1998

Passerine Use of Grasslands Managed With Two Grazing Regimes on the Missouri Coteau in North Dakota

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PASSERINE USE OF GRASSLANDS MANAGED WITH TWO GRAZING REGIMES ON THE MISSOURI COTEAU IN NORTH DAKOTA

BY

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A thesis submitted in partial fulfillment

of the requirements for the degree

Master of Science

South Dakota State University

1998

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This thesis is approved as a creditable and independent investigation by a canididate for the Master of Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Acknowledgements

I would like to thank my thesis advisor Dr. Kenneth F. Higgins for advice and support during this thesis. Special appreciation is extended to Dr. Robert Murphy for believing in me, giving me support and his insights concerning the project. Thanks is also extended to my committee members, Dr. Lester Flake, Dr. Gary Larson, and Dr. Alexandros Moutsoglu, without whom I could not have completed this thesis. I also extend thanks to Dr. Jonathan Jenks and Dr. Paul Evenson for all their statistical advice and help. I thank all of the researchers, Natalie Fahler, Jennifer Schmidt, Matt Mahrt, Neil Finke, and Heather Husband. They endured many early mornings, long-days, and ticks without losing their dedication and spirt. I would also like to thank the staffs at Chase Lake Prairie Project and Lostwood National Wildlife Refuge, who made me feel at home and lent me advice and support during this study. Sincere thanks goes to Steve Kresl who always believed in me and supported me during the time I spent at Chase Lake. Special appreciation is extended to Carol Lively and Dr. John Cornely.

I would also like to thank my family for their love and support. Special thanks goes to my mother Sue, who always believed in me and lent an ear whenever I needed one. I thank her and Mike Meyers and James Buskness, for editing, giving advice and support which made it possible for me to finish my thesis. Sincere thanks goes to Jeff Gleason for helping me find my way and giving me the confidence and support to achieve my goals. I also thank all cooperating landowners who graciously allowed this study to be conducted on their pastures.

Funding was provided by the U. S. Fish and Wildlife Service, Prairie Pothole Joint Venture, Region 6, Denver, Division of Refuges and Wildlife through the S.D. Cooperative Fish and Wildlife Research Unit (RWO No. 62) in cooperation with the U.S. Fish and Wildlife Service, the U. S. Geological Survey, the South Dakota State University, South Dakota Game, Fish and Parks Department, and the Wildlife Management Institute.

Abstract

PASSERINE USE OF GRASSLANDS MANAGED WITH TWO GRAZING REGIMES ON THE MISSOURI COTEAU IN NORTH DAKOTA

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Several rotational grazing systems have been implemented on the Missouri Coteau in central and northcentral North Dakota as part of the Prairie Pothole Joint Venture (PPJV). The impacts these systems have on grassland passerines are not fully understood. Objectives for this study include determining relative abundance, species composition and reproductive success of passerines as well as vegetation characteristics for rotational and traditional season-long grazing regimes. Passerine relative abundance and species richness were determined on rotational grazing systems during 1995-1997 and on season-long grazed pastures during 1996-1997 using 122 fixed, 100 m radius, point counts. Relative abundance was assessed by recording singing males or breeding pairs heard or seen during each count. Twenty-five grassland species were recorded in 1995, 30 in 1996 and 29 in 1997. Grasshopper sparrows, brown-headed cowbirds, and clay-colored sparrows occurred most frequently on point counts. No differences occurred between grazing regimes for species richness or relative abundance in 1996. However, in 1997, rotational grazing systems had higher species relative abundance and species richness compared to the season-long grazed pastures. Savannah sparrow, grasshopper sparrow, western meadowlark, bobolink, and Baird's sparrow all have been previously cited as being negatively affected from grazing. These grassland birds were grouped into a grazing sensitive guild, which had a higher mean relative abundance on rotational grazing systems compared with season-long pastures in 1997, but was not significantly higher in 1996. Reproductive success by species was estimated on 6 randomly selected points for each study site in 1996 and 1997 using behavioral cues. Reproductive success estimates of bird species did not differ between grazing regimes for either year. A total of 18 vegetation characteristics were used to determine differences between grazing regimes. Forb cover and shrub density were greater ($P<0.05$) on season-long grazed pastures in 1996 but not in 1997. Average litter depth was higher on rotational grazing systems ($P<0.05$) in 1997, but was not significantly different in 1996. Prescribed rotational grazing systems implemented in the Chase Lake and Northern Coteau PPJV project areas benefited landowner livestock operations without negatively impacting grassland passerines.

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CHAPTER 1. INTRODUCTION AND STUDY AREAS

INTRODUCTION

North American waterfowl populations had declined sharply in recent decades but are currently increasing. Bellrose (1976) and Baldassarre and Bolen (1994) attributed the recent decline to a decrease in suitable nesting habitat. In 1986, the North American Waterfowl Management Plan (NAWMP) was initiated to sustain waterfowl populations by enhancing, restoring and creating habitat critical for breeding waterfowl. Within the habitat section of the NAWMP, 12 specialized regional habitat areas (i.e., joint ventures) were identified including the Prairie Pothole Region.

The Prairie Pothole Region (PPR) in the United States and Canada received the highest priority due to the high value of this area to breeding waterfowl and other migratory birds. The PPR annually produces approximately 70% of the waterfowl in North America (Anonymous 1996). Currently, 2 joint ventures cover the PPR, the Prairie Habitat Joint Venture (PHJV) in Canada, and the Prairie Pothole Joint Venture (PPJV) in the United States. The PPJV encompasses parts of North Dakota and South Dakota, western Minnesota, northwestern Iowa and eastern Montana.

The PPR overlies the center of the northern Great Plains, which includes some of the largest, contiguous tracts of grassland left in North America (Samson and Knopf 1994). The conversion of native prairie to agricultural lands has been an increasing concern for some time. For example, North Dakota has lost approximately 67% of its original native prairie habitat. A total of 177 bird species breed in the PPR (Anonymous

1996). The PPJV is concerned not only with sustaining waterfowl numbers but also with other wildlife species which are dependent on wetland and grassland complexes (Anonymous 1996). Knopf (1992) and Johnson and Schwartz (1993) documented a population decline of neotropical birds which they related to the loss of grassland habitat. Ball et al. (1994) suggested that grassland passerine habitat in many instances may overlap with waterfowl habitat and management practices. Thus, in concert with waterfowl, the PPJV has placed a special emphasis on nongame migratory birds, especially neotropical migrants which includes grassland passerines.

Projects currently implemented within the PPJV focus on the objectives of the NAWMP as well as initiatives defined in the PPJV. Such projects demonstrate that profitable agriculture and sound wildlife production on private lands can coexist. This is important because 95% of North Dakota is privately owned (Berkey et al. 1993). Projects include conservation "action items" that protect or restore wetland and grassland complexes, such as prescribed rotational grazing systems, grassland easements, and wetland restoration. The cost is shared by federal, state, local and private organizations within the region. NAWMP projects such as rotational grazing systems can be offered to any landowners meeting set criteria within either one of these project areas. Since 1989, over 60 rotational grazing systems have been implemented covering over 16,200 hectares (40,000 acres) of grassland within the northwest and south-central regions of North Dakota (CLPP 1996). Information on wildlife use and habitat attributes on prescribed grazing systems are important and can influence grassland conservation management (Samson and Knopf 1994).

Vegetation structure and litter depth are enhanced more in rotational grazing systems than in season-long grazing regimes (Sedivec et al. 1990). Rotational grazing systems can be designed to enable pastures or cells to maintain prairie vegetation at a height and density which provides adequate nesting cover for migratory birds (Skinner et al. 1984, Sedivec et al. 1990, Ryan 1990). However, few studies (Messmer 1990, Sedivec 1994) have addressed the effects of deferred rotational grazing regimes on grassland passerines compared to the alternative traditional season-long grazing systems. Saab et al. (1995) were concerned that rotational grazing systems may decrease abundance of species such as horned larks (*Eremophila alpestris*) and chestnut-collared longspurs (*Calcarius lapponicus*) which prefer sparser vegetation. This study was designed to evaluate the effects of deferred rotational grazing systems on species richness, species diversity, reproductivity and habitat relationships of grassland passerines in comparison to those found on traditional season-long grazing regimes.

STUDY AREAS

The study areas selected lie within the Missouri Coteau of North Dakota, which is a physiographic region consisting of rolling hills interspersed with numerous wetlands. This Coteau was formed from the last continental glacier (Wisconsin) over 10,000 years ago. The Missouri Coteau runs from northwest to southeast through the center of the state (Figure 1). Vegetation of the Missouri Coteau is characterized as mixed-grass

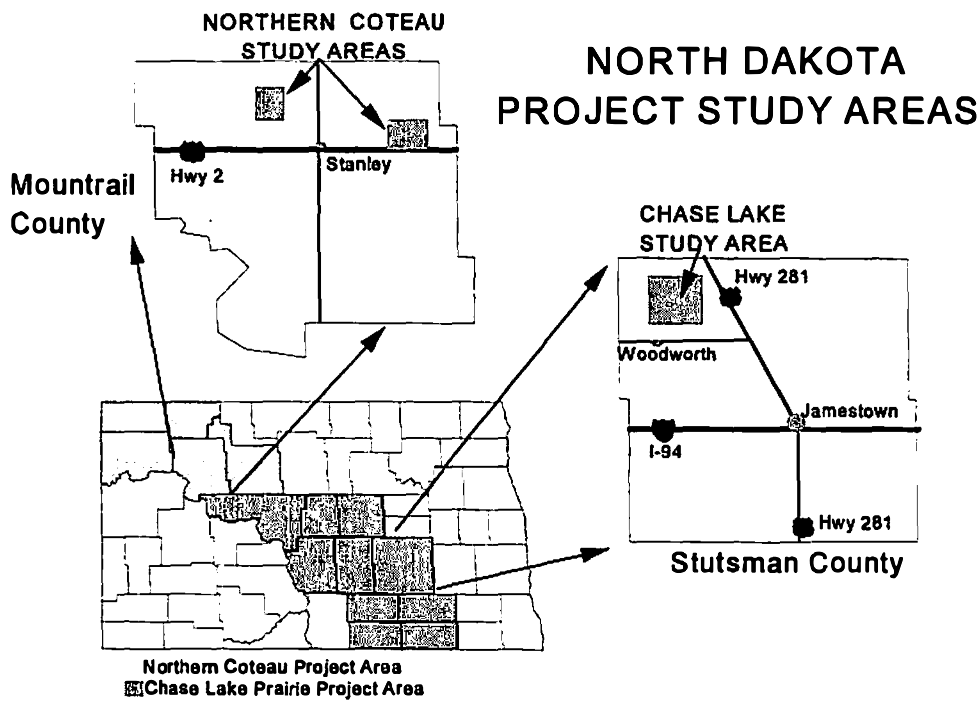


Figure 1. The location study areas by county on the Missouri Coteau and the 2 NAWMP project areas (Chase Lake Prairie Project and Northern Coteau Project).

prairie (Whitman and Wali 1975). Dominant vegetation is a mixture of short- and mid-grasses including June grass (*Koeleria macrantha*), green needlegrass (*Stipa viridula*), needle-and-thread (*Stipa comata*), blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), Kentucky bluegrass (*Poa pratensis*) and over 60 species of forbs (Meyer 1985, Kirby et al. 1988, and Hegstad 1973).

Two projects within the Prairie Pothole Joint Venture lie within the Missouri Coteau. These 2 projects include the Chase Lake Prairie Project initiated in 1989 as a flagship project of the North American Waterfowl Management Plan, and the Northern Coteau Project developed shortly thereafter in 1992.

The Northern Coteau Project area lies within the northwestern half of the Missouri Coteau inclusive of 6 counties and 2.75 million hectares (6.8 million acres). Two rotational grazing systems and 2 traditional season-long grazing sites were selected for study from this area in Mountrail County (Figure 1). The Chase Lake Prairie Project lies in the southeastern half of the Missouri Coteau and includes 11 counties encompassing approximately 2.23 million hectares (5.5 million acres). Three rotational grazing systems and 3 season-long study sites were monitored in Stutsman County which is in the Chase Lake Prairie Project area (Figure 1).

The climate of Chase Lake (CL) project area is characterized as subhumid and cool (Omodt et al. 1968). While the climate in the Northern Coteau (NC) project area is characterized as semi-arid, with some years being more humid and others being dry and arid (Weaver and Albertson 1956). This study was conducted during average to above average precipitation in 1995 and 1996, and average to slightly below average precipitation (spring and early summer) for 1997 (NOAA 1995, NOAA 1996)(Tables 1 and 2). Weather data used were collected from Chase Lake Wetland Management District located in Woodworth ND (Figure 1), which was about 16.1 km (10 miles) from the most distant study site in Chase Lake Prairie Project study area. Weather data used for the Northern Coteau study areas were collected 4.8 km (3 miles) north of Stanley, North Dakota (Figure 1) which was no farther than 16 km (15 miles) away from the sites.

In 1995, 5 rotational grazing systems were selected for monitoring in each project area. Five of the 10 were selected for use in 1996 and 1997. The remaining 5, which were not used in 1996 or 1997, were dropped due to unpredicted changes in the grazing schedules or were randomly removed. Each of the rotational grazing systems was paired with a season-long grazing regime of similar size in 1996 and 1997.

All grazing systems selected were twice-over deferred rotational grazing systems encompassing a minimum of at least 259 ha (640 acres) (Table 3). Grazing systems selected were under a 10-year lease agreement with the US Fish and Wildlife Service. These agreements are with private landowners within the project areas. The rotational systems selected were implemented at least 3 years prior to monitoring (Table 3) as a precaution to initial year effects. Twice-over deferred rotational grazing systems are divided into cells or paddocks through which the cattle are rotated twice during the grazing season (usually June through October).

Table 1. Average temperatures (C°) (Avg. Temp.), total monthly precipitation (PPT) (cm) and snow depth (Snow) (cm) (included in monthly precipitation) for Chase Lake study area. Weather information was provided by Chase Lake Wetland Management District, Woodworth, North Dakota.

	1995			1996			1997		
Month	Avg. Temp.	PPT	Snow	Avg. Temp.	PPT	Snow	Avg. Temp	PPT	Snow
April	3.2°	1.5	15.9	2.0°	0.8	13.9	-0.1°	7.0	35.6
May	10.0°	10.8		9.1°	3.6		9.7°	1.8	
June	19.3°	5.6		17.3°	6.5		18.4°	7.5	
July	19.2°	24.9		18.3°	12.8		20.2°	10.8	
August	20.2°	5.3		19.7°	4.2		19.8°	1.8	
Total		48.1			27.9			28.9	

Table 2. Average temperatures (C°) (Avg. Temp.), total monthly precipitation (PPT) (cm) and snow depth (Snow) (cm) (included in monthly precipitation) for Northern Coteau study area. Weather information was provided by National Oceanic and Atmospheric Administration for Stanley, North Dakota.

	1995			1996			1997		
Month	Avg. Temp.	PPT	Snow	Avg. Temp.	PPT	Snow	Avg. Temp	PPT	Snow
April	1.4°	5.8		0.9°	2.1		2.0°	3.5	17.8
May	9.8°	6.7		9.1°	6.1		10.0°	1.3	
June	17.9°	4.9		17.3°	8.1		17.7°	2.8	
July	18.4°	10.0		18.3°	9.0		20.1°	6.5	
August	19.6°	4.8		19.7°	2.8		19.9°	4.6	
Total		32.2			28.1			18.7	

Table 3. Rotational grazing systems used in 1996 and 1997 for Chase Lake (CL) and Northern Coteau (NC) project areas. Stocking rates, date the rotational grazing system was initiated, grazing dates, total number of grazing days, number of cells or paddocks used in rotation and total grazing system acreage and hectares are listed below for each system.

Rotational System	Year Initiated	Stocking Number	Date Cattle Released	Date Cattle Removed	Grazing Days	Number of cells	Acres/ Hectares	Stocking Rate*
CL 1	1990	100 cow/calf	June 1	October 21	122	5	800 / 324	12.5 / 30.9
CL 2	1992	190 cow/calf	May 26	November 2	161	8	1280 / 518	14.8 / 36.7
CL 3	1991	150 cow/calf	June 1	November 4	157	5	960 / 388	15.6 / 38.7
NC 1	1993	70 cow/calf	June 15	September 30	108	4	814 / 329	8.6 / 21.3
NC 2	1992	80 cow/calf	June 1	November 10	163	5	935 / 379	8.5 / 21.1

* Stocking rate equals the number of cattle per 100 acres / hectares.

All grazing systems were season-long pastures before signing the prescribed grazing agreement, therefore, season-long pastures were selected as controls. Each replicate equals 1 rotational grazing system (treatment) and 1 season-long grazing regime (control). Each paired treatment and control or replicate were matched by similar soil types, wetland area, topographic and physiographic area and surrounding land use practices. This reduced between-site variability ensuring greater likelihood of measuring treatment effects.

Stocking rates were slightly higher and grazing dates were earlier on the season-long pastures (Table 4). Since this study was done on privately owned land there was little control over how the season-long pastures were operated. Also, all sites selected were native mixed-grass prairies which have never been tilled in the last 50 to 75 years or more.

All study sites remained the same in 1996 and 1997 with the following exceptions. One season-long pasture (CL3, 1996) was on the edge of the Missouri Coteau and was not privately owned (State school section). Due to time constraints, this pasture was studied in 1996, however, in 1997 an alternative season-long pasture (CL3, 1997) was used. The new CL3 was privately owned and matched up with the paired CL3 rotational grazed system in terms of the above criteria (soils, water, surrounding land use practices and geographic location). However, monitoring and sampling data were still collected on CL3 (1996) season-long pasture in 1997 (Table 4). There were no significant differences between the two sites ($p>0.05$) and for 1997 analyses CL3 (1997)

Table 4. Season-long pastures used in 1996 and 1997 for Chase Lake (CL) and Northern Coteau (NC) project areas. Stocking rates, grazing dates, total number of grazing days, acreage, and hectares are listed below for each pasture.

Season-long pasture	Stocking Number	Date cattle were released	Date cattle were removed	Grazing days	Acres / Hectares	Stocking Rate*
CL 1	125 cow/calf	May 20	November 1	168	800 / 324	15.6 / 38.6
CL 2	100 cow/calf	May 15	November 1	173	640 / 259	15.6 / 38.6
CL 3 (1996)	80 cow/calf	June 1	November 1	154	640 / 259	12.5 / 30.9
CL 3 (1997)	75 cow/calf	May 20	November 1	168	480 / 194	15.6 / 38.6
NC 1	200 cow/calf	June 1	August 1	61	720 / 291	27.8 / 68.7
NC 2 (1996)	125 cow/calf	June 1	July 15	45	640 / 259	19.5 / 48.3
NC 2 (1997)	100 cow/calf	June 1	August 15	76	700 / 283	14.2 / 35.3

* Stocking rate equals the number of cattle per 100 acres / hectares.

was used in place of CL3 (1996). Another season-long pasture (NC2, 1996) was replaced in 1997 because the original pasture was not grazed in 1997. This pasture (NC2, 1996) was replaced by another privately owned season-long pasture (NC2, 1997). See Tables 3 and 4 for further information regarding the grazing regimes.

CHAPTER 2. EFFECTS OF GRAZING REGIMES ON RELATIVE ABUNDANCE AND SPECIES RICHNESS OF GRASSLAND PASSERINES

INTRODUCTION

Grassland birds that commonly use North American prairies have experienced precipitous declines in their populations (Samson and Knopf 1994). Population trends indicate that grassland and shrub/successional birds have the smallest percentages of positive increases, and several good years of are needed to reverse their long-term declines (Peterjohn et al. 1994). Peterjohn and Sauer (1993) found that population estimates from 1966 to 1991 showed only 17% of grassland birds were increasing in contrast to 59% for all neotropical migrants. Knopf and Samson (1995) considered 6 grassland passerines in North America as endemic to prairies and list 10 that are considered as secondary because their ranges are more widespread. Sauer et al. (1996) found that 3 of the 4 endemic grassland passerines which occur in North Dakota are declining, including the Sprague's pipit (*Anthus spragueii*), Baird's sparrow (*Ammodramus bairdii*) and the lark bunting (*Calamospiza melanocorys*). Four of the 8 secondary grassland passerines occurring in North Dakota are showing population declines including the dickcissel (*Spiza americana*), savannah sparrow (*Passerculus sandwichensis*), grasshopper sparrow (*Ammodramus savannarum*), and clay-colored sparrow (*Spizella breweri*).

The major decline of grassland passerines has been attributed to the extent of grassland conversion into tillage agriculture (Johnson and Schwartz 1993). Some bird species may be attracted to fragmented habitats which in some instances act as "population sinks" wherein the birds are more vulnerable to high rates of nest parasitism and predation (Ball et al. 1994). Herkert (1994) stated that management actions directed toward large contiguous tracts of grassland with minimal disturbance during the breeding season would be beneficial to grassland bird populations since smaller tracts of grassland were avoided by some species while leaving others vulnerable to predation.

METHODS

Species richness and relative bird abundance were measured using point count surveys (Hutto et al. 1986 and Ralph et al. 1993). Point counts contained circular plots with a fixed radius of 100 m in which 5 minute counts were used to assess grassland passerine communities. Savard and Hooper (1995) found that a 100 m radius point yielded nearly as many detections as an unlimited radius, therefore, 100 m radius plots may be more efficient than those with unlimited distances.

Ten to 12 bird survey points were placed on each study site with approximately 2 or 3 points per cell or pasture so the entire effects of the rotational grazing systems were being assessed. The points were selected using a random systematic grid for each section of land and plotted on aerial maps. Points were gridded 250 m apart which is considered an adequate distance for providing statistical independence (Hutto et al. 1986, Dale 1994). To reduce variability among points, developed roads, tree clumps, wooded draws or nonpasture habitat boundaries were avoided, or were at least 50 m away from point boundaries. Points may contain ≤ 5% of seasonally flooded wetland zones as defined by

Cowardin et al. (1979). These restrictions ensured that only the effects of grazing on upland native prairie were evaluated.

The study took place in May through August of 1995, 1996, and 1997. In 1995, 105 point counts were conducted only on deferred twice-over rotational grazing systems. Due to the addition of season-long pastures and the removal of some rotational grazed pastures, 112 new points were randomly selected in 1996 on both grazing regimes. The 1996 points were used in 1997 with the following exceptions. Due to above average precipitation in 1996, some points contained more than 5% of seasonally flooded wetlands, therefore, these points were replaced in 1997. In addition, 2 points were hayed in the fall of 1996, so 2 alternative points were selected. One additional season-long pasture (CL3, 1997) was included in the 1997 field season (see Chapter 1) which added an additional 10 points for a total of 122 point counts.

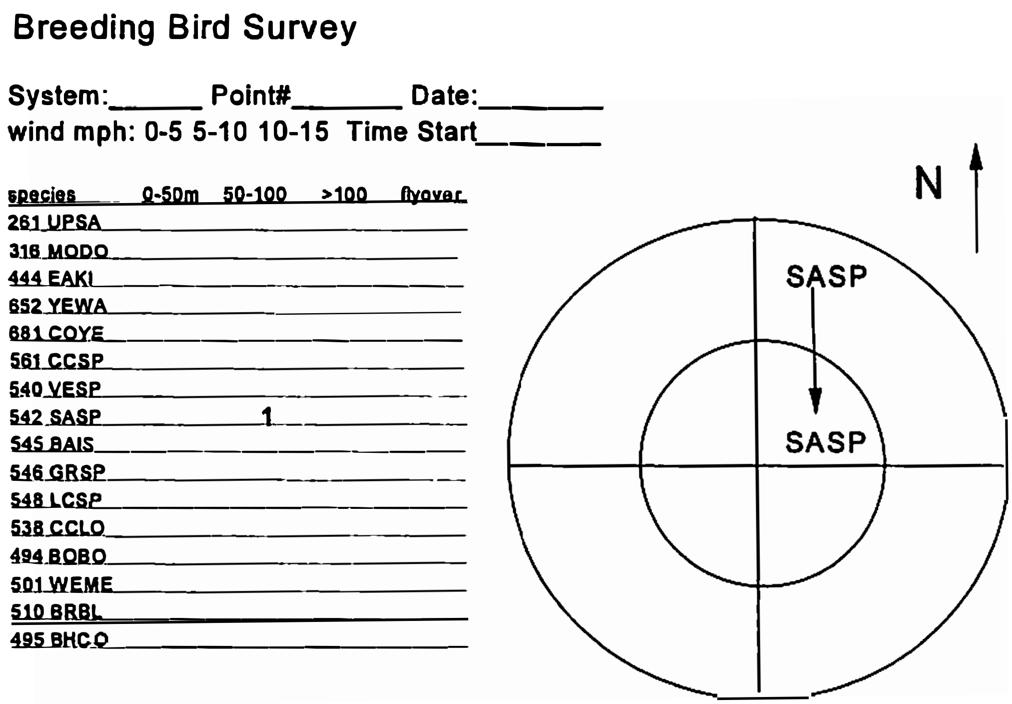
Point centers were located on the ground by pacing along compass bearings from marked points on the maps and ground truthing. When marking the center of each 100 m radius, it was important to find a suitable way to mark each point. The marker used would need to withstand disturbance by cattle (trampling and pulling out flags) and endure inclement weather conditions. Rocks were abundant on most sites and provided excellent natural markers which did not provide additional perching habitat for singing males. When gathered into small rock piles and spray painted with nontoxic fluorescent paint, these markers required little maintenance, and were easy to find throughout the year. When rocks were not available, small 1 cm diameter poles were used to mark the center of the 100 m radius. Surveyors flags or pieces of flagging tape were used to mark the 100 m boundaries in the 4 cardinal directions. Each year, rock piles were spray painted (paint wore off each year) and boundaries were reflagged.

Since results of bird sampling can vary among individuals, observers trained together prior to each field season to ensure homogeneity of data collection (O'Connor 1981, Emlen and DeJong 1992) . We (2 field assistants in 1995 and 1996 and 1 in 1997) would practice bird song and sight identification prior to each field season. Distance estimations to singing males were practiced by pacing the distance from the observer to the bird. Practicing estimation of distance was important because visual identification was not always possible and detectability of bird songs varied by species (i.e,. some bird species songs carry further than other and distances are easily overestimated, while others are more difficult to hear).

Point counts were conducted from one-half hour before sunrise to 0800 hrs. Counts were not conducted on mornings with fog or rain and wind speeds greater than 24-40 km/ph (15-25 mph) which decreases detectability of birds (Ralph et al. 1993, Dale 1994). Each point was sampled twice during 15 May to 30 June each year. Observers rotated the order of the second point count to reduce sampling bias. The same observer was used for each replicate (paired rotational and season-long regime) to reduce observer bias. An observer approached each sampling point quietly, at a slow walk attentive to where birds flushed and singing activity occurred. A point count did not begin until the observer reached the point center. Observers recorded bird detections on each plot for 5 minutes; the number of singing males or pairs seen of each species were tallied and the location of each bird was plotted on a breeding bird data sheet (Figure 2). Movements of birds were also recorded to aid in delineation of bird territories for productivity counts (discussed in Chapter 4). Only singing males or pairs were recorded and enumerated with the exception of brown headed cowbirds (*Molothrus ater*) for which the total number of males and females were recorded. If a territorial bird was unidentified, the observer waited until the point count was finished and then tried to relocate the bird and identify it to species. Only grassland passerines and upland nesting shorebirds were recorded. Species other than these were recorded on a separate species checklist. See Appendix A for a list of scientific and common names for all nongame birds and upland nesting shorebirds recorded during the study.

Statistical analyses

To calculate abundance, data were summarized by taking the greater number of detections between the 2 breeding bird counts. For example, if 2 grasshopper sparrows were recorded on the first point count and 3 grasshopper sparrows were recorded on the second count then 3 was used for that point count. Relative abundance is the mean number of territorial (singing male or pair) detections per 100 m radius (point count). Frequency is the percentage of 100 m radius point count plots at which a species was detected (e.g., if 20 grasshopper sparrows were detected on 100 points then the percentage of occurrence would be 20/100x100 or 20%).



Breeding Bird Survey

System:______ Point#_______ Date:________
wind mph: 0-5 5-10 10-15 Time Start_______

species	0-50m	50-100	>100	flyover
261 UPSA				
316 MODO				
444 EAKI				
652 YEWA				
681 COYE				
561 CCSP				
540 VESP				
542 SASP		1		
545 BAIS				
546 GRSP				
548 LCSP				
538 CCLO				
494 BOBO				
501 WEME				
510 BRBL				
495 BHCO				

Figure 2. Data sheet used for mapping and recording territorial (singing male or pair) species during point counts in 1995, 1996, and 1997.

Data collected from point counts were independent and normally distributed. Therefore, an independent sample t-test was used to determine significant differences of overall relative abundance and species richness (mean number of species detected per 100m radius point count) between treatment (rotational grazing system) and control (season-long pastures). Only 1996 and 1997 data were used for comparisons between grazing regimes because data were not collected on season-long pastures in 1995.

Only birds which occurred more than 15% of the time on point counts in 1995 were used for analysis of individual species (Table 5). Paired t-tests were used to determine significance of individual species between rotational and season-long grazing regimes. Alpha level was set at $P<0.10$ and was assessed using Bonferonni procedures (Rice 1990) to maintain alpha levels for multiple tests within the same sample unit. Ten birds were individually compared between rotational and season-long regimes. Since ten tests were conducted the alpha level needed to be corrected. This was done by taking the current alpha level (0.10) divided by the number of tests (10), therefore the corrected alpha level would equal 0.01.

Previous literature (Owens and Myers 1973, Kantrud and Kologiski 1982, Knopf 1996) suggests that some species are more sensitive to the effects of grazing than others. To determine whether rotational grazing systems provided or did not provide suitable habitat for these species versus traditional season-long pastures, a guild of species that respond negatively to grazing was created from literature review. Five of the 10 species, i.e., grasshopper sparrow, savannah sparrow, Baird's sparrow, western meadowlark, and

Table 5. Mean relative abundance values, and standard errors of singing male passerines and upland shorebirds from point counts, 1995 (n=105), 1996 (n=112), 1997 (n=122), on grazing regimes within the PPJV.

	1995			1996			1997		
Bird species	Abund[a]	SE	Freq[b]	Abund[a]	SE	Freq[b]	Abund[a]	SE	Freq[b]
American goldfinch	--	--	--	0.053	0.021	5.3	0.033	0.019	2.4
Baird's sparrow	0.486	0.060	42.8	0.553	0.098	27.6	0.286	0.055	21.3
Bobolink	0.290	0.053	23.8	0.428	0.064	32.1	0.213	0.052	13.9
Brewer's blackbird	--	--	--	0.151	0.040	12.5	0.073	0.026	7.3
Brown-headed cowbird[c]	1.200	0.172	46.6	1.848	0.185	63.3	2.163	0.146	84.4
Brown thrasher	0.009	0.009	0.9	0.008	0.008	0.8	0.049	0.019	4.9
Chestnut-collared longspur	0.780	0.097	43.8	0.508	0.085	30.3	0.631	0.104	29.5
Clay-colored sparrow	0.850	0.085	57.1	1.517	0.106	75.8	1.565	0.111	79.5
Common grackle	--	--	--	--	--	--	0.040	0.033	1.6
Common snipe	0.019	0.013	1.9	0.071	0.024	7.1	0.081	0.024	8.1
Common yellowthroat	0.046	0.024	2.8	0.053	0.027	3.5	0.037	0.028	5.7
Eastern kingbird	0.179	0.039	16.1	0.366	0.050	33.9	0.270	0.043	25.4
Grasshopper sparrow	1.019	0.089	65.7	1.098	0.078	74.1	1.246	0.103	65.6
Horned lark	0.180	0.050	14.2	0.062	0.023	6.2	0.139	0.031	13.9
Killdeer	--	--	--	0.035	0.017	3.6	0.032	0.016	3.2

Table 5. Continued.

Bird species	1995 Abund[a]	1995 SE	1995 Freq[b]	1996 Abund[a]	1996 SE	1996 Freq[b]	1997 Abund[a]	1997 SE	1997 Freq[b]
LeConte's sparrow	0.056	0.026	4.7	0.187	0.041	16.9	0.122	0.032	11.5
Morning dove	--	--	--	0.026	0.015	2.6	--	--	--
Marbled godwit	0.019	0.013	1.9	0.017	0.019	1.7	0.0323	0.016	3.2
Red-winged blackbird	0.047	0.024	3.8	0.017	0.019	1.7	0.172	0.047	13.1
Savannah sparrow	0.607	0.076	44.7	1.330	0.090	78.6	1.073	0.076	73.8
Sedge wren	0.065	0.027	4.8	0.151	0.046	9.8	0.032	0.019	2.4
Sharp-tailed sparrow	0.009	0.009	0.9	0.008	0.008	0.8	--	--	--
Song sparrow	0.057	0.026	4.7	0.017	0.012	1.7	0.016	0.012	1.6
Sprague's pipit	0.215	0.046	19.0	0.107	0.029	10.7	0.057	0.021	5.7
Upland sandpiper	0.131	0.035	12.3	0.241	0.040	24.1	0.114	0.028	11.4
Vesper sparrow	0.047	0.021	4.7	0.142	0.033	14.2	0.196	0.037	18.8
Western kingbird	--	--	--	0.026	0.015	2.6	0.032	0.016	3.2
Western meadowlark	0.411	0.053	38.0	0.678	0.051	64.2	0.581	0.062	47.5
Willet	0.093	0.028	9.5	0.133	0.034	12.5	0.073	0.023	7.4
Willow flycatcher	0.028	0.016	1.9	0.125	0.036	10.7	0.073	0.023	7.4
Yellow warbler	0.074	0.025	6.6	0.116	0.032	10.7	0.155	0.036	13.9

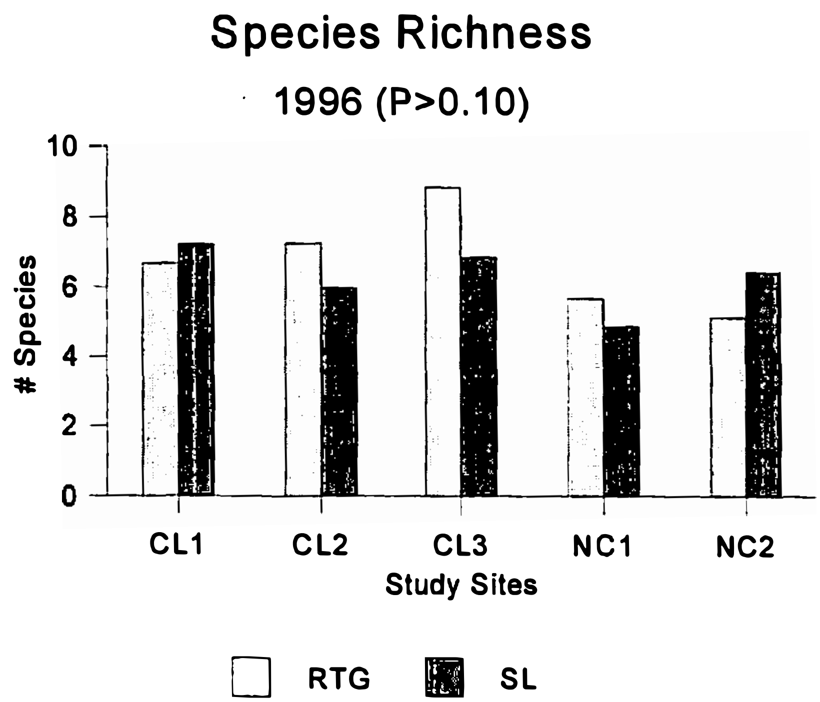
[a] Mean number of singing males per 100 m radius point count (maximum number of detections over two visits).
[b] Frequency equals the percentage of 100 m radius points at which the species was detected.
[c] Brown-headed cowbird abundance is the total number of individuals (male or female) seen.

bobolink, were all recorded as being sensitive to heavy or moderate grazing on mixed grass prairie in the northern Great Plains (Maher 1979, Owens and Myres 1973, Kantrud 1981, Kantrud and Kologiski 1982). This guild was analyzed using an independent sample t-test to test for differences in relative abundance between grazing regimes.

RESULTS

Twenty-five species of breeding nongame birds were recorded during point counts in 1995, 30 species in 1996, and 29 species in 1997 (Table 5). In 1995, the 3 most common grassland bird species detected on point counts were the grasshopper sparrow, which was detected on 66 % of all point counts (frequency), the clay-colored sparrow (57%) and the brown-headed cowbird (47%). These 3 species also were the most common in 1996, and 1997, but the order varied. In 1996, clay-colored sparrow was the most common (76%) followed by the grasshopper sparrow (74%) and the brown-headed cowbird (63%). In 1997, the brown-headed cowbird was the most common species detected (84%) followed by the clay-colored sparrow (80%) and the grasshopper sparrow (66%).

In 1996, there was no difference ($P<0.10$) in species richness ($P=0.58$) or overall relative abundance ($P=0.29$) between rotational grazing systems and season-long pastures (Figures 3 and 4). However, in 1997, species richness ($P=0.04$) and relative abundance ($P=0.08$) were greater ($P<0.10$) in rotational grazing systems than in season-long pastures (Figures 3 and 4).



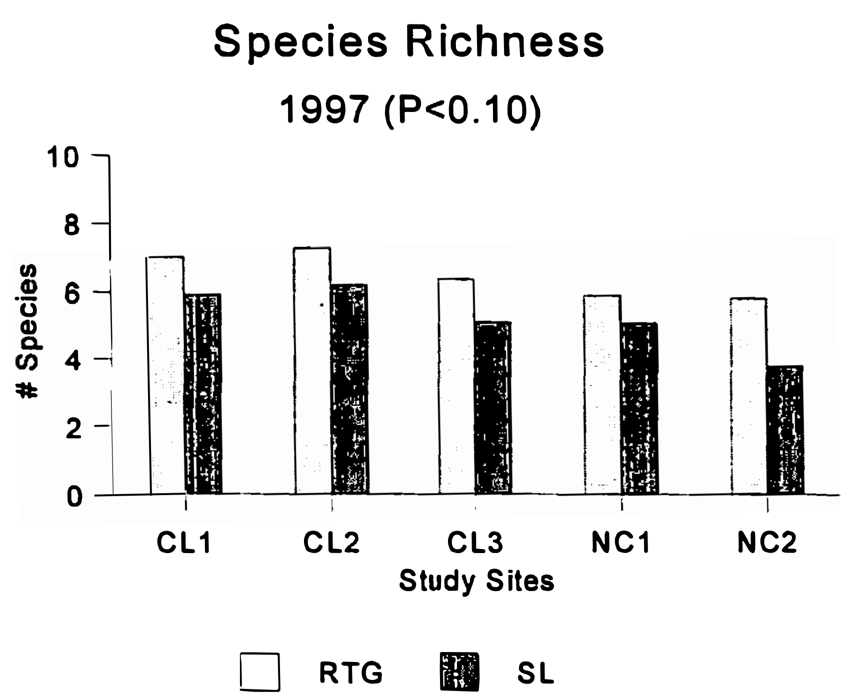
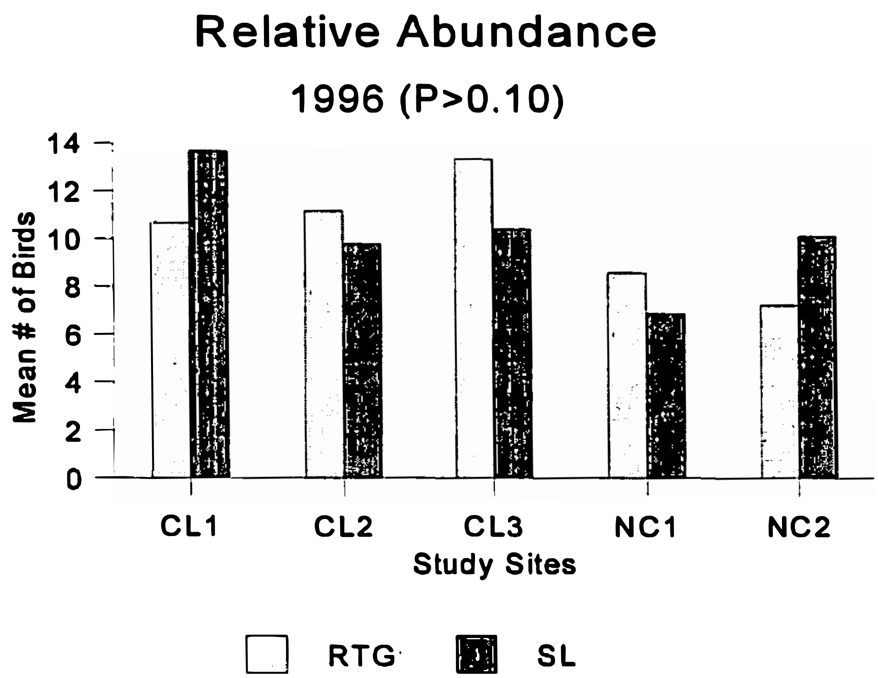


Figure 3. Species richness (mean number of species detected per 100m radius) for 5 rotational (RTG) and season-long (SL) grazing regimes in 1996 and 1997.



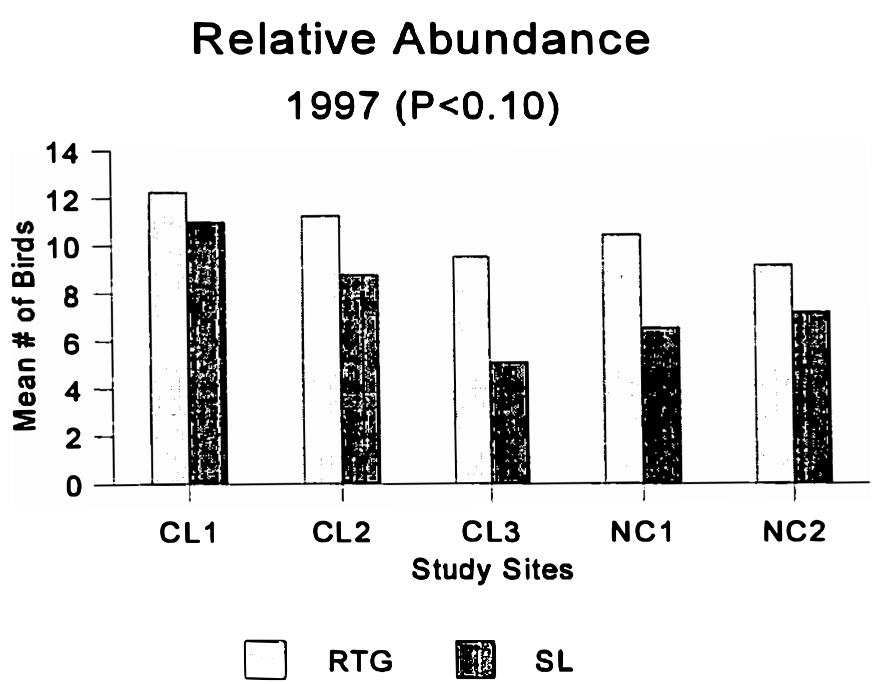


Figure 4.
Overall relative abundance (mean number of territorial birds detected per 100m radius) for 5 rotational (RTG) and season-long (SL) grazing regimes in 1996 and 1997.

Ten bird species were individually compared between grazing regimes. No statistical difference was found (P>0.01) for any of the species between the rotational and season-long grazing regimes for both 1996 and 1997 (Table 6). However, in 1997, several species, including the eastern kingbird, Sprague's pipit, chestnut-collared longspur and grasshopper sparrow were approaching statistical significance (P=0.03, P=0.22, P=0.08, P=0.14 respectively).

There was no difference (P=0.62) in combined relative abundance for the grazing-sensitive guild between the 2 grazing regimes in 1996. However, in 1997, the grazing-sensitive guild had a greater (P=0.03) relative abundance on rotational grazing systems than on season-long pastures.

DISCUSSION

This study occurred during a period of above average precipitation for the first 2 years and average precipitation in the last year of the study (NOAA 1996). This may explain the representation of birds detected over all 3 years of the study. Thirty-one different territorial nongame species were recorded which is higher than other studies conducted in this area. Madden (1996) recorded 24 different nongame grassland species on burned, ungrazed land at Lostwood National Wildlife refuge in North Dakota. Renken and Dinsmore (1987) found 29 nongame grassland species on idle, mowed and grazed areas in Stutsman County, North Dakota. Messmer (1990) found 22 nongame grassland bird species on grazed pastures, and Kennedy (1994) found 12 grassland bird species on

Table 6. Relative abundance (mean number of territorial males per 100 m radius point counts), standard errors, and p-values of 1996 and 1997 point counts for rotational and season-long grazing regimes.

	1996					1997				
	Rotational		Season-Long			Rotational		Season-Long		
Bird Species	Mean	SE	Mean	SE	P-Value*	Mean	SE	Mean	SE	P-Value*
Eastern Kingbird	0.42	0.14	0.33	0.09	0.50	0.45	1.00	0.12	0.63	0.03
Sprague's Pipit	0.12	0.11	0.11	0.08	0.91	0.13	0.09	0.00	0.00	0.22
Clay-colored Sparrow	1.44	0.27	1.53	0.25	0.48	1.75	0.32	1.41	0.42	0.56
Savannah Sparrow	1.40	0.25	1.27	0.28	0.76	1.23	0.27	0.94	0.11	0.28
Baird's Sparrow	0.46	0.32	0.67	0.50	0.64	0.27	0.19	0.30	0.18	0.93
Grasshopper Sparrow	1.19	0.17	1.04	0.21	0.60	1.68	0.39	0.88	0.30	0.14
Chestnut-collared Longspur	0.49	0.26	0.53	0.30	0.78	0.45	0.39	0.79	0.62	0.08
Bobolink	0.65	0.24	0.24	0.06	0.21	0.34	0.23	0.21	0.04	0.36
Brown-headed Cowbird	1.56	0.30	2.15	0.55	0.35	1.93	0.24	2.36	0.30	0.28
Western Meadowlark	0.75	0.08	0.64	0.13	0.67	0.77	0.24	0.42	0.08	0.09

*P-Value is significant at 0.10 alpha level (using Bonferonni's correction P-Value is significant at 0.01) grazed Conservation Reserve Program (CRP) located in areas similar to those in my study.

Species richness and overall relative abundance were higher on rotationally grazed pastures for 3 of the 5 sites (Chase Lake 2, and 3 and Northern Coteau 1) and in 1997 these values were higher on all rotationally grazed systems compared to the paired traditional season-long grazing regimes (Figures 2 and 3). The same trend held for the grazing-sensitive guild, relative abundance was only significantly higher on rotational versus season-long grazing regimes in 1997, however, not in 1996. One of the reasons for the year to year effect may be due to changes in precipitation and temperature during the growing seasons (Tables 1 and 2). In the Chase Lake study area in 1997, the average April temperature was below freezing (-0.10°C). Although there were high amounts of precipitation recorded, the precipitation was unavailable to plants because the ground was still frozen beneath heavy winter snowfall accumulations which resulted in a late spring. This coupled with a decrease in precipitation in May and June (precipitation did not occur until 21 June in the Chase Lake study area) on both study areas resulted in slower vegetative growth. Another factor may have been that landowners of traditional season-long pastures released cattle into their pastures in the first week of May both years ((Table 4) except for CL3, 1996) in comparison to late-May releases on rotational grazing systems (Table 3). Also, the precipitation and average temperatures were higher in 1996, than in 1997, possibly resulting in earlier and better vegetation growth in 1996. However, in 1997, a more suitable habitat for birds may have occurred on the rotationally grazed pastures which were idle until late May. The earlier release date of cattle on season-long grazing regimes with the decrease in precipitation may be the reason for the difference in bird abundance between years on the season-long grazing regimes.

Relative abundance values for species such as bobolinks, grasshopper sparrows, savannah sparrows, eastern kingbirds, Sprague's pipits, and western meadowlarks relative abundances were higher both years on rotational grazing systems than on season-long pastures. Baird's sparrows, chestnut-collared longspurs and brown-headed cowbirds had higher relative abundance values on the season-long pastures. The clay-colored sparrow was equally abundant on both grazing regimes in 1996 and 1997. My findings generally agree with those of Messmer (1990) except for Baird's sparrows which were found to be more abundant on rotational grazing systems in his study.

All of the grazing-sensitive species except for the Baird's sparrow had higher mean relative abundance values on rotational grazing systems than on traditional season-long pastures. This is important because it may suggest that species which are sensitive to grazing may be able to find suitable nesting habitat on rotationally grazed pastures because cells are periodically rested from grazing. Twice-over rotational grazed pastures may be a positive alternative to traditional season-long pastures for private landowners. Twice-over rotational grazing systems can benefit both private landowners and public land managers who want to manage more holistically for a greater variety of bird species.

CHAPTER 3. VEGETATIONAL CHARACTERISTICS AND BIRD-HABITAT RELATIONSHIPS

INTRODUCTION

Grassland birds are influenced by the amount and quality of vegetation (Kirsch et al. 1978) and are sensitive to subtle changes in habitat characteristics (Cody 1968, Kantrud and Kologiski 1983, Huber and Steuter 1984, Arnold and Higgins 1986, Renken and Dinsmore 1987, Knopf 1996). Land managers can manipulate grasslands to change plant structure and communities; these alterations of habitat can result in either negative or positive responses of birds, depending on the species (Wiens and Rotenberry 1981, Herkert 1994). Habitat selection of birds varies according to different landscapes. This is why land management recommendations should consider landscape influences on birds before implementing conservation policies (Flather and Sauer 1996).

Residual vegetation and litter depth are important to several species of grassland birds. Consequently, understanding species-specific habitat requirements is critical for proper management (Wiens 1969, Tester and Marshall 1961, Owens and Myers 1973, Duebbert and Lokemoen 1977). Grasslands that remain idle or unmanaged can become dominated by brush [e.g., silverberry (*Elaeagnus commutata*) and snowberry (*Symphoricarpos occidentalis*)] and tame grasses [e.g. Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*)] which may reduce the value of these habitats to some wildlife species (Kirsch et al. 1978).

Relationships between livestock grazing and wildlife populations are hard to define due to the inherent variability of the factors involved. Such factors include timing of grazing, topography, climate, and grazing intensity (Kirsch et al. 1978, Wershler 1993, Bock and Webb 1984). Litter removal due to overgrazing can be decreased by reducing grazing pressure and allowing litter to accumulate. In mixed-grass prairie, grazing rates should be managed to conserve litter, stabilize range conditions and maximize livestock production (Naeth et al.1991, Willms et al. 1993). Grazing may have detrimental affects on grassland bird populations due to the removal of the herbaceous layer (Wiens 1969, Knopf et al. 1988). Responses of grassland bird species to cattle grazing are variable with certain species increasing [e.g., horned lark (*Eremophila alpestris*) and chestnut-collared longspur (*Calcarius ornatus*)] while others showing declines [e.g. Bairds sparrow *(Ammodramus bairdii*) and Sprague's pipit (*Anthus spragueii*)] (Owens and Myers 1973, Ryder 1980, Kantrud and Kologiski 1982, Renken and Dinsmore 1987). Heavy grazing had a negative affect on grassland passerines in North Dakota and resulted in lower species richness and diversity (Kantrud 1981).

METHODS

All methods of vegetation measurements were kept the same throughout the 3 field seasons (1995-1997). Vegetation sampling was conducted in late June to early July on all point count survey plots. Sampling procedures followed those of Dale (1994). For each point, 8 subsamples of vegetation measurements were taken. Two randomly selected subsampling points were placed on transects in each of the 4 cardinal directions from the point center, the first point falling between 5-50 m and the second point between 51-75 m (Figure 5).

Vegetation structure was measured using the methods described by Robel et al. (1970). Visual obstruction readings using a Robel pole were taken in each of the 4 cardinal directions from a height of 1 m and a distance of 4 m at each subsample point. A reading was taken at a point on the pole above the ground where the vegetation last obscured the pole by 100% and was rounded to the nearest dm.

Litter depth and vertical vegetation structure was calculated using a thin 1-m long rod which was 6 mm in diameter and was marked in 1 dm increments (Wiens 1969, Rotenberry and Wiens 1980). The rod was placed 0.5 m perpendicular from the east and west sides of the Robel pole, resulting in 2 vertical structure and litter depth measurements for every 1 visual obstruction reading. Litter depth was measured in cm by noting the height of the dead vegetation which formed a mat-like layer. The total number of contacts (hits) by plants which hit the pole in each dm increment was recorded as vertical vegetation structure. Hits were also recorded as the total number of vegetative "live" or "dead" hits. The plant density index was the total number of contacts and the plant vigor index was the live:dead ratio of all plant contacts.

Percent areal cover was collected using Daubenmire's (1959) 6 coverage classes (0-5, 5-25, 25-50, 50-75, 75-95 and 95-100%). Percentage value for bare ground, forbs, grasses and shrubs were estimated within a 0.5m radius around the Robel pole.

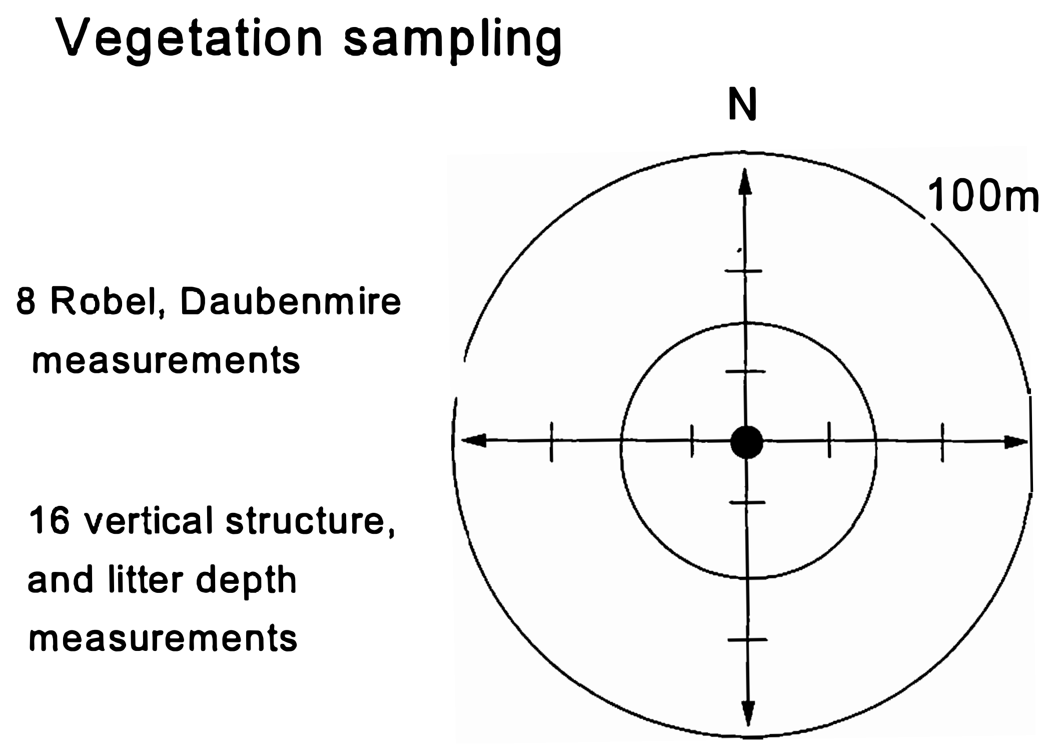


Figure 5. Vegetation transects within the point count plots. Hash marks indicate where vegetation measurments were taken. At each mark 2 vertical structure measurments were taken as well as 2 litter depth and 1 canopy cover (Daubenmire 1959) and 1 visual obstruction reading (Robel et al. 1970). Vegetation measurement were recorded for each point.

Plant community types were also recorded at each vegetation sampling point in 1997 (Appendix B).

Some passerines may be associated with low shrubs such as prairie wild rose (*Rosa arkansana*), silverberry (*Elaeagnus commutata*) or western snowberry (*Symphoricarpos occidentalis*). Therefore, shrubs were estimated for each point by recording the number of shrubs along a transect that was parallel to the vegetation transect. The observer walked back from the last station in which vegetation measurements were recorded toward the center of the 100 m radius plot. The total number of steps that a shrub occurred at along the transect was divided by the total number of possible steps and was used as an index of shrub density. This was done on 3 of the 4 vegetation transects for each point (see Figure 5 for the location of the vegetation transects).

Vegetation data treatment

For each vegetation structure variable, excluding plant community data, the mean and coefficient of variation (CV) were calculated for each point. Coefficient of variation was used to measure vegetation variation among samples which can help in determining if the variable is uniformly distributed (Roth 1976). Some of the vegetation variables measured similar vegetation attributes, e.g. litter depth and aerial coverage percentage of litter both estimated litter accumulations. Therefore, many of the vegetation variables used in this study were highly correlated with one another and were characterizing the same vegetation structure. Thus, 10 vegetation variables and 8 plant community variables were retained for further analysis. The vegetation variables retained are listed in Table 7.

Vegetation variables were pooled over all 3 years of the study for bird and habitat associations. This was because I was not concerned with yearly effects but with long-term associations. Spearman rank correlation was used to determine associations among bird abundance (Chapter 2) and vegetation variables as well as correlations between these 2 groups. Litter depth was retained in favor of average percent of litter cover, because it gave a more accurate picture of the amount of litter accumulation over the years than did areal coverage percentage. Visual obstruction readings (i.e. Robel pole readings) were highly correlated with maximum height assessed from vertical vegetation measurement (r_s=0.85). Therefore, visual obstruction readings were used instead of maximum height measurements. Shrub density was correlated with areal percent of shrub cover (r_s=0.66). Low shrub density was retained in favor of areal percent cover of shrubs because it was associated with more bird species. The remaining vegetation variable, percentage of live vegetative hits was removed because it was not correlated with any of the 10 grassland bird species abundance. Only 2 CV were retained (CV Bare and CV Vor, see Table 7 for definitions) due to the lack of association with bird abundance.

Plant communities were adopted from a list of 25 compiled by Madden (1996) for her study at Lostwood National Wildlife Refuge (Appendix B). Although plant communities varied among the 2 project areas (NC and CL), 1 list was used to simplify

Table 7. Description of vegetation variables measured at point count locations. Vegetation variables are mean or Coefficient of variation (CV) of 8 or 16 (Density and Litter depth) subsamples taken at each point.

Vegetation Variables	**Description**
%Club	Average percent areal ground cover of clubmoss (*Selaginella densa*)
%Grass	Average percent areal ground cover of grass
%Forb	Average percent areal ground cover of forbs
%Bare	Average percent areal ground cover of bare ground
CV Bare	Coefficient of variation of %Bare
Litter depth	Average litter depth (cm)
Vor	Visual obstruction reading (dm) - using Robel height/density
CV Vor	Coefficient of variation of Vor
Lwshrub	Average density of low shrubs
Density	Total number of vegetative "hits" (vertical measurement)
Plant communities	
Shrub	Dominance of Western snowberry (*Symphoricarpos occidentalis*) and Silverberry (*Elaeagnus commutata*)
Shrub/Exotic	Dominance of shrub and exotic grasses (*Bromus inermis*, *Poa pratensis* and *Agroypon repens*)
Shrub/Native	Dominance of shrub and native grasses (*Stipa, Bouteloua, Koeleria, Schizachyrium*)
Exotic	Dominance of exotic grasses
Kentucky/Native	Dominance of Kentucky bluegrass and native grasses
Brome/Native	Dominance of smooth brome (*Bromus inermis*) and native grasses
Native	Dominance of native grasses
Wet meadow	Dominance of wet meadow zone (Stewart and Kantrud 1971)

recording. Only the dominant plant community was marked for each subsample (See methods for details on vegetation measurements.). This resulted in only a few of the communities being used from the plant community list. A total of 8 plant subsamples were taken for each point. The frequency of number of occurrences for each plant community was then recorded for each point (i.e., if native grasses were found on 6 of 8 samples then native would equal 6 for that point). To simplify and reduce the number of plant communities, plant communities were combined into 8 groups (see Table 7 for plant communities and definitions).

Statistical tests between grazing regimes

I used a Mann-Whitney U test to determine if vegetation structure and plant communities differed between rotational and season-long grazing regimes. Vegetation variables were not normally distributed, so nonparametric statistics were used for all vegetation analyses. Since data in 1995 was only collected on rotational grazing systems, all 1995 data were eliminated from this analysis. Data collected in 1996 and 1997, were analyzed separately for treatment comparisons because of significant ($p<0.05$) differences in vegetation between the 2 grazing regimes.

In 1996, a total of 112 points were sampled, 57 on rotational grazing systems and 55 on season-long grazed pastures. In 1997, 122 points were sampled, 56 on 5 rotational grazing systems and 66 on 6 season-long pastures (extra season-long pasture as discussed in Chapter 1). Statistical significance was determined at the 0.05 alpha level (using

Bonferonni correction, alpha level of 0.005 in 1996 and 0.003 alpha level in 1997 to be statistically significant).

Bird-habitat association statistical tests

Relative bird abundance was used for birds which occurred on greater than 15 percent of all point counts (Chapter 2). Bird count data, along with vegetation structure variables were pooled over all 3 years and over both grazing regimes. Plant communities were only recorded for all study sites in 1997. These data were then analyzed using Spearman rank correlation.

Vegetation means and individual bird presence or absence were assessed using a Mann-Whitney U test for paired data. All data were pooled for all 3 years (except plant communities) and grazing regimes. A total of 341 points was used for vegetation structure variables and 122 points were used for plant communities. Presence or absence was determined for individual species which occurred on greater than 15 % of all point counts in 1995 (Chapter 2). If the bird species was present on a point it was assigned a value of a 1, if absent it received a 0. Since vegetation data were collected from the same point as bird species presence data, bird-habitat relationships could be assessed. Statistical significance was determined using 0.05 alpha level (using Bonferonni correction the alpha level (0.05) is divided by number of tests (13) which equals 0.00038).

Logistic regression models were used for 10 bird species which occurred on greater than 15% of all point counts for 1995 (Chapter 2). Presence or absence was used for logistic regression modeling. Eight vegetation structure variables which were measured on the same points were used to predict the presence of individual bird species. All vegetation data and bird presence or absence were pooled over all 3 years and grazing regimes.

RESULTS

Principal Component Analysis

Principal component analysis (PCA) of vegetation data was completed to reduce vegetation variables to 3 groups (see Table 8 for eigenvector component loadings). All vegetation data collected over all 3 years and both regimes were pooled for this analysis. PC 1 explained the highest amount of variance (39 %). This PC had high positive coefficient loadings for litter depth, visual obstruction readings, total number of vegetative "hits", and negative loadings for bare ground, and clubmoss cover. This appears to represent density of vegetation structure because all positive loadings were related to density and negative loadings represent negative associations with dense vegetative cover. PC 2 explained 14% of the total variance. PC 2 had high eigenvector component loadings for grass and forb cover. This was interpreted as percent of areal vegetative cover. The final PC (3) explained 11% of the variance and had 1 high loading (shrub cover), which makes the third interpretation self explanatory. However, since principal components can be difficult to understand and interpret, they were used only in the Spearman rank correlation.

Table 8. Eigenvector component loadings of principal components (PC1, PC2, PC3) of vegetation variables for the combined years of 1996 and 1997.

Vegetation Variable	PC1	PC2	PC3
Percent Clubmoss Cover	-0.61	0.25	-0.06
Percent Grass Cover	0.44	0.56	-0.37
Percent Forb Cover	0.14	0.68	0.35
Percent Bare Ground Cover	-0.69	-0.29	0.17
CV Bare Ground Cover	0.66	0.37	-0.22
Litter Depth	0.83	-0.34	0.03
Visual Obstruction Reading	0.80	-0.05	0.26
CV Visual Obstruction Reading	-0.52	0.14	0.35
Lowshrub cover	0.39	0.12	0.73
Total Number of Vegetation "Hits"	0.78	-0.37	0.01
Percent of Variance Explained	38.68	13.50	10.57
Total Variance Explained	38.68	52.18	62.75

Vegetation associations between grazing regimes

In 1996, 10 vegetation variables were analyzed between grazing regimes (Table 9). Forb cover and shrub cover were greater ($P=0.003$ and $P<0.001$) on season-long grazed pastures than on the rotationally grazed systems. No significant differences ($P>0.005$) occurred between grazing regimes with the remaining vegetation variables.

In 1997, 10 vegetation structure variables and the 5 most prominent plant community variables were analyzed (Table 10). The only significant difference between grazing regimes in regard to vegetation variables was with litter depth. In 1997 litter depth was greater on rotational grazing systems ($P=0.001$) than on season-long grazed pasture. All other variables were nonsignificant ($P>0.003$). However, bare ground cover, low shrub density and total vegetative hits or density were approaching significance ($P=0.008$, $P=0.010$, $P=0.004$ respectively). These results are listed in Tables 11 and 12 with the positive or negative r_s values and level of significance.

Spearman rank correlations

Eastern kingbirds, clay-colored sparrows, savannah sparrows, grasshopper sparrows, and bobolinks were positively associated with litter depth, visual obstruction, vegetation density, and PC 1; and negatively associated with percent clubmoss and native plant community (Tables 11 and 12). Percent grass cover was associated positively with eastern kingbirds, savannah sparrows, grasshopper sparrows, bobolinks, brown-headed cowbirds, and western meadowlarks, it was negatively associated with Sprague's pipits, Baird's sparrow and chestnut-collared longspurs (Tables 11 and 12).

Table 9. Vegetation variables means, medians, standard error, and P-Value (based on Mann-Whitney U test) among grazing regimes for 1996.

	Rotational Grazing System (n=57*)			Season-long Grazing (n=55*)			
Vegetation Variable	Mean	SE	Median	Mean	SE	Median	P-Value
Clubmoss cover	3.94	0.86	0.00	4.72	1.04	0.31	0.813
Grass cover	57.54	1.48	59.06	57.67	1.68	61.56	0.619
Forb cover	16.23	1.03	16.25	20.71	0.90	20.63	0.003**
Bare ground cover	1.58	0.46	0.31	2.25	0.41	0.31	0.221
CV Bare ground	231.46	12.83	282.84	210.94	11.74	216.93	0.162
Litter depth	2.64	0.21	2.25	2.46	0.06	2.00	0.600
Visual Obstruction	1.17	0.07	1.09	1.05	0.06	1.07	0.300
CV Visual Obstruct.	59.48	3.65	54.27	65.46	4.33	53.10	0.449
Low shrub density	0.35	0.03	0.36	0.53	0.03	0.53	0.000**
Total # of "hits"	12.35	0.63	12.13	11.29	0.69	9.50	0.160

*Number of point counts sampled for vegetation structure

**Values which were significantly different between regimes, Significance was determined based on Bonferonni procedure (alpha level (0.05)/ 10 = 0.005).

Table 10. Vegetation variables means, medians, standard error, and P-Value (based on Mann-Whitney U test) among grazing regimes for 1997.

	Rotational Grazing (n=56*)			Season-long Grazing (n=66*)			
Vegetation Variable	Mean	SE	Median	Mean	SE	Median	P-Value
Clubmoss cover	3.38	0.77	0.00	4.46	1.03	0.00	0.964
Grass cover	31.17	1.55	31.88	31.41	1.37	29.38	0.930
Forb cover	11.75	1.04	12.03	14.72	0.96	13.59	0.042
Bare ground cover	5.36	0.97	1.88	8.62	1.07	6.23	0.008
CV Bare ground	178.64	10.00	152.34	154.29	9.21	138.01	0.056
Litter depth	2.38	0.18	2.06	1.62	0.15	1.22	0.001**
Visual Obstruction	0.61	0.04	0.52	0.61	0.66	0.54	0.394
CV Visual Obstruct.	71.93	4.82	60.17	80.53	3.66	76.66	0.036
Low shrub density	0.31	0.02	0.28	0.39	0.23	0.39	0.010
Total # of "hits"	8.49	0.29	8.13	7.29	0.31	6.91	0.004
Shrub community	0.05	0.04	0.00	0.17	0.88	0.00	0.342
Shrub/Exotic grass	1.11	0.16	1.00	1.12	0.16	1.00	0.826
Exotic grass	0.09	0.04	0.00	0.17	0.02	0.00	0.501
K. Blue/Native	4.79	0.35	5.00	4.32	0.32	5.00	0.250
Native	0.28	1.70	0.00	0.20	0.35	0.00	1.000

*Number of point counts sampled for vegetation structure

**Values which were significantly different between regimes. Significance was determined based on Bonferonni procedure (alpha level (0.05)/13 = 0.003).

Table 11. Spearman rank correlations (r_s) between bird abundance and vegetation variables pooled over all three years (1995, 1996, and 1997, n = 341). See table 7 for vegetation variables definitions.

Species	%club	%grass	%forb	%bare	litter depth	vor	lwshrub	density	PC1	PC2
Eastern kingbird	*** -0.20	*** +0.19			*** +0.27	** +0.15		*** +0.22	*** +0.23	* +0.15
Spragues pipit	*** +0.31	** -0.17			*** -0.25		** -0.13	*** -0.18		* -0.15
Clay-colored sparrow	*** -0.21		*** +0.20		*** +0.25	*** +0.21	*** +0.41	** +0.16	*** +0.43	
Savannah sparrow	*** -0.39	*** +0.30			*** +0.39	** +0.15	*** +0.20	*** +0.30	*** +0.26	** +0.19
Baird's sparrow	*** +0.50	** -0.17			*** -0.36	** -0.15	* -0.11	*** -0.27		*** -0.31
Grasshopper sparrow	*** -0.30	* +0.12			*** +0.31	** +0.17	* +0.12	*** +0.29	*** +0.22	*** +0.35
Chestnut-collared longspur	*** +0.38	* -0.13		*** +0.22	*** -0.47	*** -0.38	** -0.39	*** -0.40	*** -0.19	*** -0.33
Bobolink	*** -0.32	*** +0.28		*** -0.24	*** +0.47	*** +0.44	*** +0.21	*** +0.49	** +0.17	*** +0.46
Brown-headed cowbird	*** -0.30	* +0.13			*** +0.24		** +0.17		*** +0.43	
Western meadowlark		** +0.16			** +0.15		* +0.12		*** +0.27	
Total Passerines	*** -0.19	** +0.16			*** +0.21		*** +0.24		*** +0.26	

* P- value < 0.05

** P- value < 0.01

*** P- value < 0.001

Table 12. Spearman rank correlations (r_s) between grassland bird abundance and plant communities, n=122 (number of samples) in 1997. See table 7 for plant communities definitions.

Species	Shrub	Shrub& Exotic	Shrub& Native	Exotic	Kentucky Blue & Native	Brome & Native	Native	Wet meadow
Eastern kingbird					+0.21*		-0.21*	
Spragues pipit					-0.18*		+0.20*	
Clay-colored sparrow	-0.19*	+0.35***					-0.21*	-0.21*
Savannah sparrow					+0.31**		-0.33***	
Baird's sparrow					-0.24**		+0.38***	-0.19*
Grasshopper sparrow		+0.26**			+0.19*		-0.28**	
Chestnut-collared longspur		-0.20*			-0.33***		+0.43***	
Bobolink					+0.19*		-0.26**	
Brown-headed cowbird					+0.21*		-0.32***	
Western Meadowlark								
Total Passerines		+0.19*			+0.25**		-0.36***	

* P- value < 0.05
** P- value < 0.01
*** P- value < 0.001

Sprague's pipits, Baird's sparrows, and chestnut-collared longspurs were negatively associated with percent grass, litter depth, low shrubs, vegetation density, PC2, and Kentucky bluegrass with native grass plant community, and positively associated with percent clubmoss, and native grass plant community (Tables 11 and 12).

Unoccupied vs occupied bird-habitat associations

Eastern kingbirds occupied 88 points and were not present on 253 points (Table 13). Percent grass cover, litter depth, and total vegetative "hits" were greater (P<0.0038) on occupied sites than on unoccupied sites (P=0.001, P<0.001, P<0.001). Percent clubmoss cover was greater (P<0.001) on unoccupied sites.

Sprague's pipits occupied 40 points and were not present on 301 points (Table 14). Percent clubmoss cover was significantly higher (P<0.001) on occupied sites versus unoccupied sites. Percent grass cover (P=0.002), litter depth (P<0.001), and total vegetative "hits" (P=0.001) were greater on unoccupied sites.

Clay-colored sparrows occupied 244 points and were not present on 97 points (Table 15). Six vegetation variables, including percent forb cover (P=0.001), litter depth (P<0.001), visual obstruction reading (P<0.002), shrub density (P<0.001), total vegetation "hits" (P=0.003) and presence of shrub and exotic grasses (P<0.001) were greater (P>0.0038) for occupied points versus unoccupied points. Only percent clubmoss cover was significantly higher (P<0.001) on unoccupied sites.

Savannah sparrows occupied 227 points and were not present on 114 points (Table 16). Percent grass cover (P<0.001), litter depth (P<0.001), low shrub density

Table 13. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of eastern kingbirds on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

Vegetation variable	Occupied (n=88)			Unoccupied (n=253)			
	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	2.24	0.58	0.00	5.46	0.54	0.00	.000*
% Grass	46.00	1.86	44.06	38.84	1.06	35.31	.001*
% Forb	14.57	0.84	14.69	14.35	0.51	13.75	.338
% Bare	2.46	0.49	0.31	4.15	0.41	0.63	.160
Litter Depth	2.72	0.14	2.50	1.98	0.10	1.50	.000*
Vor	1.07	0.06	1.04	0.93	0.04	0.77	.007
Lwshrub	38.90	0.02	0.38	34.40	0.01	0.36	.093
Total hits	11.67	0.49	10.53	9.99	0.34	8.56	.000*
**Shrub	0.07	0.05	0.00	0.13	0.07	0.00	.878
**Shrub&Exotic	1.13	0.26	1.00	1.11	0.12	1.00	.732
**Exotic	0.10	0.07	0.00	0.04	0.03	0.00	.441
**Native	0.90	0.32	0.00	2.19	0.28	0.00	.019
**Kentucky & Native	5.45	0.46	6.00	4.22	0.27	4.00	.016

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=31 occupied, n=91 unoccupied)

Table 14. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of Sprague's pipits on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=40)			Unoccupied (n=301)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	8.50	1.24	6.72	4.12	0.45	0.00	.000*
% Grass	33.26	2.45	27.03	41.67	0.99	39.38	.002*
% Forb	13.72	1.05	13.44	14.50	0.47	14.06	.728
% Bare	2.76	0.72	0.00	3.84	0.36	0.63	.136
Litter Depth	1.20	0.13	1.03	2.30	0.09	2.00	.000*
Vor	0.83	0.06	0.77	0.99	0.04	0.88	.368
Lwshrub	0.28	0.04	0.21	0.37	0.01	0.37	.014
Total hits	7.76	0.44	7.22	10.78	0.31	9.06	.001*
**Shrub	0.00	0.00	0.00	0.12	0.05	0.00	.503
**Shrub&Exotic	1.57	0.48	2.00	1.09	0.12	1.00	.259
**Exotic	0.00	0.00	0.00	0.06	0.03	0.00	.575
**Native	3.71	0.81	3.00	0.23	0.23	0.00	.026
**Kentucky & Native	2.43	1.00	2.00	4.66	0.24	5.00	.043

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=7 occupied, n=115 unoccupied)

Table 15. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of clay-colored sparrows on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=244)			Unoccupied (n=97)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	3.56	0.42	0.00	7.33	1.03	2.50	.000*
% Grass	40.72	1.06	37.81	40.59	1.91	37.81	.740
% Forb	15.27	0.51	14.69	12.22	0.77	11.25	.001*
% Bare	3.39	0.35	0.63	4.53	0.77	0.31	.758
Litter Depth	2.32	0.10	1.97	1.76	0.15	1.38	.000*
Vor	1.02	0.04	0.94	0.82	0.06	0.69	.002*
Lwshrub	0.41	0.01	0.39	0.23	0.02	0.16	.000*
Total hits	10.80	0.33	8.91	9.45	0.54	7.25	.003
**Shrub	0.14	0.06	0.00	0.00	0.00	0.00	.168
**Shrub&Exotic	1.29	0.13	1.00	0.40	0.19	0.00	.000*
**Exotic	0.06	0.03	0.00	0.04	0.04	0.00	.963
**Native	1.47	0.22	0.00	3.36	0.65	3.00	.006
**Kentucky & Native	4.67	0.25	5.00	4.00	0.62	0.62	.357

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=97 occupied, n=25 unoccupied)

Table 16. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of savannah sparrows on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=227)			Unoccupied (n=114)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	3.02	0.41	0.00	7.84	0.93	3.75	.000*
% Grass	43.29	1.13	40.94	35.48	1.53	31.88	.000*
% Forb	14.84	0.54	14.38	13.52	0.72	12.97	.166
% Bare	3.59	0.41	0.63	3.96	0.56	0.63	.788
Litter Depth	2.45	0.10	2.19	1.60	0.12	1.25	.000*
Vor	0.98	0.04	0.94	0.94	0.07	7.27	.082
Lwshrub	0.39	0.02	0.39	0.30	0.02	0.27	.001*
Total hits	10.98	0.34	9.50	9.30	0.50	7.59	.000*
**Shrub	0.16	0.07	0.00	0.00	0.00	0.00	.106
**Shrub&Exotic	1.16	0.14	1.00	1.00	0.17	1.00	.940
**Exotic	0.03	0.03	0.00	0.13	0.07	0.00	.080
**Native	1.54	0.25	0.00	2.75	0.45	3.00	.009
**Kentucky & Native	4.80	0.27	5.00	3.78	0.47	3.50	.057

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=90 occupied, n=32 unoccupied)

(P=0.001) and total vegetative "hits" (P<0.001) were greater (P=0.0038) on occupied points versus unoccupied points. Once again, only percent clubmoss cover was greater (P<0.001) on unoccupied points.

Baird's sparrows occupied 103 points and were not present on 238 points (Table 17). Percent clubmoss cover (P<0.001), and native grass plant community (P<0.001) were greater on occupied versus unoccupied points. However, three variables, i.e., percent grass cover (P<0.001), litter depth (P<0.001) and total vegetative "hits" (P<0.001), were greater (P<0.0038) on unoccupied points.

Grasshopper sparrows occupied 233 points and were not present on 107 points (Table 18). Four variables, i.e. percent grass cover (P<0.001), litter depth (P=0.001), visual obstruction readings (P<0.001) and total vegetative hits (P<0.001), were greater (P<0.0038) on occupied versus unoccupied points. Percent clubmoss cover (P<0.001) and native grass plant community (P<0.001) were greater (P<0.0038) on unoccupied points. Percent of bare ground was approaching significance (P=0.004) and was higher on unoccupied points.

Chestnut-collared longspurs occurred on 117 points and were not present on 224 points (Table 19). Percent clubmoss cover (P<0.001), percent of bare ground (P<0.001) and frequency of native grass plant community (P<0.001) were greater (p<0.0038) on occupied versus unoccupied points. Litter depth (P<0.001), visual obstruction reading (P<0.001), low shrub density (P<0.001), total vegetative "hits" (P<0.001), and Kentucky

Table 17. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of Baird's sparrows on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=103)			Unoccupied (n=238)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	9.20	0.93	6.88	2.66	0.41	0.00	.000*
% Grass	35.81	1.61	29.69	42.80	1.11	40.63	.000*
% Forb	13.88	0.77	13.44	14.64	0.52	14.06	.375
% Bare	3.64	0.59	0.00	3.75	0.40	0.63	.194
Litter Depth	1.38	0.10	1.19	2.51	0.10	2.31	.000*
Vor	0.83	0.05	0.68	1.03	0.04	0.94	.007
Lwshrub	0.31	0.02	0.26	0.37	0.12	0.38	.014
Total hits	8.37	0.38	7.25	11.31	0.36	9.69	.000*
**Shrub	0.00	0.00	0.00	0.15	0.07	0.00	.158
**Shrub&Exotic	0.69	0.20	0.00	1.23	0.13	1.00	.221
**Exotic	0.04	0.04	0.00	0.06	0.03	0.00	.927
**Native	3.69	0.56	3.50	1.37	0.22	0.00	.000*
**Kentucky & Native	3.35	0.57	2.00	4.85	0.25	5.00	.015

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)
**using 1997 data only (n=26 occupied, n=96 unoccupied)

Table 18. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of grasshopper sparrows on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=233)			Unoccupied (n=107)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	3.16	0.43	0.00	7.66	0.94	4.69	.000*
% Grass	43.06	1.15	40.94	35.68	1.48	32.19	.000*
% Forb	14.86	0.54	14.06	13.48	0.71	13.13	.223
% Bare	2.82	0.32	0.31	5.71	0.76	2.19	.004
Litter Depth	2.46	0.1	2.19	1.53	0.13	1.00	.000*
Vor	1.05	0.04	0.98	0.80	0.06	5.86	.000*
Lwshrub	0.38	0.02	0.37	0.31	0.02	0.32	.025
Total hits	11.37	0.34	9.75	8.43	0.48	6.63	.000*
**Shrub	0.16	0.08	0.00	0.02	0.02	0.00	.242
**Shrub&Exotic	1.34	0.15	1.00	0.69	0.13	0.00	.017
**Exotic	0.05	0.03	0.00	0.07	0.05	0.00	.784
**Native	1.28	0.23	0.00	2.98	0.44	2.50	.001*
**Kentucky & Native	4.88	0.27	5.00	3.88	0.43	4.00	.053

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=80 occupied, n=42 unoccupied)

Table 19. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of chestnut-collared longspurs on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=117)			Unoccupied (n=224)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	8.80	0.97	5.94	2.46	0.34	0.00	.000*
% Grass	38.36	1.57	34.69	41.90	1.15	40.78	.048
% Forb	13.69	0.72	12.19	14.78	0.54	14.36	.211
% Bare	5.80	0.70	2.19	2.63	0.33	0.31	.000*
Litter Depth	1.27	0.09	1.13	2.64	0.10	2.47	.000*
Vor	0.69	0.04	0.63	1.11	0.04	1.04	.000*
Lwshrub	0.24	0.02	0.17	0.42	0.01	0.42	.000*
Total hits	8.10	0.40	7.13	11.64	0.36	10.13	.000*
**Shrub	0.14	0.07	0.00	0.11	0.07	0.00	.111
**Shrub&Exotic	0.79	0.19	0.00	1.26	0.14	1.00	.044
**Exotic	0.08	0.06	0.00	0.05	0.03	0.00	.595
**Native	3.39	0.47	3.00	1.22	0.22	0.00	.000*
**Kentucky & Native	3.36	0.42	3.00	5.02	0.27	5.50	.002*

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=36 occupied, n=86 unoccupied)

bluegrass and native grass plant community (P=0.002) were greater (p<0.0038) on unoccupied points.

Brown-headed cowbirds occupied 222 points and were not present on 119 points (Table 20). Only 2 variables were significant: percent clubmoss (P<0.001) and native grass community (P<0.000) were greater (P<0.0038) on unoccupied versus occupied points. Kentucky bluegrass and native grass plant community were approaching statistical significance (P<0.004).

Western meadowlarks occupied 171 points and were not present on 170 points (Table 21). Only 2 variables, percent grass cover (P=0.001) and litter depth (P=0.002), were greater (P<0.0038) on occupied versus unoccupied points.

Bobolinks occupied 80 points and were not present in 261 points (Table 22). Percent grass cover (P<0.001), litter depth (P<0.001), visual obstruction reading (P<0.001), low shrub density (P<0.001), and total vegetative "hits" were greater (P<0.0038) on occupied versus unoccupied points. Two variables, percent clubmoss cover (P<0.001), and percent bare ground (P<0.001), were greater (P<0.0038) on unoccupied points.

Logistic regression models

Logistic regression models were used for 10 bird species. Eight vegetation structure variables were used to predict the presence of individual bird species. Clubmoss was found rarely in Chase Lake study areas and was mostly found on the Northern Coteau study areas. Therefore, bird species associated with clubmoss cover can only be

Table 20. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of brown-headed cowbirds on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=222)			Unoccupied (n=119)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	3.44	0.45	0.00	6.87	0.87	2.81	.000*
% Grass	41.87	1.16	39.91	38.47	1.56	35.00	.090
% Forb	14.35	0.54	14.06	14.51	0.73	13.75	.954
% Bare	4.17	0.44	0.94	2.88	0.47	0.00	.022
Litter Depth	2.35	0.10	2.13	1.82	0.13	1.44	.001
Vor	0.95	0.04	0.82	1.00	0.06	0.92	0.32
Lwshrub	0.37	0.02	0.38	0.33	0.02	0.33	.063
Total hits	10.58	0.36	8.94	10.12	0.48	8.63	.327
**Shrub	0.13	0.06	0.00	0.05	0.05	0.00	.902
**Shrub&Exotic	1.12	0.12	1.00	1.11	0.29	1.00	.970
**Exotic	0.07	0.04	0.00	0.00	0.00	0.00	.329
**Native	1.52	0.23	0.00	3.69	0.61	4.00	.000*
**Kentucky & Native	4.85	0.03	5.00	2.84	0.60	2.00	.004

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=103 occupied, n=19 unoccupied)

Table 21. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of western meadowlarks on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=171)			Unoccupied (n=170)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	3.56	0.49	0.00	5.70	0.70	0.00	.047
% Grass	43.88	1.36	42.03	37.51	1.24	35.00	.001*
% Forb	14.71	0.61	14.38	14.11	0.61	13.44	.386
% Bare	3.09	0.40	0.63	4.34	0.53	0.31	.629
Litter Depth	2.36	0.11	2.09	1.98	0.12	1.63	.002*
Vor	1.00	0.05	0.85	0.94	0.05	0.84	.208
Lwshrub	0.38	0.02	0.36	0.33	0.02	0.33	.045
Total hits	10.84	0.40	8.94	10.01	0.42	8.63	.050
**Shrub	0.12	0.08	0.00	0.11	0.07	0.00	0.79
**Shrub&Exotic	1.20	0.17	1.00	1.03	0.15	1.00	.528
**Exotic	0.02	0.02	0.00	0.10	0.05	0.00	.192
**Native	1.71	0.30	0.00	2.00	0.34	0.00	.701
**Kentucky & Native	4.68	0.34	5.00	4.40	0.33	5.00	.500

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=63 occupied, n=59 unoccupied)

Table 22. Vegetation variables mean, median, standard error, and significance determined by the presence or absence of bobolinks on point counts (n=341) over 1995, 1996, and 1997. For 1997 only n=122.

	Occupied (n=80)			Unoccupied (n=261)			
Vegetation variable	Mean	SE	Median	Mean	SE	Median	P-Value
% Club	1.11	0.46	0.00	5.71	0.53	0.63	.000*
% Grass	48.73	1.68	46.88	38.22	1.06	34.69	.000*
% Forb	14.88	0.92	13.75	14.26	0.49	14.06	.564
% Bare	1.03	0.20	0.00	4.54	0.42	1.56	.000*
Litter Depth	3.49	0.17	3.75	1.76	0.08	1.44	.000*
Vor	1.47	0.07	1.38	0.81	0.03	0.68	.000*
Lwshrub	0.44	0.02	0.44	0.33	0.01	0.32	.000*
Total hits	15.29	0.63	14.22	8.93	0.26	7.81	.000*
**Shrub	0.24	0.24	0.00	0.10	0.05	0.00	.942
**Shrub&Exotic	1.06	0.28	1.00	1.12	0.13	1.00	.997
**Exotic	0.19	0.12	0.00	0.05	0.03	0.00	.667
**Native	0.18	0.09	0.00	2.13	0.25	0.00	.005*
**Kentucky & Native	5.82	0.42	6.00	4.32	0.26	5.00	.036

*significant at the 0.05 alpha level determined using Bonferonni correction (0.05/13(variables) = 0.0038)

**using 1997 data only (n=17 occupied, n=105 unoccupied)

accurately predicted for the Northern Coteau study area. All variables were eliminated using a forward-elimination routine and were removed from the model at greater than 0.05 significance alpha level. A significant model was detected for 9 of the 10 species (Table 23).

Bobolinks were correctly classified 85.8% of time using 3 variables: bare ground, litter depth and vegetation density or total number of vegetative "hits." Presence of bobolinks increased with decreasing bare ground and increasing litter depth and vegetation density (Table 23). Other bird species which were predicted by 3 variables included the Baird's sparrow, brown-headed cowbird, and grasshopper sparrow. Baird's sparrows were correctly classified 78.2% of the time using clubmoss cover, bare ground and litter depth. Baird's sparrows presence increased with clubmoss and decreased bare ground and litter (Table 23). Brown-headed cowbirds were correctly classified 67.4% of the time using clubmoss cover, litter, and visual obstruction readings. Brown-headed cowbirds presence increased with a decrease in clubmoss, and visual obstruction readings and an increase in litter (Table 23). Grasshopper sparrows were correctly classified 70.2% of the time using clubmoss, bare ground, and litter. Presence of grasshopper sparrows increased with decreasing clubmoss and bare ground, and increasing the accumulation of litter (Table 23).

Chestnut-collared longspurs were correctly classified 82.4% of the time using 4 variables: grass cover, bare ground, litter depth, and low shrubs density. Chestnut-collared longspurs presence increased with increasing grass cover and bare ground and

Table 23. Logistic regression models which best predict the occurrence of grassland passerines. Variables used were selected from 8 vegetation variables using a forward-elemination routine.

Bird Species	Logit[a]	osl[b]	Somers'D	%Correct Classified
Bobolink	-3.53 - 0.18(BARE)[c] + 0.31(LITTER) + 0.16(DENSITY)	.033	.718	85.8%
Chestnut-collared Longspur	+0.52 + 0.028(GRASS) + 0.06(BARE) - 0.88(LITTER) - 2.79(SHRUB)	.011	.650	82.4%
Baird's Sparrow	-0.07 + 0.07(CLUB) - 0.05(BARE) - 0.49(LITTER)	.030	.568	78.2%
Brown-headed Cowbird	+1.03 - 0.05(CLUB) + 0.33(LITTER) - 0.87(VOR)	.003	.352	67.4%
Grasshopper Sparrow	+0.52 - 0.04(CLUB) - 0.05(BARE) + 0.32(LITTER)	.042	.408	70.2%
Savannah Sparrow	+0.35 -0.06(CLUB) + 0.02(GRASS) + 0.42(LITTER) - 0.96(VOR)	.034	.469	73.3%
Clay-colored Sparrow	-0.31 + 3.93(SHRUB)	.020	.469	73.3%
Sprague's Pipit	-0.39 - 0.07(BARE) - 0.83(LITTER)	.026	.509	75.1%
Eastern Kingbird	-1.78 + 0.31(LITTER)	.001	.363	67.6%

[a] Logit of the equation estimating probability of occurrence of a bird species where the equation is $e^{logit}/1+e^{logit}$ and $logit=b_0+b_1(x_1)...+b_p(x_p)$.

[b] observed significance level (osl) for the overall model.

[c] BARE = bare ground cover, LITTER = litter depth (cm), DENSITY = total number of vegetative "hits", SHRUB = low shrub cover, CLUB = % clubmoss cover, VOR = visual obstruction reading, GRASS = grass cover.

decreases in litter depth and low shrub density (Table 23). Savannah sparrows were also predicted by 4 variables. Clubmoss cover, grass cover, litter depth and visual obstruction were used to correctly classify savannah sparrows 73.3% of the time. Savannah sparrow presence increased with a decrease in clubmoss and visual obstruction and increasing grass cover and litter depth (Table 23).

Sprague's pipits were correctly classified 75.1% of the time using 2 variables, bare ground and litter depth. Presence of Sprague's pipits increased with decreases in bare ground and litter depth (Table 23). The remaining 2 grassland passerines required only 1 variable to predict their presence. Clay-colored sparrows were correctly classified 73.3% of the time using low shrub density. Increases in low shrub resulted in increasing the presence of clay-colored sparrows (Table 23). Eastern kingbirds were correctly classified 67.6% of the time using the variable litter depth. Increases in litter depth resulted in increasing the presence of eastern kingbirds (Table 23).

DISCUSSION

Vegetation differences among grazing regimes

Vegetation structure varied between 1996 and 1997. Precipitation and temperature can affect the growth of grasses and vegetation structure (Dormaar et al. 1997). In 1997, the late spring delayed vegetation growth and the lack of rainfall in May and June (most of it not occurring until 21 June, Tables 1 and 2) resulted in vegetative differences between the 2 years. In 1996 and 1997, vegetation density and litter depth were higher on rotational grazing systems but in 1997 only litter depth was found to be statistically significant. The season-long pasture had greater mean values for bare ground, clubmoss (on NC project areas only), forb cover, and low shrub density in both 1996 and 1997. However, only forb cover and low shrub density in 1996 were found to be significantly higher on season long pastures. This agrees with the findings of Sedivec et al. (1990) who found increases in vegetation cover as well as increases in litter depth on rotational grazing systems versus season-long grazed pastures. The higher amounts of bare ground, clubmoss and shrubs can be a result of a higher grazing intensity in certain areas on season-long grazed pastures (Ellison 1960, Ryder 1980, Bailey and Rittenhouse 1989). Season-long grazed pastures may contain areas where cattle spend more time grazing resulting in sparser vegetation and increases in bare ground (Burleson and Leininger 1988). This may be why there is an increase in habitat characteristics such as bare ground, percent clubmoss cover and shrub density on season-long pastures rather than on rotational pastures on which the cattle are moved from cell to cell and are less likely to remain in one area.

Bird-habitat relationships

Eastern kingbird

Eastern kingbirds nest in low shrubs or trees (Mackenzie and Sealy 1981). Renken (1983) indicated a positive relationship between eastern kingbirds and shrub densities. However, no correlation occurred between eastern kingbirds and low shrub density. Eastern kingbirds showed the highest correlations with grass cover, vegetation density and litter depth, all of which were significantly higher on occupied versus unoccupied points. Using the logistic regression model, litter depth was the strongest vegetation variable predicting the presence of eastern kingbirds in grazed sites.

Sprague's pipit

Sprague's pipits were found to be less abundant on areas of introduced grasses compared to native grasslands (Kantrud 1981, Wilson and Belcher 1989, Johnson and Schwartz 1993). Sprague's pipits also have a negative relationship with litter depth and vegetation height (Madden 1996, Dale 1997). My results generally supported the findings of these earlier studies. Sprague's pipits had negative correlations with litter depth, vegetation density and grass cover, and a positive correlation with native grasses. In predicting Sprague's pipit occurrence, decreasing bare ground and litter depth were important in predicting the presence of this grassland bird.

Clay-colored sparrow

Presence of clay-colored sparrows has been documented as being positively correlated with shrubby habitat (Owens and Myer 1973, Kantrud 1981, Renken 1983, and Madden 1996). Clay-colored sparrows also have been found to be positively associated with litter depth (Renken 1983, Messmer 1990). My results support these earlier studies. Clay-colored sparrows were found to have positive correlations with low shrub density, vegetation density, forb cover, and litter depth and were significantly higher on occupied sites with these variables present. However, shrub density was the strongest predictor of clay-colored sparrows occurrence.

Savannah sparrow

Savannah sparrows tend to occur more frequently on grassland areas with litter accumulations (Tester and Marshall 1961, Owens and Myer 1973, Renken 1983) and exotic grasses (Renken 1983, Madden 1996, Dale 1997). In this study, savannah sparrows were positively associated with grass cover, litter depth, and vegetation structure. Savannah sparrows also showed a negative association with clubmoss. These variables were also important in predicting the presence of savannah sparrows. However, decreasing visual obstruction was found to increase the presence of savannah sparrows in the logistic regression model. This could be because unoccupied areas had not only some of the lowest visual obstruction readings but also some of the highest. Although visual obstruction was found to be a positive correlation with savannah sparrows, areas with high visual obstruction readings appear to decrease the presence of this grassland bird.

Baird's Sparrow

Baird's sparrows are found to be associated with native prairie (Wilson and Belcher 1989, Dale 1997). Madden (1996) found increases in grass cover, and forb cover; and decreases in low shrub and visual obstruction best predicted the presence of Baird's sparrow on Lostwood National Wildlife Refuge. Renken (1983) also found similar results among Baird's sparrows in central North Dakota but also included high amounts of litter accumulations as important. My results did not corroborate what other researchers have found. Baird's sparrows occupied areas with dominant native grass plant communities and decreased grass cover, litter depth, and vegetation density. The strongest predictors of Bairds sparrows were decreasing litter depth, and bare ground. Baird's sparrows were found in greater numbers in the NC project study area than in CL project study area. The CL project area generally has more vegetative cover than does the NC project area. This may be why some vegetation variables had higher means on areas where Baird's sparrows were not present. However, Baird's sparrows were also found on those sites with the least amount of vegetation in the NC project area.

Grasshopper sparrows

Rotenberry and Wiens (1980) found grasshopper sparrows were negatively associated with bare ground. These results differ from previous studies which indicated grasshopper sparrows used areas with decreases in vegetation density (Renken 1983) and decreases in litter depth (Wiens 1969, Madden 1996). In my study, grasshopper sparrows were found on point count plots with higher grass cover, litter depth, visual obstruction, and vegetation density. Grasshopper sparrows were not found on areas with high amounts of club moss, or bare ground. The best predictors of grasshopper presence were increased litter depth and decreased amounts of bare ground and clubmoss. However, my study was conducted on grazed areas which may explain the difference in results with previous studies. Mean litter depth for occupied grasshopper sparrow points was 2.5 cm in my study, compared to 3.8 in a study by Madden (1996), and 2.8 in a study by Renken (1983). One of the reasons for conflicting results may be because maximum litter depth, along with grass cover and vertical density were not reached on grazed pastures.

Chestnut-collared longspur

Chestnut-collared longspurs have been associated with moderately to heavily grazed habitats in previous studies (Owens and Myers 1973, Kantrud 1981, Renken 1983). Chestnut-collared longspurs have been associated with sparse cover, low litter accumulations, and bare ground (Renken 1983). My results agree with earlier findings. Chestnut-collared longspurs occupied sites with higher amounts of bare ground, decreased litter depth, visual obstruction, shrub density and vegetation density. The best predictors of chestnut-collared longspurs were an increase in bare ground and a decrease in shrub and litter depth.

Brown-headed cowbird

Brown-headed cowbirds are associated with a wide variety of habitats (Rothenstein et al. 1986), which includes grazed sites (Saab et al. 1995). Brown-headed cowbirds are parasitic nesters and breed in areas where hosts are prevalent (Rothenstein et al. 1986). Even though it was difficult for me to determine breeders from users, the number of birds detected in relation to habitat associations may provide some insight for brown-headed cowbird abundance on grazed areas. I found brown-headed cowbirds were associated with increases in litter depth and decreases in visual obstruction and clubmoss. Decreased amounts of visual obstruction may assist brown-headed cowbirds in locating potential nests. An increase in litter layer is positively associated with all grassland passerines (Table 11) and may provide suitable nesting habitat. This may attract brown-headed cowbirds, since this is where most grassland birds nest.

Western meadowlark

Western meadowlarks are habitat generalists and occupy a wide range of habitats (Rotenberry and Wiens 1980, Renken 1983). This results in a lack of association with vegetation variables. Madden (1996) found western meadowlarks were positively associated with high forb and grass cover and negatively associated with shrub cover and visual obstruction. Western meadowlarks have also been associated with moderate litter depth, and grass cover (Wiens 1969). My results indicated an increase in grass cover and litter depth on point count plots occupied by western meadowlarks. However, no model predicted the presence of western meadowlarks due to the lack of strong associations with vegetation variables.

Bobolink

Bobolinks in central North Dakota have been associated with high forb and grass cover, and tall, dense vegetation (Renken 1983, Madden 1996). I found the best predictors of bobolink occurrence were an increase in litter, vegetation density and a decrease in bare ground. Bobolinks were also positively associated with grass cover, visual obstruction and shrub density.

Total passerines

All grassland passerines detected on point counts were positively associated with grass cover, litter depth and shrub density and were negatively associated with clubmoss cover. Vegetational characteristics tend to be very important to most grassland passerines on grazed regimes and may determine the occurrence of many species.

CHAPTER 4. **EFFECTS OF GRAZING REGIMES ON GRASSLAND PASSERINE PRODUCTIVITY**

INTRODUCTION

Relative abundance or population densities of grassland birds is frequently used as an indicator of habitat quality with larger numbers indicating suitable habitat (Van Horne 1983). It is also believed, that an increase in bird populations will lead to an increase in reproductive success, however, this can be misleading (Vickery et al. 1992b).

Trampling of nests by cattle is common in grazed areas and can have significant impacts on the success of grassland birds (Paine et al. 1996). Predators such as red fox (*Vulpes vulpes*) and other canids have increased throughout the Great Plains due to changes in agricultural practices (Johnson and Sargeant 1977). Therefore, it is beneficial to not only determine habitat quality but also to determine grassland passerine reproductive success, because a large number of territorial bird species does not always indicate quality nesting habitat and high reproductive success (Van Horne 1983).

METHODS

Passerine reproductive success was determined using an index based on behavioral cues. This is a relatively new method developed by Vickery et al. (1992a) and modified by Dale (1994). This method was implemented instead of the traditional nest search method due to time and personnel constraints, as well as the difficulty of locating passerine nests (Dale 1994). Reproductive index or productivity counts were conducted after the completion of point count surveys (June 15-30th) through the first week of

August for all 3 years (1995-1997) of the study. Productivity counts were conducted during 0700 through 1200 hrs, which is when the birds are actively feeding (Dale 1994). These time periods were used when the mean ambient temperature was ≤ 29° C due to the decrease in feeding activity attributed to temperatures ≥ 29° C (Dale 1994). Productivity counts were not conducted on days of rain, fog, or excessive winds ≥ 20 km/hr (Dale 1997).

Productivity counts were conducted on the same point count plots used for breeding bird surveys. However, due to time constraints only 6 randomly selected points were used for productivity counts for each site out of the 10-12 used for breeding bird surveys. A total of 60 points per year were selected for productivity counts in both 1996 and 1997. Each productivity plot was surveyed 3 times at 10 day intervals, starting approximately 10 days after the breeding bird surveys were conducted. Ten days is the average incubation period of most grassland passerines (Dale 1994).

An observer walked slowly through the 100 m radius plot for 30 min and recorded behavior of all birds detected (Dale et al. 1997). Observers were attentive to where the behavior of the bird was directed as some birds searched for food outside of their territories. Detection of birds is variable and dependent on individual observers. Therefore, the same observer conducted both the point counts and productivity counts on each study site. Since point counts and productivity counts are indices, it is critical that the same observer be used for the duration of the field season (Kepler and Scott 1981, Dale 1994).

Bird behavior from both the point counts and the productivity counts were used to rank reproductive success. A rank of 0.5 was assigned if a territorial male on 1 point count and a rank of 1 was assigned for a singing male being present on both point counts. Ranks 2, 3, 4, and 5 are based on behavioral cues during productivity counts. A rank of 2 indicates presence of a territorial pair, rank of 3 was given to a pair observed building a nest, incubating eggs, or giving a distraction display, and a rank of 4 was given for adults observed carrying food. The maximum score a pair can receive was 5 indicating a successful nest with fledglings observed.

Statistical analysis

Only 1996 and 1997 data were used for productivity estimate analyses. Productivity data were analyzed separately for each year due to significant differences in bird abundance between years (Chapter 2). Territories were defined for each point count and the maximum rank over all counts was used for each individual species. Only species which were found at greater than 15% of all point counts were used for analysis. Brown-headed cowbirds were not used because they are obligate parasitic nesters and nesting behavior was hard to detect and assess.

Ranks were divided into 3 groups: low success, intermediate success, and high success (Vickery et al. 1992a). Ranks 0.5 to 1 were considered low success, 2-3 intermediate success and 4-5 high success. Each individual bird territory present was given a 1 for the group which matched its rank and a 0 for the other 2 groups. For example a grasshopper sparrow territory which has a maximum ranking of 4 was entered as 1 for the high success group and received a 0 for intermediate and low success groups. The Wilcoxon 2-sample statistical test was used to indicate statistical differences of reproductive success among individual grassland passerines between grazing regimes (rotational grazing systems versus season-long grazed pastures).

RESULTS

There were no differences in passerine productivity ($P<0.05$) between grazing regimes for any of the individual grassland species analyzed in any of the 3 groups: low, intermediate, or high success for either 1996 or 1997 (Tables 24-29). All grassland passerines were represented in the low success group for both grazing regimes. Baird's sparrows and Sprague's pipit were not well documented in the intermediate success group and were not found either year in the high productivity success group. Seven of the 9 species had at least one individual territory in the high reproductive rank for both years including the western meadowlark, clay-colored sparrow, grasshopper sparrow, savannah sparrow, chestnut-collared longspur, bobolink and eastern kingbird.

DISCUSSION

Passerine productivity was virtually the same between rotational grazing systems and season-long grazed pastures. This is important because confining cattle to a smaller area has been cited to increase cattle trampling of simulated nests in grasslands (Paine et al.1996). I submit that prescribed rotational grazed systems on the Missouri Coteau did not lower passerine reproductive success when compared to season-long grazed pastures, even though cattle were confined in smaller areas. This could be because rotations

Table 25. Mean, median and standard errors for number of territories in high reproductive success group on rotational and season-long grazing regimes for 1996. P-values were based on the Wilcoxon significance test.

	Rotational n=5			Season-long n=5			
Grassland Species	Mean	SE	Median	Mean	SE	Median	P-Value
Western Meadowlark	1.80	1.48	2.00	1.20	0.84	1.00	0.584
Clay-colored sparrow	3.60	4.00	1.52	5.20	3.83	6.00	0.401
Grasshopper sparrow	0.80	0.84	1.00	0.20	0.45	0.00	0.232
Savannah sparrow	1.80	1.30	2.00	1.60	1.14	2.00	0.829
Bobolink	1.00	1.00	1.00	0.20	0.45	0.00	0.192
Eastern kingbird	0.40	0.55	0.00	1.60	1.82	1.00	0.366
Chestnut-collared longspur	0.60	0.00	0.89	0.00	0.00	0.00	0.180
Baird's sparrow	0.00	0.00	0.00	0.40	0.89	0.00	0.424
Sprague's pipit	0.00	0.00	0.00	0.00	0.00	0.00	

Table 26. Mean, median and standard errors for number of territories in intermediate reproductive success group on rotational and season-long grazing regimes for 1996. P-values were based on the Wilcoxon significance test.

	Rotational n=5			Season-long n=5			
Grassland Species	Mean	SE	Median	Mean	SE	Median	P-Value
Western Meadowlark	0.60	0.55	1.00	0.40	0.55	0.00	0.631
Clay-colored sparrow	1.60	1.32	1.00	2.60	1.34	2.00	0.286
Grasshopper sparrow	1.40	1.67	1.00	2.60	1.14	3.00	0.243
Savannah sparrow	3.60	2.15	3.00	5.60	3.44	7.00	0.456
Bobolink	1.20	1.79	0.00	0.40	0.55	0.00	0.723
Eastern kingbird	0.80	0.84	1.00	1.00	0.70	1.00	0.734
Chestnut-collared longspur	1.40	1.95	0.00	0.80	1.30	0.00	0.813
Baird's sparrow	0.00	0.00	0.00	0.20	0.45	0.00	0.424
Sprague's pipit	0.00	0.00	0.00	0.00	0.00	0.00	-------

Table 27. Mean, median and standard errors for number of territories in low reproductive success group on rotational and season-long grazing regimes for 1996. P-values were based on the Wilcoxon significance test.

	Rotational n=5			Season-long n=5			
Grassland Species	Mean	SE	Median	Mean	SE	Median	P-Value
Western Meadowlark	4.00	1.58	4.00	3.20	2.17	3.00	0.670
Clay-colored sparrow	4.80	1.79	5.00	3.40	1.67	3.00	0.242
Grasshopper sparrow	7.00	4.30	9.00	6.60	2.41	6.00	1.000
Savannah sparrow	5.80	2.05	6.00	5.40	1.52	5.00	0.830
Bobolink	1.80	1.30	2.00	2.00	1.58	2.00	0.915
Eastern kingbird	1.20	1.30	1.00	1.40	1.14	1.00	0.829
Chestnut-collared longspur	2.60	2.00	2.79	1.40	1.67	1.00	0.588
Baird's sparrow	3.80	5.76	0.00	3.40	4.78	0.00	0.906
Sprague's pipit	2.60	3.72	0.00	2.40	3.29	0.00	0.906

Table 28. Mean, median and standard errors for number of territories in high reproductive success group on rotational and season-long grazing regimes for 1997. P-values were based on the Wilcoxon significance test.

	Rotational n=5			Season-long n=5			
Grassland Species	Mean	SE	Median	Mean	SE	Median	P-Value
Western Meadowlark	4.00	0.55	0.00	0.80	1.30	0.00	0.905
Clay-colored sparrow	2.60	1.82	3.00	2.00	1.58	2.00	0.670
Grasshopper sparrow	0.40	0.55	0.00	0.20	0.45	0.00	0.601
Savannah sparrow	1.60	2.07	1.00	0.80	0.84	1.00	0.742
Bobolink	0.40	0.89	0.00	0.00	0.00	0.00	0.424
Eastern kingbird	1.00	1.00	1.00	0.00	0.00	0.00	0.071
Chestnut-collared longspur	1.00	1.73	1.00	2.80	5.22	0.00	0.906
Baird's sparrow	0.00	0.00	0.00	0.00	0.00	0.00	-------
Sprague's pipit	0.00	0.00	0.00	0.00	0.00	0.00	-------

Table 29. Mean, median and standard errors for number of territories in intermediate reproductive success group on rotational and season-long grazing regimes for 1997. P-values were based on the Wilcoxon significance test.

	Rotational n=5			Season-long n=5			
Grassland Species	Mean	SE	Median	Mean	SE	Median	P-Value
Western Meadowlark	0.40	0.55	0.00	0.20	0.45	0.00	0.601
Clay-colored sparrow	2.60	1.95	2.00	3.60	4.04	2.00	1.000
Grasshopper sparrow	1.60	1.52	1.00	0.80	0.84	1.00	0.443
Savannah sparrow	3.60	3.05	4.00	2.40	0.89	3.00	0.596
Bobolink	0.40	0.89	0.00	0.40	0.55	0.00	0.796
Eastern kingbird	1.00	0.71	1.00	1.20	0.84	1.00	0.734
Chestnut-collared longspur	1.20	2.17	0.00	1.40	2.19	0.00	1.000
Baird's sparrow	0.00	0.00	0.00	0.00	0.00	0.00	-------
Sprague's pipit	0.20	0.45	0.00	0.20	0.45	0.00	0.881

Table 30. Mean, median and standard errors for number of territories in low reproductive success group on rotational and season-long grazing regimes for 1997. P-values were based on the Wilcoxon significance test.

	Rotational n=5			Season-long n=5			
Grassland Species	Mean	SE	Median	Mean	Median	Stand. Error	P-Value
Western Meadowlark	3.00	1.00	3.00	2.60	1.14	3.00	0.664
Clay-colored sparrow	6.60	4.39	7.00	2.40	1.52	3.00	0.168
Grasshopper sparrow	8.20	4.60	8.00	5.00	3.32	4.00	0.340
Savannah sparrow	3.60	1.52	3.00	3.80	1.48	4.00	0.829
Bobolink	1.80	1.79	2.00	0.80	1.30	0.00	0.434
Eastern kingbird	0.80	0.45	1.00	0.20	0.45	0.00	0.093
Chestnut-collared longspur	1.40	2.61	0.00	2.00	1.73	1.00	0.230
Baird's sparrow	1.60	1.82	1.00	2.00	2.55	1.00	1.000
Sprague's pipit	1.20	1.79	0.00	0.40	0.89	0.00	0.439

between pastures or cells were at approximately 20-30 day intervals which would leave enough time for grassland birds to reproduce before or after cattle disturbance.

On the other hand, reproductive success was not significantly higher on rotational grazing systems for any of the grassland passerines in this study. However, grasshopper sparrows, and western meadowlarks had slightly more territories in all 3 reproductive groups on rotational grazing systems in 1996 and 1997. Bobolinks also had more territories in the high reproductive success group on rotational grazing systems in 1996 and 1997. Eastern kingbirds were approaching significance (P=0.07) and had more territories in the high reproductive group for rotational than the season-long grazing regimes in 1997.

Assessment of reproductive success based on behavioral cues may be biased. This technique can be more accurate in locating breeding activity than nest searching since it is difficult to find all the nests (Delisle and Savidge 1996). However, when conducting these counts, I found birds were easier to detect on shorter, sparser grasslands. This may be because the birds are more noticeable in shorter grass, but there may be a possibility that species can also detect predators such as an observer more quickly in shorter grass and respond accordingly. Nests and fledglings are also easier to detect in shorter grass and may flush more quickly than in dense vegetative cover. Birds may also use defense calls and distraction displays to distract predators rather than hide in denser vegetation. If all bird behavior was detected and all nest and fledglings located, then this would not be a factor. However, if all detections are not made it may be easier to detect more birds in shorter vegetation than dense vegetation resulting in bias (underestimation in dense vegetation). Hartley (1994) also indicates that grasslands bird behavior may be easier to detect in short- to mid- height native grassland than in tall vegetative cover such as DNC (dense nesting cover).

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

Although many authors believe several grassland species have negative responses to grazing, I found high relative abundance and reproductive success for most bird species using twice-over deferred rotational and season-long grazing regimes. However, 6 out of 10 grassland species had higher relative abundance on rotational grazing systems in both years. Overall relative abundance and species richness was also higher on rotational grazing systems in both years. However, 1997 showed the strongest associations with bird presence on rotational grazing systems. This makes sense when considering the strong relationships birds have with vegetation and precipitation (Zimmerman 1992). The combination of a late spring with low precipitation in 1997 may have caused the trends to be more noticeable during this year.

Habitat changes were also evident between the years, and individual species seemed to be affected by these habitat changes. Forb cover and shrub density were higher on season-long grazing regimes in 1996. Only 1 grassland species, the clay-colored sparrow was positively associated with both of these vegetation variables. Clay-colored sparrows had a slightly higher relative abundance on season-long grazed pastures in 1996. Clay-colored sparrows also had strong associations with litter depth and vegetation density which were both found to be higher on rotational grazing systems both years but only litter depth was significantly different in 1997. This may have been why clay-colored sparrows had a slightly higher mean relative abundance on rotational grazing systems than season-long grazed pastures in 1997.

Five of the 6 grassland bird species (eastern kingbird, grasshopper sparrow, savannah sparrow, western meadowlark, and bobolink) had higher relative abundance means both years, all had positive associations with litter depth and vegetation density. Litter depth seemed to be a significant key to the presence of many grassland nongame birds. Litter depth was a predictive indicator in 8 of the 9 individual passerine models used to predict the presence of each grassland bird species. Eastern kingbird, bobolink, grasshopper sparrow, and savannah sparrow all indicate increasing litter depth increases prediction of these birds occurrence. Presence of chestnut-collared longspurs, Baird's sparrows, and Sprague's pipit was predicted with a decrease in litter depth. In all but 2 instances (Sprague's pipit and brown-headed cowbird) relative abundance trends matched with litter depth trends. Since average litter depth was higher on rotational grazing systems in both years, the average relative abundance of eastern kingbirds, bobolinks, grasshopper sparrows and savannah sparrows were also higher. Since average litter depth was lower on season-long grazed pastures, Baird's sparrows and chestnut-collared longspurs showed higher relative abundances on season-long grazed pastures. Sprague's pipits occurrence decreased when high amounts of bare ground were present. Rotational grazing systems had lower amounts of bare ground than season-long pastures in both 1996 and 1997. This could be the reason why Sprague's pipits mean relative abundance was higher on rotational grazing systems.

Although, I did not find significant differences in relative abundance for any individual grassland bird species between grazing regimes, I did find that litter depth was significantly different in 1997. This is important because of the close relationship which appears to exist between litter depth and many grassland passerines. When all grassland passerines detected were pooled together a positive association was found with litter depth. This could explain why overall grassland passerine relative abundance and species richness were significantly higher on rotational grazing systems in 1997. This may also be the reason why the negative grazing guild (bobolink, grasshopper sparrow, savannah sparrow, Baird's sparrow and western meadowlark) were significantly higher on rotational grazing systems in 1997 than on season-long grazed pastures.

Baird's sparrows did not appear to be grazing sensitive. In fact they preferred sites with less vegetative cover. Other studies have indicated positive associations with Baird's sparrows and litter depth, however, this study found the exact opposite. Almost everything previous studies have indicated about the Baird's sparrow was contrary to my findings. Although no explanation can be offered for this occurrence, it should be noted that Baird's sparrows were found on all grazing regimes, but high productivity was not recorded. This does not mean that reproductive success was not occurring on these sites, it simply indicates that it was not detected. This could be due to lack of observer skills, the fact that only half of the points were used in reproductive counts, or that high reproductive success among Baird's sparrows was limited on these areas.

Rotational grazing systems have a high amount of variation associated with them. The way in which rotational grazing systems are designed make it extremely difficult to keep variation low in habitat factors. Since cattle are rotated throughout the cells at different times of the year, several different types of vegetative structure exist. This may attract several different types of grassland birds which require different vegetative structure. However, the variation remains so high it is difficult to measure statistically significant differences because the variations results in a high standard error. The lack of uniform structure of these systems, may allow many grassland birds the opportunity to breed in suitable habitat lacking in overgrazed pastures, but also makes them difficult to test.

Although, I found some relationships of grassland passerines with grazing regimes, I did not find a statistical difference for any passerine species. However, with an increase in sample size (more replicates), and less variation, some differences may have been found. What can be said about grassland passerines is that they do not appear to be harmed by converting season-long grazed pastures into deferred twice-over rotational grazing systems. Reproductive success of grassland passerines was shown to be equivalent on both grazing regimes and if negative effects occurred from nest trampling on rotational grazing systems, it may have been counteracted by cells left idle during parts of the breeding season. Rotational grazing systems may also be an alternative to leaving pasture idle in the effort to increase grassland passerines sensitive to grazing. For species which preferred season-long grazing systems, there will always be an abundance of overgrazed pastures or moderately grazed pastures available.

In conclusion, I recommend that prescribed deferred twice-over rotational grazing systems continue to be placed in native prairie on private land along the Missouri Coteau in North Dakota. Prescribed rotational grazing systems implemented in the Chase Lake and Northern Coteau PPJV project areas benefited landowner livestock operations without negatively impacting grassland passerines.

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Appendix A. Common and scientific names of passerines and upland shorebird species observed on 100 m radius point counts and productivity counts within CLPP and NCP study sites.

Common Name & Scientific Name	Common Name & Scientific Name
American goldfinch *Carduelis tristis*	LeConte's sparrow *Ammodramus leconteii*
American robin *Turdus migratorious*	Marbled Godwit *Limosa fedoa*
Baird's sparrow *Ammodramus bairdii*	Marsh wren *Cistohorus palustris*
Barn swallow *Hirundo rustica*	Mountain bluebird *Sialia currucoides*
Black-billed cuckoo *Coccyzus erythropthalmus*	Nothern Flicker *Colaptes auratus*
Balck-billed magpie *Pica pica*	Red-winged blackbird *Agelaius phoeiceus*
Bobolink *Dolichonyx oryzivorus*	Savannah sparrow *Passerculus sandwichensis*
Brewers blackbird *Euphagus cyanocephalus*	Sedge Wren *Cistothorus platensis*
Brown thrasher *Toxostoma rufum*	Song sparrow *Melospiza melodia*
Brown-headed cowbird *Molothrus ater*	Sprague's pipit *Anthus spragueii*
Chestnut-collared longspur *Calcarius ornatus*	Sharp-tailed sparrow *Ammodramus caudacutus*
Clay-colored sparrow *Spizella pallida*	Upland sandpiper *Bartramia longicauda*
Common grackle *Quiscalus quiscula*	Vesper sparrow *Pooecetes gramineus*
Common yellowthroat *Geothlypis trichas*	Western kingbird *Tyrannus verticalis*
Eastern kingbird *Tyrannus tyrannus*	Western meadowlark *Sturnella neglecta*
Grasshopper sparrow *Ammodramus savannarum*	Willet *Catoptrophorus semipalmatus*
Gray catbird *Dumetella carolinensis*	Willow flycatcher *Empidonax trailii*
Henslow sparrow *Ammodramus henslowii*	Yellow warbler *Dendroica petechia*
Horned Lark *Eremophilia alpestris*	Yellow-headed blackbird *Xanthocephalous xanthocephalous*
Killdeer *Charadrius vociferus*	

Appendix B. Plant community list used during 1997 vegetation sampling.

CODE	PLANT COMMUNITY
1) SYOC	snowberry (*Symphoricarpus occidentalis*)
2) SYOC/ELCO	snowberry and silverberry (*Elaegnus commutata*)
3) SYOC/POPR	snowberry and Kentucky bluegrass (*Poa pratensis*)
4) SYOC/BRIN	snowberry and smooth brome (*Bromus inermis*)
5) SYOC/AGRE	snowberry and quack grass (*Agropyron repens*)
6) SYOC/NTVS	snowberry and native grasses
7) ELCO/POPR	silverberry and Kentucky bluegrass
8) ELCO/NTVS	silverberry and native grasses
9) POTR/SALX	aspen (*Populus tremuloides*) and/or willow (*Salix* spp.)
10) AM/PR/CR	Tall shrub thickets - juneberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*) and/or hawthorne (*Crataegus chysocarpa*)
11) POPR	Kentucky bluegrass
12) POPR/NTVS	Kentucky bluegrass and native grasses
13) AGRE	quack grass
14) BRIN	smooth brome
15) BRIN/NTVS	smooth brome and native grasses
16) ST/BO/CA	needle-and-thread grass (*Stipa comata*), blue grama (*Bouteloua gracilis*) and thread-leafed sedge (*Carex filafolia*)
17) ST/CA/MU	needle-and-thread grass, thread-leaf sedge, and prairie muhly (*Muhlenbergia cuspidata*)
18) ST/KO/AG	needle-and-thread grass, prairie Junegrass (*Koeleria pyramidata*), and wheatgrass (native *Agropyron* spp.)
19) ST/SC/MU	porcupine grass (*Stipa spartea*), little bluestem (*Schizachyrium scoparius*), and mat muhly (*Muhlenbergia richardsonii*)

Plant community table continued.

CODE	PLANT COMMUNITY
20) ANGE	big bluestem (*Andropogon gerardi*)
21) FESC	rough fescue (*Festuca scabrella*)
22) LPZ	low prairie zone
23) LPZ/EXTC	wet meadow zone with exotic grasses
24) WMZ	wet meadow zone
25) WMZ/EXTC	wet meadow zone with exotic grasses
26) CMZ	central marsh zone
27) CMZ/EXTC	central marsh zone with exotic grasses