Distribution and habitat requirements of eight grassland songbird species in southern Saskatchewan.

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EXECUTIVE SUMMARY

While grassland songbirds have declined at a significant rate in North America, detailed knowledge of the life history and habitat requirements of these species is lacking. In 1994, we examined the breeding distribution and habitat requirements of eight species of grassland songbirds which are common to the prairie regions of southern Saskatchewan, Canada: Horned Lark (*Eremophila alpestris*), Sprague's Pipit (*Anthus spragueii*), Clay-colored Sparrow (*Spizella pallida*) , Vesper Sparrow (*Pooecetes gramineus*), Savannah Sparrow (*Passerculus sandwichensis*), Baird's Sparrow (*Ammodramus bairdii*), Chestnut-collared Longspur (*Calcarius ornatus*), and Western Meadowlark (*Sturnella neglecta*). Specific objectives of the study were to: 1) identify regions of the province where grassland songbirds occur in higher densities; 2) determine whether the frequency of occurrence of grassland songbirds is influenced by habitat type; 3) determine whether range condition and grazing intensity influence relative abundance of grassland songbirds in native mixed-grass prairie; 4) identify structural components of native grassland vegetation which are important in predicting the relative abundance of grassland songbirds in mixed-grass prairie.

A total of 1739 point counts were conducted on 93 routes situated throughout the grasslands of southern Saskatchewan. Endemic grassland songbirds such as Sprague's Pipit, Baird's Sparrow and Chestnut-collared Longspur were detected more frequently in the southern grasslands and least often in the parkland fringe region. Sprague's Pipit and Chestnut-collared Longspur were found to be grassland specialists preferring native pasture over tame pasture, hayland and cropland. In contrast, no significant difference was found for Baird's Sparrow in native and tame pasture. Each of these species appeared to select different niches within native pasture.

Horned Lark, Clay-colored Sparrow, Vesper Sparrow, Savannah Sparrow and Western Meadowlark were found to be flexible in their habitat selection. Horned Lark was the only species detected most often in cropland while Clay-colored, Savannah and Vesper sparrows were frequently observed in hayland habitat. Meadowlarks were detected most often in native and tame pasture.

Range condition scores were significantly higher in pastures where Sprague's Pipit, Baird's Sparrow and Chestnut-collared Longspur were detected compared to pastures where they were absent. Baird's Sparrow and Sprague's Pipit were recorded significantly more frequently in lightly or moderately grazed native pasture compared to heavily grazed pasture. Savannah Sparrows were observed more frequently in lightly grazed pasture whereas Horned Larks were detected significantly more often in moderately or heavily grazed native pasture. Clay-colored Sparrows were observed more frequently in lightly or heavily grazed native pasture than in moderately grazed pasture.

INTRODUCTION

According to data from the Breeding Bird Survey (BBS), grassland songbirds have declined more than any other group of birds in North America (Peterjohn and Sauer 1993, Dobkin 1994). These declines may be attributed to habitat loss and degradation resulting from human activities such as the conversion of native grassland to cropland (Owens and Myers 1972, Herkert 1994). In Saskatchewan for example, approximately 75% of the native prairie has been cultivated (Statistics Canada 1987).

Although the BBS provides long term population trend estimates and insight into bird distributions, it does not adequately sample grassland birds in Saskatchewan because few routes are situated in the grassland ecoregion and many of these routes are dominated by cropland habitat. We initiated a study in 1994 to collect critical baseline information on the relative abundance, distribution and habitat selection of grassland birds in southern Saskatchewan. A study of this magnitude has not been previously conducted in the province or anywhere in the Canadian prairies.

In this paper we examine the distribution and habitat selection of the 8 most common grasslands songbird species encountered in the 1994 survey; Horned Lark (*Eremophila alpestris*), Sprague's Pipit (*Anthus spragueii*), Clay-colored Sparrow (*Spizella pallida*) , Vesper Sparrow (*Pooecetes gramineus*), Savannah Sparrow (*Passerculus sandwichensis*), Baird's Sparrow (*Ammodramus bairdii*), Chestnut-collared Longspur (*Calcarius ornatus*), and Western Meadowlark (*Sturnella neglecta*). The objectives of this study were to: 1) identify regions of the province where grassland songbirds occur in higher densities; 2) determine whether the frequency of occurrence of grassland songbirds is influenced by habitat type; 3) determine whether range condition and grazing intensity influence relative abundance of grassland songbirds in native mixed-grass prairie; 4) identify structural components of native grassland vegetation which are important in predicting the relative abundance of grassland songbirds in mixed-grass prairie.

METHODS

Study Area

The study was conducted in the grassland ecoregion of southern Saskatchewan which was divided into four geographic regions; Southwest (SW), West Mixed (WM), East Mixed (EM) and

Parkland Fringe (PF) (Fig. 1). Four habitat types were sampled in each region; native grassland, tame grassland, hayland and cropland. Native Grassland (N) was defined as pasture which had never been ploughed. It was characterized by *Stipa* spp., june grass (*Koeleria cristata*) northern wheatgrass (*A. dasystachyum*), western wheatgrass (*A. smithii*), blue grama grass (*Bouteloa gracilis*), *Carex* spp., club moss (*Selaginella densa*), pasture sage (*Artemisia frigida*) and various forbs. Tame Grassland (T) grassland was defined as land which had been broken and seeded with tame perennial grasses for pasture; most commonly crested wheatgrass (*Agropyron cristatum*) or brome grass (*Bromus spp.*). Occasionally some alfalfa (*Medicago spp.*) or sweet clover (*Melilotus spp.*) was present. Hayland (H) was defined as cultivated areas seeded to perennial crops which were intended for haying. Vegetation varied among different hay sites ranging from 100% alfalfa, to mixes of alfalfa, sweet clover and introduced grasses (eg. brome grass, crested wheatgrass or bluegrass, *Poa* spp). Cropland (C) included cultivated areas seeded to annual crops for harvesting (eg. *Triticum aestivum* or canola, *Brassica spp.*)

Relative Bird Abundance

Estimates of singing male abundance were obtained using fixed 100-m radius point counts of five minutes duration (Hutto et al. 1986, Ralph et al. 1993). These were conducted along designated survey routes at approximate 0.8 km intervals from roads or trails between 4 June and 2 July, 1994. Surveys were only conducted on days with no precipitation and winds less than 20 km/hr. Surveys commenced thirty minutes before sunrise and continued for up to four hours duration. Each point count was subsequently sub-divided into half-circle counts by recording if birds were heard on the left or right side of the trail or road because each side sometimes differed in habitat type and grazing history.

Sample units consisted of random and "non-random" survey routes within each region. Random routes (n=74) were designed to be comprised of at least 80% grassland habitat, whereas "non-random" routes (n=19) were situated in locations that historically had, or were suspected of having, high numbers of Baird's Sparrows. Each route accommodated 20-25 stops and included both small and large pastures. Routes were often comprised of 2-3 disjunct segments occasionally up to 20 km apart to ensure sampling of small isolated grasslands.

Habitat Quality

Range condition and grazing intensity were assessed independently by a range specialist to provide information on the quality of native pastures. Range condition, a measure of plant species composition, was determined in a manner similar to that described by Wroe et al. (1988) and Abouguendia (1990). Grazing intensity was categorized as lightly, moderately, or heavily grazed. Heavily grazed pasture was characterized by: a) virtually all litter and plant material removed; b) greater than 20% bare soil; c) greater than 40% club moss (*Selaginella densa*); and d) small plants with poor vigour. Lightly grazed pasture was defined as having: a) little or no evidence of grazing; b) abundant litter and plant material; c) less than 10% bare soil; d) less than 10% club moss; and e) robust and vigorous plants. Moderately grazed pastures exhibited characteristics which were intermediate between the previous two types.

Vegetative Structure

Surveyors sampled vegetative structure by passing a 0.6 dia. metal rod vertically through the vegetation and counting the number of contacts by different vegetation types (Table 1) in successive 10 cm height intervals (see Rotenberry and Wiens 1980). Vegetative measurements were taken from four random points per half-circle at approximately half of all half circles in native grassland. Each lifeform was quantified in two height categories: 1) a ***1st dm*** category which is equivalent to the number of contacts made in the first 1 dm and 2) a ***2-10 dm*** category which is equivalent to the sum of contacts made at above 1 dm. Litter depth was measured with a 30 cm rule which was inserted vertically into the litter until making contact with the ground below. Distance to the nearest shrub (DNS) was visually estimated by the observer. When no shrubs were observed within the 100-m half-circle, DNS was recorded as 125 m. This value was arbitrarily set to be larger than the sampling area itself (100m), but not overly large so as to bias the mean DNS for half-circles in any given route.

Statistical Analyses

For all analyses except those noted below, songbird abundance data was dichotomized to a bird "present/absent" classification and comparisons were made by contingency table analyses; PROC FREQ (CHISQR option, alpha=0.05)(SAS Institute Inc. 1989). This reclassification, and the accompanying statistical approach, was necessitated by the fact that measures of bird

abundance could not be transformed to approximate normality using commonly applied transformations (ie. LOG(x+1) or SQRT(x)+SQRT(x+1)). These reclassifications were applied using randomly selected half-circle point counts from random routes as the sampling unit because using full-circle point counts would be problematic for two reasons: 1) it would require that adjacent half-circles be of the same habitat type and thus a considerable number of sampling points (those where left and right half-circles were of different habitat types) would be discarded; and 2) use of the present/absent dichotomy for full-circle point counts results in higher information loss and reduced statistical power due to the reduction of points where bird counts are greater than one.

Range condition scores were compared among half-circles in native grassland from routes where a given species was present or absent using the Student's T-test option (alpha=0.05) of the Systat 5.0 statistical package (Wilkinson 1990).

A multivariate assessment of relative bird abundance and vegetative structure in native grassland was conducted using stepwise multiple regression (SAS PROC REG; alpha=0.05). All fourteen vegetative variables were included in each analysis. These analyses used route-averaged data from both random and non-random routes.

For some species, route-averaged measures of bird abundance were transformed to meet the assumption that the regression residuals were normally distributed. In these instances, the transformation performed is noted. Cases where standard transformations (ie. LOG(x+1) or SQRT(x)+SQRT(x+1)) failed to normalize the regression residuals (Lilliefors alpha < 0.05) were noted and the analysis was carried out with untransformed abundance estimates.

RESULTS

Savannah Sparrow was the only species that was detected equally among geographic regions (Table 2). Baird's Sparrow, Horned Lark, Sprague's Pipit and Chestnut-collared Longspur were detected least frequently in the Parkland Fringe whereas Vesper and Clay-colored Sparrows were recorded most often in this region. Horned Lark, Sprague's Pipit and Chestnut-collared Longspur were detected significantly more often in the Southwest than in any other region.

Horned Larks were detected most often in cropland whereas all other species were observed less frequently in cropland compared to either tame or native grassland (Table 3). Baird's,

Savannah, Vesper, Clay-colored sparrows and Western Meadowlarks were also observed less frequently in cropland compared to hayland habitats.

Clay-colored Sparrow, Horned Lark, Chestnut-collared Longspur and Sprague's Pipit were detected more frequently in native than tame pasture, whereas Baird's Sparrow, Vesper Sparrow and Western Meadowlark exhibited no preference between these two types of pasture. Savannah Sparrow was the only species which occurred more frequently in tame than in native pasture.

Range condition scores were significantly higher in pastures where Sprague's Pipit, Baird's Sparrow and Chestnut-collared Longspur were detected compared to pastures where they were absent (Table 4). Range condition did not differ significantly between occupied and unoccupied pastures for the other five species.

Grazing intensity was found to influence the frequency of occurrence of five species in native pasture (Table 5). Baird's Sparrow and Sprague's Pipit were recorded significantly more frequently in lightly or moderately grazed native pasture compared to heavily grazed pasture. Savannah Sparrows were observed more frequently in lightly grazed pasture than either moderately or heavily grazed habitat whereas Horned Larks were detected significantly more often in moderately or heavily grazed native pasture. Clay-colored Sparrows were observed more frequently in lightly or heavily grazed native pasture than in moderately grazed pasture.

Stepwise multiple regression analyses of route-averaged bird abundance and vegetation variables yielded models with varying levels of explanatory power (Table 6). Several trends in songbird preference for various vegetative characteristics within native grassland habitat were evident from these analyses. Shrub 2-10 dm was the variable most commonly fitted in the multiple regression models. This variable was positively associated with bird abundance in the models of Vesper and Clay-colored sparrows whereas Baird's Sparrow, Sprague's Pipit, Horned Lark, and Western Meadowlark were negatively associated with Shrub 2-10 dm.

Broad-leaf grass variables were fitted in the models of four species. The 1dm category of this variable was fitted in three models; a positive association was obtained for Vesper and Clay-colored Sparrows while a negative association was found for Baird's Sparrow. The Vesper Sparrow model fit a negative estimate for the 2-10 dm broad-leafed grass category. Narrow-leaf grass variables (1dm) were positively associated with Sprague's Pipit and Western Meadowlark.

The 1dm forb vegetation variable was positively associated with Vesper Sparrow and negatively associated with Chestnut-collared Longspur.

Litter depth and dead vegetation variables were fit into multiple regression models of four species. Litter depth was positively associated with Baird's Sparrow and negatively associated with Chestnut-collared Longspur. A positive relationship with dead vegetation in the 1 dm category was also fitted for Baird's Sparrow whereas the dead 2-10 dm category variable was positively related to Savannah Sparrow abundance and negatively related for Horned Larks.

DISCUSSION

Baird's Sparrow, Chestnut-collared Longspur and Sprague's Pipit are endemic grassland birds that evolved within the Great Plains (Mengel 1970, Knopf 1994). Their distribution in this study supports this contention as they were detected least frequently in the parkland fringe region. This area represents the transition zone between the mixed-grass prairie and aspen parkland and delineates the northern edge of these species' breeding range (Godfrey 1986). Sprague's Pipit and Chestnut-collared Longspur were detected significantly more often in the arid grasslands of the southwest whereas Baird's Sparrows were detected more often in the moist west-mixed prairie.

Sprague's Pipit and Chestnut-collared Longspur were more narrow in their habitat selection compared to Baird's Sparrow. Pipits and longspurs may best described as being native prairie specialists due to their high frequency of occurrence in only native grassland habitat. In comparison, Baird's Sparrows occurred in equal frequency in native and tame pasture (see also Stewart 1975, Sutter et al. 1995, Davis and Duncan unpubl. data) and were detected more often in hayland and cropland than the other two species.

These three endemic grassland species were also the only birds that occurred more frequently on native pastures in better condition. Sprague's Pipit and Baird's Sparrow were detected least frequently in heavily grazed pastures whereas Chestnut-collared Longspurs showed no difference in their response to grazing intensity on native pasture. The response to grazing pressure by these species, however, likely varies geographically (Kantrud 1981, Kantrud and Kologiski 1982). Although each of the endemic species preferred native pasture in better condition, they appeared to select different niches within the pastures. Chestnut-collared

Longspurs appeared to prefer open areas with low cover as they exhibited a strong affinity for areas with lesser amounts of litter and fewer forbs in the first decimeter. Sprague's Pipit were associated with areas with greater coverage of narrow-leafed grasses and fewer taller shrubs although the explanatory power of the model was small. Baird's Sparrow were associated with pasture with greater litter depth and dead vegetation but avoided areas with shrubs and broad-leaf grasses.

The remaining species: Horned Lark, Clay-colored Sparrow, Vesper Sparrow, Savannah Sparrow, and Western Meadowlark; are species secondarily evolved to the grasslands and subsequently have a broader distribution than the endemic grassland songbirds (Mengel 1970). The results of this study support this contention as these five species were detected relatively frequently in each geographic region compared to the Sprague's Pipit and Chestnut-collared Longspur. Clay-colored and Vesper sparrows, however, were detected more often in the parkland fringe whereas Horned Lark and Western Meadowlarks were detected least frequently in this region.

Horned Larks were unique in this study as they were the only species which was most frequently observed in cropland. They were, however, also attracted to native pasture over tame pasture and hayland and were detected more often in tame pasture compared to hayland. The attractiveness of cropland and pasture over hayland to Horned Larks reflects this species preference for habitat with little or low vegetative cover (see also Owens and Myers 1973). Within native grassland, Horned Larks were attracted to moderately or heavily grazed pasture with low shrub coverage and little residual vegetation providing further support for this species preference for habitat with sparse vegetation.

Clay-colored Sparrow, Savannah Sparrow, Vesper Sparrow and Western Meadowlark were all detected least frequently in cropland. The three sparrow species, however, were detected as frequently, or more frequently in hayland than native pasture while Western Meadowlarks were detected more often in native pasture than hayland. The preference of Savannah and Vesper sparrows for hayland over native pasture, indicating a strong response to habitat features other than those typically found on native grassland, is reflective of the broad breeding distribution of these species into parkland/forest areas. Clay-colored Sparrows were detected more frequently in

tame compared to native pasture. Tame pasture may not have been attractive to these sparrows because the pastures have few shrubs which are important to the sparrows in nest-site selection (Knapton 1978). The fact that Clay-colored Sparrows were strongly associated with native pasture with a high density of shrubs greater than 10 cm high in this study supports the latter statement.

Although range condition on native pasture did not influence any of these species, they exhibited differential responses to grazing intensity. Savannah Sparrows preferred lightly grazed pastures as previously recorded by Wiens (1969) and Kantrud (1981). Clay-colored Sparrows favoured either lightly or heavily grazed over moderately grazed pastures. This latter finding is not supported by previous studies which showed that Clay-colored Sparrows were significantly more abundant on lightly grazed pastures (see Kantrud and Kologiski 1982 for a review). Although Vesper Sparrow and Western Meadowlarks were not influenced by grazing intensity in this study, others have found these species to respond differently in various regions throughout their breeding range (see Kantrud and Kologiski 1982 for a review). The abundance of Savannah Sparrows on native pasture was strongly correlated with taller dead vegetation and, secondarily, greater distance to shrubs. Their apparent preference for dense ground cover is reflected in the strong preference for lightly grazed pastures. The lack of response of the Western Meadowlark to grazing intensity and range condition, combined with the low predictive power of any of our measured vegetative variables, illustrate its flexibility in habitat choice.

These results support the contention that the conversion of native grassland to cropland has likely been a primary factor in the decline of many grassland songbirds as 7 of the 8 species in this study were detected least frequently in cropland. Relative abundance of singing males as we examined here, however, is only one indicator of habitat quality. The reproductive consequences of selecting alternative nesting habitat must also be considered when assessing habitat quality (Van Horne 1983, Johnson and Temple 1986, Vickery et al. 1992). Information on nesting success and productivity is required to determine: a) if grassland songbirds use altered habitats for nesting, and b) how productive grassland songbirds breeding in altered habitats are compared to native habitat.

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Table 1. Vegetative structure variables used in multiple regression analyses of grassland songbird abundance.

Variable	Description	Measure
Dead	Standing dead vegetation.	NOC
Litter Depth	Nonstanding dead vegetation	Depth (mm)
Broad LG	Grasses, sedges or grass-like plants where blade width > 6 mm.	NOC
Narrow LG	Grasses, sedges or grass-like plants where blade width < 6 mm.	NOC
Shrub	Plants less than 2 m high that have above ground woody stems but are not dwarf shrubs	NOC & DNS[2] (cm)
Dwarf Shrub	Woody plants less than 25 cm high and spreading in their growth form.	NOC

[1]NOC= number of contacts
[2]DNS= distance to nearest shrub

Table 2. Frequency of singing males detected in four geographic regions of southern Saskatchewan (EM =East Mixed, WM = West Mixed, SW = Southwest, PF = Parkland Fringe). Pairwise comparisons restricted to native pasture.

Species	EM	PF	SW	WM	Pairwise Comparisons
n[1]	367	293	900	298	
Horned Lark	30.0	13.7	45.0	30.9	SW>EM, WM, PF EM, WM>PF
Sprague's Pipit	12.0	5.8	25.9	15.8	SW>EM, WM, PF EM, WM>PF
Clay-colored Sparrow	42.5	60.1	19.0	36.6	PF>EM, SW, WM EM, WM>SW
Vesper Sparrow	20.2	34.5	24.4	26.8	PF>EM, WM, SW WM>EM
Savannah Sparrow	18.3	16.0	19.1	19.5	No differences detected
Baird's Sparrow	35.7	15.0	26.4	37.9	EM, SW, WM>PF WM>SW
Chestnut-collared Longspur	21.8	1.7	30.8	15.8	SW>EM, WM, PF EM, WM>PF EM>WM
Western Meadowlark	24.8	21.5	27.3	28.9	WM, SW>PF

[1]n = number of half-circles

Table 3. Frequency of singing males detected in native pasture (N), tame pasture (T), cropland (C), and hayland (H) in 4 geographic regions in southern Saskatchewan. Sample sizes are shown in parentheses (# of half-circles).

SPECIES	REGION	NATIVE		TAME		CROP		HAY		PAIRWISE COMPARISONS
Horned Lark	EM	30.0	(367)	21.6	(88)	64.6	(82)	13.6	(66)	C>N, T, H N>H
	PF	13.7	(293)	19.2	(104)	23.8	(105)	4.3	(69)	C>N, H N, T>H
	SW	45.0	(900)	41.7	(108)	37.2	(86)	19.4	(31)	N, T>H
	WM	30.9	(298)	42.9	(21)	46.3	(82)	36.4	(22)	C>N
	All	34.8	(1858)	29.0	(321)	41.7	(355)	13.8	(188)	C>N, T, H N>T, H T>H
Sprague's Pipit	EM	12.0	(367)	12.5	(88)	0.0	(82)	3.0	(66)	N>H, C T>H, C
	PF	5.8	(293)	2.9	(104)	0.0	(105)	0.0	(69)	N>C
	SW	25.9	(900)	15.7	(108)	1.2	(86)	6.5	(31)	N>T, H, C T>C
	WM	15.8	(298)	9.5	(21)	1.2	(82)	4.5	(22)	N>C
	All	18.4	(1858)	10.3	(321)	0.6	(355)	2.7	(188)	N>T, H, C T>H, C
Clay-colored Sparrow	EM	42.5	(367)	33.0	(88)	11.0	(82)	34.8	(66)	N, T, H>C
	PF	60.1	(293)	39.4	(104)	29.5	(105)	36.2	(69)	N>T, H, C
	SW	19.0	(900)	10.2	(108)	2.3	(86)	29.0	(31)	N, T, H>C N, H>T
	WM	36.6	(298)	33.3	(21)	18.3	(82)	31.8	(22)	N>C
	All	32.9	(1858)	27.4	(321)	16.3	(355)	34.0	(188)	N, T, H>C N>T
Vesper Sparrow	EM	20.2	(367)	21.6	(88)	8.5	(82)	16.7	(66)	N, T>C
	PF	34.5	(293)	35.6	(104)	30.5	(105)	44.9	(69)	None
	SW	24.4	(900)	18.5	(108)	7.0	(86)	25.8	(31)	N, T, H>C
	WM	26.8	(298)	14.3	(21)	18.3	(82)	63.6	(22)	H>N, T, C
	All	25.6	(1858)	24.6	(321)	16.9	(355)	34.0	(188)	H>N, T, C N, T>C
Savannah Sparrow	EM	18.3	(367)	27.3	(88)	20.7	(82)	19.7	(66)	None
	PF	16.0	(293)	32.7	(104)	22.9	(105)	36.2	(69)	T, H>N
	SW	19.1	(900)	17.6	(108)	8.1	(86)	25.8	(31)	N, H>C
	WM	19.5	(298)	14.3	(21)	14.6	(82)	31.8	(22)	None
	All	18.5	(1858)	24.9	(321)	16.9	(355)	28.2	(188)	H>C, N T>N, C
Baird's Sparrow	EM	35.7	(367)	36.4	(88)	7.3	(82)	28.8	(66)	N, T, H>C
	PF	15.0	(293)	16.3	(104)	1.0	(105)	17.4	(69)	N, T, H>C
	SW	26.4	(900)	21.3	(108)	3.5	(86)	9.7	(31)	N, T>C T>H
	WM	37.9	(298)	57.1	(21)	14.6	(82)	27.3	(22)	N, T>C N,T>H
	All	28.3	(1858)	26.2	(321)	6.2	(355)	21.3	(188)	N, T, H>C N>H
Chestnut-collared Longspur	EM	21.8	(367)	13.6	(88)	0.0	(82)	0.0	(66)	N>H, C T>H, C
	PF	1.7	(293)	0.0	(104)	0.0	(105)	0.0	(69)	None
	SW	30.8	(900)	32.4	(108)	2.3	(86)	9.7	(31)	N>H, C T>H, C
	WM	15.8	(298)	0.0	(21)	0.0	(82)	0.0	(22)	N>C
	All	22.0	(1858)	14.6	(321)	0.6	(355)	1.6	(188)	N>T, H, C T>H, C
Western Meadowlark	EM	24.8	(367)	26.1	(88)	6.1	(82)	15.2	(66)	N, T>C
	PF	21.5	(293)	17.3	(104)	4.5	(105)	18.8	(69)	N, T, H>C
	SW	27.3	(900)	21.3	(108)	5.8	(86)	25.8	(31)	N, T, H>C
	WM	28.9	(298)	19.0	(21)	4.9	(82)	13.6	(22)	N>C
	All	26.2	(1858)	21.2	(321)	5.4	(355)	18.1	(188)	N, T, H>C N>H

Table 4. A comparison of range condition scores in native pasture where grassland songbirds were present versus absent. Comparisons were made using students T-test.

	Absent			Present			
Species	Mean	STD	n	Mean	STD	n	p-value
Horned Lark	55.33	19.50	363	52.73	16.87	191	0.119
Sprague's Pipit	53.17	18.75	443	59.47	17.48	111	0.001
Clay-colored Sparrow	55.18	18.40	364	53.01	19.11	190	0.195
Vesper Sparrow	54.98	18.19	409	52.90	19.92	145	0.249
Savannah Sparrow	54.12	18.81	474	56.31	17.75	80	0.331
Baird's Sprrarrow	52.95	18.31	395	58.11	19.07	159	0.003
Chestnut-collared Longspur	53.58	19.08	426	57.27	16.96	128	0.005
Western Meadowlark	54.86	18.92	397	53.36	18.01	157	0.349

Table 5. Frequency of singing males detected in native pasture with light (L), moderate (M), and heavy (H) grazing pressure.

Species	Light	Moderate	Heavy	Pairwise Comparisons
n	198	222	128	($p < 0.05$)
Horned Lark	0.242	0.392	0.430	M>L, H>L
Sprague's Pipit	0.212	0.243	0.117	L>H, M>H
Clay-colored Sparrow	0.389	0.275	0.398	L>M, H>M
Vesper Sparrow	0.232	0.302	0.242	None
Savannah Sparrow	0.217	0.108	0.102	L>M, L>H
Baird's Sparrow	0.323	0.302	0.211	L>H
Chestnut-collared Longspur	0.232	0.243	0.219	None
Western Meadowlark	0.273	0.288	0.281	None

Table 6. Results summary of the stepwise multiple regression analyses of grassland songbird abundance and vegetative structure in native pasture. Variables presented in the order in which they were entered into the model.

Species	Variable	p-value	Partial r^2	Model r^2	Parameter Estimate	Standardized Estimate
Horned Lark	Dead 2-10 dm	0.000	0.215	0.215	-0.454	-0.412
	Shrub 2-10 dm	0.003	0.086	0.301	-0.594	-0.296
	Dwarf Shrub 2-10 dm	0.048	0.037	0.338	-2.565	-0.193
Sprague's Pipit	Narrow 1st dm	0.001	0.090	0.090	0.070	0.370
	Shrub 2-10 dm	0.016	0.070	0.160	-0.375	-0.274
Clay-colored Sparrow	Shrub 2-10 dm	0.000	0.293	0.293	0.792	0.467
	Broad 1st dm	0.002	0.086	0.379	2.635	0.257
	DNS	0.031	0.039	0.418	-0.004	-0.223
Vesper Sparrow	Broad 1st dm	0.000	0.202	0.202	3.483	0.548
	Shrub 2-10 dm	0.002	0.100	0.302	0.329	0.313
	Forb 1st dm	0.019	0.051	0.353	0.182	0.236
	Broad 2-10 dm	0.015	0.052	0.405	-0.806	-0.240
Savannah Sparrow	Dead 2-10 dm	0.000	0.277	0.277	0.543	0.542
	DNS	0.006	0.072	0.349	0.006	0.269
Baird's Sparrow	Dead 1st dm	0.000	0.089	0.089	0.121	0.472
	Litter Depth	0.000	0.070	0.160	0.022	0.538
	Shrub 2-10 dm	0.000	0.123	0.283	-0.768	-0.442
	Broad 1st dm	0.001	0.098	0.381	-3.352	-0.319
	Shrub 1st dm	0.033	0.039	0.420	-1.114	-0.220
Chestnut-collared Longspur	Litter Depth	0.000	0.203	0.203	-0.025	-0.464
	Forb 1st dm	0.034	0.048	0.251	-0.373	-0.220
Western Meadowlark	Narrow 1st dm	0.002	0.088	0.088	0.062	0.358
	Shrub 2-10 dm	0.035	0.055	0.142	-0.305	-0.242