.52, P = 0.22). Three of these burn-graze units were sampled for birds for comparison with an earlier study; the mean and variation of structural characteristics of this subsample were identical to those of respective characteristics of all 5 units, except for total hits ($\bar{x}$ = 8.5, $s_{\bar{x}}$ = 0.5 in subsample, versus $\bar{x}$ = 8.3, $s_{\bar{x}}$ = 0.3 in Table 3).

Frequencies of occurrence for grassland birds were comparable between prescribe-burned prairie that was being grazed by livestock during our study and prairie with a similar fire history but no grazing, studied earlier at LNWR (Table 4). Among common species, however, Brown-headed Cowbird occurred 2.4 times more frequently on burned and grazed prairie than on burn-only prairie.

DISCUSSION

Makeup of breeding grassland bird species at LNWR seemed to change little during the first years of rotation grazing treatment at moderate stocking rates in a fire-managed, northern mixed-grass prairie. However, Brown-headed Cowbirds occurred much more frequently on burned and grazed prairie than on burn-only prairie. In the Great Plains the cowbird once associated with American bison (*Bison bison*) herds but now associates with cattle herds (Lowther 1993). Nest parasitism by Brown-headed Cowbirds can reduce productivity of northern prairie birds such as Baird's Sparrow (Davis and Sealy 1998), but implications of increased cowbird abundance for host species on burned and grazed mixed-grass prairie are currently unmeasured.

Bird species we documented as common during post-fire grazing treatments of prairie at LNWR included nearly all species characteristic of upland, northern mixed-grass prairie (Stewart 1975:25). Chestnut-collared Longspur was not common in our study, however, probably because it favors areas with heavier grazing pressure (Kantrud 1981, Hill and Gould 1997). Madden et al. (1999) also rarely noted longspurs on ungrazed prairie at LNWR that had fire histories similar to those of our management units. Two other species listed by Stewart (1975)—Lark Bunting (*Calamospiza melanocorys*) and Red-winged Blackbird (*Agelaius phoeniceus*)—were not observed on survey plots in this study. Lark Bunting is nomadic and occurs sporadically in the LNWR area (U.S. Fish and Wildlife Service 1998), and Red-winged Blackbird is mainly associated with wetland habitats (Stewart 1975), which were excluded in our sampling.

During consecutive years of grazing, the bird community closely followed a post-fire pattern. Abundances of Baird's Sparrow, Bobolink, Grasshopper Sparrow, and Sprague's Pipit were lowest in 1998 ($\bar{x}$ = 1.8 years post-fire), a result similar to a 1st-year, post-fire response in mixed-grass prairie (Pylypec 1991,

TABLE 3. Structure and general composition of vegetation on prescribe-burned, mixed-grass prairie at Lostwood National Wildlife Refuge during rotation grazing treatments 1–4 years post-fire, and on prairie treated by prescribed burning only.

	Burn-graze						Burn-only	
	1998 (n = 4)[a]		1999 (n = 5)		2000 (n = 5)		1999 (n = 4)	
Variable	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Density (total hits)	7.6	0.4	8.3	0.3	9.1	0.5	10.9	0.6
Litter depth (cm)	1.2	0.1	1.3	0.1	1.2	0.1	2.4	0.7
VOR[b] (dm)	—[c]	—[c]	1.3	0.1	1.5	0.1	2.0	0.2
Maximum height (dm)	2.0	0.1	2.6	0.1	2.8	0.1	3.5	0.1
Herbaceous %	51.1	2.4	42.8	6.3	44.2	4.4	42.1	3.1
Native %	75.3	4.6	84.6	1.3	88.3	2.1	82.5	2.8

[a]Number of management units.
[b]Visual obstruction reading (Robel et al. 1970).
[c]No data.

TABLE 4. Frequency of occurrence (%)[a] of singing male passerines on prescribe-burned management units (1994; n = 3) and on burned and grazed units (1999; n = 3) with similar precipitation and fire indices at Lostwood National Wildlife Refuge.

	Burn-only[b]		Burn-graze	
Species	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}$	$s_{\bar{x}}$
Sprague's Pipit	16.7	8.8	30.0	17.3
Clay-colored Sparrow	88.3	7.3	82.2	9.6
Vesper Sparrow	10.3	2.9	12.2	9.0
Savannah Sparrow	93.3	3.3	96.6	3.3
Baird's Sparrow	60.7	22.5	57.7	18.9
Grasshopper Sparrow	50.0	25.0	43.3	20.2
Bobolink	57.3	19.7	54.4	17.2
Western Meadowlark	25.0	13.2	23.3	8.8
Brown-headed Cowbird	25.0	13.2	60.0	17.3

[a]Percentage of 75-m-radius plots at which a species was detected.
[b]Data for burn-only units are a subset from Madden et al. (1999).

Johnson 1997, Madden et al. 1999). Abundances of these species increased in 1999 and 2000 ($\bar{x}$ = 2.7 and 3.7 years post-fire), except Bobolink, which increased and then decreased in abundance. This pattern of change also characterized a fire-only regime studied previously at LNWR (Madden et al. 1999). Horned Larks, however, deviated from the typical post-fire pattern. This species was never common in burn-only prairie studied by Madden et al. (1999) but was common in the 1st year of our study, possibly because the relatively short, post-fire vegetation height and density likely were further reduced by livestock grazing, creating relatively barren habitat preferred by the lark (Beason 1995). Plant density, VOR, and litter depth on the burned and grazed prairie in our study were slightly lower than on burn-only prairie at LNWR with similar fire histories as reported in Madden (1996: 136). When vegetation data were collected for both treatments in our study (1999), the burned and grazed prairie also was shorter and sparser than burn-only prairie with similar fire histories.

Models in Madden et al. (2000) predicted bird species occurrence based on absolute measures of vegetation on prescribe-burned, mixed-grass prairie at LNWR. For example, VOR best predicted occurrence of Baird's Sparrow, Grasshopper Sparrow, and Sprague's Pipit. Baird's Sparrow occurrence is predicted to be 45%–75% when the VOR is 1.3 dm (Madden et al. 2000). Our data on burn-graze units (1999) support this prediction; the mean VOR and associated frequency of occurrence of

Baird's Sparrow were 1.3 dm and 58%, respectively. VOR models in Madden et al. (2000) for Grasshopper Sparrow and Sprague's Pipit were similarly supported by our data. These comparisons with models derived from fire-managed prairie also suggest that alternate defoliation tools or combinations of tools may be used to reach the same habitat targets for grassland bird occurrence at LNWR.

A contrasting point between our study and earlier work by Madden et al. (1999) at LNWR is that we measured bird occurrence and vegetation during the habitat treatment phase rather than afterward. Clearly, study of effects of a combined fire and grazing regime in northern mixed-grass prairie should include a post-grazing component, in addition to more extensive replication and random treatment and control assignment. Regardless, 2–3 consecutive summers of rotation livestock grazing at moderate stocking rates during our study appeared to maintain the relatively high breeding bird diversity noted on fire-treated, northern mixed-grass prairie at LNWR by Madden et al. (1999).

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