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HABITAT SELECTION AND DETECTABILITY OF BAIRD'S SPARROWS IN SOUTHWESTERN ALBERTA

BY

C. LISA MAHON ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science.

DEPARTMENT OF BIOLOGICAL SCIENCES

Edmonton, Alberta
SPRING 1995

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UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled HABITAT SELECTION AND DETECTABILITY OF BAIRD'S SPARROWS IN SOUTHWESTERN ALBERTA submitted by C. LISA MAHON in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE.

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Dr. J.F. Addicott

DATE: 30 Nov. 1994

DEDICATION

I dedicate this thesis to my parents, Harry and Marlene Schmidt. Although reluctant to accept this undertaking at its inception, I think my Father is secretly proud. My Mother is a source of inspiration and a closet birder who seems to have a special place in her heart for sparrows. I thank my parents for their support and understanding of my academic endeavours.

ABSTRACT

Breeding season habitat selection and detectability of the Baird's Sparrow (*Ammodramus bairdii*) were examined in southwestern Alberta rangeland. Territories were mapped on two grass communities (native and non-native) on the Milk River Ridge during 1991 and 1992. Vegetation structure was compared for areas occupied and unoccupied by Baird's Sparrows in each grass community twice during the breeding season. Males established territories in areas with high densities of low and middle canopy grasses and high forb coverage at both native and non-native sites in June and July. I suggest that standing grass provided cover for adults and nests, while tall forbs provided perches for singing males. Structural features, as opposed to species composition, determined whether habitat is suitable for Baird's Sparrows. Range managers can maintain Baird's Sparrow habitat at recommended cattle stocking rates in southwestern Alberta provided specific habitat requirements are met.

Singing activity of territorial males was monitored throughout the breeding season. Song output of male Baird's Sparrows can peak in late May followed by a decline in June, or can remain at high levels throughout the breeding season. This pattern is likely linked to pairing status. Singing intensity was highest during early morning hours and was enhanced by the presence of other singing male Baird's Sparrows and inhibited by heavy rainfall. Surveys of singing males conducted in early and mid-June underestimated population size by 67-75%. Census procedures involving Baird's Sparrows should consider the importance of seasonal variation in singing intensity in order to estimate population size accurately.

ACKNOWLEDGMENTS

I received support, both financial and emotional, from a number of sources while undertaking this research project. I am grateful to the many people and institutions who gave of their time and funds and if I have omitted mention of any contribution, it is by oversight and not by intention.

My supervisor, W. Bruce McGillivray, helped me to refine my project and also introduced me to new field techniques. His helpful comments contributed greatly to the many research proposals and drafts of this thesis that crossed his busy desk. I appreciated his support of this project and his dedication to it over the years since it began.

I am greatly in debt to my hard-working and entertaining field assistants, Todd Mahon, Beverly Gingras, and Krista Cruikshanks who worked long hours in sun, wind, rain and sometimes hail while collecting behavioural and vegetation data. Their keen interest in the project despite seemingly endless singing observations, vegetation plots, and instructions was greatly appreciated. Todd Mahon introduced me to several valuable field techniques and to many new grassland species. His assistance with data management and statistical procedures helped me to manipulate and summarize my data. His continued support and patience during the long road to completion was greatly appreciated. Gary Erickson, Mike Luchanski, and Bill Weimann of the Provincial Museum of Alberta provided logistical support and equipment.

I thank my committee members Susan Hannon and Mark Dale for their suggestions at my committee meetings and for their comments on the drafts of this thesis. I also thank Ralph Thrall Jr., Ralph Thrall III and the staff of the McIntyre Ranch for their assistance and cooperation. I also thank them for allowing us to stay at the bunkhouse on the ranch. It greatly reduced our travel time and increased our sleep time throughout the field season.

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1.0 THESIS INTRODUCTION

1.1 Life History Characteristics of the Baird's Sparrow (*Ammodramus bairdii*)

The Baird's Sparrow (*Ammodramus bairdii*) is an uncommon grassland specialist that breeds in the Great Plains regions of Canada and the United States. Breeding habitat can consist of grazed or ungrazed shortgrass or mixed-grass native prairie (Cartwright *et al.* 1937, Johnsgard 1979), fescue prairie (Smith 1987, Wershler 1990), and a variety of non-native habitats such as hayfields (Kantrud and Kologiski 1982), weedy grainfields and roadside boundaries (Salt and Salt 1976), and alfalfa-wheat grass grasslands (Renken and Dinsmore 1987). Despite the variety of habitats that can be occupied by Baird's Sparrows, populations have been in decline over the past 20 years (DeSmet and Miller 1989), and as a result, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) added the Baird's Sparrow to its list of *threatened* species in 1989.

Baird's Sparrows can be distinguished easily from similar species by a buffy head and nape, a necklace of short black streaks on the breast, and a short, distinctive song consisting of 3 or 4 introductory notes followed by a lower-pitched trill (*sip-sip-sip-srrr-rrr*) (Salt and Salt 1976). In Alberta, Baird's Sparrows arrive on their breeding sites from late April to mid-May and leave during mid-to-late August. Breeding data is scarce for this species, but evidence of pairs producing more than one clutch in a single nesting season has been documented (Cartwright *et al.* 1937, DeSmet and Conrad 1989). Clutch size is usually 4-5 eggs, although later clutches often contain 3-4 eggs (DeSmet and Conrad 1989). The female incubates the eggs for 11-13 days. When leaving the nest the female often walks 10-20 m away before taking to flight. Return trips to the nest are equally secretive (pers. obs.). Hatching generally occurs during a single day with the female performing the feeding and brooding. Four to five days after hatch, the young can stand and daytime brooding ends. They leave the nest 8-10 days after hatching and hide in the surrounding grass. The male begins to help the female feed at this time, bringing in leafhoppers and grasshoppers to the fledglings (pers. obs.). By day 13, fledglings are attempting short flights and by day 18-19 they can fly well enough to disperse from the nesting area.

1.2 Conservation and the Baird's Sparrow: Habitat Selection and Census Procedures

Avian conservation encompasses two main areas of research: assessment of risk of extinction, and identification of causes and consequences of changes in population parameters. As a result, conservation projects often involve examining ecological requirements, breeding success, and the effect of environmental factors on populations of a species (Green and Hirons 1991). Bernstein *et al.* (1991) also suggest considering the distribution of the study species between different habitats in order to assess the best mixture of habitats and the scale needed for conservation.

Habitat selection by grassland birds occurs at both a regional and local scale due to the considerable geographic and temporal variation within grassland vegetation types (Cody 1985). Causes of this heterogeneity are: fire; extreme wet/dry cycles that influence vegetation growth and composition (McNicholl 1988); livestock grazing that encourages the invasion of woody plants and favours short-stature sodgrasses over taller bunchgrasses (Bock *et al.* 1992); and agricultural practices that remove uncultivated or semi-natural habitats and reduce the favourability of agricultural fields for foraging and nesting due to chemical use and mechanization (Rodenhouse *et al.* 1992). Baird's Sparrows can utilize a variety of grassland habitat types, but the habitat variables common to each habitat type which make it suitable for the species are unknown. Determining which habitat variables are used by birds as cues when selecting a suitable breeding territory is complex. Some habitat features may be important to the success of the species, while others may be indirectly correlated with the actual factors influencing habitat choice (Martin 1989). Determining the importance of habitat features to a species requires an examination of the breeding behaviours and biological processes that influence reproductive output and survival.

In order to assess Baird's Sparrow habitat use across the prairie landscape, it is necessary to estimate the size of existing populations. For secretive bird species, like the Baird's Sparrow, the census procedures most often utilized involve counts of singing males (for a review of census procedures see Ralph and Scott 1981). A number of factors can influence the singing activity of territorial males: temperature (Slagsvold 1977, Garson and Hunter 1979, Gottlander 1987, Reid 1987); wind and rain (Robbins 1981); time of day (Henwood and Fabrick 1979, Kacelnik 1979, Kacelnik and Krebs 1982, Montgomerie 1985, Cuthill and Macdonald 1990, Palmeirim and Rabaca 1994); and phase of the breeding cycle (Bell *et al.* 1968, Best 1981, Gibbs and Wenny 1993). Factors that influence singing activity may also affect the ability of an observer to detect singing males in the population. How the above factors influence the accuracy of census procedures for threatened and endangered species should be considered by those attempting to assess population size and distribution.

The objective of my research was to examine breeding success, habitat selection, and detectability of territorial Baird's Sparrows in southwestern Alberta rangeland. Due to difficulties in obtaining breeding data, only the latter two objectives were examined in detail. In Chapter 2.0, I examine the habitat characteristics of Baird's Sparrows in two grassland habitats. I measured and compared habitat variables in areas occupied and unoccupied by Baird's Sparrows in a native and non-native grass community. In Chapter 3.0, I examine the effects of time of day, time of season, and environmental factors on the singing activity and detectability of territorial Baird's Sparrows.

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2.0 HABITAT CHARACTERISTICS OF THE BAIRD'S SPARROW IN SOUTHWESTERN ALBERTA

2.1 Introduction

The Baird's Sparrow (*Ammodramus bairdii*) is an uncommon grassland species of the Northern Great Plains. Loss of native grassland to agriculture and increased grazing pressure on remaining native grassland areas have resulted in population declines of this species across the Canadian prairies over the past 20 years (DeSmet and Miller 1989). In 1989, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Baird's Sparrow as a *threatened* species. A *threatened* species, as defined by COSEWIC, is any indigenous species of fauna of flora that is threatened with imminent extinction or extirpation throughout all or a significant portion of its Canadian range, owing to human action (DeSmet and Miller 1989).

Historically, Baird's Sparrows were found breeding in shortgrass native prairie (Cartwright *et al.* 1937) and large areas of ungrazed or lightly grazed mixed-grass native prairie (Johnsgard 1979). More recently, Baird's Sparrows have been found inhabiting hayfields (Kantrud and Kologiski 1982), meadows and pastures covered with long grass (Salt and Wilk 1966), and alfalfa-wheat grass grasslands (Renken and Dinsmore 1987). The wide variety of habitats supporting Baird's Sparrow populations suggests that combinations of structural features may provide the habitat requirements necessary for breeding success. Unstable populations and secretive behaviour make the Baird's Sparrow a difficult species to study and as a result, there is little information on the specific habitat requirements of this species. Despite the absence of quantitative information on habitat selection, some authors have suggested that Baird's Sparrows are sensitive to litter depth and grass height (Lane 1968, Salt and Salt 1976, Sousa and McDonal 1983).

Baird's Sparrow populations also show some seasonal instability, with individuals and pairs arriving throughout the breeding season (Cartwright *et al.* 1937, Mahon pers.

obs). Understanding patterns of temporal change in sites selected by Baird's Sparrows is also important in assessing habitat requirements for this species.

The purpose of this study is to determine whether sites occupied by Baird's Sparrows can be distinguished from unoccupied sites nearby on the basis of vegetative structure. Quantitative assessment of vegetation was conducted in native and non-native grazed habitats during two periods within the breeding season.

2.2 Study Area

2.2.1 Vegetation

I conducted this study from May to August 1991 and 1992 on the McIntyre Ranch (49°10'N 112°50'W) near Magrath, Alberta (Figure 11-1). The ranch includes most of the western end of the Milk River Ridge, a transition zone from mixed-grass prairie in the east to fescue prairie in the west. Mixed prairie, dominated by western porcupine grass-wheat grass (*Stipa-Agropyron*) associations, is found on the dark brown soils at lower elevations and south-facing slopes, while fescue prairie, dominated by rough fescue (*Festuca scabrella*), is found on the black soils at higher areas and north-facing slopes (Hrapko 1982). Efforts by the ranch owners to maintain low cattle densities, to re-seed fallow hayfields, and to conserve a variety of grassland communities have resulted in a large region of lightly grazed grassland with a minimum of agricultural influences.

Two sites supporting Baird's Sparrows were monitored in 1991 and 1992. Both sites were on the south shores of Anderson Lake (Figure II-1). Site A was dominated by rough fescue (*Festuca scabrella*), Kentucky blue grass (*Poa pratensis*), and smooth brome (*Bromus inermis*). Site B was a non-native grass community dominated by crested wheat grass (*Agropyron cristatum*), a species that had been planted in the 1930s as a source of hay. Other species associated with the crested wheat grass were alfalfa (*Medicago sativa*), smooth brome, Kentucky blue grass, and timothy (*Phleum pratense*). Common forb species at both sites included prairie crocus (*Anemone patens*), low larkspur (*Delphinium bicolor*), three-flowered avens (*Genus triflorum*), silvery lupine (*Lupinus*

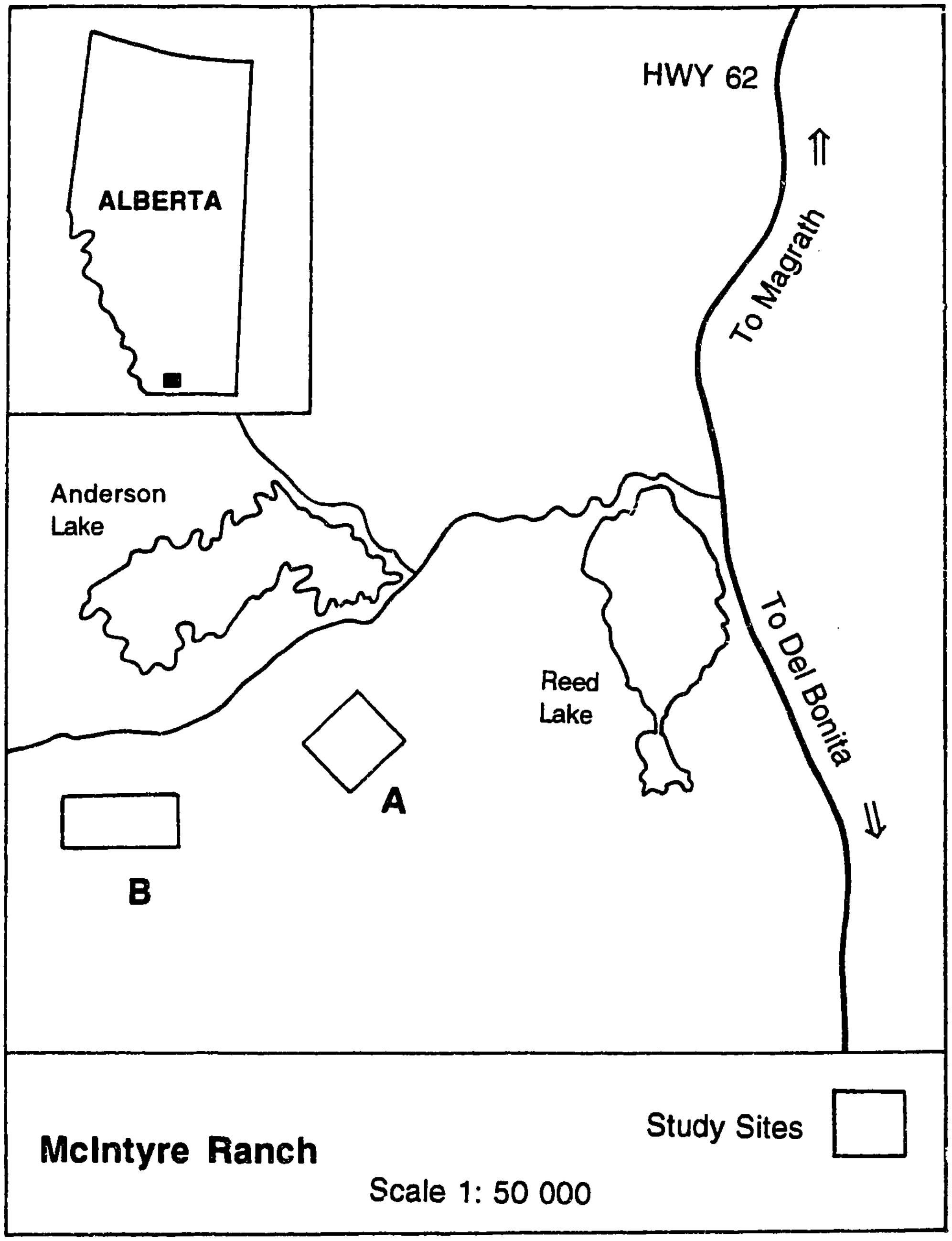

FIGURE II-1. Map of study sites in southwestern Alberta. 1 cm = 500 m.

argenteus), golden bean (*Thermopsis rhombifolia*), sticky geranium (*Geranium viscosissimum*), nuttall's yellow violet (*Viola nutallii*), moss phlox (*Phlox hoodii*), yarrow (*Achillea millefolium*), prairie sage (*Artemisia ludoviciana*), and pasture sage (*Artemisia frigida*).

May to early August temperatures could reach 33° C in mid-afternoon, but often dropped below 0° C at night. Wind was continuous and ranged from light breezes to 50-70 km/hr gusts. Late afternoon and evening thunderstorms and short periods of rain were common. Hailstorms were infrequent but occurred during both seasons. Light snow fell during mid-May of both 1991 and 1992.

2.2.2 Fauna

The following provides an overview of fauna observed frequently on or near the study area. Whitetail deer (*Odocoileus virginianus*), pronghorn (*Antilocapra americana*), and whitetail jackrabbits (*Lepus townsendi*) were seen frequently in the study sites. Potential mammalian nest predators included meadow voles (*Microtus pennsylvanicus*), deer mice (*Peromyscus maniculatus*), Richardson's ground squirrels (*Citellus richardsoni*), thirteen-lined ground squirrels (*Citellus tridecemlineatus*), longtail weasels (*Mustela frenata*), striped skunks (*Mephitis mephitis*), American badgers (*Taxidea taxus*), and coyotes (*Canis latrans*). Birds frequently encountered in the study sites included Marbled Godwits (*Limosa fedoa*), Long-billed Curlews (*Numenius americanus*), Willets (*Catoptrophorus semipalmatus*), Upland Sandpipers (*Bartramia longicauda*), Red-tailed Hawks (*Buteo regalis*), Sharp-tailed Grouse (*Tympanuchus phasianellus*), Horned Larks (*Eremophila alpestris*), Sprague's Pipits (*Anthus spragueii*), Vesper Sparrows (*Pooecetes gramineus*), Savannah Sparrows (*Passerculus sandwichensis*), Chestnut-collared Longspurs (*Calcarius ornatus*), Bobolinks (*Dolinchonyx oryzivorus*), Western Meadowlarks (*Sturnella neglecta*), Brewer's Blackbirds (*Euphagus cyanoecephalus*), and Brown-headed Cowbirds (*Molothrus ater*). Potential avian nest predators included

Northern Harriers (*Circus cyaneus*), Prairie Falcons (*Falco mexicanus*), and Short-eared Owls (*Asio flammeus*).

2.3 Methods

2.3.1 Mist-netting Techniques

Male Baird's Sparrows were mist-netted with medium-mesh (3.2 cm) 12 m nets attached to 1.52 m mist-net poles. A carved wooden decoy elevated on a simulated grass 'perch' and a recording of a singing male Baird's Sparrow were placed in the center of the net to attract territorial males. Males more often approached the net if it was positioned near a territory boundary. Placing the net in the center of the territory seemed to disturb males, and discouraged them from approaching. Often males would fly to within 1-5 m of the net, drop to the ground and walk to the base of the decoy chipping loudly. These birds were captured by driving them into the mist nets. Banding success was highest during the late morning (between 10:00 am and 12:00 pm). Only males were banded, as females did not approach the mist net except when pursuing males. Each bird was marked with a unique combination of two colour bands and one aluminum number band. Sexes do not differ in plumage and must be distinguished by behaviour. Males are most often seen singing from grass or forb perches throughout the day, while females are secretive and are encountered only when feeding in short grass or when interacting with males during breeding.

2.3.2 Territory Mapping

Each year in two sites containing Baird's Sparrows, grid systems with 50 x 50 m squares were established. Site A was approximately 350 x 450 m (68 grid squares), while site B was approximately 350 x 600 m (67 grid squares). Baird's Sparrow territories within the sites were delimited using the consecutive flush procedure (Wiens 1969) and spot mapping. Territory mapping continued throughout the breeding season to monitor changes due to movement in and out of the study sites.

2.3.3 Vegetation Sampling

In late August of 1990, portions of the study area were mowed and raked by the landowners. Male Baird's Sparrows arriving on the study area during the spring of 1991 established territories in unmowed refugia within the mowed region. Due to the inability to collect vegetation data in unmowed control areas, only vegetation data collected in 1992 will be considered in this chapter.

Vegetation data were collected within areas occupied (territories) and unoccupied (control areas) by Baird's Sparrows in study sites A and B during June and July. Data were collected twice during the 1992 breeding season: from June 4-16 and July 6-8. Data collected in June describes habitat used by Baird's Sparrows in their first nesting attempt. Data collected in July describes habitat used by birds attempting to re-nest or start a second nest. Although attempts were made to collect data quickly and over a short period of time, a rain delay in June resulted in a 12-day sampling period.

2.3.3.1 Vegetation Sampling - June

Sampling procedures and vegetation analyses follow Wiens and Rotenberry (1981), but were modified to fit the habitat on the McIntyre Ranch (Dale pers. comm.).

In site A, vegetation data were collected within the territories of all 9 males (occupied areas) and within 9 control areas (unoccupied areas). As territories were approximately the same size as one 50 x 50 m grid square, and were dispersed throughout the study grid, 9 control squares were randomly chosen as a comparison for each of the 9 territorial males (Figure II-2).

In site B, vegetation data were collected within the territories of 10 of 16 territorial males. Control areas were not selected randomly because: a) not all territorial males were included in the vegetation sampling scheme, and b) territories were located in previously mowed and unmowed areas. A stratified random approach ensured that an equal number of controls were selected in mowed and unmowed areas (Figure II-2).

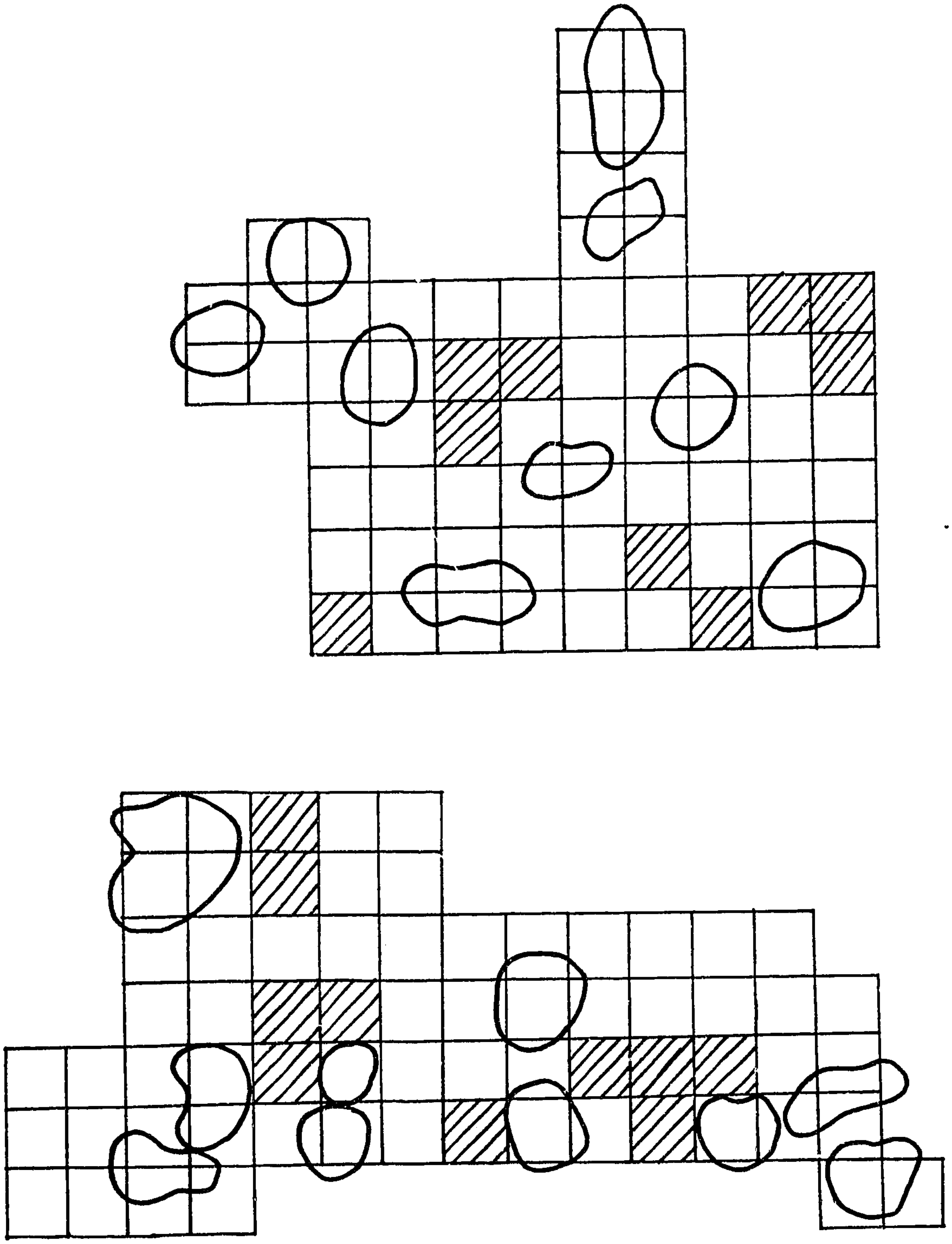

FIGURE II-2. Map showing locations of occupied and unoccupied areas in Baird's Sparrow study sites A (top) and B (bottom) during June 1992. Territory boundaries are enclosed in bold lines whereas control areas are shaded. Scale 1 : 5000. Grid squares are 50 m x 50 m.

2.3.3.2 Vegetation Sampling - July

By the start of July many territorial males had abandoned their territories. Only 3 territorial males remained in site A, while 7 remained in site B. Three territories and 3 controls were sampled in the manner described above for sites A and B (Figure II-3).

2.3.3.3 Vegetation Analysis

In each occupied and unoccupied area, 30 sample units were chosen using a stratified random selection procedure. To ensure that sample units were distributed throughout the territory or control area, researchers walked systematically through the sample area throwing the 30 x 30 cm square frame. As a result, units were spaced approximately equal distances apart throughout the entire territory or control area (Figure II-4). Within each sample unit, a variety of physiognomic vegetation variables were measured. These variables fall into two basic categories: coverage and structure. Coverage was measured by estimating the percent occurrence of the following variables within a 30 x 30 cm square frame: shrub, forb, grass, bare ground, and cattle dropping. Structural variables were measured at four sample points located around the frame: vertical height density in four height intervals (number of hits of living or dead standing plant parts in each decimetre height interval of a 1.5 cm rod passed vertically through the vegetation), litter depth, maximum height, and distance to nearest forb or shrub taller than 20 cm (Table II-1). The distinction between sizes of forbs and shrubs was made for the distance variable because only taller forbs and shrubs may be used as perches by Baird's Sparrows.

2.3.4 Statistical Analysis

All coverage variables, which are recorded as percentages, in each of the two data sets (June and July) were transformed using the arcsine transformation ($p'=\text{arcsine}\sqrt{p}$) to normalize distributions and allow for analysis with parametric statistics (Zar 1984). Values for structural variables were determined by calculating the mean for each of the

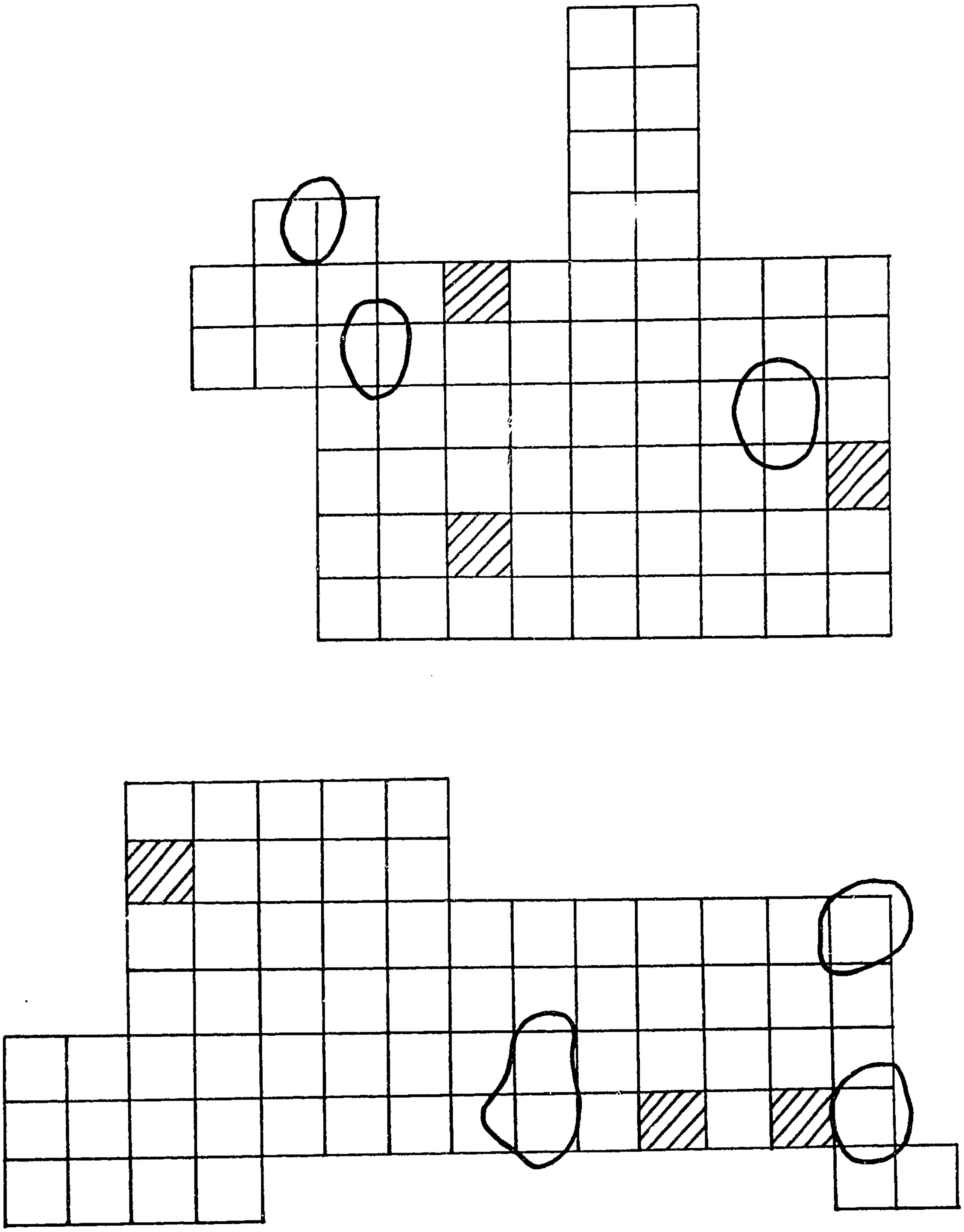

FIGURE II-3. Map showing locations of occupied and unoccupied areas in Baird's Sparrow study sites A (top) and B (bottom) during July 1992. Territory boundaries are enclosed in bold lines whereas control areas are shaded. Scale 1 : 5000. Grid squares are 50 m x 50 m.

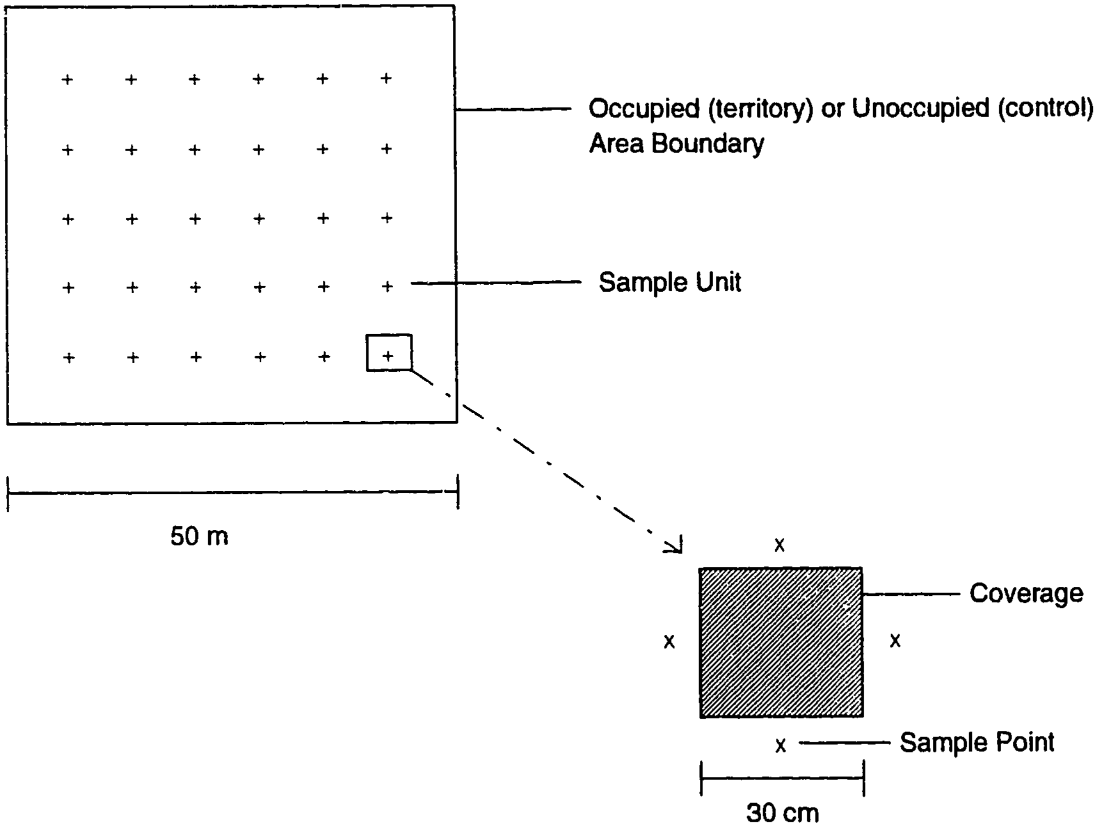

FIGURE II-4. Sampling method for vegetation analysis in areas occupied and unoccupied by Baird's Sparrows in southwestern Alberta.

TABLE II-1

Definitions of Habitat Features from Measured Variables at Occupied and Unoccupied Areas of Baird's Sparrows in Southwestern Alberta

Variable	Definition
Coverage	
PSHRUB	Percentage shrub coverage in sample unit
PFORB	Percentage forb coverage in sample unit
PGRASS	Percentage grass coverage in sample unit
PBARE	Percentage bare ground coverage in sample unit
PCADR	Percentage cattle dropping coverage in sample unit
Structural	
MVHD0-10	Mean number of hits from 0-10 cm
MVHD10-20	Mean number of hits from 10-20 cm
MVHD20-30	Mean number of hits from 20-30 cm
MVHD30-40	Mean number of hits from 30-40 cm
MVHD40-50	Mean number of hits from 40-50 cm
MLD	Mean depth of dead vegetation above ground (cm)
MMHT	Mean maximum height of any living or dead standing vegetation hitting the rod (cm)
MDI	Mean distance in cm to a maximum of 100 cm to the nearest forb or shrub above 20 cm in height (cm)

VHD = Vertical Height Density: Number of hits of living or dead standing plant parts in each decimetre height interval of a 1.5 cm rod passed vertically through vegetation.

Mean values for structural variables determined from 4 sample points within each sample unit.

four observations taken for each sample unit. All variables were tested for deviations from normality.

2.3.4.1 Univariate Analysis

I used t-tests to compare mean values for each variable between occupied and unoccupied Baird's Sparrow areas in study sites A and B.

2.3.4.2 Correlation Matrix

I used a Pearson product moment correlation to examine relationships between vegetation variables for June and July.

2.3.4.3 Principal Components Analysis

Wiens and Rotenberry (1981) suggest that multivariate analysis of habitat variables is suitable for two reasons. First, it is possible that birds may respond to combinations of habitat variables rather than single variables. Second, because so many habitat variables are intercorrelated, a multivariate technique such as PCA permits consideration of habitat gradients (defined by orthogonal components) independent of one another.

I used Principal Components Analysis (PCA) to determine if correlations among the 13 vegetation variables (5 coverage variables and 8 structural variables) would yield components which represent significant fractions of the total variance in the data set. PCA is a method for reducing the number of variables in the data set to a smaller set of orthogonal (uncorrelated) components that can account for a large part of the total variation in the original data set. Component loadings determine the extent to which the original variables are correlated with the resulting components. It is hoped that components can be interpreted in ecological terms based on an assessment of variables with high component loadings. As Principal Components Analysis generates linear combinations of original variables, they are normally distributed.

From a statistical perspective, separations of occupied and unoccupied sites in a multivariate space would be best achieved by a Discriminant Function Analysis. I decided that although it was interesting to separate sites statistically, for management purposes, it was essential that the sites be compared along the axes of major variation in the data set--in other words, along the PC axes. If differences could be found between occupied and unoccupied sites along these axes, then in might be possible to define grazing or cutting programs that facilitated Baird's Sparrow breeding. If the differences were subtle (i.e., not detectable along the PC axes) then the chance of prescribing a beneficial management program would be remote.

For each period of vegetation sampling, I used a nested ANOVA to examine differences between study sites for components 1 and 2 (PC-I and PC-II). I used t-tests to examine differences between occupied and unoccupied areas for each component at each study site during each period of vegetation sampling.

All of the above analyses were performed using Systat for Windows, Version 5.0 (1992).

2.4 Results

2.4.1 Univariate Analyses

Table II-2 and Table II-3 present mean values, standard errors, t and p values for vegetation variables in occupied and unoccupied areas in study sites A and B respectively, during June. In study site A, occupied areas were defined by high forb coverage and high densities of vegetation in 0-10 and 10-20 cm height ranges. Unoccupied areas had high grass coverage and greater distances to tall forbs. In study site B, occupied areas had high forb coverage, high bare ground coverage and high densities of vegetation in the 0-10 cm height range. Unoccupied areas were defined by higher shrub coverage, high litter depth, higher maximum height of vegetation, and greater distances to tall forbs.

Mean values, standard errors, t and p values for vegetation variables in occupied and unoccupied areas in study sites A and B during July are presented in Table II-4 and II-5 respectively. In study site A, occupied areas were characterized by high forb coverage and high densities of vegetation in the 0-10 cm height range. Unoccupied areas had high grass coverage and greater distances to tall forbs. In study site B, occupied areas

TABLE II-2

Mean Values ($\bar{x}$) and Standard Errors (SE) for Habitat Features in Occupied and Unoccupied Areas of Baird's Sparrows in Study Site A During June 1992.

	Occupied N=270		Unoccupied N=272			
	$\bar{x}$	SE	$\bar{x}$	SE	t	p
Coverage						
PGRASS	78.66	0.07	89.62	0.06	4.11	**$p<0.001$**
PSHRUB	3.1x10^{-5}	1.7x10^{-5}	5.4x10^{-5}	2.7x10^{-5}	0.27	$p>0.50$
PFORB	1.46	0.01	0.84	0.01	2.09	**$p<0.05$**
PBARE	3.3x10^{-3}	1.9x10^{-4}	0.01	2.2x10^{-3}	1.00	$p>0.20$
PCADR	3.6x10^{-3}	3.7x10^{-4}	1.7x10^{-3}	4.8x10^{-4}	0.65	$p>0.50$
Structural						
MVHD0-10	2.73	0.08	2.36	0.09	3.03	**$p<0.005$**
MVHD10-20	3.06	0.10	2.60	0.09	3.52	**$p<0.001$**
MVHD20-30	0.71	0.05	0.88	0.06	2.11	$p>0.05$
MVHD30-40	0.16	0.04	0.24	0.03	1.66	$p>0.10$
MVHD40-50	0.02	0.01	0.05	0.01	1.36	$p>0.10$
MLD	5.76	0.13	6.02	0.14	1.31	$p>0.10$
MMHT	19.22	0.32	19.58	0.48	0.62	$p>0.05$
MDI	78.02	1.68	88.12	1.42	4.60	**$p<0.001$**

TABLE II-3

Mean Values ($\bar{x}$) and Standard Errors (SE) for Habitat Features in Occupied and Unoccupied Areas of Baird's Sparrows in Study Site B During June 1992.

	Occupied N=300		Unoccupied N=300			
	$\bar{x}$	SE	$\bar{x}$	SE	t	p
Coverage						
PGRASS	83.38	0.06	87.23	0.06	1.63	$p>0.10$
PSHRUB	$5.1x10^{-4}$	$4.9x10^{-5}$	0.01	$4.0x10^{-4}$	4.56	**$p<0.001$**
PFORB	1.03	0.01	0.50	$8.6x10^{-3}$	2.18	**$p<0.05$**
PBARE	0.03	$1.1x10^{-3}$	$5.8x10^{-3}$	$3.5x10^{-4}$	2.20	**$p<0.02$**
PCADR	$7.4x10^{-3}$	$7.7x10^{-4}$	0.01	$9.1x10^{-4}$	0.46	$p>0.50$
Structural						
MVHD0-10	3.46	0.11	2.67	0.10	5.33	**$p<0.001$**
MVHD10-20	3.96	0.13	3.97	0.11	0.06	$p>0.50$
MVHD20-30	0.66	0.05	0.80	0.05	1.93	$p>0.05$
MVHD30-40	0.06	0.01	0.08	0.02	0.98	$p>0.20$
MVHD40-50	0.02	0.01	0.01	$3.6x10^{-3}$	1.32	$p>0.10$
MLD	5.89	0.16	6.52	0.14	3.05	**$p<0.005$**
MMHT	17.93	0.30	19.21	0.28	3.11	**$p<0.002$**
MDI	81.53	1.49	87.28	1.31	2.90	**$p<0.005$**

TABLE II-4

Mean Values ($\bar{x}$) and Standard Errors (SE) for Habitat Features in Occupied and Unoccupied Areas of Baird's Sparrows in Study Site A During July 1992.

	Occupied N=90		Unoccupied N=90			
	$\bar{x}$	SE	$\bar{x}$	SE	t	p
Coverage						
PGRASS	71.72	0.16	90.56	0.19	4.21	**p<0.001**
PSHRUB	$7.9x10^{-4}$	$7.9x10^{-4}$	$3.1x10^{-5}$	$3.1x10^{-5}$	0.79	p>0.20
PFORB	4.42	0.05	1.10	0.05	3.35	**p<0.001**
PBARE	$3.1x10^{-3}$	$3.4x10^{-4}$	$2.5x10^{-3}$	$6.9x10^{-4}$	0.17	p>0.50
PCADR	$1.2x10^{-4}$	$1.2x10^{-4}$	$2.6x10^{-3}$	$2.1x10^{-3}$	0.85	p>0.20
Structural						
MVHD0-10	2.83	0.15	2.33	0.14	2.46	**p<0.02**
MVHD10-20	3.82	0.18	3.80	0.15	0.07	p>0.50
MVHD20-30	1.12	0.11	1.30	0.10	1.20	p>0.20
MVHD30-40	0.35	0.08	0.34	0.06	0.15	p>0.50
MVHD40-50	0.06	0.03	0.03	0.01	0.92	p>0.20
MLD	5.69	0.22	6.16	0.22	1.52	p>0.50
MMHT	21.71	0.58	22.21	0.59	0.60	p>0.50
MDI	76.17	3.05	86.99	2.43	2.77	**p<0.01**

TABLE II-5

Mean Values ($\bar{x}$) and Standard Errors (SE) for Habitat Features in Occupied and Unoccupied Areas of Baird's Sparrows in Study Site B During July 1992.

	Occupied N=90		Unoccupied N=90			
	$\bar{x}$	SE	$\bar{x}$	SE	t	p
Coverage						
PGRASS	91.96	0.12	87.41	0.15	1.44	p>0.10
PSHRUB	0.02	$1.3x10^{-3}$	$3.1x10^{-3}$	$9.8x10^{-4}$	1.76	p>0.05
PFORB	0.46	0.03	0.58	0.02	0.34	p>0.50
PBARE	$3.1x10^{-3}$	$4.7x10^{-4}$	0.02	$3.5x10^{-3}$	1.36	p>0.10
PCADR	$2.0x10^{-3}$	$7.3x10^{-4}$	$4.5x10^{-3}$	$1.6x10^{-3}$	0.47	p>0.50
Structural						
MVHD0-10	2.84	0.19	2.59	0.15	1.03	p>0.20
MVHD10-20	3.59	0.20	3.70	0.16	0.46	p>0.50
MVHD20-30	1.14	0.12	0.81	0.09	2.16	**p<0.05**
MVHD30-40	0.23	0.05	0.12	0.03	1.79	p>0.50
MVHD40-50	0.01	N/A	0.04	0.02	2.20	**p<0.05**
MLD	5.52	0.28	5.91	0.21	1.09	p>0.20
MMHT	20.20	0.61	19.41	0.55	0.97	p>0.20
MDI	82.23	2.64	90.72	2.26	2.44	**p<0.02**

were defined by high densities of vegetation in the 20-30 cm height range, while unoccupied areas had high densities of vegetation in the 40-50 cm height range and greater distances to tall forbs.

2.4.2 Correlation Matrix of Vegetation Variables

Correlations between vegetation variables measured in June and July are presented in Table II-6 and Table II-7 respectively. The number of significant pair-wise correlations points to the potential for trends or factors in the data that may be detectable through a Principal Components Analysis. The large sample sizes (1142 and 360 respectively) mean that statistical significance can be achieved with relatively low correlations. The biological significance of individual correlations however, was not presumed from the significance level shown in Tables II-6 and II-7 as any pair of variables is not independent from the effects of the other variables in the data set. These tables are useful to confirm the biological interpretations of the factors generated by the Principal Components Analyses.

2.4.3 Principal Components Analysis of Vegetation Variables - June

The first two components of the PCA of vegetation variables accounted for 38.4% of the total variation in the June habitat matrix (Table II-8). Components 3-13 each accounted for ≤ 10% of the total variation in the June PCA and are therefore not included in the following analysis. The first PCA axis accounts for 25.4% of the total variance and represents a gradient in features from low to high vegetation density. Litter depth and maximum height of vegetation are also correlated to vegetation density. The second PCA axis accounts for 13.0% of the total variance and represents a gradient from low to high forb coverage.

2.4.4 Principal Components Analysis of Vegetation Variables - July

Only two PCA factors accounted for 41.2% of the total variance in the July habitat matrix (Table II-9). Components 3-13 each accounted for < 10% of the total variance in the July PCA and are not considered in the analysis. The first axis accounts for 28.4% of the total variance and follows the same pattern as PC-I in the June analysis. The second

TABLE II-6

Correlations[1] Between Vegetation Variables Measured in Baird's Sparrow Habitat in June 1992

	PGR	PSHR	PFOR	PBAR	PCADR	MVHD 0-10	MVHD 10-20	MVHD 20-30	MVHD 30-40	MVHD 40-50	MLD	MMHT	MDI
PGR	-----												
PSHR	-0.073	-----											
PFOR	**-0.641**	-0.059	-----										
PBAR	**-0.195**	-0.016	0.007	-----									
PCADR	**-0.169**	0.011	-0.023	-0.026	-----								
MVHD 0-10	**-0.140**	-0.013	**0.120**	0.075	0.042	-----							
MVHD 10-20	**0.115**	0.040	**-0.145**	-0.060	0.059	**-0.203**	-----						
MVHD 20-30	**0.135**	0.007	**-0.104**	-0.064	0.009	**-0.358**	**0.343**	-----					
MVHD 30-40	0.090	-0.029	-0.055	-0.028	-0.033	**-0.180**	0.047	**0.333**	-----				
MVHD 40-50	0.040	-0.022	-0.039	-0.022	-0.021	-0.076	0.002	**0.177**	**0.397**	-----			
MLD	**0.205**	0.047	**-0.222**	**-0.146**	-0.022	**-0.594**	**0.518**	**0.461**	**0.191**	0.087	-----		
MMHT	**0.180**	-0.035	**-0.149**	**-0.090**	-0.030	**-0.417**	**0.420**	**0.664**	**0.428**	**0.263**	**0.538**	-----	
MDI	**0.290**	-0.042	**-0.351**	-0.033	0.022	-0.093	0.081	**0.103**	0.042	0.015	**0.143**	**0.154**	-----

[1] Bold r values indicate significance at $p<0.001$, N = 1142.

TABLE II-7

Correlations[1] Between Vegetation Variables Measured in Baird's Sparrow Habitat in July 1992

	PGR	PSHR	PFOR	PBAR	PCADR	MVHD 0-10	MVHD 10-20	MVHD 20-30	MVHD 30-40	MVHD 40-50	MLD	MMHT	MDI
PGR	-----												
PSHR	-0.098	-----											
PFOR	**-0.813**	-0.085	-----										
PBAR	-0.163	-0.049	-0.045	-----									
PCADR	-0.112	-0.030	-0.071	0.031	-----								
MVHD 0-10	**-0.225**	0.045	**0.212**	0.036	-0.015	-----							
MVHD 10-20	**0.201**	-0.040	**-0.228**	-0.108	-0.022	**-0.244**	-----						
MVHD 20-30	**0.236**	0.011	**-0.210**	-0.097	-0.002	**-0.410**	**0.355**	-----					
MVHD 30-40	0.163	0.019	-0.120	-0.020	-0.047	**-0.224**	0.166	**0.522**	-----				
MVHD 40-50	0.064	0.051	-0.082	-0.018	-0.029	-0.100	0.143	**0.203**	**0.319**	-----			
MLD	**0.369**	-0.034	**-0.307**	**-0.195**	-0.047	**-0.603**	**0.397**	**0.531**	**0.326**	0.166	-----		
MMHT	**0.242**	0.22	**-0.222**	-0.109	-0.046	**-0.345**	**0.401**	**0.720**	**0.594**	**0.310**	**0.508**	-----	
MDI	**0.282**	-0.103	**-0.266**	0.090	0.047	-0.120	0.013	0.054	0.064	0.034	0.137	0.014	-----

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[1] Bold r values indicate significance at $p<0.001$, N = 360.

TABLE II-8

Correlations of Baird's Sparrow Habitat Features With PC-I and PC-II During June 1992. Component Loadings ≥0.062 or ≤-0.062 are Significant at $p<0.05$.

Variable	PC-I	PC-II
Relative % of total variance accounted for by the PC components	25.4	13.0
Cumulative % of total variance accounted for by the PC components	25.4	38.4
Correlation of habitat variables with the principal components		
Coverage		
PGRASS	0.437	-0.725
PSHRUB	0.002	0.025
PFORB	-0.413	0.735
PBARE	-0.187	0.116
PCADR	-0.044	0.099
Structural		
MVHD0-10	-0.624	-0.129
MVHD10-20	0.559	0.071
MVHD20-30	0.724	0.274
MVHD30-40	0.467	0.308
MVHD40-50	0.299	0.266
MLD	0.782	0.077
MMHT	0.816	0.253
MDI	0.311	-.0519

TABLE II-9

Correlations of Baird's Sparrow Habitat Features With PC-I and PC-II During July 1992. Component Loadings ≥0.105 or ≤-0.105 are Significant at $p<0.05$.

Variable	PC-I	PC-II
Relative % of total variance accounted for by the PC components	28.4	12.8
Cumulative % of total variance accounted for by the PC components	28.4	41.2
Correlation of habitat variables with the principal components		
Coverage		
PGRASS	0.579	-0.683
PSHRUB	-0.016	0.144
PFORB	-0.537	0.695
PBARE	-0.171	-0.088
PCADR	-0.047	-0.062
Structural	-0.608	-0.002
MVHD10-20	0.543	0.072
MVHD20-30	0.776	0.295
MVHD30-40	0.610	0.360
MVHD40-50	0.355	0.278
MLD	0.778	0.005
MMHT	0.792	0.346
MDI	0.215	-0.520

axis accounts for 12.8% of the total variance and also follows the same pattern as PC-II in the June analysis.

2.4.5 Variation Between Study Sites

Study sites A (native) and B (non-native) did not differ significantly for PC-I (vegetation density) for June (F=0.039, p>0.844) or July (F=1.50, p>0.208). Sites A and B did differ significantly for PC-II (forb coverage) for June (F=7.57, p<0.006) and July (F=31.96, p<0.000).

2.4.6 Variation Within Study Sites - June

For PC-I (vegetation density), t-tests revealed that differences between occupied ($\bar{x}$=-0.105) and unoccupied areas ($\bar{x}$=0.117) were significant for site A (t=2.463, df=540, p<0.014). Occupied ($\bar{x}$=-0.160) and unoccupied areas ($\bar{x}$=0.148) also differed significantly for PC-I for site B (t=4.028, df=598, p<0.000). For PC-II (forb coverage), differences between occupied ($\bar{x}$=0.206) and unoccupied areas ($\bar{x}$=-0.036) were significant for site A (t=2.726, df=540, p<0.007). Occupied ($\bar{x}$=-0.024) and unoccupied areas ($\bar{x}$=-0.129) did not differ significantly for PC-II for site B (t=1.343, df=598, p>0.180).

2.4.7 Variation Within Study Sites - July

Occupied ($\bar{x}$=-0.103) and unoccupied areas ($\bar{x}$=0.235) differed for PC-1 for site A (t=2.178, df=178, p<0.031). For site B, occupied ($\bar{x}$=-0.034) and unoccupied areas ($\bar{x}$=-0.098) did not differ significantly (t=0.459, df=178, p>0.647). For PC-II, differences between occupied ($\bar{x}$=0.588) and unoccupied areas ($\bar{x}$=-0.029) were significant for site A (t=4.083, df=178, p<0.000). Occupied ($\bar{x}$=-0.208) and unoccupied areas ($\bar{x}$=-0.350) did not differ for site B (t=1.117, df=178, p>0.265).

2.5 Discussion

2.5.1 Baird's Sparrow Habitat in June

In site A, Baird's Sparrows occupied areas with high forb coverage and high densities of vegetation in the 0-20 cm height range. It is likely that the majority of these low to mid-canopy grasses are new growth. Although I did not differentiate between old (last season's) and new (this season's) vegetation during data collection, it is assumed that early in the season, vegetation close to the ground is composed of new and old grasses, while taller vegetation is composed of standing grass from last season. Later in the growing season, taller vegetation is a mixture of new and old grass. New and old standing vegetation is needed to provide cover for adults and nests early in the breeding season. The high forb coverage within territories confirms that Baird's Sparrows seek out territories with suitable numbers of perches as suggested Cartwright *et al.* (1937). Although male Baird's Sparrows can use bunches of ungrazed grass as perching sites, they prefer to use tall forbs, except very early in the breeding season. Data collected during singing observations suggests that male Baird's Sparrows alter their selection of unconcealed perches as the season progresses. Grass perches outnumber forb perches (54.9 to 38.0%) only until mid-May. By early July, Baird's Sparrows use forb perches almost exclusively (93.2 to 3.4%). Last season's ungrazed grass bunches become less suitable as perches because as new grass appears these perches become indistinguishable within the grass community (pers. obs.). Unoccupied areas had higher grass coverage and greater distances to tall forbs. These univariate patterns are also reflected in the t-tests performed on PC-I and PC-II scores; vegetation density is higher in unoccupied areas, and forb coverage is higher in occupied areas. The higher vegetation density in the unoccupied area of site A suggests that very dense grass is unsuitable for Baird's Sparrows. This site contained dense patches of smooth brome that were not occupied by Baird's Sparrows. Cartwright *et al.* (1937) suggested that slight changes in vegetation density can make an area unsuitable for Baird's Sparrows. Bollinger *et al.* (1990) in their study of Bobolinks found that dense grass impedes the capture of prey items.

The crested wheat grass-alfalfa hayfield (site B) appears to be a more structurally heterogeneous grass community than the rough fescue community during June. At this site, occupied areas had high forb coverage, high bare ground coverage, and high densities of vegetation in the 0-10 cm height range. Unoccupied areas were defined by higher shrub coverage, higher litter depth, higher maximum height of vegetation , and greater distances to tall forbs. Despite the structural variability of this grass community, t-tests revealed that vegetation density (PC-I) was once again higher in unoccupied areas. Patches dominated by smooth brome were also present within this study site, as were dense patches of crested wheat grass and timothy. Forb coverage (PC-II) did not differ significantly between occupied and unoccupied areas. These results suggest that perching forbs could have been distributed uniformly throughout the study site and were not limiting to male Baird's Sparrows selecting territories. This site contained considerable alfalfa and silvery lupine, both of which were often used as perch sites by territorial males (Mahon unpubl.). Perching forbs in site A may have been distributed in patches or clumps throughout the study site, causing territorial males to seek out these patches within the site.

These data suggest that early in the season, Baird's Sparrows can select territories with similar structural characteristics within highly variable grassland environments.

2.5.2 Baird's Sparrow Habitat in July

In site A, Baird's Sparrows occupied sites with the same vegetation characteristics that were exhibited in June. T-tests on PC scores revealed the same patterns as in June; vegetation density is higher in unoccupied areas, while forb coverage is higher in occupied areas.

In site B, Baird's Sparrows chose areas with high densities of vegetation in the 20-30 cm height range while unoccupied areas had high densities of vegetation in the 40-50 cm height range and greater distances to tall forbs. Despite these univariate differences, there was no significant difference in vegetation density or forb coverage for occupied and unoccupied areas at the site. By July, this crested wheat grass-alfalfa site appeared to be more homogeneous with respect to vegetation density and forb coverage than the rough fescue site. Site B may have appeared more homogeneous later in the season because this type of grass community can withstand intensive grazing and drought conditions without injuring the stand or reducing its long-term yielding capacity (Looman 1983). Rough fescue can be grazed out readily and replaced with increaser and invader species (Smoliak *et al.* 1988). (An increaser is a plant species of the original vegetation that will increase with continued overuse; an invader is a plant species that is absent from the undisturbed original vegetation, but will invade with continued overuse). The presence of increaser species like rose (*Rosa spp.*), moss phlox, and pasture sage and invader species like Kentucky blue grass, and goat's-beard (*Tragopogon dubius*) in site A may have created a more heterogeneous grass community, providing suitable Baird's Sparrow habitat only within certain areas of the study site. As suggested in the discussion of June habitat characteristics, it is likely that uniform forb distribution in site B created favourable Baird's Sparrow habitat throughout this study site.

Although only half of the Baird's Sparrow territories selected for vegetation analysis in July were newly arrived males, habitat trends were similar to those exhibited in the June analysis. This suggests that the same habitat cues are important during early and late habitat selection.

The primary difference between sites A and B was the relative dominance of a non-native grass (crested wheat grass) in site B as opposed to the dominance of a native species (rough fescue) in site A. Despite this, and differences in forb coverage and patchiness, Baird's Sparrows found suitable habitat for territories and nest sites in both sites. In a study comparing grazed native prairie and ungrazed alfalfa-wheat grass plots in North Dakota, Renken and Dinsmore (1987) found Baird's Sparrows in both plots, although the highest densities were found in the grazed plot. A comparison of vegetation variables revealed that grazed native plots had less forb cover, more bare ground, thinner litter, and shorter vegetation, while alfalfa-wheat grass plots had denser vegetation. The above data from North Dakota suggests that both grazed and ungrazed plots have habitat features that are selected by Baird's Sparrows.

Light to moderate rotational grazing can create habitats that contain features found in grazed and ungrazed areas. Grazing creates patchiness due to the non-depleting foraging behavior of cattle. Small areas of grass not grazed by cattle during spring, summer, or winter season-long grazing can remain as clumps or bunches in areas of shorter, grazed grass. These ungrazed areas are important to Baird's Sparrows because this vegetation provides perches and cover early in the season. The areas of shorter grass provide openings for foraging and also prevent the grass canopy from becoming too dense. Light to moderate rotational grazing also ensures that enough carry-over (45-50% of current year's growth in the form of ground litter and standing dead vegetation) is left on the range to reduce erosion and increase water penetration (Adams *et al.* 1986). The increase in weedy invader species that result from grazing (Smoliak *et al.* 1988) may also provide perch sites for singing males (examples in sites A and B are silvery lupine and goat's-beard). Intensive grazing keeps grass tillers close to the ground preventing them from producing enough food to build strong roots. These plants can not compete for moisture and nutrients and are replaced by increaser and invader species. Continuous or season-long intensive grazing leaves little available cover, perches, and litter for birds arriving the following season. The patchy environment created by light to moderate grazing seems suitable to Baird's Sparrows as it provides available perches, ground litter, and open areas o low to mid-canopy vegetation suitable for foraging (pers. obs.). In both native and non-native grazed habitats in southwestern Alberta, Baird's Sparrows selected territories with similar structural features: low to mid-canopy vegetation, and high forb coverage.

The two variables, maximum grass height and litter depth, suggested by Sousa and McDonal (1983) did not appear to directly influence habitat selection by Baird's Sparrows in this study. Litter depth and standing dead vegetation were relatively homogeneous across the study area as a result of moderate, carefully monitored winter grazing by the ranch owners.

2.5.3 Management Implications

In a study of habitat selection by the Henslow's Sparrow (*Ammodramus henslowii*), a species similar to the Baird's Sparrow, Zimmerman (1988) suggests that any agricultural practice that removes considerable amounts of standing vegetation will exclude the species. I also observed that Baird's Sparrows did not use hayfields one year after mowing. Herkert (1994) examined the effects of burning and mowing on Henslow's Sparrow habitat selection. He found that this species only utilized burned areas with at least three growing seasons post-burn, and that there were 90% more Henslow's Sparrows on unmowed areas than mowed areas. Although no such experiments have been performed for Baird's Sparrows, it is reasonable to suggest, based on the data presented here, that the effects of either burning or mowing on grass density, litter depth, and forb density would reduce potential Baird's Sparrow habitat. Mowing inccurs a greater risk to grassland breeders because it often occurs during the nesting cycle. Frawley and Best (1991) suggest that mowing generally has a negative impact on many grassland birds because forage managers want to harvest when forage crops have the highest amount of digestible nutrients/ha. In Iowa, alfalfa is first harvested in early June, again after 5.5 weeks, and for a third time after 11 weeks. Bollinger *et al.* (1990) found that Bobolink egg, nestling, and fledgling mortality was 85% after the mowing and raking of hayfields. Another 9% mortality resulted from the predation of exposed nests. During 1991 and 1992, a number of Baird's Sparrow individuals and pairs arrived on my study sites in mid-June just after many surrounding hayfields had been mowed. I suspect that mowing and raking caused pairs to abandon their territories after losing their nests.

Grazing may be the least harmful practice affecting Baird's Sparrow populations if range conditions are monitored carefully. In some mixed-grass ecosystems, livestock grazing has favoured short-stature grasses over taller bunchgrasses whereas in shortgrass ecosystems, low-stature grasses that tolerate grazing are also those that can tolerate frequent periods of drought. The features that allow grasses to withstand drought and grazing are complementary. The result is that livestock grazing has little effect on species composition and grassland structure in shortgrass ecosystems (Milchunas *et al.* 1988). Range plant dynamics suggests that considerable time and effort must be given to planning a grazing system in order to maintain healthy rangeland in different grassland ecosystems.

Previous studies of the effects of grazing on grassland avifauna have suggested that Baird's Sparrows can be found in lightly grazed areas (Kantrud and Kologiski 1982), but not in areas of heavy grazing (Kantrud 1981). Renken and Dinsmore (1987) found more Baird's Sparrows in grazed as opposed to ungrazed plots, while Owens and Myres (1973) found no Baird's Sparrows in grazed fescue plots in Alberta. Clearly, grazing intensity and range condition is the key to determining whether rangeland is suitable Baird's Sparrow habitat. Unfortunately, previous studies have made no attempt to quantify: (1) grazing pressure (only qualitative assessments are given - light, moderate, heavy), or 2) specific Baird's Sparrow habitat requirements. Results from this study suggest that at a stocking rate of 0.32-0.41 ha/AUM during November and December, considerable Baird's Sparrow habitat remained in native (rough fescue) and non-native (crested wheat grass-alfalfa) grass communities. Animal unit month (AUM) is the grazing required to support an animal unit (450 kg cow with or without her weaned calf) for 1 month. The grazing intensity of this study area on the McIntyre Ranch was only slightly less than the recommended stocking rate for rough fescue in excellent condition (0.4-0.6 ha/AUM) (Adams *et al.* 1986). My results demonstrate that important habitat variables such as tall and middle canopy grass cover, tall forbs, and litter depth can be maintained as a result of a carefully monitored season-long (winter) grazing system.

My results suggest that to conserve this species, landowners, farmers, and conservation agencies should be encouraged to:

(1) Create or maintain patches of light to moderate grazed pasture dominated by middle and tall canopy grass species. Short-stature grass species and scattered tall forbs (silvery

lupine, goat's-beard, alfalfa) should also be encouraged. Native and non-native grass communities can be considered candidates for these types of patches.

(2) Create large patches (>10-15 ha) whenever possible. Brown-headed Cowbird (*Molothrus ater*) parasitism tends to be higher in small grassland patches (Johnson and Temple 1990).

(3) Patches should be winter grazed only. Winter grazing is more critical for native grass species because they are most likely to be damaged during their growth period. Medin (1986) suggests that late winter grazing results in pasture with the lowest shrub cover, the highest grass cover and the tallest average grass height. Early winter grazing results in lower forb cover, lower average grass and shrub heights and lower grass and shrub patchiness. Winter grazing allows grass to grow throughout the growing season, producing rangeland with a greater abundance of tall grass and grass litter present the following spring. A complementary grazing system may be beneficial for landowners with seeded and native rangeland. Seeded range can be grazed during the growing season with little damage to overall range quality, while native range should be grazed in fall and winter to ensure maintenance of native climax species. Deferred-rotation grazing may also be a possibility in areas where differences exist between palatability of plants and convenience of areas for grazing (Holecheck *et al.* 1989). This system does require that some part of the range is grazed during the growing season.

(4) Careful monitoring of range conditions with special attention given to Baird's Sparrow habitat requirements. Middle and tall canopy grass cover, tall forbs, and grass litter are habitat requirements in the mixed prairie-fescue prairie transition zone of the Milk River Ridge. Similar habitat requirements may exist in other grass communities in this species' breeding range. Landowners should be prepared to exclude cattle from areas where poor range conditions threaten Baird's Sparrow populations.

(5) Landowners with hayfields supporting Baird's Sparrow populations should refrain from mowing until after the middle of July (preferably in August) to avoid nest mortality.

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3.0 SEASONAL AND DIURNAL VARIATION IN SONG INTENSITY AND DETECTABILITY OF BAIRD'S SPARROWS

3.1 Introduction

The Baird's Sparrow (*Ammodramus bairdii*) is a grassland specialist occupying native grassland, lush non-native hayfields, and rangeland. Fragmentation of the prairie grasslands for agriculture and poor management of remaining native tracts have resulted in a decrease in suitable Baird's Sparrow habitat and a decline in populations across the prairies This species was designated as *threatened* in 1989 by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) (DeSmet and Miller 1989).

Accurate census data for endangered or threatened species is essential to the development of a species recovery or management plan. Population densities of secretive bird species, like the Baird's Sparrow, are determined from counts of singing males (Franzeb 1981, Scott *et al.* 1981). Song counts are valid, however, only if factors influencing song frequency, and therefore detectability, are understood.

Singing behaviour during the breeding season has been studied for many passerine species. Seasonal patterns of song frequency may be related to events during the breeding cycle (Catchpole 1973, Jarvinen *et al.* 1977, Slagsvold 1977), and mating status of males. For example, song production of breeding male Redwings (*Turdus iliacus*) reaches a peak just prior to egg-laying (Lampe and Espmark 1987), while song production of non-breeding male Stonechats (*Saxicola torquata* Greig-Smith 1982) and Field Sparrows (*Spizella pusilla* Best 1981) remains high throughout the breeding season.

The song frequency of territorial males may be influenced by the presence of singing conspecifics. An increase in the number of neighbouring songsters increases song output by territorial male Song Sparrows (*Melospiza melodia* Harris and Lemon 1976), Redwings (Lampe and Espmark 1987), and Yellow-breasted Chats (*Icteria virens* Ritchison 1988).

Diurnal variation in song activity will influence detectability. Peaks in song frequency for many passerines occur during the period immediately following dawn due to increased sound transmission (Henwood and Fabrick 1979), low foraging success (Kacelnik 1979), and high risk of territorial intrusion (Kacelnik and Krebs 1982, Mace 1986, 1987b, 1989, Cuthill and Macdonald 1990).

Weather may greatly influence song frequency. Temperature extremes may inhibit song production due to the energetic costs of exposure in cold or heat (Reid 1987). The effects of wind, rain, and fog on song frequency have been less studied.

The type of perch used by singing males may also influence song frequency. Song perches that are elevated increase sound transmission (Henwood and Fabrick 1979).

In this chapter I will examine the effects of time of season, time of day, weather, presence of singing conspecifics, and perch type on the song production of Baird's Sparrows. The effects of these factors on detectability will be explored, and the relationship between detectability and census numbers discussed.

3.2 Study Area

For a complete description of the study area and study sites see section 2.2 Study Area. Two sites supporting Baird's Sparrows were monitored in 1991 and 1992. Both sites were on the south shores of Anderson Lake (see Figure II-1). Site A was dominated by rough fescue (*Festuca scabrella*), Kentucky blue grass (*Poa pratensis*), and smooth brome (*Bromus inermis*). Site B was a non-native grass community dominated by crested wheat grass (*Agropyron cristatum*), a species that had been planted in the 1930s as a source of hay. Other species associated with the crested wheat grass were alfalfa (*Medicago sativa*), smooth brome, Kentucky blue grass, and timothy (*Phleum pratense*). Vegetation is described in detail in section 2.2.1 Vegetation. For a review of fauna present within the study area see section 2.2.2 Fauna.

3.3 Methods

3.3.1 Mist-netting Techniques

For a complete description of techniques see section 2.3.1 Mist-netting Techniques. Although attempts were made to capture and band all territorial males on the study area, due to poor weather conditions for mist-netting (continuous wind) not all males were banded.

3.3.2 Territory Mapping

For a description of methods see section 2.3.2 Territory Mapping.

3.3.3 Singing Observations

During the 1991 season (May to August), the singing behaviour of colour-banded male Baird's Sparrows was assessed by monitoring time spent singing, song rate, and bout length during 20 minute observation periods that began at 6:30, 7:00, and 7:30 am. Baird's Sparrows peak in singing activity approximately one half hour after dawn, after which singing gradually decreased (Robbins 1981a, Mahon pers. obs.). Time spent singing is the total time spent singing during the observation period, song rate is the songs per minute during each song bout (average song rate is calculated for each observation period), and bout length is a period of continuous singing (song phrases followed by silent pauses). On three mornings per week, the singing activity of 11 different territorial males was measured. Observation days and the time periods during which the individuals were observed were chosen randomly. At the end of the 1991 season, 100 observation periods on 19 separate days had been recorded.

During the 1992 season (May to July) the singing activity of territorial males was measured during 20 minute observation periods that began at 6:00, 6:30, and 7:00 am. Time spent singing, song rate, bout length, perch type (exposed-i.e., all of singing bird is clearly visible; concealed-i.e., only a portion or none of singing bird is visible to the observor), perch composition (grass, forb ground, grid pole, other), perch height, number of conspecifics singing during each bout, weather characteristics (cloud cover, presence of rain and fog, wind speed at ground and 1.5 m, and temperature at ground and 1.5 m) were measured. Data were collected six mornings per week. Each male was observed three times per week on alternating days to reduce disturbances of territorial males by the researchers. At the end of the 1992 season, 253 observation periods over 34 days had been recorded.

During both years, severe weather conditions clearly affected singing behaviour. Observations continued during light to moderate winds and during light rain. When wind speed was high (>25 km/h) or during heavy rain or hail, observation periods were canceled.

Considerable movement of individuals in and out of the study sites occurred during both years. Observations of singing males continued until territories were abandoned and/or males no longer responded to playback. The singing behaviour of new males entering the sites and establishing territories throughout the breeding season was also monitored.

To determine patterns of diurnal variation in song production, territorial males were observed from early morning to early evening on June 3, 1992. During each hour from 6:00 am to 6:00 pm, the singing behaviour of each male was monitored for 20 minutes. Song intensity was recorded following the procedure for early morning observations in 1992.

3.3.4 Breeding Status

In an attempt to find nests and to determine the breeding status of all males on territory, extensive rope-dragging using a heavy, 6 cm diameter jute rope with attached rock-filled aluminum cans was carried out. Although the time of day was varied to ensure that females were on nests during dragging, no nests were found after rope-dragging the sites at three different periods during the breeding cycle. Since this time I have successfully found nests using this technique on a study area in southeastern Alberta where the depth of ground litter was considerably less. Nests concealed within the heavy ground litter on sites A and B were most likely not disturbed because the rope was floating above the ground litter and large clumps of bunchgrass tillers. The secretive behaviour of male and female Baird's Sparrows does not facilitate nest-finding until both parents begin intensive feeding of nestlings just prior to fledging. Despite attempts to find nests by observing pairs, few nests were located in 1991 and 1992. Because of the low success in finding nests and evidence of breeding, I did not attempt to relate seasonal song output with timing of the breeding cycle.

3.3.5 Detectability

During the 1992 season all territorial male Baird's Sparrows in both study sites were surveyed once per week to determine changes in detectability during the breeding season (detectability is the percentage of individuals detected in a known population). Only days of 'good' (i.e., little cloud cover, little or no fog, no rain, low wind speed). weather conditions were chosen for census days

Starting one half hour after sunrise, each known territory within a site was visited for five minutes, or until the territorial male was heard and located. The time to first detection was recorded, as was the location of the territorial male (time to first detection is the time until the territorial male is heard during the five minute time period). Not all territorial males were colour-banded, therefore only singing could be used as a detection criterion because each territorial male could be recognized by his own characteristic song. Weather conditions were recorded at the start and finish of censusing both study sites. Known territories were those that were mapped until the observer was confident that the territory boundaries plotted were accurate (usually 3-5 attempts using the consecutive flush procedure). Territorial males were checked daily to ensure that they were present on the study sites. Any territorial males that were suspected of abandoning territories (no sightings or singing heard during the week) were removed from the weekly census.

3.3.6 Statistical Analysis

All variables were tested for deviations from normality. Only song rate, bout length, and wind speed were found to be not normally distributed. Non-parametric tests of significance were employed in analyses including these variables.

3.3.6.1 Seasonal Trends

Spearman Rank Correlations were used to identify correlations between time spent singing and song rate, and time spent singing and bout length for summary data from 1991 and 1992 . Song rate and bout length were found to be strongly correlated with time spent singing in 1991 (song rate: $r=0.493$, $p<0.02$, $n=19$; bout length: $r=0.768$, $p=0.001$, $n=19$) and 1992 (song rate: $r=0.539$, $p<0.001$, $n=34$; bout length: $r=0.751$, $p=0.001$, $n=34$). Hence in subsequent analyses, time spent singing was used as the measure of singing intensity.

All observed males in 1991 and 1992 whose territorial status was unknown were deleted from analyses of seasonal trends of song intensity. These included males who briefly appeared to defend a territory within the study site, but did not remain on territory for more than a few days.

3.3.6.2 Diurnal Trends

I used a one-way ANOVA to compare differences in time spent singing among three early morning time periods for 1991 and 1992 data.

3.3.6.3 Weather Effects

Examining the effects of weather on singing behaviour proved complicated due to strong seasonal influences. I attempted to use polynomial regressions to assess variation due to weather variables, but seasonal variation is confounded with weather effects. As a consequence, it is necessary to standardize intensity of singing so that days of relatively high singing intensity can be separated from days of relatively low singing intensity. In order to determine if each weather variable is related to time spent singing, I utilized parametric and non-parametric two sample tests to compare days of relatively high and low song output for each variable. From a plot of time spent singing versus date, peaks and valleys of song intensity were identified. Peaks are days when the time spent singing is high relative to the sampling period immediately before and the one immediately after the peak. Valleys occur when time spent singing is low relative to adjacent sampling periods. Use of 'peaks' and 'valleys' adjusts the data for seasonal variation. The null hypothesis being tested is that weather has no effect on relative levels of singing intensity.

I used t-tests to test for differences between cloud cover and temperature and Mann-Whitney tests with tied ranks to test for differences in wind speed for 'peak' versus 'valley' days.

The categorical variables of rain and fog were not analyzed by the above procedure due to small numbers of days with rain or fog present. I instead used nested ANOVAs to determine if rain and fog affect time spent singing of territorial males during all observation periods.

3.3.6.4 Effects of Singing Conspecifics

I used linear regression to examine the relationship between time spent singing and the total number of singing conspecifics. Pooled data from all observation days in 1992 were used for this regression.

To remove the effect of season I used t-tests to examine differences in the number of singing conspecifics on days of high and low song output. I used the peak and valley method described above to determine days of high and low song output for each site.

3.3.6.5 Effects of Perch Use

To determine if type of perch influenced singing behaviour, t-tests were performed on data pooled from all observation days in 1992. I examined the difference between: (1) mean bout length, and (2) the number of songs in a bout for birds using exposed and concealed perches.

Programs used for the above analyses included Statview SE + Graphics (1988) and SuperANOVA (1989) for the Macintosh computer system.

3.4 Results

3.4.1 Seasonal Trends

Average time spent singing did not remain constant over the breeding season. Although time spent singing fluctuates during the breeding season, both years show fluctuations and declines in song output in early June followed by increases in late June through July (Figure III-1).

Individual males from 1991 and 1992 showed considerable seasonal variation in their song intensity (Figure III-2 and Figure III-3 respectively). Males W/W (1991) and Bl/BW (1992) show similar patterns of highly variable song output. Males O/O (1991) and O/W (1992) have high song output in late May with continued decline until early to mid June. At this time, song output may stop completely or continue briefly at very low levels. R/B (1992) exhibits another common pattern of seasonal song output. A peak in late May is followed by a dramatic decline and period of low song output until song output rises sharply again in late June and early July.

3.4.2 Diurnal Trends

Individual birds also showed high variation in daily patterns of song production (Figure III-4). Bl/BW shows a decline in time spent singing after a peak at 7:00 am. Song production does not reach zero until 4:00 pm, followed by an increase to 62.4% (12.47 min) at 6:00 pm. Bl/G shows a decline in time spent singing after a peak at 6:00 am. Song production reached 0 at noon then began increasing at 3:00 pm, reaching a high of 34.2% (6.83 min) at 5:00 pm. O/W showed an initial increase after the start time of 6:00 am to peak at 92.2% (18.45 min) at 7:00 am. Time spent singing dropped to 0 at 10:00 am, after which it increased slightly before falling to 0 at 1:00 pm. No singing was recorded again during the observation time period.

Little variation existed for time spent singing among the three early morning time periods in 1991 (F=0.078, p>0.50), 1992 (F=0.178, p>0.50).

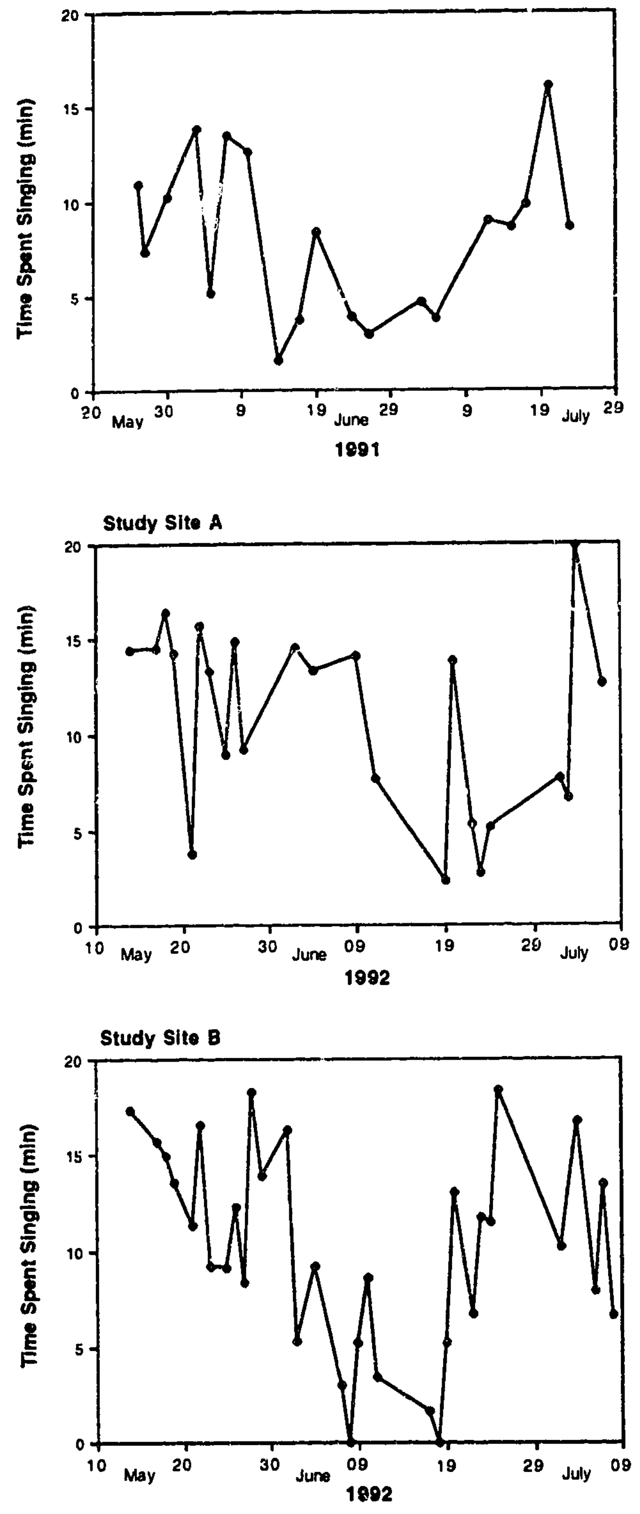
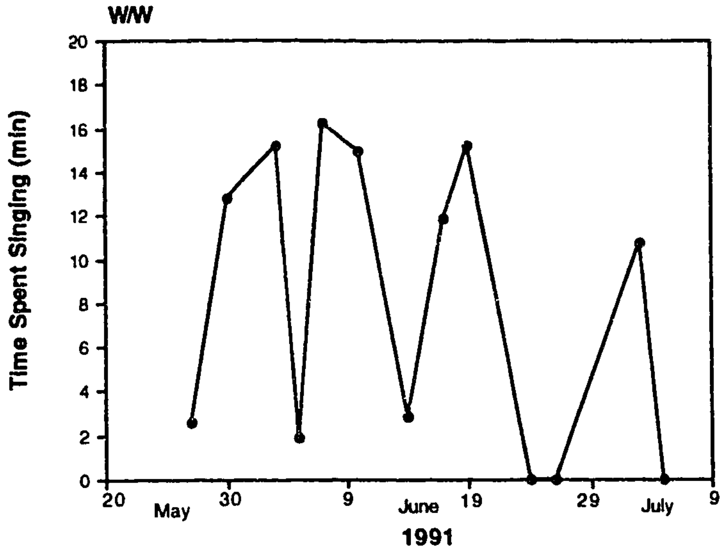


Figure III-1. Seasonal song variation of Baird's Sparrows. Data combine all individuals for each observation day from all study sites in 1991 and study sites A and B in 1992.



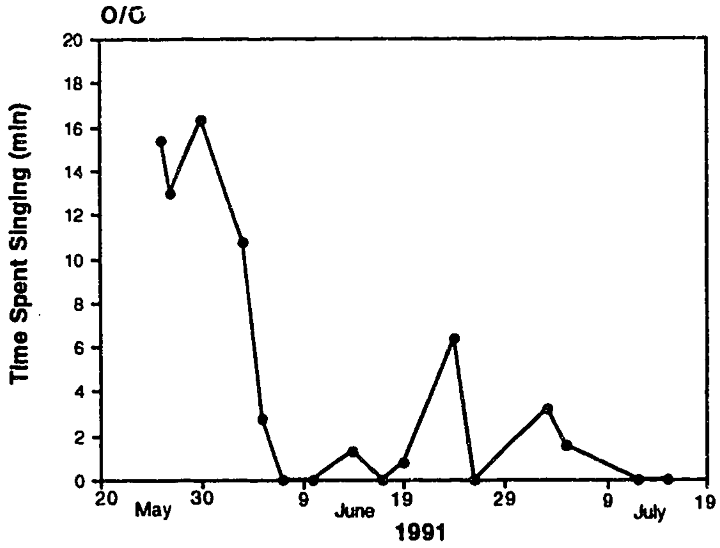


Figure III-2. Seasonal song variation of individual Baird's Sparrows W/W and O/O during 1991.

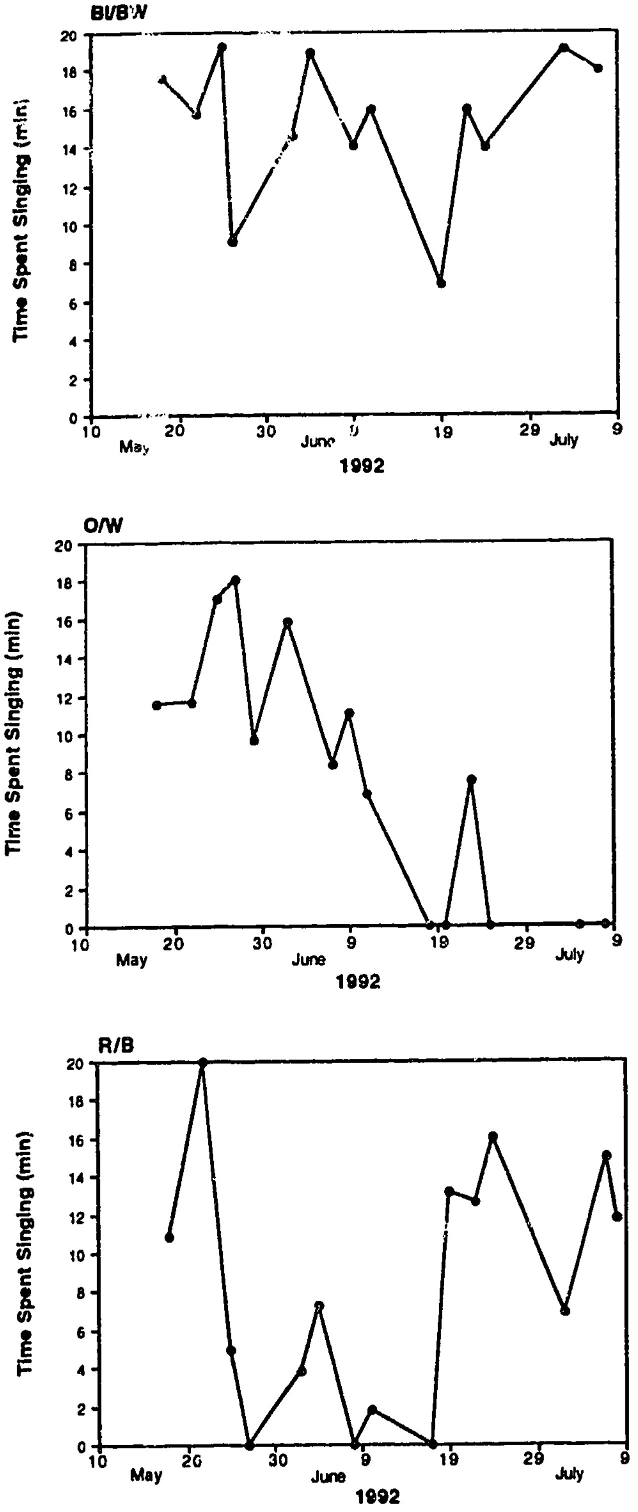


Figure III-3. Seasonal song variation of individual Baird's Sparrows Bl/BW, O/W, and R/B during 1992.

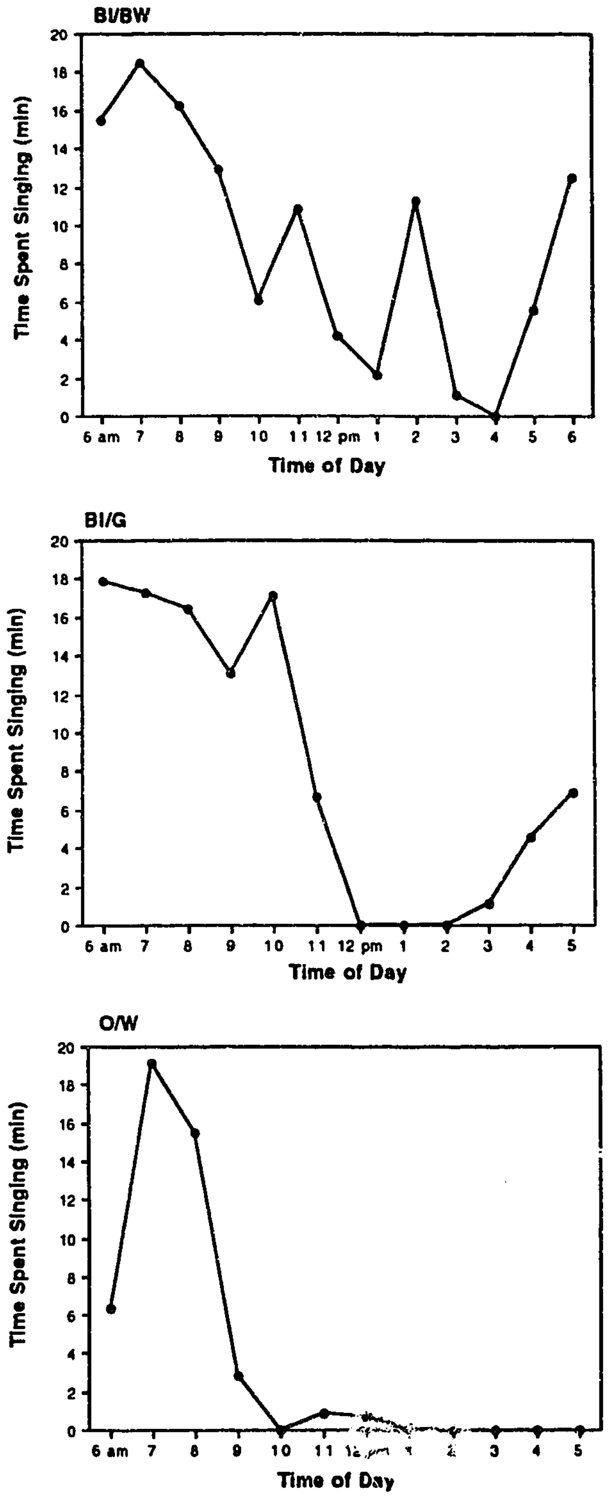


Figure III-4. Diurnal song variation of Baird's Sparrows during 1992. Territorial males BI/BW, BI/G, and O/W were observed for 12 hours June 3, 1992.

3.4.3 Weather Effects

The effects of cloud cover, temperature, and wind speed on time spent singing were examined using two sample tests that compared days of high and low song output. There were no significant differences in cloud cover (site A: $t=0.16$, $df=30$, $p>0.50$; site B: $t=0.36$. $df=63$, $p>0.50$), temperature at ground level (site A: $t=0.79$, $df=30$, $p>0.20$; site B: $t=1.10$, $df=63$, $p>0.20$), or at 1.5 m (site A: $t=0.98$, $df=30$, $p>0.20$; site B: $t=1.03$, $df=63$, $p>0.20$). Wind speed was also not significantly different between days of high and low song output at ground level (site A: $U=132.5$, $n1=15$ $n2=17$, $p>0.20$; site B: $U=537.5$, $n1=36$ $n2=29$, $p>0.50$), or at 1.5 m (site A: $U=115.5$, $n1=14$ $n2=17$, $p>0.20$; site B: $U=538.0$, $n1=36$ $n2=29$, $p>0.50$).

The effects of rain and fog on time spent singing were also examined based on presence or absence during an observation period. Although birds sang significantly less or rainy days ($F=6.943$, $p<0.05$), there was no significant difference between time spent singing on foggy and non-foggy days ($F=0.120$, $p>0.50$).

3.4.4 Effects on Singing Conspecifics

In this study, singing conspecifics were considered to be all males audible to the observer from the observed male's territory. During each observation period, the number of other males heard singing during each bout was recorded. A positive correlation existed between the number of singing males and the time spent singing ($r=0.455$, $p=0.0001$, $n=149$).

When the effects of seasonality were removed using the peak and valley method described earlier, there was no difference in the number of singing conspecifics on days of high and low song output (site A: $t=0.93$, $df=21$, $p>0.20$; site B: $t=0.32$, $df=50$, $p>0.50$).

3.4.5 Effects of Perch Use

Male Baird's Sparrows must make use of unconcealed, elevated perches within their territories to: (1) advertise their presence to competing males, and (2) attract females for mating. There was seasonal variation in exposed and concealed perch use

(Figure III-5). As the breeding season progressed, perch use declined corresponding to declines in singing intensity. Males used more exposed perches than concealed perches during the breeding season. Males singing from exposed perches sang significantly more songs (t=3.75, df=440, p<0.01), and in longer bouts (t=3.06, df=440, p<0.005) than those singing from concealed perches.

3.4.6 Detectability

In both sites A and B, almost all males were detected during the sampling periods in May (Figure III-6). In site A, 33% of known individuals were detected during the weeks of June 7 and 17, followed by an increase until censusing ended. In site B, detectability dropped to a low of 25% during the week of June 17, followed by increases and declines until censusing ended. The average time to detection for site A rose to a high of 116.33 seconds during the week of June 17, and 70.43 seconds for site B during the week of June 21 (Table III-1).

3.5 Discussion

3.5.1 Factors Influencing Singing Intensity

Seasonal variation in singing activity is caused by events in the breeding cycle. Breeding male Stonechats and Redwings reduce or stop singing activity during incubation (Greig-Smith 1982, Lampe and Espmark 1987), but begin again after fledging. Increases in song output after a breeding attempt may facilitate song-learning in young (Triesman 1978), stimulate the female to start a second clutch (Lampe and Espmark 1987), prevent the female from mating with neighbours, attract neighbouring females, and defend the territory against wandering males (Greig-Smith 1982). Although breeding data could not be included in this study, trends in singing activity suggest patterns reported previously for other passerines. Following peaks in singing activity in late May, song output of Baird's Sparrows declines or stops before increasing in late June and July (Figure III-2 O/O and Figure III-3 R/B). Baird's Sparrows are facultative re-nesters (DeSmet and Miller 1989). Increased singing by males may represent an attempt at a second brood.

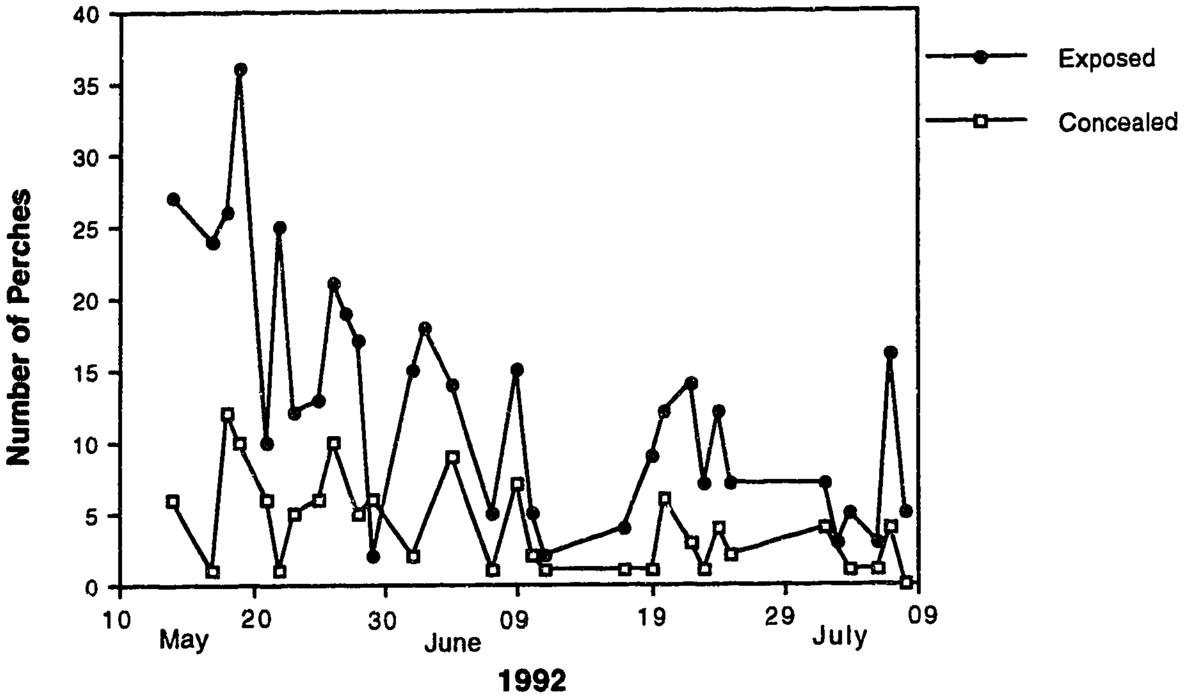


Figure III-5. Seasonal variation of exposed and concealed perch use during 1992. Data combine all individuals for each observation day from all study sites.

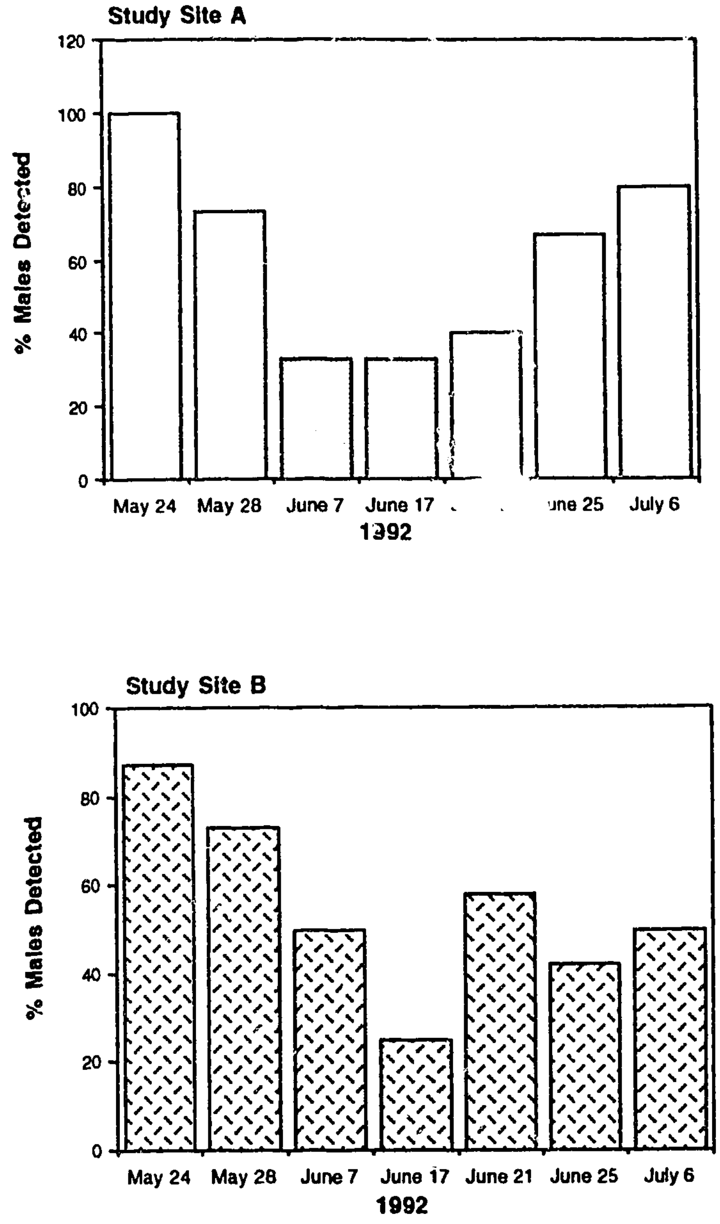


Figure III-6. Seasonal detectability by song of male Baird's Sparrows on known territories during 1992. Data were collected during a weekly census of study sites.

Table III-1
Time to First Detection of Censused Males in Study Sites A and B During 1992.

		Site A Detection Time (s)		Site B Detection Time (s)		
Census Date	N	$\bar{x}$	SE	N	$\bar{x}$	SE
May 24	9	0.44	0.44	13	39.46	21.11
28	8	5.38	3.18	11	4.09	1.97
June 7	3	13.67	13.67	8	27.88	22.14
17	3	116.33	80.43	4	26.25	14.89
21	2	0.00*	0.00	7	70.43	46.88
25	4	7.75	3.45	5	14.40	11.48
July 6	4	106.00	56.41	4	6.25	3.66

N=Number of detected males at each site.

*Time to first detection=0.00 s.

There is considerable individual variation in singing patterns during the breeding season due to nesting asynchrony, nest and mate loss, and mating status of territorial males. The singing intensity trends exhibited by W/W (Figure III-2) and Bl/BW (Figure III-3) suggests that not all males in the study sites are mated. It is likely that these males were not mated as no evidence of breeding was found. Greig-Smith (1982) studying male Stonechats and Gibbs and Wenny (1993) studying Ovenbirds (*Seiurus aurocapillus*) and Kentucky Warblers (*Oporonis formosus*) found that unmated males sing at a higher intensity than mated males throughout the breeding season.

For many passerines, diurnal variation in singing intensity is well documented. Time spent singing in Baird's Sparrows peaks in the hours just after dawn and declines to a lower level later in the morning. Singing intensity reaches its lowest point in the early afternoon before increasing with the onset of dusk. Other species that sing at their highest intensity during the dawn chorus include the Long-billed Marsh Wren (*Cistothorus palustris* Verner 1965), the Reed Warbler (*Acrocephalus schoenobaenus* Catchpole 1973), and the Pied Flycatcher (*Ficedula hypoleuca* Gottlander 1987).

Why birds sing at dawn is not easily understood. Henwood and Fabrick (1979) suggested that acoustic conditions at dawn are best for transmitting song over a wide area due to the lack of other background sounds. Given that many birds do sing at dawn, singing in the dawn chorus may not be effective for species with quiet songs (Mace 1987a). Kacelnik (1979) demonstrated that low light levels imposed a visual constraint on the foraging success of captive Great Tits (*Parus major*), and suggested that singing replaced foraging during periods of low light levels (dawn and dusk).

Mate acquisition is often cited as a cause for singing at dawn. Dawn may be the best time for non-territorial males to seek territories vacated by males that have died in the night (Kacelnik and Krebs 1982). Dawn may also be the best time to acquire a new female that has arrived during the night (Gottlander 1987). Singing at dawn may be a form of mate-guarding for Great Tits (Mace 1986, 1987b), used only when other males are perceived as a threat (Mace 1989).

Montgomerie (1985) has suggested that since food reserves are low at dawn, singing provides an honest advertisement of energetic status. A study of the blackbird (*Turdus merula*) by Cuthill and Macdonald (1990) demonstrates that both the nutritional state of the male and his mate's fertility affect the timing and intensity of dawn and dusk song in the blackbird.

The effects of temperature on singing activity have been well-studied. Cold overnight temperatures are linked to lower levels of morning singing activity due to energetic limitations (Garson and Hunter 1979, Reid 1987). After a cold night, energy reserves are at their lowest and males will spend more time foraging than singing. This relationship may only be reliable when it is quite cold. Reid (1987) found that song output in Ipswich Sparrows (*Passerculus sandwichensis*) varied annually due to the rise and fall of nightly temperatures around the average daily minimum. During mild seasons song output was higher than in cold seasons. Within seasons, Reid found only a weak relationship between warm nightly temperatures and increased song output.

Other studies have suggested that cold air temperatures are directly related to decreased singing activity (Slagsvold 1977, Gottlander 1987). Although birds may sing at higher rates during warmer parts of the day (afternoon or evening), peak singing activity still occurs in the hour just after dawn (Reid 1987). The positive temperature-activity relationships in the studies above were obtained by combining observation data from throughout the day. To determine the effect of temperature on peak singing activity, only data from early morning time periods should be considered.

I measured temperatures during early morning observation periods and found no differences in temperature on days of high and low singing intensity. These results suggest that other factors, such as time of season and number of singing conspecifics, may have a greater effect on the singing intensity of Baird's Sparrows during peak hours.

Weather variables such as cloud cover, wind speed, fog and rain have not been studied as extensively as temperature. Reid (1987) suggested that cloud cover and wind speed explained little of the variation in the time budgets of male Ipswich Sparrows. Robbins (1981b) in his study of weather effects on bird activity, used Breeding Bird Survey data to show that high wind speeds (> 20 km/h) and steady rain had the greatest effect on bird activity. Strong winds and heavy rain force birds to take shelter and stop singing. Although no strong winds were recorded during observation periods, steady rain did cause a significant decrease in the singing intensity of male Baird's Sparrows. Robbins (1981b) also suggests that a heavy overcast sky can delay the dawn chorus, but that the onset of singing depends on temperature and wind conditions. Although fog reduces visibility and therefore the ability to see birds during a census, it also improves the transmission of sound. Cloud cover and fog appeared to have no effect on Baird's Sparrow singing behaviour.

It was surprising that weather effects did not have a greater impact on singing intensity. Part of this is due to the cessation of observations during storm events or periods of extreme weather. This environment however is exposed to severe weather, particularly high winds, on a regular basis. As a consequence, the behaviour of birds may be less affected by these conditions than is the observer.

The presence of singing males appears to influence the time that a territorial male Baird's Sparrow spends singing. This relationship may be strongly influenced by seasonal effects on singing patterns. Although there was no significant difference between the number of singing conspecifics on days of high and low song output, there did exist a positive relationship between time spent singing and number of singing males when all data were examined. This suggests that males may only sing in response to other males at certain times in the breeding season. Competition between Baird's Sparrows appears to be most intense early in the breeding season when males are competing for territories and mates. Although males may sing to defend mates from intruders (Lampe and Espmark

1987), song patterns of Baird's Sparrows consistently show the highest song output at the start of the breeding season.

Data collected during this study suggests that singing behaviour differs for exposed and concealed perches. Selecting elevated perches may be a good strategy by male Baird's Sparrows as perches above the substrate increase the area of broadcast coverage (Greig-Smith 1982), therefore making song output more effective in mate attraction or territorial defense. The risk of predation is low as aerial predators in the grasslands of southwestern Alberta feed primarily on mammals (Godfrey 1986).

Males may choose concealed perches: (1) when they want to be heard but not seen (hiding from aerial predators) (pers. obs.), and (2) when they do not need to transmit sound across distance (communication with nearby mates) (Thorpe 1961).

3.5.2 Singing Intensity and Detectability: Implications for Census Techniques

How do factors influencing singing intensity affect the ability of a species to be detected during a census? For secretive species like the Baird's Sparrow, the seasonal and daily timing of a census, weather, and the number of singing conspecifics can restrict the observer's ability to detect a singing male.

Conducting a census too late in the breeding season may result in many territorial males not being detected due to periods of low singing activity. Despite differences in arrival dates in 1991 and 1992, suspected hatch dates and the onset of lower singing intensity occurred within the first two to three weeks of June in both years. Conducting a census during this time period would underestimate the true population size by 67-75%. Baird's Sparrows, like many other passerine species, peak in singing intensity just after dawn. Conducting a census late in the morning or at other times of the day will also underestimate true population levels.

Cloud cover, temperature, low to moderate wind speeds, and fog did not influence the singing behaviour of male Baird's Sparrows. Only rain will cause males to stop singing and take cover. Detectability will drop substantially in steady rain due to difficulties in hearing songs above the noise associated with rainfall. Rain not only alters the observer's ability to hear the bird, but also to locate it. Eye-glasses, and binoculars become objects of nuisance in rainstorms. Strong winds and extreme temperatures may also influence the behaviour of singing males and should be avoided during censusing to maximize detectability.

The presence of singing conspecifics appears to increase the singing intensity of territorial male Baird's Sparrows. The singing intensity of male Baird's Sparrows is likely driven by male-male competition to protect territories and mates. If the presence of surrounding males increases the detectability of a territorial male, small populations or populations of widely-spaced territories may be more difficult to detect.

Detectability is a function of a species' behaviour during the breeding cycle. Bell *et al.* (1968) documented that Sedge Warblers (*Acrocephalus scirpaceus*) became far more difficult to locate after pairing. Best (1981) also found that the ability to detect Field Sparrow (*Spizella pusilla*) males greatly declined after the onset of egg-laying. Baird's Sparrow males, although conspicuous when perched and singing, appear to disappear from their territories, only to be located again days or weeks later (pers. obs.). The secretive behaviour of this species provides a challenge to census takers. Consideration of temporal and environmental effects on the singing behaviour of Baird's Sparrows will increase the accuracy of census results. Obtaining reliable census results is an important part of conservation and management planning. Individuals or agencies involved in Baird's Sparrow surveys are encouraged to follow the above suggestions.

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4.0 THESIS DISCUSSION

4.1 Habitat Characteristics of the Baird's Sparrow

Baird's Sparrows have been found to occupy a number of habitats varying in vegetative composition and structure. Although little or no research has focused on determining the quantitative factors influencing habitat selection and breeding success in specific habitats, it has been suggested that the most important habitat for Baird's Sparrows is idle or lightly-grazed native prairie (for a review see DeSmet and Miller 1989). If the above suggestion is correct, the Baird's Sparrow is likely in serious peril as only small amounts of idle or conservatively grazed native prairie exist in the Canadian prairie ecosystem. Loss of habitat is complicated by range expansion and contraction where Baird's Sparrows are more abundant at moister sites during dry years, and at drier sites during wet years (Salt and Salt 1976, Kantrud and Faanes 1979). Clearly, it is necessary to determine specific habitat requirements in a variety of grassland habitats, including native and non-native grass communities, and rangeland with quantitative information on grazing intensity (stocking rate).

My results from Chapter 2.0 describe Baird's Sparrow habitat requirements in a native (rough fescue) and non-native (crested wheat grass-alfalfa) grass community. My findings support the suggestion by Sousa and McDonal (1983) that Baird's Sparrows will occupy non-native sites that have a similar vegetative structure to native sites (litter depth, upper stratum of mid-grasses and an understory of short grasses). The PC analyses showed that Baird's Sparrows could find habitats of similar structure in both sites A and B despite the differences in species composition. Baird's Sparrows selected areas that provided suitable perch sites for males and cover for adults and nests. Preferred perch sites were tall forbs, although clumps of tall grass that remained after grazing were also selected by male Bairds' Sparrows early in the season (pers. obs.). These results agree with those of Cartwright *et al.* (1937), who stated that Baird's Sparrows seek out territories with suitable perch numbers. Cover for adults and nests early in the season was provided by grass litter and new (this season's) and old (last season's) vegetation. Vegetation close to the ground was most likely a mixture of new and old vegetation, while taller vegetation was composed of ungrazed clumps of grass from last season. Later in the season, cover was provided by low, middle and tall canopy grasses, as well as a variety of forb species. At both sites Baird's Sparrows consistently chose areas with high forb coverage and significant vegetation density in the 0-20 cm range during June and July. The crested wheat grass-alfalfa site appeared to have uniform forb distribution and by July, was more homogeneous with respect to vegetation density that the rough fescue site. Areas with high grass densities were avoided in both sites, most likely due to reduced foraging efficiency in areas of dense grass (Bollinger *et al.* 1990). Recent studies of the Henslow's Sparrow (*Ammodramus henslowii*), a grassland specialist similar to the Baird's Sparrow, have described optimum habitat as grassland areas with tall, dense vegetation with high percentages of standing dead vegetation (Zimmerman 1988, Herkert 1994). Areas with high densities of standing dead vegetation and deep ground litter have a negative effect on the growth of new grass (Knapp and Seastedt 1986). The result is a more open habitat that may be more beneficial for ground dwelling species like the Henslow's Sparrow (Zimmerman 1988). Baird's Sparrows also appear to benefit from this type of open environment.

Agricultural practices like mowing and raking, and intensive grazing systems can remove extensive amounts of grass litter and standing vegetation making many habitats unsuitable for Baird's Sparrows. No experimental research has examined the effects of specific agricultural practices on breeding Baird's Sparrow populations. This study suggests however, that given the habitat requirements of this species, it is unlikely that these practices can be incorporated into management plans for this species. A number of studies examining the effects of grazing on grassland bird densities have included Baird's Sparrows (Owens and Myres 1973, Kantrud 1981, Kantrud and Kologiski 1982, Renken and Dinsmore 1987). Unfortunately, none of these studies included quantitative measures of grazing intensity, or data that specified Baird's Sparrow habitat features. This is the first study to specify range condition, grazing intensity, and structural vegetative characteristics for Baird's Sparrow habitat. Future studies could attempt to assess habitat requirements in manipulated range plots. Minimum and maximum values for litter depth, vegetation density, and forb coverage at different stocking rates could be determined. Only when habitat requirements are studied and understood in a variety of grassland environments can land managers begin to integrate Baird's Sparrow habitat requirements successfully into the agricultural and range practices of the prairie ecosystem.

Although repeated attempts were made to locate all nests of pairs in the study sites using a rope-dragging technique, this proved unsuccessful due to deep ground litter and large bunchgrass tillers that prevented the rope from flushing incubating females (pers. obs.). Some nests were found when observations of parents feeding nestlings revealed the nest location. Because I could not substantiate breeding attempts by all territorial males on the study sites, I could not compare habitat characteristics of successful and unsuccessful breeders. Martin (1989) suggests that habitat variables associated with reproductive success and survival influence habitat selection. In the above study sites, breeding success could have been significantly influenced by high populations of Richardson's ground squirrels (*Citellus richardsoni*) in the study area. Predation by Richardson's ground squirrels on eggs, nestlings, and fledglings of conspecifics in the study area was witnessed in three separate events and a predation study confirmed that the Richardson's ground squirrel was the primary nest predator in the study area (Mahon and Mahon 1994, in prep.). Studies examining breeding success in sites throughout the breeding range are necessary to determine if predation, as well as habitat loss and manipulation, could be causing population declines.

4.2 Factors Influencing Baird's Sparrow Detectability

The data presented in Chapter 3.0 suggests that Baird's Sparrow singing activity can be an indicator of events in the breeding cycle. My results suggest that mated birds peaked in singing intensity in late May just prior to egg-laying, while unmated birds sang at high intensities throughout the breeding season. These patterns of singing behaviour support similar findings for other passerines (Best 1981, Greig-Smith 1982, Lampe and Espmark 1987, Gibbs and Wenny 1993). Individuals planning to census Baird's Sparrows should schedule surveys during May or early June to maximize detectability.

Following individual patterns of singing intensity over the breeding season can provide an estimation of paired and unpaired birds within a population. This may be useful if data on breeding success is unattainable. Determining numbers of paired and unpaired males in a population could be critical if significant numbers of males are unpaired. Low reproductive output as a result of unpaired males can also contribute to population declines. High numbers of unpaired individuals within a population may be the result of sex-biased overwinter survival and age-biased survivorship (Terborgh 1989).

Baird's Sparrow surveys should take place in the early hours of the morning to maximize detectability, as singing declines and may stop completely later in the day.

Baird's Sparrow detectability may be reduced in areas with small numbers of territorial males or in areas with widely-spaced territories due to less male-male competition for territories and mates. The time spent conducting a census in these areas may have to be increased to accommodate low song output.

Environmental factors should also be considered during a census. Strong winds and heavy rain can affect the behaviour of territorial males and the ability of an observer to collect reliable data (Robbins 1981). Temperature, cloud cover, low to moderate wind speeds and fog did not appear to influence Baird's Sparrow singing behaviour.

Although only regional in its scope, this study has identified habitat requirements for Baird's Sparrows in the mixed prairie-fescue prairie transition zone in southwestern Alberta, as well as examining factors influencing detectability and therefore census results. This information will be valuable to conservation agencies, resource and wildlife managers, and private landowners who are interested in the preservation of this prairie specialist.

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