Passerine communities and bird-habitat relationships on prescribe-burned, mixed grass prairie in North Dakota

by Elizabeth Marie Madden

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biological Sciences
Montana State University

Abstract:
To more effectively manage remaining native grasslands and declining populations of prairie passerine birds, linkages between disturbance regimes, vegetation, and bird abundance need to be more fully understood. Therefore, I examined bird-habitat relationships on northern mixed-grass prairie at Lostwood National Wildlife Refuge in northwestern North Dakota, where prescribed fire has been used as a habitat management tool since the 1970's. I sampled bird abundance on upland prairie at 310 point count locations during 1993 and 1994 breeding seasons. I then measured vegetation structure and composition at each location. Complete fire histories were available for each point, with over 80% being burned 1 to 4 times in the last 15 years. Striking differences in bird species abundance were apparent among areas with different fire histories. Baird's, grasshopper, and Le Conte's sparrows, Sprague's pipits, bobolinks, and western meadowlarks were absent from unburned prairie, but were among the most common birds seen overall. In contrast, common yelIowthroats and clay-colored sparrows both reached highest abundance on unburned prairie. These data emphasize the importance of disturbance in maintaining grassland communities, and indicate that periodic defoliations by disturbances such as fire are crucial to the conservation of endemic grassland bird populations. Bird species examined were well-distributed over gradients of vegetation structure and composition. Sprague's pipits used the shortest and sparsest cover available. Baird's sparrows, grasshopper sparrows, and western meadowlarks used more moderate amounts of vegetation cover. Bobolinks and Le Conte's sparrows preferred taller and denser cover, especially of exotic grasses. Savannah sparrows were ubiquitous, clay-colored sparrows and common yellowthroats were distinctly shrub-associated, and brown-headed cowbirds were habitat generalists. Sprague's pipits and Baird's sparrows showed preferences for native grasses. The results indicate that a mosaic of vegetation successional stages maximizes avian biodiversity.

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APPROVAL

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Elizabeth Marie Madden

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

To more effectively manage remaining native grasslands and declining populations of prairie passerine birds, linkages between disturbance regimes, vegetation, and bird abundance need to be more fully understood. Therefore, I examined bird-habitat relationships on northern mixed-grass prairie at Lostwood National Wildlife Refuge in northwestern North Dakota, where prescribed fire has been used as a habitat management tool since the 1970's. I sampled bird abundance on upland prairie at 310 point count locations during 1993 and 1994 breeding seasons. I then measured vegetation structure and composition at each location. Complete fire histories were available for each point, with over 80% being burned 1 to 4 times in the last 15 years. Striking differences in bird species abundance were apparent among areas with different fire histories. Baird's, grasshopper, and Le Conte's sparrows, Sprague's pipits, bobolinks, and western meadowlarks were absent from unburned prairie, but were among the most common birds seen overall. In contrast, common yellowthroats and clay-colored sparrows both reached highest abundance on unburned prairie. These data emphasize the importance of disturbance in maintaining grassland communities, and indicate that periodic defoliations by disturbances such as fire are crucial to the conservation of endemic grassland bird populations. Bird species examined were well-distributed over gradients of vegetation structure and composition. Sprague's pipits used the shortest and sparsest cover available. Baird's sparrows, grasshopper sparrows, and western meadowlarks used more moderate amounts of vegetation cover. Bobolinks and Le Conte's sparrows preferred taller and denser cover, especially of exotic grasses. Savannah sparrows were ubiquitous, clay-colored sparrows and common yellowthroats were distinctly shrub-associated, and brown-headed cowbirds were habitat generalists. Sprague's pipits and Baird's sparrows showed preferences for native grasses. The results indicate that a mosaic of vegetation successional stages maximizes avian biodiversity.

CHAPTER 1: THESIS INTRODUCTION

Grasslands of the North American Great Plains historically were maintained as treeless, herbaceous communities by climate and periodic disturbances, especially fire and grazing (Sauer 1950, Wells 1970, Kucera 1981). European settlement of the Great Plains disrupted these natural processes. Large tracts of prairie were lost completely upon conversion to cropland. Fire suppression and replacement of native herbivores (e.g., bison [Bison bison] and prairie dogs [Cynomys ludovicianus]) with domestic livestock altered natural disturbance patterns on remaining prairie.

In response to the dynamic environment of the Great Plains, grassland birds show considerable fluctuations in seasonal ranges and densities, and bird diversity and density are low in grasslands compared with most other habitats (Cody 1985). Climate, especially climatic instability, is believed to be the main driver of these bird populations (Wiens 1974, Zimmerman 1992). It affects birds both directly (i.e., effects of drought/flooding), and indirectly, through its influence on vegetation. The role of vegetation structure and composition in determining grassland bird habitat use has been well-documented (Cody 1968, Wiens 1969, Rotenberry and Wiens 1980). Grassland vegetation is patterned largely by climate, and locally by disturbance and land use practices (e.g., fire, herbivory, agriculture), and area geomorphology. These processes, in turn, all drive grassland bird abundance and distribution (Figure 1).

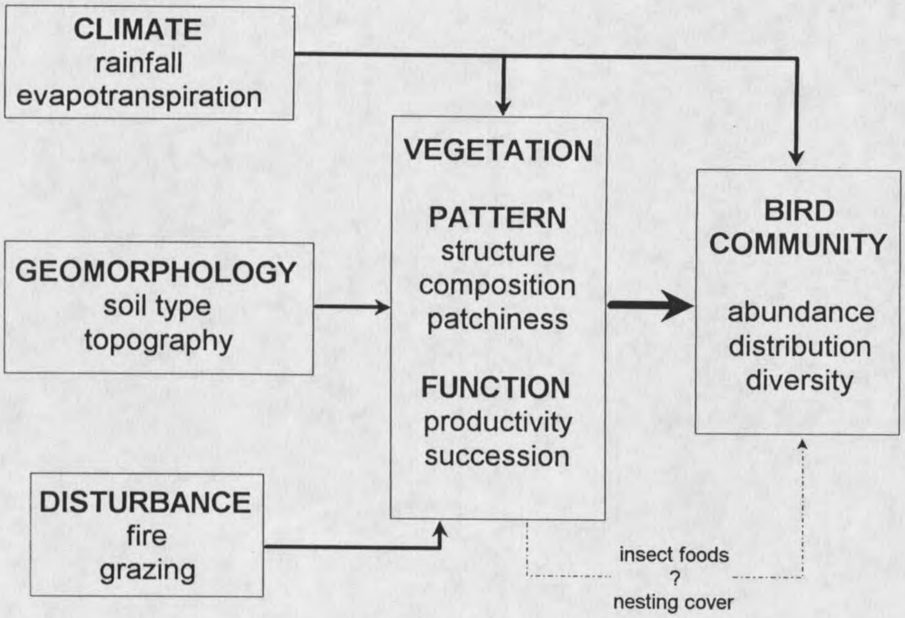

Figure 1. Factors driving grassland bird populations on the Great Plains.

This thesis explores the role of one type of grassland disturbance, fire, in defining vegetation patterns and bird communities in mixed-grass prairie. Fire is integral to grassland ecology; without it, most grasslands would ultimately succeed to forest or shrubland (Sauer 1950, Wells 1970). Fire reduces woody vegetation, increases productivity by removing dead plant material and releasing soil nutrients bound up in litter, and increases native vegetation growth and reproduction (Kucera 1981, Wright and Bailey 1982).

Although fire has always played a large role in maintaining Great Plains grasslands, it is difficult to estimate historic grassland fire patterns without trees to carry records of burning in fire scars. Extrapolating from fire histories in grasslands under pine forests, Wright and Bailey (1982) estimated a 5-10 year fire frequency for grasslands. Assessing rates of fuel accumulation and woody plant invasion has produced estimates of 3-4 year fire return intervals (FRI) in tallgrass prairie, 4 years in sandhill prairie, 6 years in northern mixed prairie (with up to 25 years in the dry, western mixed prairie), and 5-10 years in short-grass prairie (Bragg 1995). Grasslands receiving more moisture have higher productivity and thus are more fire-dependent (Kucera 1981). The distinction between drier and mesic mixed prairies is important, as fire effects appear to differ greatly with varying moisture conditions between these areas (Higgins et al. 1989, Wright and Bailey 1982).

Resource managers on the Great Plains often incorporate prescribed fire into habitat management, but information on fire effects is sparse, and managers often must rely on personal experience as a gauge for management decisions. Objectives of this thesis were to define relationships among bird abundance, habitat features, and fire history on northern mixed-grass prairie. The ultimate goal was to provide land managers with predictive models relating vegetation characteristics and bird occurrence. My general approach was to sample vegetation and birds over the stages of fire succession and explore relationships among them. Chapter 2 examines the effects of prescribed fire on prairie bird communities, and secondarily on prairie vegetation. Chapter 3 defines grassland bird-habitat associations. A final summary links conclusions and implications of both parts.

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CHAPTER 2

EFFECTS OF PRESCRIBED FIRE ON MIXED-GRASS PRAIRIE PASSERINE COMMUNITES IN NORTHWESTERN NORTH DAKOTA

INTRODUCTION

In the past 30 years, grassland birds have exhibited the most significant, widespread declines of any group of North American birds, including neotropical migrants (Knopf 1994). Declines in nonmigratory grassland birds (Finch 1991, Dobkin 1992) indicate that declines are at least partly due to problems on the breeding grounds.

Grasslands represent the largest vegetative province in North America (Knopf 1994). Cumulative effects of overgrazing, suppression of fire, and conversion of prairie to cropland have severely reduced and fragmented grassland habitats throughout the Great Plains. Remaining tracts of native prairie thus become increasingly valuable, and their proper management critical.

Individual bird species do not respond alike to common grassland management practices, with various species preferring specific habitat conditions along a continuum of prairie succession (reviews in Kirsch et al. 1978, Ryan 1990, Dobkin 1992). Species that prefer vegetation communities promoted by human activities such as mowing, season-long grazing, and fire suppression generally have benefited, while those requiring more natural disturbance regimes (i.e., periodic fire and grazing) have suffered serious declines in recent years (Dobkin 1992).

To improve the effectiveness of managing both grassland birds and remaining native prairies, linkages between disturbance regimes, vegetation, and bird communities need to be more clearly understood. Given that avian demographic data are expensive and difficult to collect, habitat studies based on bird abundance provide a practical alternative for studying multi-species communities (Hansen et al. 1993). Although such studies cannot determine causal mechanisms for the observed patterns or be assumed to measure actual habitat quality or selection (Van Horne 1983), they are useful in determining and predicting bird occupancy patterns for management purposes.

Few studies have addressed effects of fire on prairie passerines. These typically include only a single burn and control (Huber and Steuter 1984, Pylypec 1991) and most follow responses for only 1-3 years postfire (Forde et al. 1984, Herkert 1994). My goal was to document longer-term effects of fire by examining multiple, independent burns done over an extended period (15 years) in mixed-grass prairie.

The objective of this study was to quantitatively define relationships between fire history and bird abundance in northern mixed-grass prairie, and secondarily, to assess associated vegetation. Key questions were:

1) How do songbird abundance and species richness vary over stages of fire succession in northern mixed-grass prairie?

2) What are the characteristics of vegetation associated with these successional stages?

STUDY AREA

Lostwood National Wildlife Refuge (LNWR) covers 109 km^2 of rolling to hilly, mixed-grass prairie in Mountrail and Burke counties, northwestern North Dakota (48°37'N; 102°27'W) (Figure 2). Its large tracts of grassland are interspersed with more than 4100 wetland basins and many clumps of quaking aspen (Populus tremuloides). Habitat composition is 55% native prairie, 21% previously-cropped prairie (revegetated with tame and native prairie plants), 20% wetland, 2% trees, and 2% tall shrubs (Murphy 1993). Major vegetation is a needlegrass-wheatgrass (Stipa spp.- Agropyron spp.) association (Coupland 1950), with diverse forbs and scattered shrubs.

When delimiting the study area, I excluded the extreme southern and western portions of the refuge because they differed significantly from the rest of the refuge in topography, soils, and vegetation. Several other areas, including 6 western-most sections of the Lostwood Wilderness Area (Figure 2), were excluded because many parts had been tilled and cropped into the 1950s and were dominated by tame grasses.

LNWR lies within the Great Plains physiographic region known as the Missouri Coteau (Bluemle 1980). This 20-30 km wide strip of dead-ice moraine deposited by the Wisconsin glacier is characterized by knob-and-kettle

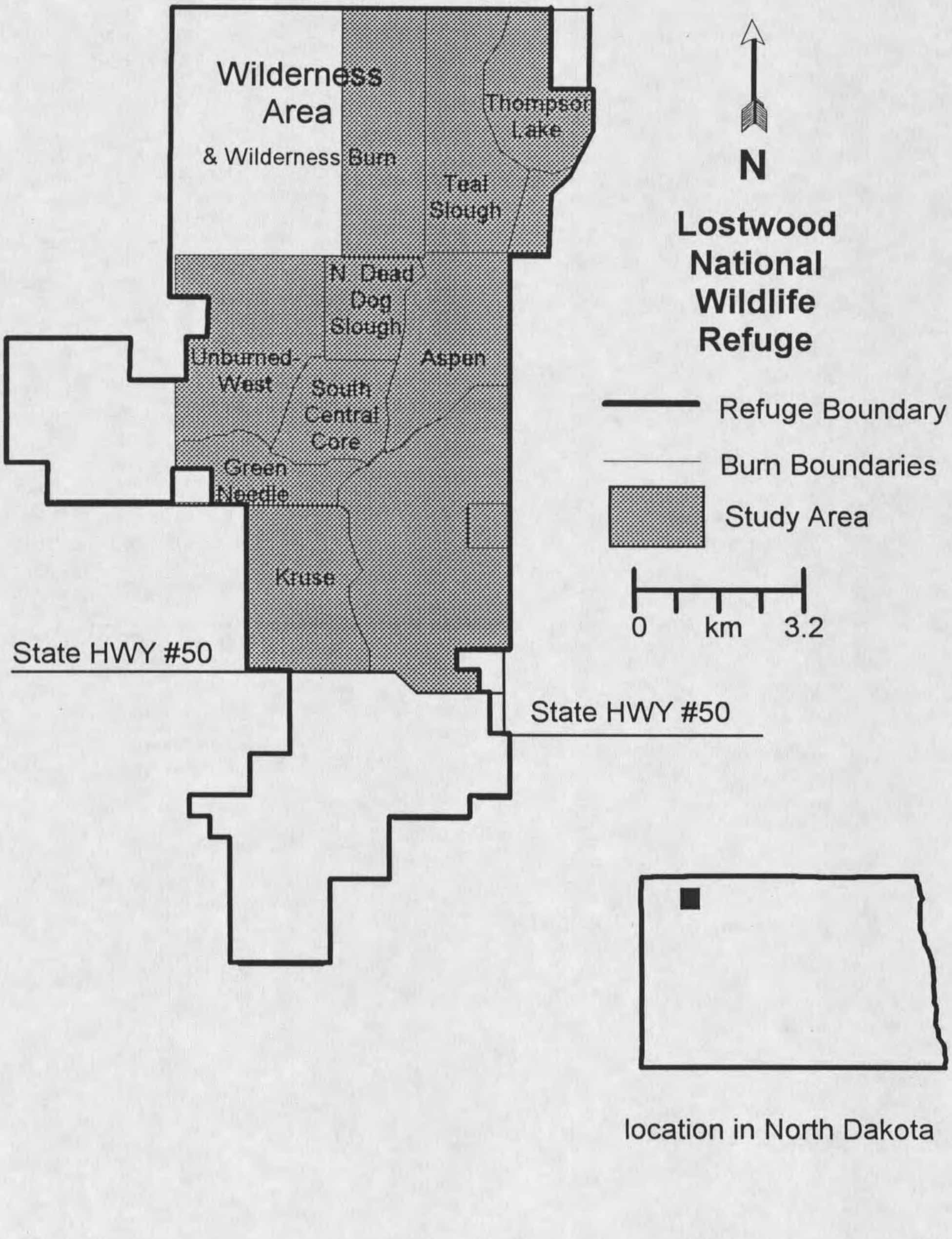

Figure 2. Lostwood National Wildlife Refuge, North Dakota, with area of study and burn units delimited.

topography (685 - 747m) with non-integrated drainage (i.e., precipitation collects in wetland basins via surface runoff and seepage) and prairie pothole wetlands of varied sizes and hydrologic types (see Stewart and Kantrud 1971).

The climate in this region is semi-arid, with individual years ranging from humid to arid (Weaver and Albertson 1956). Drought occurs often, and dry years tend to be grouped together, alternating with years of above-average precipitation. Temperatures range widely, with average monthly temperatures of 20°C in July and -15°C in January (Jensen 1972). Mean annual precipitation on the refuge is 42 cm, with a range of 22-74 cm (1936-89; USFWS unpubl. refuge files). Most (>75%) precipitation falls as rain between April and September, with May and June normally the wettest months. This study incorporated one extremely wet season (1993) and one drier season (1994). It was initiated at the end of 6 years of drought: most wetlands except major lakes were completely dry in early spring 1993. This drought ended during the 1993 breeding season, when 38 cm of rain fell in May, June, and July (54-year average for this period is 20 cm; USFWS unpubl. refuge files). Wetland basins began filling over the summer, and heavy snowfall over winter further filled basins. The 1994 field season was much drier, with only 14 cm of rain falling in May, June, and July.

LNWR is within the northern region of the mixed-grass prairie (Singh et al. 1983), supporting a mix of approximately 60% cool-season (C_3 photosynthetic pathway) and 40% warm-season (C_4) grasses. Although upland vegetation is dominated by needlegrasses and wheatgrasses, the plant community is extremely diverse; tall- and short-grass prairie types are intermixed. LNWR's undulating topography provide diverse vegetation microsites based on soil type, moisture, and slope and aspect. Native mesic communities include big bluestem (Andropogon gerardii), switchgrass (Panicum virgatum), prairie dropseed (Sporobolus herterolepis), porcupine grass (Stipa spartea), and little bluestem (Schizachyrium scoparium). Native xeric sites (usually hilltops) are comprised mainly of blue grama (Bouteloua gracilis), threadleaf sedge (Carex filafolia), prairie junegrass (Koeleria gracilis), and plains muhly (Muhlenbergia cuspidata). Family Asteraceae dominates the forb community, but over 40 other families are represented (LNWR Herbarium List 1991, unpubl. data). Western snowberry (Symphoricarpos occidentalis) is the dominant low (<1m) shrub, with silverberry (Elaeagnus commutata) and western wild rose (Rosa woodsii) also common. Tall (1-4m) shrub thickets of chokecherry (Prunus virginiana), serviceberry (Amelanchier alnifolia), and round-leaved hawthorn (Crataegus chrysocarpa) are scattered over the landscape. Exotic grasses (Kentucky bluegrass [Poa pratensis], smooth brome [Bromus inermis], and quack grass [Agropyron repens]) have become established on large areas of the refuge.

Before European settlement, the landscape of LNWR was a treeless expanse of mixed-grass prairie, maintained in a shorter grass, or even barren state due to frequent fire and bison impacts (Murphy 1993). Reconstruction of pre-settlement vegetation patterns for the area indicate western snowberry probably covered <5% of upland areas, and almost no trees existed in the late 1800's (Murphy 1993). Aspen was limited to aspen suckers and saplings around wetland borders. Murphy's (1993) review of early historical accounts also indicated that the area had periodic rest from disturbance, during which vegetation would recover. Best estimates are that this region supports a 5 to10-year fire return interval (Wright and Bailey 1982:81, Murphy 1993, Bragg 1995).

Although some of LNWR was tilled and farmed during the early 1900s, most (70%) upland areas remained unbroken and were either rested or grazed season-long during 1930s-1970s. Settlers suppressed lightning fires, resulting in a loss of early successional vegetation (i.e., grassland). Western snowberry, quaking aspen, and exotic grasses have proliferated and now dominate the mixed-grass community. By 1985 western snowberry covered >50% of upland areas, and aspen had increased from no tree clumps in 1910 to 518 clumps covering 184 ha: most of LNWR could now be classified as aspen parkland instead of mixed-grass prairie (Murphy 1993).

Several studies have made reference to the idea of present-day LNWR being better classified as aspen parkland. In a floristic study of northwestern North Dakota, Hegstad (1973) noted that the area of Missouri Coteau around LNWR is slightly higher and cooler, and has higher rainfall than surrounding areas of the Coteau, creating a unique floristic composition that "...has the appearance of an aspen parkland..." (Hegstad 1973:26). Murphy (1993) also refers to the uniqueness of this area, delineating approximately 900 km^2 of the Missouri Coteau (including LNWR) as being more suitable for development of woody vegetation. This localized area of mesic and forested prairie stands out as a small island on the range map of aspen in western United States (DeByle and Winokur 1985:9).

LNWR was created in 1935 "... as a refuge and breeding ground for migratory birds and other wildlife..." (Executive Order 7171-A 1935). The refuge mission is:

> To restore and preserve the indigenous biological communities of the mid- to late 1800s on a representative sample of the physiographic region known as the Missouri Coteau of the Northern Great Plains' mixed-grass prairie..

Since the 1970s, USFWS has used prescribed fire to reduce woody vegetation and restore a more natural diversity of successional stages to LNWR. The refuge is divided into approximately 20 prescribed burn units, ranging from 5 to 2265 ha, with an average size of 310 ha. Between 1978 and 1993, 5-35% of the refuge was burned annually ($\underline{n}$ = 63 burns), with most prescribed burns (75%) conducted in summer (mid-July through August), and the remainder in late spring (late April through early May). Burns typically were conducted in 10-30 kmh wind, 20-40% relative humidity, and 10-30°C, and generally removed 80-95% of above-ground biomass. Short-duration grazing has also been used since 1989 to help accomplish habitat management objectives.

Management geared toward restoring or maintaining indigenous plant and wildlife species at LNWR involves three phases (U.S. Fish and Wildlife Service 1994): 1) Renovation, 2) Renovation-Maintenance, and 3) Maintenance. The first phase, Renovation, utilizes burning 3-5 times over 7-10 years. Currently 50% of the refuge is in this phase. The second stage, Renovation-Maintenance, involves about 3 years of grazing, 2-3 years of rest, and 1-2 burns over a 7-year period. 15% of the refuge is in this phase. In the third stage, Maintenance, burning and grazing would be alternated with rest periods of 2-3 years. None of the refuge is yet in this phase. Thirty percent of the refuge has not yet received any treatment except rest or season-long grazing from 1940-1970, and another 5% (all previously cropped) is in a re-seeding program for native grasses and forbs.

At least 226 species of birds occur on LNWR, with 104 species documented as breeding on the refuge (Murphy 1990). These include many wetland-dependent species (waterfowl, rails, shorebirds, passerines), as well as upland breeders (raptors, shorebirds, sharp-tailed grouse [Tympanuchus phasianellus], passerines). Common migratory songbirds breeding on upland areas include eastern kingbird, house wren, Sprague's pipit, common yellowthroat, a variety of grassland sparrows (grasshopper, Baird's, Le Conte's, vesper, savannah, song, clay-colored), bobolink, western meadowlark, Brewer's blackbird, brown-headed cowbird, and American goldfinch (See Appendix A for scientific names of bird species).

METHODS

Study Design

This study was designed in conjunction with an assessment of vegetation correlates of prairie bird abundance (Chapter 3). I measured bird abundance and vegetation characteristics on 160 (1993) and 150 (1994) sample points distributed over 9 independent burns. Sample point selection was done systematically in 1993, and was then modified to include a randomized, systematic design in 1994. Sample points were $\geq$ 250 m apart to provide statistical independence in terms of birds and vegetation (Hutto et al. 1986, Ralph et al. 1993) (see Chapter 3). Sample points within a burn unit were not independent in terms of fire history. Therefore data within a burn were averaged when comparing birds and vegetation among units of different burn history.

Plot Selection

1993 Field Season

In 1993 sample points were located systematically over upland prairie across the study area. On a map of the study area I gridded each square mile section into 268- by 268-m blocks and used the grid intersections as potential point count locations. This assured that all points were >250 m apart. To be included as sample points, points had to be: (1) located in "upland prairie" as delineated by the National Wetland Inventory (NWI) map of cover types of LNWR (NWI Project 1989), (2) ≥200 m from any aspen grove, (3) ≥50 m from roads or firebreaks, and (4) currently ungrazed. These restrictions limited confounding effects from surrounding habitats and alterations, allowing me to concentrate on upland prairie treated with fire. Large areas of cropland that had been tilled through the 1950s also were omitted, but pre-1935 cropland areas, which were revegetated with native plants and appeared similar to existing native prairie, were included for sampling (about 12% of points were in pre-1935 cropland).

Although these points were not chosen using a random sampling probability design, the grid pattern placed points in essentially a random pattern relative to landscape features (i.e., the grid pattern did not follow any obvious environmental gradients or biases). In all likelihood selected points were independent of vegetation and environmental patterns.

Of 185 selected sampling points, the 10 most remote were omitted to improve sampling efficiency, and an additional 15 were omitted after ground-truthing revealed unexpected problems (e.g., chemical spraying/mowing for leafy spurge [Euphorbia esula]). One hundred and sixty points ultimately were selected and sampled. A field assistant and I located points in the field by pacing on a compass bearing from marked section corners and then ground-truthing with aerial photographs (1:7920). Each point was marked with a flagged, 1-m tall wooden stake painted white at the top. A 50-m radius was measured and flagged at a conspicuous spot. Points could be easily relocated by an observer travelling north-south or east-west from point to point.

1994 Field Season

In 1994 I used the same study area as 1993, but plot selection incorporated a random sampling design. I generated a random, systematic grid for each square mile section by randomly picking 2 numbers between 0-250 m to serve as the X and Y coordinates in the southwest corner of the section. From this random starting point, I gridded points every 250 m north and south across the grid. With this grid overlaid on it, each square mile section had 49 possible point count locations (each grid intersection was a possible point count location). I then excluded any points not meeting the 1993 selection criteria, although I reduced the buffer from roads and aspen from 200 m to 100 m based on 1993 sampling observations, and added a 50 m buffer from any seasonally flooded wetland zone because of high water levels. To improve sampling efficiency, the 10 most remotely-situated points in each burn unit were omitted from consideration. This left a total of 265 potential points, from which I randomly selected 150 sample points.

A field assistant and I located points in the field as in 1993, and measured and flagged 30-, 50-, and 75-m radii with 0.2-m wire surveying flags to facilitate accurate distance estimation to birds. If ground-truthing revealed unexpected problems, e.g., chemical spraying for leafy spurge, we paced an additional 50 m on the same orientation and placed the point.

Fire History

Fire history for each plot was compiled from LNWR maps and narratives (Table 1). Fire history was described as: 1) number of years since the plot was burned (0.5-8 or >80 years), and 2) number of times the plot was burned in last 15 years (0-4 times). Fire variables were later divided into categories to test for differences in bird abundance and vegetation among them.

Number of years since last burn and number of burns were correlated (r = -0.62), i.e., areas burned recently tended to have been burned many times. This could potentially confound results, making it difficult to tease out relative impacts of each variable. As both variables played a role in defining fire history, I combined them into an index to describe the amount of fire an area had experienced:

Fire Index (FI) = Number of Burns/Years Since Last Fire

Using this formula, sampled burn units were scaled from 0 (no fire) to 6 (many burns, recently). Although there may be problems extrapolating this precise index to all fire histories, it appeared to aptly describe the 9 burns sampled in this study, extending them along a reasonable gradient of amount of fire experienced.

Table 1. Prescribed burn units sampled, LNWR, 1993 and 1994.

		1993				1994			
Burn name	Size (ha)	n[a]	No. burns	YSF[b]	Fire Index[c]	n[a]	No. burns	YSF[b]	Fire Index[c]
Unburned - West	526	17	0	>80	0.00	12	0	>80	0.00
Unburned - C[d]	75	3	0	>80	0.00	----	----	----	----
Unburned - S.C.Core	445	15	0	>80	0.00	18	0	>80	0.00
Green Needle	398	11	1	6	0.17	6	1	7	0.14
Wilderness	2265	34	2	5	0.44	25	2	6	0.33
N. Dead Dog Slough	89	5	4	7	0.57	9	4	8	0.50
Kruse	645	23	2	3	0.67	20	3	0.5	6.00
Aspen	518	10	2	0.5	4.00	20	2	2	1.00
Thompson Lake	372	14	4	1	4.00	20	4	2	2.00
Teal Slough	494	28	4	1	4.00	20	4	2	2.00

[a] Number of sample points within burn unit
[b] YSF = Years Since last Fire
[c] Fire Index = Number of burns/years since last fire
[d] Not used in fire analyses in 1993 and not sampled in 1994

Bird Abundance Sampling

To estimate bird abundance, I used the fixed-radius method for point counts (Hutto et al. 1986) in 1993. In 1994 I modified methods to include distance sampling (Buckland et al. 1993). This involved estimating the distance