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Grassland Songbird Response To Landscape Composition And Vegetation In Northeastern And East-Central North Dakota

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GRASSLAND SONGBIRD RESPONSE TO LANDSCAPE COMPOSITION AND VEGETATION IN NORTHEASTERN AND EAST-CENTRAL NORTH DAKOTA

By

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ABSTRACT

Grassland songbirds are declining faster and more consistently than other avifauna of North America. This has resulted in many species being placed on state and federal lists as species of concern. These declines can be linked to former and current land use practices which have resulted in an extensive loss of habitat. Natural resource agencies are trying to offset these habitat losses by reconstructing grasslands formerly cropped areas and protecting remaining grassland tracts. Few studies have addressed how the location in the landscape and vegetation composition of these reconstructions affects grassland birds. This thesis describes data collected from 32 locations on habitat use and the influence of the surrounding landscape on twenty grassland obligate, grassland user, and wetland bird species. I found that site composition of grassland reconstructions matters in terms of bird species richness in northeastern and east-central North Dakota, as well as the amount of native vegetation within a site. It was also found that certain landscape variables (e.g., amount of open water and woody vegetation) influence bird species richness suggesting that seed mix and location of grassland reconstruction is fundamental to maintaining or increasing grassland obligate, grassland user, and wetland avian populations.

CHAPTER I

INTRODUCTION TO HABITAT ASSOCIATIONS OF GRASSLAND BIRDS

Introduction

Grasslands are one of the eight major biomes of the world and can be defined as "large, flat lands or areas with rolling hills" (Gray 2000). Grasslands have nutrient rich, highly productive soils (Piper 1995) that support a variety of plant and animal species and benefit local economies through tourism, pollination, ecosystem services, and cooperative agreements (e.g., haying and grazing). These productive soils are ideal for production of annual, agricultural crops and have resulted in the conversion of prairie to crop production. Loss of remnant prairie has resulted in an overall decline in plant and animal biodiversity (Samson and Knopf 1994, Bragg and Steuter 1995, Johnson 1996, Davis et al. 1999, Madden et al. 2000, Stephens et al. 2005), occasionally resulting in threatened or endangered species. Loss of biodiversity can also directly impact local businesses. The overall decline in grasslands and the plant and animal species that inhabit them has resulted in a stronger focus by natural resource organizations on managing and protecting these declining resources.

Grasslands

General Description

In North America, remnant prairie can be broken into three categories: tallgrass, mixed-grass, and shortgrass prairie (Carpenter 1940, Hagen et al. 2005) based on the height and species of grasses present, which is often a result of the total annual precipitation (Ladd et al. 1995). As the annual precipitation increases from west to east, conditions allow for taller, more robust grasses (USFWS 2008a). The northern tallgrass prairie is primarily composed of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), slender wheatgrass (*Elymus trachycaulus*), and porcupine grass (*Hesperostipa spartea*; Ladd et al. 1995, Johnson and Larson 1999, Hagen et al. 2005, USFWS 2008a). The mixed-grass prairie is primarily composed of prairie Junegrass (*Koeleria macrantha*), blue grama (*Bouteloua gracilis*), little bluestem, big bluestem, western wheatgrass (*Pascopyron smithii*), needle and thread (*Hesperostipa comata*), porcupine grass, green needlegrass (*Nassella viridula*), prairie cordgrass (*Spartina pectinata*), and northern reedgrass (*Calamagrostis stricta*; Johnson and Larson 1999, Hagen et al. 2005, NDGF 2005, USFWS 2008a). The shortgrass prairie is primarily composed of western wheatgrass, needle and thread, green needlegrass, blue grama, sideoats grama (*Bouteloua curtipendula*), little bluestem, and buffalograss (*Bouteloua dactyloides*; Johnson and Larson 1999, Hagen et al. 2005, USFWS 2008a).

Trends and Functions

Historically, prairies were the largest ecosystem in North America, covering almost 1.5 million square kilometers (Knopf 1994). Today, they are one of the most threatened ecosystems having declined by as much as 80% nationwide (Samson and Knopf 1994, Noss et al. 1995, Samson et al. 1998, Conner et al. 2001). In North Dakota, there has been an estimated 70% grassland acreage loss since settlement (Conner et al.

2001), resulting in less than 1% eastern tallgrass prairie and about 32% mixed-grass prairie remaining (Samson and Knopf 1994, Samson et al. 1998).

Grasslands provide numerous beneficial ecosystem services on the landscape. They serve as primary nesting habitat for countless bird species, staging and feeding areas for waterfowl and shorebirds, provide an important food source for small mammals and insects, and support larger wildlife species (USFWS 2008a). Additionally, grasslands control erosion, maintain clean air and water, provide income from recreation and tourism, and provide rich soil (USFWS 2008a). Public recognition of the decline of remnant prairie in North Dakota and throughout the Great Plains has increased over the past decade (USFWS 2008a). Along with this, several programs are now in place by state, federal, and non-profit natural resource organizations to protect the remaining remnant prairies.

Reconstructions

Many natural resource organizations have worked to convert areas of agricultural production into grassland habitat. This not only puts habitat on the landscape, but a portion of the habitat that is reconstructed is done so by using a diverse mix of plant species that would commonly be found on undisturbed, remnant prairie. Recreating the elements found in the original communities may be the optimal method for ensuring continued species interactions (Howell 1988). However, diverse seed mixes are not always utilized and are a relatively new practice on the landscape. Traditionally, in North Dakota, areas of agricultural production were reconstructed with seed mixes that included introduced grasses (tall wheatgrass *Thinopyrum ponticum*, intermediate wheatgrass *Thinopyrum intermedium*, yellow sweetclover *Melilotus officinalis*, alfalfa *Medicago* *sativa*; USFWS 2008b). Seed mixes containing these introduced grasses are referred to as dense nesting cover (DNC). In North Dakota today, more reconstructions are taking place that use mixtures of native grass and forb seed over the traditional DNC seed mix that included introduced grasses.

Grassland Birds

Grassland birds can be defined as "any species that has become adapted to and reliant on some variety of grassland habitats for part or all of its life cycle" (Vickery et al. 1999). Grassland birds are a suite of species that depend on what has now become a rare cover type on the landscape, grasslands, for breeding sites. Due to their dependence on a decreasing cover type, grassland birds have shown more significant declines than bird species associated with other North American vegetation types (Knopf 1995, Giuliano and Daves 2002, Rich et al. 2004). Grassland passerines are migratory species in which most species winter primarily in the southern United States and northern Mexico; however, a few are Neotropical migrants (Vickery et al. 1995). Grassland birds arrive on the breeding grounds between mid- to late-April and the peak breeding season begins in early-May and extends through mid-July (Stewart 1975, Winter et al. 2004).

Extensive bird surveys throughout North America did not begin until the mid-1960s (Robbins et al. 1986, Sauer et al. 1997). A roadside survey method was tested in 1965 which formally became the North American Breeding Bird Survey (BBS) in 1966 (Sauer et al. 1997). During the initial year, about 600 routes were surveyed throughout the United States and Canada (Sauer et al. 1997). By 1997, there were roughly 3,700 routes that were actively surveyed (Sauer et al. 1997). These surveys did not begin until well after European settlement, the period in which conversion of remnant prairie to agricultural production was initiated (Johnson and Igl 2001). Because these BBS routes have been in effect for the past 35 years, the data serves as the first and most quantitative evidence of change in grassland bird populations (Johnson and Igl 2001). The BBS results in the only information for population modeling for many species (Suaer and Link 2001). BBS data from 1968-2008 indicates that populations of North American grassland bird species declined significantly (Sauer and Link 2011). Grassland bird populations in South America (Vickery et al. 1999), Europe (Newton 1998), and other parts of the world (Goriup 1988) have also declined following such conversion.

Landscape Effects

The overall decline and degradation of remnant prairie not only reduces the amount of available habitat for grassland birds, but also creates a fragmented landscape. Habitat fragmentation results in smaller habitat patches and increased edge rather than interior habitat (Temple and Cary 1988, Wiens 1995). It is also an important factor threatening biological diversity (Noss 1991). In addition to patch size and edge effects influencing grassland bird abundance, the type of land cover within the fragmented landscape affects grassland bird presence (Hanson and Urban 1992, McGarigal and McComb 1995, Bakker et al. 2002, Fletcher and Koford 2002, Winter et al. 2006), as well as local level characteristics, such as vegetation structure and composition (Wiens 1969, Rotenberry and Wiens 1980, Madden et al. 2000, Grant et al. 2004). As grassland birds have shown a response to local and landscape level characteristics, it is important to understand the influence of scale. Determining the effect of landscape composition and the scale at which these landscape level effects take place will be useful when managing grasslands through reconstruction.

Conservation Status

Across North America, grassland bird populations are being threatened primarily due to habitat loss and degradation (Sugden and Beyersbergen 1984, Batt et al. 1989, Johnson and Schwartz 1993, Peterjohn and Sauer 1993, Herkert 1994a, Knopf 1994, Dale et al. 1997, Sauer et al. 1999, McMaster et al. 2005, Dahl 2006, Askins et al. 2007). As a result, several species of grassland birds have recently been placed as species of high conservation concern in North Dakota (Hagen et al. 2005). Having declined at such an alarming rate, conservation of remaining habitat will be critical in maintaining or increasing grassland bird populations.

Management Needs for Grassland Birds

Through protection of remnant prairie and grassland reconstruction projects, habitat for grassland birds remains on the landscape. Some remnant prairies are protected through federal programs, such as Waterfowl Production Areas (WPAs; USFWS 2008a), National Wildlife Refuges (NWRs; Gergely et al. 2000), and grassland easements (USFWS 2008a). Other areas of remnant prairie remain on privately owned lands. Grassland reconstruction projects vary in the type of seed mix used when converting former agricultural land back to grassland habitat. There have been three main seed mixtures used to reconstruct grasslands within the United States Fish and Wildlife Service (USFWS). Historically, areas were reconstructed by seeding with DNC mixtures or warm-season native (WSN) grass mixtures. More recently, there has been an increase in seeding with multi-species native grass and forb mixtures (MSN; Cami Dixon, personal communication).

With the decline in remnant prairie and natural habitat for grassland birds, it is important to understand grassland bird use of reconstructed habitat and the influence of the surrounding landscape as land managers select sites to reconstruct habitat on the landscape with varying seed mixes.

Study Objectives

The combination of population declines and habitat loss have made grassland birds important species to study in terms of local grassland type and landscape level influences. The goal of this study is to investigate the relationships among landscape composition, grassland type, vegetation structure and composition, and grassland bird species richness in northeastern and east-central North Dakota. To achieve this overall goal, the objectives of this study are to: 1) evaluate grassland bird species richness in the following grassland types: multi-species native, warm-season native, dense nesting cover, old dense nesting cover, and remnant prairie, and 2) assess landscape variables that may impact grassland bird species richness. A combination of the findings related to both objectives will assist land managers in prioritizing sites for grassland reconstructions and identify the appropriate vegetation seed mixes.

CHAPTER II

DETERMINING FAVORABLE GRASSLAND TYPES AND HABITAT CHARACTERISTICS FOR GRASSLAND BIRDS

Abstract

Since European settlement, land use practices have resulted in prairie loss and degradation directly impacting grassland birds by reducing and fragmenting available breeding habitat. In North Dakota, there has been an estimated 70% grassland acreage loss since settlement, resulting in less than 1% eastern tallgrass prairie and about 32% mixed-grass prairie remaining. The primary methods for grassland conservation in the eastern mixed-grass prairie portion of North Dakota are grassland reconstruction and protection of the remaining remnant prairies (REM). There have been three main seed mixtures used to reconstruct prairie in the eastern mixed-grass prairie of North Dakota. Historically, formerly cropped areas were reconstructed by seeding with dense nesting cover (DNC) mixtures or warm-season (WSN) grass mixtures. Many of the DNC reconstructions occurred ≥ 15 years ago. These reconstructions are referred to as old dense nesting cover (ONC). More recently, there has been an increase in seeding with multi-species native grass and forb mixtures (MSN). Point counts were conducted on the above mentioned grassland reconstructions and remnant prairie sites (n = 32) to monitor grassland bird species richness. Three habitat variables, percent native vegetation, visual obstruction reading, and litter depth, were also measured on each study site. Twenty

grassland obligate, grassland user, and wetland bird species were observed during the course of this study (2008-2011). In terms of bird species richness, DNC, REM, MSN, and the WSN grassland types were similar; and ONC and REM were similar. It was found, however, that DNC, MSN, and WSN grassland types were statistically different from the ONC grassland type. MSN and DNC had the highest bird species richness, while ONC had the lowest bird species richness. Grassland type and percent native vegetation were more predictive of grassland bird species richness than average visual obstruction reading and average litter depth. Grassland type also influenced percent native vegetation and average litter depth.

Introduction

Historically, prairies were the largest ecosystem in North America, covering almost 1.5 million square kilometers (Knopf 1994). Prairie typically has nutrient rich, highly productive soils (Piper 1995) that are ideal for agricultural production which has resulted in the conversion of prairie to row crop production. Due to agricultural intensification, prairies are now among the most threatened ecosystems, with northern mixed-grass prairie having declined by 72-99% from historic levels (Samson and Knopf 1994, Noss et al. 1995). In North Dakota, there has been an estimated 70% grassland acreage loss since settlement (Conner et al. 2001), resulting in less than 1% eastern tallgrass prairie and about 32% mixed-grass prairie remaining (Samson and Knopf 1994, Samson et al. 1998). Remnant prairies and associated wildlife have also suffered from fragmentation, habitat loss (Samson and Knopf 1994, Bragg and Steuter 1995, Johnson 1996, Stephens et al. 2005), invasive species, and encroaching woody vegetation (Johnson 1996, Robbins and Dale 1999, USDA 1999, Green et al. 2002, Grant et al.

2004a, Ahlering 2005, Davis 2005) resulting in an overall decline in plant and animal biodiversity (Davis et al. 1999, Madden et al. 2000).

In particular, the loss and degradation of remnant prairie has directly impacted grassland birds by reducing and fragmenting the available breeding habitat for grassland nesting species (Sugden and Beyersbergen 1984, Batt et al. 1989, Johnson and Schwartz 1993, Peterjohn and Sauer 1993, Herkert 1994a, Knopf 1994, Dale et al. 1997, Sauer et al. 1999, McMaster et al. 2005, Dahl 2006, Askins et al. 2007). Consequently, grassland bird populations have steeper declines than birds in other North American vegetation types (Knopf 1995, Giuliano and Daves 2002, Rich et al. 2004). Breeding Bird Survey (BBS) data from 1968-2008 indicates that populations of 13 North American grassland bird species declined significantly (Sauer and Link 2011). Grassland bird populations in South America (Vickery et al. 1999), Europe (Newton 1998), and other parts of the world (Goriup 1988) have also declined. Additionally, many grassland and wetland dependent birds have few alternatives to the Great Plains (Igl and Johnson 1995); whereas birds associated with forested vegetation appear to have larger distributions across the continent (Johnson et al. 1994).

Loss of remnant prairie flora and fauna can ultimately be linked to former and current land use practices (Peterjohn and Sauer 1999). Changes in the landscape matrix (fragmentation, increase in shelterbelts, agricultural, housing, and commercial development), changes to disturbance regime (loss of natural fire and grazing and changes to mowing/haying), and vegetation composition (plant invasion and seeding cool-season grasses) have all negatively impacted native bird populations (Knopf 1994, Peterjohn and Sauer 1999, Giuliano and Daves 2002, Grant et al. 2004b). However, the most notable cause of the regional declines of grassland birds appears to be agricultural intensification, especially in North and South Dakota (Askins et al. 2007). Agricultural intensification reduces viable grassland bird habitat via land alteration through drainage and plowing, monocultures, chemical use, earlier harvesting or mowing, and increased grazing pressure (Newton 1998, Askins et al. 2007). Grazing practices today are often more intense and restricted by fences than the free-range grazing bison prior to settlement, presenting grassland birds with a different vegetation structure and often a different vegetative composition due to differences in grazing pressure (Peden et al. 1974, Schwartz and Ellis 1981). Grazing at intense or continuous rates may reduce competition between grasses and woody species and accelerate weed invasion (Brown and Archer 1989, Engle et al. 1995, Johnson and Matchett 2001). Restricted, intense grazing practices that are in place today require additional feed for the grazers. This often results in mowing and haying of native cool-season grasses, which produce the most biomass during the nesting season; further reducing grassland bird populations through nest disturbance and destruction (Giuliano and Daves 2002). At the other extreme, natural burning and grazing of remnant prairie has ceased for several decades. Historically, fire caused by lightning or Native Americans was contained by natural barriers and was responsible for prairie expansion (Sargent and Carter 1999). These natural fires promoted prairie grasses and wildflowers while reducing competition from weeds and woody vegetation (Sargent and Carter 1999). Today, natural fires are controlled thereby reducing the stimulation of prairie plants and the control of weeds and woody vegetation.

Idle grassland, as defined by Klett et al. (1988), is remnant prairie which has not been disturbed (i.e., haying, grazing, etc.), during the present or previous growing season. Several sources suggest that continual idleness over the long-term results in degradation of prairies, changing the grassland structure and/or function (Johnson et al. 1994, Ogle et al. 2003, Henderson and Naeth 2005). Continually idled prairie is not beneficial for endemic grassland birds and has reduced grassland bird occupancy (Askins et al. 2007). This may be due to idle prairie being susceptible to plant invasion since the lack of disturbance allows the invasive plants to out-compete the native plants, essentially degrading the habitat as invasive species increase and native species decrease (Higgins et al. 2001); reducing the diversity of the plant community (Flanders et al. 2006) and the diversity of habitat structure. Wilson and Belcher (1989) found that Eurasian plant species in the North American prairie not only replace the native plant community through competition, but also impact species compositions at higher trophic levels through bird displacement. Six of 10 grassland bird species surveyed showed a negative relationship with exotic plant species and a positive relationship with native plant species (Wilson and Belcher 1989). Similarly, Flanders et al. (2006) showed a 32% greater bird abundance on native plant dominated prairies than on exotic plant dominated prairies. Increasing woody vegetation also negatively influences grassland birds by fragmenting the prairies, providing habitat for multiple predator species, and attracting forest-edge bird species which may displace grassland bird species (Knopf 1986).

The primary methods for grassland conservation in the eastern mixed-grass prairie portion of North Dakota are grassland reconstruction and protection of the remaining remnant prairies. Reconstructed and remnant prairies are actively managed to control the invasion of woody and invasive plant species. There have been three main seed mixtures used to reconstruct prairie in the eastern mixed-grass prairie of North Dakota. Historically, formerly cropped areas were reconstructed by seeding with dense nesting cover (DNC) mixtures or warm-season (WSN) grass mixtures. The DNC mixture consists of non-native grasses, typically containing two species (intermediate wheatgrass *Thinopyrum intermedium* and tall wheatgrass *Thinopyrum ponticum*), along with alfalfa (*Medicago sativa*) and/or yellow sweetclover (*Melilotus officinalis*). The warm-season mixture consists of native grasses, typically containing three species (big bluestem *Andropogon gerardii*, indiangrass *Sorghastrum nutans*, and switchgrass *Panicum virgatum*) and occasionally a forb, such as alfalfa (*Medicago sativa*). More recently, there has been an increase in seeding with multi-species native grass and forb mixtures (MSN), typically containing 12-30 plant species. Due to the different species in the seed mix, the cost/acre of each seed mix is highly variable (Table 1). The 1997 Refuge Improvement Act requires that National Wildlife Refuge (NWR) lands be managed in a way that strives to provide and maintain "biological integrity, diversity, and environmental health of the Refuge System" (Public Law 105-57 – October 9, 1997). This is another justification when considering seeding native plants rather than DNC on refuge lands (Schroeder et al. 2004).

DNC has been shown to reach maximum growth between years two and four after seeding (Higgins and Barker 1982). These plantings provide adequate food and cover to wildlife for ≥ six years (Higgins and Barker 1982) gradually degrading to year 10 if not actively managed. The gradual degrading process is often caused by the invasion of invasive plants species, such as smooth brome (*Bromus inermis*). This can result in a monotypic stand of an invasive, non-native plant species (i.e., old dense nesting cover; ONC).

Although native prairies have declined at an alarming rate due to agricultural conversions and other uses, some remaining remnant prairies are protected by the USFWS through the establishment of Waterfowl Production Areas (lands managed for the production of waterfowl and other wildlife species; WPAs; USFWS 2012), NWRs (lands that are managed to protect specific wildlife populations and/or wildlife habitats; Gergely et al. 2000), and United States Fish and Wildlife Service (USFWS) grassland easements (lands managed cooperatively between the USFWS and the landowner; USFWS 2008c). Both WPAs and NWRs are actively managed and owned by the USFWS. Grassland easements cannot be cultivated. However, grazing by livestock is permitted, as well as harvesting of hay or grass seed after 15 July of each year (USFWS 2008c). After 15 July, most grassland nesting species should have produced fledglings and will be less susceptible to mowing (Dale et al. 1997, USFWS 2008c). Landowners who place their land in a grassland easement receive a cash incentive not to cultivate their lands (USFWS 2008c).

Grassland bird research in northeastern and east-central North Dakota has focused on grassland bird use of remaining remnant prairies and Conservation Reserve Program sites (Johnson and Schwartz 1993, Johnson and Igl 1995, Koford 1999). Previous research has not addressed the specific question of bird use of grasslands reconstructed with native vegetation and bird community response at sites that have been reconstructed with native vegetation in this region (i.e., mixed-grass prairie). Most research on grassland bird responses to prairie reconstruction were conducted on sites in the tallgrass prairie (e.g., Herkert 1994b, Fletcher and Koford 2002). In most cases, land management agencies continue to implement such reconstructions with the assumption that they are benefiting grassland bird species.

This research is focused on comparing grassland bird use and response on grassland sites reconstructed with four different seed mixes to grassland bird use and response on remnant prairie sites. Similar research has been performed in the tallgrass prairie; however, this has yet to be performed in the mixed-grass prairie, specifically, in northeastern and east-central North Dakota (Fletcher and Koford 2002, Bakker and Higgins 2009).

Methods

Study Area

The Devils Lake Wetland Management District (WMD), as delineated by the USFWS, was established in 1962 to manage important upland and wetland habitat needed by waterfowl and other wildlife. The Devils Lake WMD encompasses eight counties (Benson, Cavalier, Grand Forks, Nelson, Pembina, Ramsey, Towner, and Walsh; see Figure 1) totaling 26,524 square kilometers in northeastern North Dakota. To provide this crucial habitat for waterfowl and other wildlife, the Devils Lake WMD manages 222 WPAs, 4 NWRs, and 2,809 easements that cover 103,416 hectares of wetland and upland habitat. The Arrowwood WMD, established in 1961, encompasses the counties of Eddy and Foster in east-central North Dakota (Figure 1). Arrowwood

WMD manages 28 WPAs, 1 NWR, and 318 easements that cover 10,202 hectares of wetland and upland habitat.

The Devils Lake and Arrowwood WMDs are located within the tallgrass and mixed-grass prairies within the Drift Prairie physiographic region (Bluemle 1991). Tallgrass prairie is specifically located within the Red River Valley physiographic region in the eastern portion of the Devils Lake WMD, while the mixed-grass prairie is situated throughout the remaining portion of the study area. The Drift Prairie physiographic region of North Dakota is classified in the wheatgrass-bluestem-needlegrass (*Agropyron-Andropogon-Stipa*) category as delineated by Kuchler 1964. Plant species that historically dominated the landscape in this region consist of cool- and warm-season grasses such as western wheatgrass (*Pascopyron smithii*), slender wheatgrass (*Elymus trachycaulus*), green needlegrass (*Nassella viridula*), prairie Junegrass (*Koeleria macrantha*), needle and thread (*Hesperostipa comata*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), big bluestem (*Andropogon gerardii*), and little bluestem (*Schizachyrium scoparium*; Kuchler 1964). Native forbs found in this region are comprised of fringed sage (*Artemisia frigida*), white sage (*Artemisia ludoviciana*), white prairie aster (*Symphyotrichum falcatum*), purple coneflower (*Echinacea purpurea*), blazing star species (*Liatris* spp.), silver-leaf scurf pea (*Psoralea argophylla*), prairie rose (*Rosa arkansana*), Missouri goldenrod (*Solidago missouriensis*), and soft goldenrod (*Solidago mollis*; Kuchler 1964).

Study Site Selection

Between 2008-2011 (Table 2), I surveyed five types of grasslands for grassland birds: 1) multi-species natives (MSN) - areas seeded with a mixture of 12-30 native grasses and forbs, 2) warm-season natives (WSN) - areas seeded with three to four warm-season grasses and not more than six forbs, 3) dense nesting cover (DNC) – areas seeded with a wheatgrass (*Thinopyrum* spp.), alfalfa (*Medicago sativa)*, and yellow sweetclover (*Melilotus officinalis*) mixture within the last 15 years, 4) old dense nesting cover (ONC)– areas seeded with a form of dense nesting cover (i.e., non-native grasses, such as smooth brome (*Bromus inermis*)) ≥ 15 years ago, and 5) remnant prairie (REM) - areas that have never been plowed (see Appendix A for site specific seed mixtures). All sites were on WPAs, NWRs, and a private grassland easement within the Devils Lake and Arrowwood WMDs, located in Cavalier, Benson, Ramsey, Towner and Eddy counties, northeastern and east-central North Dakota, USA (Figure 1; Table 3).

Sites were selected for the five grassland types described above from available habitat within the mixed-grass prairie across the Devils Lake and the Arrowwood WMDs. MSN, WSN, and DNC sites are uncommon in this study area as these seed mixtures are either new reconstruction practices (MSN and WSN) or age restricted (DNC), which limited available sites. To qualify as a study site, the species seeded for a particular grassland type had to make up > 50 percent of the study site. REM sites were selected based on historical land use records rather than vegetation cover. The ONC sites were selected based on time since seeding (i.e., these sites were seeded ≥ 15 years ago). Using the qualifiers described above, 32 sites were chosen among the five grassland types (Table 4). The median site size (n = 32) for the study period, 2008-2011, was 88 ha. The maximum site size was 264 ha (Haven WPA), while the minimum site size was 32 ha (Stinkeoway WPA).

Nearly all of the study sites selected contained a single grassland type surrounded by an agricultural matrix. However, to obtain a large enough sample size, two of the WPAs contained multiple grassland types no nearer than 1.61 km of each other. A minimum distance of 1.61 km between sites was chosen maximize site independence. The Martinson WPA contained WSN and MSN grassland types and the Register WPA contained DNC and MSN grassland types. Both WPAs were categorized as two separate sites. Register WPA was split into the sites Register 1 and Register 2, while Martinson WPA was split into sites Martinson 1 and Martinson 2.

Bird Survey Methods

Survey points were distributed within each site in proportion to the amount of habitat available within the five grassland types (Table 5). The number of survey points per grassland type reflects differences in size of available habitat and the amount of hectares contained within each site. Survey points were placed in a restricted randomization design (random locations with restrictions on placement) within the 32 sites. I used ‘Geospatial Modeling Environment’ (‘Hawth’s Analysis Tools’) in ArcMap™ 9.3.1 (Environmental Systems Research Institute, Redlands, CA), to place survey points within the boundaries of each WPA, NWR, or grassland easement. To meet sampling restrictions, points were repositioned if placed within a wetland, < 100 m from a site edge, and/or < 300 m from another point.

The Register 1 and Register 2 sites contained eleven survey points in total. Two observers were required to complete the survey of the WPA in a single day. The primary observer trained the secondary observer on survey protocol prior to performing surveys. A “practice point” was surveyed by both observers simultaneously and observer results were compared. Upon completion of the "practice point," the primary and secondary observers surveyed their portion of the eleven survey points within the Register site.

Throughout the course of the study (2008-2011), one survey point was eliminated and two survey points were excluded for a year. In 2010 a DNC survey point was removed from the Tarvestad WPA because of rising water. Langley WPA and Haven WPA were added in 2010 to increase the number of survey points within REM.

Survey points and sites were uploaded into a Trimble® GeoXT™ GPS Unit (Trimble Navigation Limited, Sunnyvale, CA) upon completion of making a map in ArcMap™ 9.3.1. Survey sites were located using a Trimble® GeoXT™ GPS Unit and identified a day in advance to ensure survey locations were accessible. Each bird survey point was surveyed twice per field season using a 100 m fixed-radius survey method to catch the peak breeding season for grassland birds, which begins early-May and ends mid-July (Stewart 1975, Winter et al. 2004). Point counts with a 100 m fixed radius may be the most appropriate for bird surveys in open habitats, such as grasslands (Cyr et al. (1995, Savard and Hooper 1995). The first round of surveys began no earlier than 15 May and finished no later than 18 June. The second round of surveys began immediately after the first round was completed and continued until July. All surveys were completed by 08 July each year (Table 2). Surveys started with the southernmost sites and worked north, which ensured the breeding birds had arrived at their breeding sites. The order of sites stayed consistent from the first round of surveys to the second. The same points were surveyed each year with additional sites and survey points added in 2010 to obtain a larger sample size (Table 4). An additional grassland type, ONC, was also added in 2010 (Table 4).

Surveys took place between sunrise and 1030 Central Standard Time (CST) with four to seven points surveyed per person per day. Surveys ceased when wind speed exceeded 24 km/h based on a Kestrel® 4500/4500 NV Weather Meter™ (Kestrel® Sylvan Lake, MI) or if precipitation exceeded a drizzle (adapted from protocols in Anderson and Ohmart 1977, Robbins 1981, Ralph et al. 1995). A single observer recorded data at each survey point with two single observers during the full study period (2008-2011). Each survey was conducted over a 12-minute period, which included a two-minute cool down stage upon arrival at the point. This resulted in 10 minutes of actual survey time within a 100 m fixed-radius. The cool down stage ensured the birds became acclimated to observers' presence and behaved as naturally as possible (Bollinger et al. 1988). Singing male birds within the 100 m fixed-radius were recorded after identification (song or sight). This gave singing male densities at each point. Double counting and overestimating the number of individuals at each point was avoided by spacing survey points by a distance of > 300 m (Ralph et al. 1995). Birds that flew over the 100 m fixed-radius survey area without landing were only recorded if they were using the habitat for acts such as displaying or aerial feeding (Johnson and Igl 2001). Data from the first and second round of surveys in each year were pooled to get a representation of all the birds observed at a point. If a site contained multiple points, all points were pooled to determine the site-level species composition (see Appendix B for site specific avian observations). I calculated bird species richness of grassland obligate, grassland user, and wetland species for each study site surveyed (n = 32).

Vegetation Survey Methods

To evaluate local habitats, vegetation composition and structure were surveyed on all sites between 2009 and 2011 (Table 6). Vegetation was sampled using: 1) a belt transect method to estimate plant species composition and frequency of plant groupings (Grant et al. 2004b); 2) visual obstruction reading (VOR) as a measure of vegetation density and height (Robel et al. 1970); and 3) litter depth as a measure of dead, accumulated vegetation from previous growing seasons (Facelli and Pickett 1991). Habitat use by grassland birds has been shown to be influenced by vegetation composition and structure (Wiens 1969, Whitmore 1979, Rotenberry and Wiens 1980, Madden et al. 2000, Grant et al. 2004a, Fisher and Davis 2010). Litter depth has also been shown to have an influence on grassland birds. Studies have shown a strong correlation between grassland bird abundance and litter depth (Wiens 1973, Grzybowski 1976, Rotenberry and Wiens 1980, Renfrew and Ribic 2001, Swengel and Swengel 2001, Fisher and Davis 2010). Facelli (1974) showed a positive relationship between arthropod abundance and the presence of litter, which may drive the relationship between grassland bird abundance and litter depth. Additionally, it has been shown that the amount of litter can affect the reproductive success and nest-site selection in some species (Wiens 1969, Wray and Whitmore 1979). Vegetation composition was measured during peak biomass (July-August 2009-2011; Grant et al. 2004b). VOR and litter depths were measured during the first round of bird surveys in 2011 (Table 2) as these factors may affect nest-site selection as different bird species require different litter depths and vegetation structure for nesting (Tester and Marshall 1961, Wiens 1969, Fletcher and Koford 2004, Jones and Bock 2005). Remnant prairie has taken decades to decline and become invaded due to idleness (Grant et al. 2004b and Murphy and Grant 2005). This suggests that vegetation species composition within grasslands changes at a slow pace, as a result, composition measurements were not taken each year. VOR and litter depth were not measured each year due to time constraints and USFWS protocol.

Vegetation was sampled on all sites that were surveyed for grassland birds. Bird survey points marked the beginning of some, but not all, vegetation transects. Within each site, one transect was placed for every eight to 10 acres and one VOR point was placed for every five to eight acres using restricted randomization design (Table 6). I placed vegetation transects and VOR points within WPAs, NWRs, and a grassland easement using the same methods used to place bird survey points (see *Bird Survey Methods*). Litter depth was measured at each VOR point. Most transects were stratified by ecological sites (e.g., hilltops and hillsides) to address soils and environmental variation (Sedivec and Printz 2012). However, transects and VOR points were repositioned if placed in a wetland or < 150 m apart from other vegetation transects or points or < 100 m from roads or site edges, making it a restricted randomization design.

I measured vegetation composition along 25 m transects. Both ends of each vegetation transect were marked with Stake Chasers®, (Abilene, TX), attached to a wooden stake inserted flush with the soil and recorded with a Trimble® GeoXT™ GPS Unit. Vegetation classes were recorded at 0.5 x 0.1 m intervals according to the most prevalent vegetation cover (Appendix C; Grant et al. 2004b). Each 0.5 m interval of the

25 m transect could be categorized as one of 44 possible vegetation classes (Appendix C; Grant et al. 2004b) for fifty observations per transect. Herbaceous codes available to use in the belt transect method (Appendix C) were sorted into a “native” and “non-native” category (Grant et al. 2004b). To be considered a “native” code, >50% dominance of native herbaceous plants, including forbs, was required. To be considered a “non-native” code, <50% dominance of native herbaceous plants, including forbs, was required. Using the “native” and “non-native” categories, the average number of times a “native” code was used to describe the vegetation in a transect interval across all transects per site estimated the proportion of the vegetation which was native for that site. This was done for each site surveyed. Each transect was sampled once during the study period (2008-2011) and all transects within a site were measured in one year.

VOR was measured using a Robel pole that had alternating decimeters (dm) painted red or white. Additionally, each half-dm was marked with a black stripe (adapted from protocols in Robel et al. 1970). The highest dm or half-dm where vegetation begins to completely hide the pole and no other part of the pole can be seen below this mark was recorded in each of the four cardinal directions 4.0 m from the Robel pole with the observer’s eye 1.0 m above the ground (Robel et al. 1970). The average VOR reading per point per site was determined to get a representation of the entire site. This was done for each site surveyed. Each VOR point was sampled once during the study period (2008-2011) and all VOR points within a site were measured in one year. VOR was measured once during the study period due to minimal management activities taking place during the study period, which would limit yearly variation.

Litter was defined as dead vegetation accumulated from previous growing seasons (Facelli and Pickett 1991) and was measured from the soil surface (cm). The average litter depth reading per site was determined to get a representation of the entire site. This was done for each site surveyed. Each litter depth point was sampled once during the study period (2008-2011) and all litter depth points within a site were measured in one year. Litter depth was measured once during the study period due to minimal management activities taking place during the study period, which would limit yearly variation.

Statistical Analyses

I hypothesized that different grassland types would influence bird species richness. I hypothesized that vegetation structure, composition, and litter depth could also play a role in influencing bird species richness. I calculated bird species richness of grassland obligate, grassland user, and wetland species. I used a Tukey's Post-hoc test on the results of an ANOVA to determine bird species richness differences between grassland types (R Development Core Team 2010).

I used an Analysis of Covariance (ANCOVA) to determine if grassland type influenced bird species richness after taking into consideration the percent native vegetation (PNV), the mean Robel reading, and the mean litter depth using separate ANCOVA analyses (R Development Core Team 2010). ANOVA was also used to determine if PNV, average VOR, and average litter depth differed between the five grassland types (R Development Core Team 2010). All assumptions (normality of residuals, homogeneity of variance, homogeneity of regression slopes, linearity of regression, and independence of error terms) were tested and met and each statistical test was considered significant at $P \leq 0.05$.

Results

Twenty grassland obligate, grassland user, and wetland bird species were observed during the course of this study within the five grassland types (2008-2011). MSN and DNC had the highest bird richness; while ONC had the lowest bird richness (Table 7). Of the twenty species observed, two species were found only on MSN sites (Marbled Godwit *Limosa fedoa* and Horned Lark *Eremophila alpestris*; Table 8).

Overall species richness varied with grassland types (1-way ANOVA, $F_{4, 27} = 6.3319$, $p = 0.0010$). Based on a Tukey's Post-hoc test, the mean bird species richness of WSN, DNC, and MSN were statistically higher than ONC but REM could not be distinguished from either ONC or the group of WSN, DNC, and MSN (Figure 2).

The ANCOVA with the PNV as a covariate indicated a significant effect of PNV and grassland type on bird species richness, but no significant interaction between the two (Table 10). Bird richness increased as the PNV within a site increased (Figure 5). The ANCOVA with the average VOR as a covariate indicated a significant effect of grassland type on bird species richness, but no significant effect of average VOR or the interaction between the two (Table 10). The ANCOVA with the average litter depth as a covariate indicated a significant effect of grassland type, on bird species richness but no significant effect of average littler depth or the interaction between the two (Table 10).

The results also suggest that certain grassland types influence PNV (Table 9, 1-way ANOVA, $F_{4, 27} = 18.021$, $p = < 0.001$). A Tukey's Post-hoc test was performed on the results of an ANOVA and found the mean PNV of WSN, REM, and MSN was significantly higher than ONC and DNC (Figure 3). However, the mean PNV was not statistically different between WSN, REM, and MSN, or between DNC and ONC (Figure 3). Additionally, it was shown that certain grassland types influence average litter depth (Table 9, 1-way ANOVA, $F_{4, 27} = 2.8996$, $p = 0.0406$). A Tukey's Post-hoc test was performed on the results of an ANOVA and found the mean average litter depth of WSN was statistically higher than ONC (Figure 4). However, the mean average litter depth was not statistically different between WSN, MSN, DNC, and REM nor between ONC, MSN, DNC, and REM (Figure 4).

Discussion

In agreement with my predictions, I found grassland type and the percent native vegetation within a site had a significant influence on the bird species richness of USFWS lands by grassland birds (Table 9). However, neither the average litter depth nor the average VOR within a site affected bird species richness. These results suggest a multitude of grassland types as being beneficial or usable habitat. It was also found that grassland type had a significant influence on the percent native vegetation within a site as well as the amount of litter. However, it was not shown to influence the Robel reading within a field.

Vegetative variables contained within each grassland type are influencing the bird species richness as well as the grassland type overall. With a higher PNV within a site showing a statistically positive relationship with bird species richness, this would suggest that the MSN sites would have a higher bird species richness than the other grassland types, which I found (mean bird species richness = 12; Figure 5). Similar results were found by Wilson and Belcher (1989) and Flanders et al. (2006). Wilson and Belcher

(1989) surveyed sites in which the native plant community was being replaced by Eurasian species as a result of competition. This also resulted in bird displacement as the native plant community decreased, resulting in six of 10 grassland bird species displaying a negative relationship with exotic plant species (Wilson and Belcher 1989). Flanders et al. (2006) also showed greater bird abundance on sites dominated with native plants species. Higher bird species richness on sites with more native vegetation may be the result of vegetation structural differences from grass and forb species on native vegetation dominated sites over the grass species on non-native vegetation dominated sites. Additionally, the invasion of non-native, woody vegetation also negatively influences grassland birds by fragmenting the prairies, providing habitat for multiple predator species, and attracting forest-edge bird species (Knopf 1986).

This research project had a few limitations that may have impacted the significance of the results. The quality of the remaining remnant prairies is continually declining in many instances (Samson and Knopf 1994, Bragg and Steuter 1995). This has resulted in not only few remnant prairie sites to sample, but also few remnant prairie sites of good quality. As a result, some, if not most, of the remnant prairie sites that were sampled were of poor or declining quality potentially causing a lower observed bird species richness than one would expect. In addition, the study area experienced annual spring flooding during most of the study period (2008-2011). This continually changed the size of the survey sites and the amount of available habitat on a yearly basis. The overland flooding may also have created more favorable habitat for certain species of songbirds as it often created a wet meadow type habitat. The Arrowwood and Devils

Lake WMDs strive to actively manage their lands to provide suitable habitat for wildlife populations. The management activities (e.g., grazing, prescribed fire, haying) that took place on some of the surveyed sites may have altered the results obtained during bird and vegetation surveys. Even with the proposed limitations, results of this study provide valuable information for land managers on usable habitat available for grassland birds.

In conclusion, I can suggest that grassland types with higher percent native vegetation (e.g., REM, MSN, and WSN) are more beneficial to grassland obligate, grassland users, and wetland avian species than grassland types with lower percent native vegetation (e.g., ONC and DNC; Wilson and Belcher 1989, Flanders et al. 2006). Therefore, it was discovered that land management agencies have more than one option when converting formerly cropped or idled lands into reconstructed grasslands. The warm-season native and multi-species native grassland types had statistically similar mean bird species richness as well as statistically similar percent native vegetation. This suggests that these two reconstruction practices appear to be the most beneficial of the grassland types surveyed. Even though remnant prairie, which had a high percent native vegetation, did not have the highest bird species richness (n = 9), the grassland type still has a major impact in the amount of usable habitat available. Although dense nesting cover did not have a high percent native vegetation, it showed to be beneficial when looking at bird species richness alone, giving it the potential for use in future reconstructions. This mixture of native and non-native vegetation may provide suitable habitat for grassland birds (Kennedy et al. 2009). However, since old dense nesting cover had the lowest observed bird species richness (n = 7; Wilson and Belcher 1989) and has a low percent native vegetation, a management decision to reconstruct these sites to a different seed mix (e.g., multi-species native or warm-season native) would make the land more beneficial to grassland obligates, grassland users, and wetland bird species in the future.

Results of this work will aid in improving and informing future management decisions and reconstruction projects conducted by land managers in the federal, state, and private sectors. Based on the results of this study, management decisions can now be made with the knowledge that all grassland types are not equally beneficial to grassland obligate, grassland users, and wetland species of songbirds. The results of my study also provide measureable indicators to reflect the effectiveness of this costly and intensive reconstruction strategy as well as providing an option to land managers. While dense nesting cover and multi-species native seed mixes showed higher bird species richness than the other grassland types, they were not statistically different from the warm-season native seed mix. Thus, giving land managers three seed mixes to choose from when restoring land. This option will prove important when planning their yearly reconstruction projects around annual budgets as the average cost/acre for these three seed mixes is drastically different, ~\$50, ~\$175, and ~\$25, respectively (Table 1). As many grassland bird species have been shown to be area-sensitive (i.e., requiring large tracts of grassland for breeding; Peterson 1983, Bollinger 1988, Bollinger et al. 1990, Bollinger and Gavin 1992, Smith 1992), conservation and reconstruction of grasslands will play a significant role in reversing the current, negative population trend of grassland songbirds.

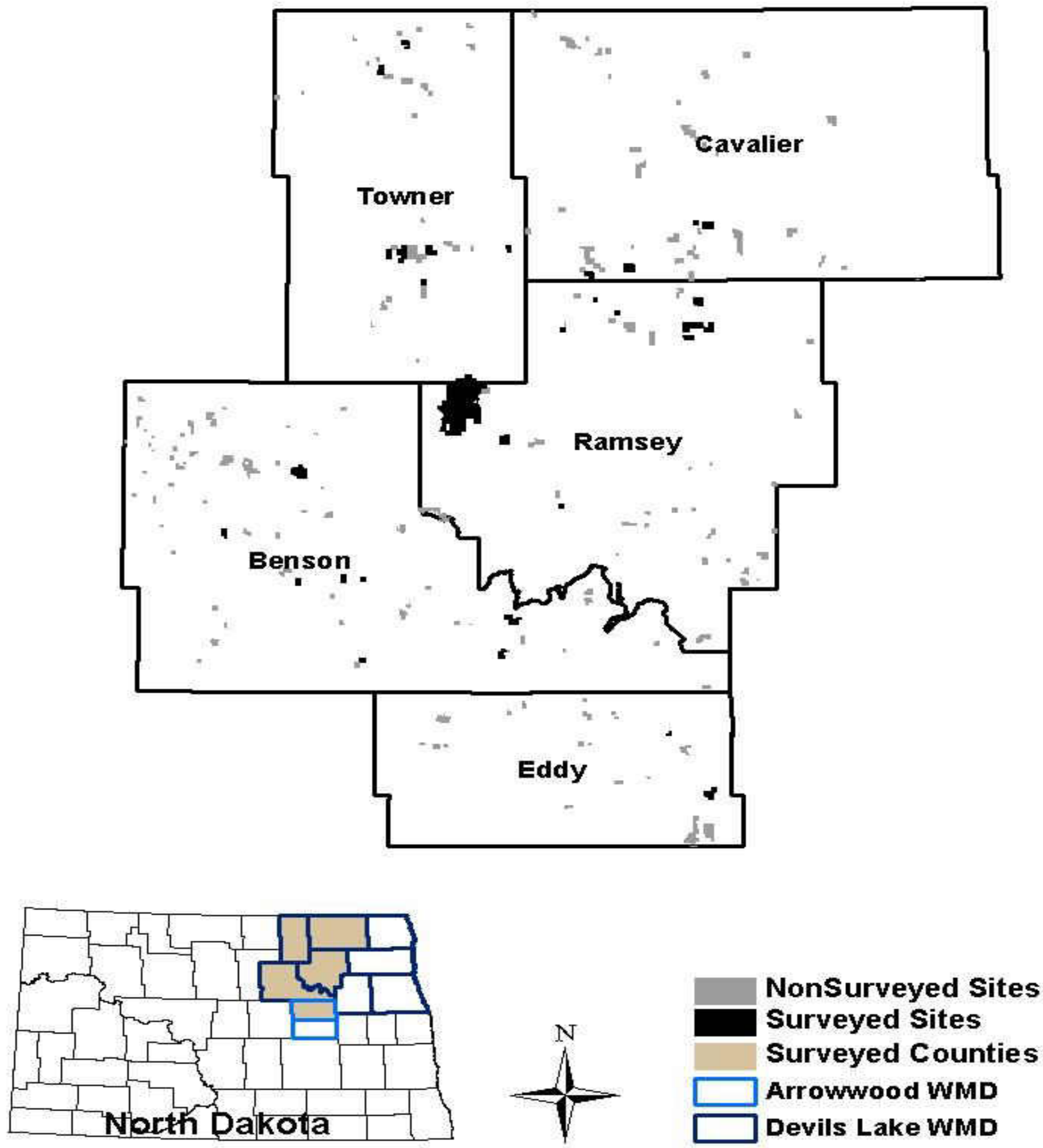

Figure 1. Survey locations for grassland birds on WPAs, NWRs, and private lands (n = 32) in northeastern and east-central North Dakota, USA, 2008-2011.

Table 1. Average cost/acre of each seed mixture. Prices vary depending on year and species contained within mixture (Devils Lake Wetland Management District Staff, personal communication).

Seed Mixture	Average Cost/Acre
MSN (grass/forb)	$175 (Ranges from $120-$300+)
WSN (grass)	$50
DNC (grass)	$25

Table 2. Start and end dates of 100 m fixed-radius point count surveys for grassland birds. Note: The second round of the 2009 field season began prior to the completion of the first round due to an additional site added to the REM grassland type to increase the sample size.

	Round 1		Round 2	
Year	Start	End	Start	End
2008	28 May	16 June	18 June	01 July
2009	18 May	03 June	28 May	24 June
2010	15 May	12 June	13 June	01 July
2011	18 May	11 June	14 June	08 July

Table 3. Plant species included in each grassland type seed mixture seeded within the Devils Lake WMD, North Dakota, USA. Note: Not every species within the seed mixture is seeded at each site of the corresponding grassland type. Additionally, each species may or may not have been present during the study period. See Appendix A for site specific seed mixtures.

Plant Species			Grassland type			
Family	Scientific Name	Common Name	DNC	ONC	MSN	WSN
Apiaceae	*Zizia aurea*	Golden Alexander				X
Asteraceae	*Echinacea angustifolia*	Purple Coneflower				X
	Gaillardia aristata	Blanket Flower			X	
	Helianthus maximilianii	Maximilian Sunflower			X	
	Helinathus annuus	Wild Sunflower				X
	Liatris ligulistylis	Meadow Blazingstar			X	
	Liatris pycnostachya	Prairie Blazingstar			X	
	Liatris spp.	Blazingstar spp.				X
	Ratibida columnifera	Prairie Coneflower			X	
	Rudbeckia hirta	Black-eyed Susan			X	
	Solidago rigida	Stiff Goldenrod			X	X
Fabaceae	*Amorpha canescens*	Leadplant			X	
	Astragalus canadensis	Canada Milkvetch			X	
	Dalea candida	White Prairie Clover			X	
	Dalea purpurea	Purple Prairie Clover			X	
	Medicago sativa	Alfalfa	X	X		X
	Melilotus officinalis	Yellow Sweetclover	X	X		X
	Vicia americana	American Vetch			X	

Table 3 Cont.

Plant Species			Grassland type			
Family	Scientific Name	Common Name	DNC	ONC	MSN	WSN
Lamiaceae	*Monarda fistulosa*	Wild Bergamot			X	
Linaceae	*Linum lewisii*	Lewis Flax			X	
Poaceae	*Thinopyrum ponticum*	Tall Wheatgrass	X	X		
	Thinopyrum intermedium	Intermediate Wheatgrass	X	X		
	Pascopyrum smithii	Western Wheatgrass	X	X	X	X
	Elymus trachycaulus	Slender Wheatgrass		X	X	X
	Andropogon gerardii	Big Bluestem			X	X
	Andropogon scoparius	Little Bluestem			X	X
	Bouteloua curtipendula	Sideoats Grama			X	X
	Bouteloua gracilis	Blue Grama			X	
	Bromus inermis	Smooth Brome		X		
	Calamovilfa longifolia	Prairie Sandreed			X	
	Elymus canadensis	Canada Wildrye			X	X
	Nassella viridula	Green Needlegrass		X	X	
	Panicum virgatum	Switchgrass	X		X	X
	Phalaris arundinacea	Reed Canarygrass		X		
	Sorghastrum nutans	Indiangrass			X	X
	Spartina pectinata	Prairie Cordgrass			X	
	Sporobolus heterolepis	Prairie Dropseed				X
	Hesperostipa comata	Needle and thread			X	

Table 3 Cont.

Plant Species			Grassland type			
Family	Scientific Name	Common Name	DNC	ONC	MSN	WSN
	Hesperostipa spartea	Porcupine Grass			X	
Ranunculaceae	*Thalictrum pubescens*	Tall Meadowrue				X
Rosaceae	*Rosa arkansana*	Prairie Rose			X	X
Rubiaceae	*Galium boreale*	Northern Bedstraw				X
Scrophulariaceae	*Penstemon grandiflorus*	Shell-leaf Penstemon			X	

Table 4. Surveyed sites for grassland birds within the Devils Lake and Arrowwood WMDs, North Dakota, USA. Multi-species natives (MSN) - areas seeded with a mixture of native grasses and forbs. Warm-season natives (WSN) - areas with seeded three to four warm-season grasses and not more than six forbs. Dense nesting cover (DNC) – areas seeded with a wheatgrass (*Agropyron)* species, alfalfa (*Medicago sativa)*, and yellow sweetclover (*Melilotus officinalis*) mixture. Old dense nesting cover (ONC) – areas seeded with a form of dense nesting cover (i.e., non-native grasses, such as smooth brome (*Bromus inermis*)) ≥ 15 years ago. Remnant prairie (REM) - areas that have never been plowed. 2008 – '08, 2009 – '09, 2010 – '10, and 2011 – '11.

					Years Surveyed			
Site	County	Grassland type	Area (ha.)	Survey Points	'08	'09	'10	'11
Phil Aus	Ramsey	DNC	130	2	X	X	X	X
Register 1	Towner	DNC	69	3	X	X	X	X
Stephens	Towner	DNC	130	2	X	X	X	X
Tarvestad	Ramsey	DNC	65	2	X	X	X	X
Hofstrand	Benson	MSN	89	2		X	X	X
Lake Alice	Ramsey	MSN	44	2	X	X	X	X
Martinson 2	Ramsey	MSN	130	2		X	X	X
Register 2	Towner	MSN	130	8	X	X	X	X
Edwards	Cavalier	ONC	251	2			X	X
Freund	Towner	ONC	61	1			X	X
Howes	Ramsey	ONC	41	1			X	X
Pintail	Ramsey	ONC	61	1			X	X
Putman	Towner	ONC	65	1			X	X
Solberg	Cavalier	ONC	65	2			X	X
Stinkeoway	Cavalier	ONC	32	1			X	X
Tweten	Benson	ONC	53	1			X	X
Waltz	Towner	ONC	179	4			X	X
Deep Valley	Benson	REM	121	2	X	X	X	X
Grassland Easement	Benson	REM	112	3	X	X	X	X
Haven	Eddy	REM	264	2			X	X
Langley	Eddy	REM	49	2			X	X
Lone Tree	Benson	REM	113	2	X	X	X	X
Melass	Benson	REM	97	2			X	X
Native Prairie Unit	Benson	REM	61	2	X	X	X	X
Ziegler	Ramsey	REM	65	1	X	X	X	X
Avocet Island	Ramsey	WSN	41	1	X	X	X	X
Breakey	Ramsey	WSN	130	2	X	X	X	X
Elias	Ramsey	WSN	65	2	X	X		
Halvorson	Towner	WSN	190	2	X	X	X	X
Martinson 1	Ramsey	WSN	65	2	X	X	X	X
Rolling Rock	Benson	WSN	65	2		X	X	X

Table 4 Cont.

Site	County	Grassland Type	Area (ha.)	Survey Points	Years Surveyed '08	'09	'10	'11
SBA	Towner	WSN	65	2		X	X	X

Table 5. Yearly sample sizes (number of sites surveyed) for five grassland types surveyed for grassland birds within the Devils Lake and Arrowwood WMDs, North Dakota, USA.

Grassland type	Yearly Sample Size (number of sites surveyed) 2008		2009		2010		2011	
	Points	Sites	Points	Sites	Points	Sites	Points	Sites
DNC	9	4	9	4	9	4	9	4
ONC	0	0	0	0	14	9	14	9
MSN	10	2	14	4	14	4	14	4
REM	9	5	9	5	13	8	13	8
WSN	9	5	13	7	11	6	11	6

Table 6. Sample sizes of surveyed sites for vegetation composition, vegetation structure, and litter depth within the Devils Lake and Arrowwood WMDs, North Dakota. MSN - areas seeded with a multi-species native mixture. WSN - areas that have been seeded specifically with a warm-season mixture. DNC – areas seeded with a wheatgrass/alfalfa mixture. ONC – areas seeded to dense nesting cover ≥ 15 years ago. REM - areas that have never been plowed. Sample sizes are presented as XX/YY, where XX is the number of vegetation transects surveyed and YY is the number of VOR and litter depth points surveyed.

		Sample Size and Year Surveyed			
Site	Grassland Type	2008	2009	2010	2011
Bull Moose	DNC	-/-	09/-	-/-	-/17
Phil Aus	DNC	-/-	11/-	-/-	-/20
Register	DNC	-/-	10/-	-/-	-/16
Tarvestad	DNC	-/-	-/-	10/-	-/06
Edwards	ONC	-/-	-/-	-/-	06/71
Freund	ONC	-/-	-/-	05/-	-/13
Howes	ONC	-/-	-/-	07/-	-/05
Pintail	ONC	-/-	-/-	08/-	-/21
Putman	ONC	-/-	-/-	06/-	-/15
Solberg	ONC	-/-	-/-	-/-	10/20
Stinkeoway	ONC	-/-	-/-	-/-	06/10
Tweten	ONC	-/-	-/-	03/-	-/09
Waltz	ONC	-/-	-/-	-/-	17/48
Hofstrand	MSN	-/-	-/-	-/-	19/30
Lake Alice	MSN	-/-	-/-	-/-	07/15
Martinson	MSN	-/-	-/-	-/-	12/28
Register	MSN	-/-	-/-	-/-	11/26
Deep Valley	REM	-/-	-/-	20/-	-/21
Grassland Easement	REM	-/-	-/-	-/-	25/47
Haven	REM	-/-	-/-	14/-	-/43
Langley	REM	-/-	-/-	08/-	-/18
Lone Tree	REM	-/-	-/-	16/-	-/13
Melass	REM	-/-	-/-	21/-	-/13
Native Prairie Unit	REM	-/-	-/-	38/-	-/30
Ziegler	REM	-/-	-/-	08/-	-/10
Avocet Island	WSN	-/-	-/-	08/-	-/02
Breakey	WSN	-/-	11/-	-/-	-/14
Elias	WSN	-/-	11/-	-/-	-/14
Halvorson	WSN	-/-	09/-	-/-	-/15
Martinson	WSN	-/-	10/-	-/-	-/12
Rolling Rock	WSN	-/-	-/-	06/-	-/09
SBA	WSN	-/-	-/-	10/-	-/18

Table 7. Variation of grassland and wetland bird species richness per grassland type.

Grassland type	Number of Sites	Min. Species Richness	Max. Species Richness
ONC	9	3	10
REM	8	5	12
WSN	6	9	12
MSN	4	9	15
DNC	4	10	13

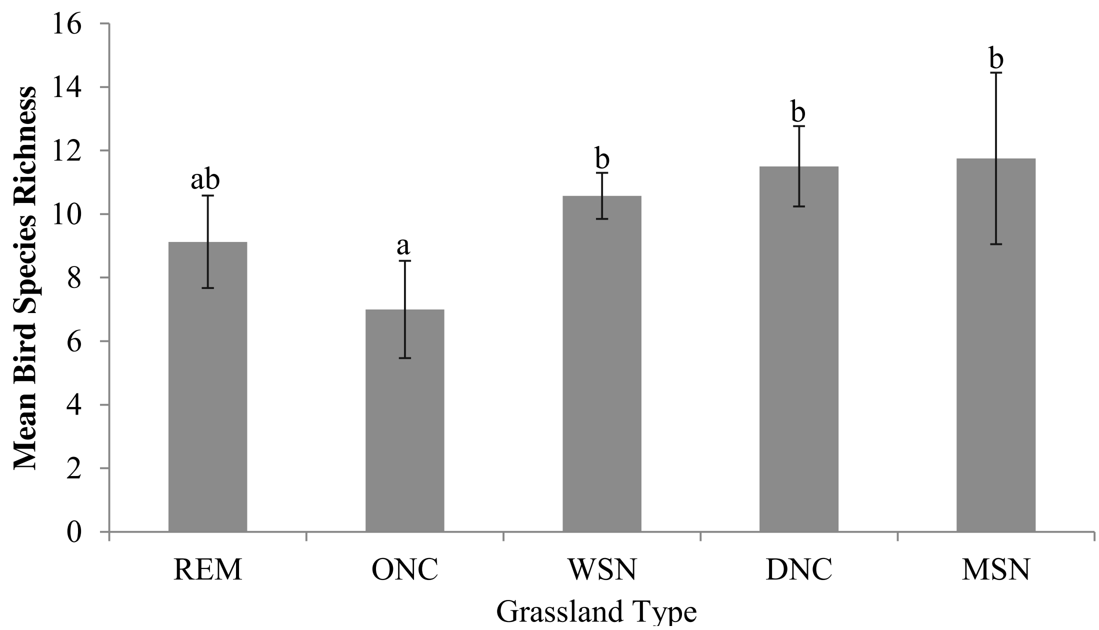

Figure 2. Mean species richness for each grassland type (REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native). Error bars represent 95% confidence intervals. Letters indicate groups that are different based on the Tukey's Post-hoc test.

Table 8. Presence and absence of 20 grassland obligate, grassland user, and wetland avian species on five grassland types.

Avian Species			Grassland Type				
Family	Scientific Name	Common Name	DNC	MSN	WSN	ONC	REM
Alaudidae	*Eremophila alpestris*	Horned Lark		X			
Charadriidae	*Charadrius vociferus*	Killdeer		X	X		
Emberizidae	*Ammodramus leconteii*	Le Conte's Sparrow	X	X	X	X	X
	Ammodramus nelsoni	Nelson's Sparrow	X	X	X	X	X
	Ammodramus savannarum	Grasshopper Sparrow	X	X	X		X
	Passerculus sandwichensi	Savannah Sparrow	X	X	X	X	X
	Pooecetes gramineus	Vesper Sparrow		X			X
	Spizella pallida	Clay-colored Sparrow	X	X	X	X	X
Icteridae	*Agelaius phoeniceus*	Red-winged Blackbird	X	X	X	X	X
	Dolichonyx oryzivorus	Bobolink	X	X	X	X	X
	Molothrus ater	Brown-headed Cowbird	X	X	X	X	X
	Sturnella neglecta	Western Meadowlark	X	X	X	X	X
	Xanthocephalus xanthocephalus	Yellow-headed Blackbird	X	X	X	X	X
Parulidae	*Geothlypis trichas*	Common Yellowthroat	X	X	X	X	X
Scolopacidae	*Bartramia longicauda*	Upland Sandpiper	X		X		X
	Gallinago delicata	Wilson's Snipe	X	X	X		
	Limosa fedoa	Marbled Godwit		X			
Troglodytidae	*Cistothorus platensis*	Sedge Wren	X	X	X	X	X

Table 8 Cont.

Avian Species			Grassland Type				
Family	Scientific Name	Common Name	DNC	MSN	WSN	ONC	REM
Tyrannidae	*Tyrannus tyrannus*	Eastern Kingbird	X	X	X	X	X
	Tyrannus verticalis	Western Kingbird	X	X			X

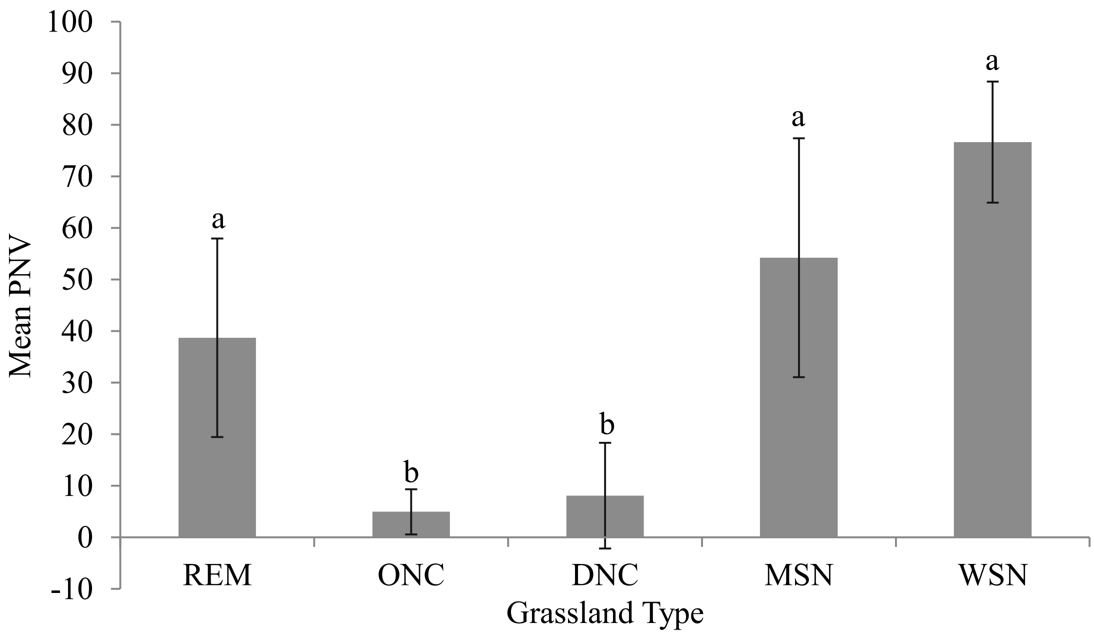

Figure 3. Mean percent native vegetation for each vegetation type (REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native). Error bars represent 95% confidence intervals. Letters indicate groups that are different based on the Tukey's Post-hoc test.

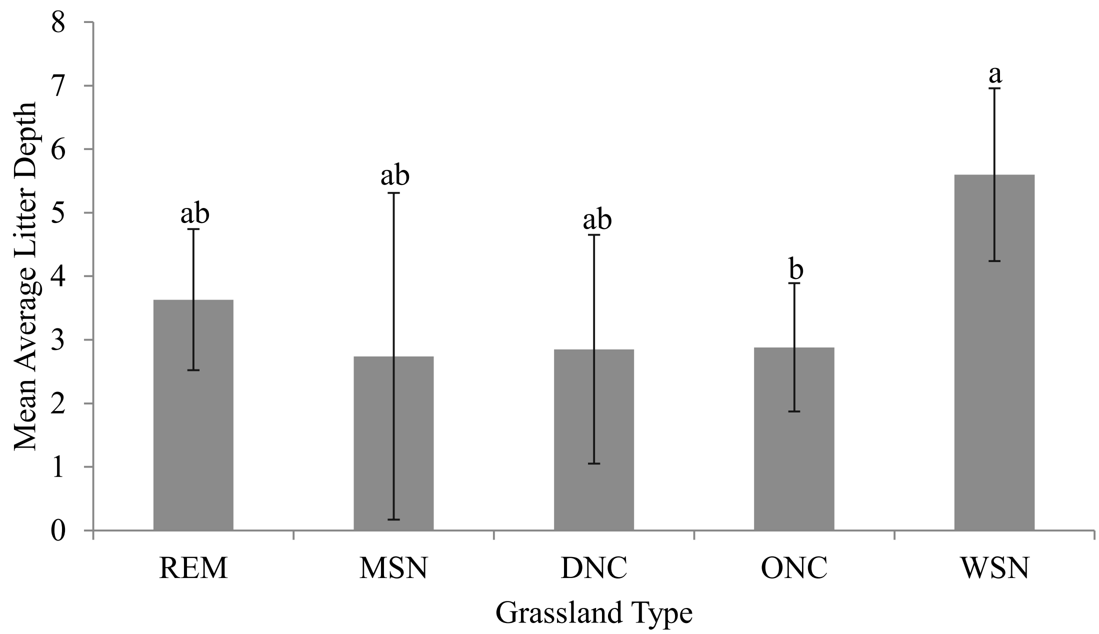

Figure 4. Mean litter depth for each grassland type (REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native). Error bars represent 95% confidence intervals. Letters indicate groups that are different based on the Tukey's Post-hoc test.

Table 9. Results of three 1-way ANOVAs for PNV, average VOR and average litter depth of grassland types. Factors were grassland type (DNC, MSN, WSN, ONC, and REM). PNV = percent native vegetation; VOR = visual obstruction reading.

Covariate		Df	F Value	P Value
PNV				
	Grassland type	4	18.021	<0.001***
	Residuals	27		
Average VOR				
	Grassland type	4	0.770	0.554
	Residuals	27		
Average Litter Depth				
	Grassland type	4	2.900	0.041*
	Residuals	27		

Significant Codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '' 1

Table 10. Results of ANCOVAs of three vegetation measurements influenced by grassland type. PNV = percent native vegetation; VOR = visual obstruction reading.

Covariate	Terms	Df	F Value	P Value
PNV				
	PNV	1	8.403	0.008**
	Grassland type	4	4.205	0.011*
	PNV x Grassland type	4	0.916	0.472
	Residuals	22		
Average VOR				
	Average VOR	1	0.008	0.931
	Grassland type	4	6.454	0.001**
	Average VOR x Grassland type	4	0.849	0.509
	Residuals	22		
Average Litter Depth				
	Average Litter Depth	1	0.817	0.376
	Grassland type	4	5.752	0.003**
	Average Litter Depth x Grassland type	4	0.308	0.869
	Residuals	22		

Significant Codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '' 1

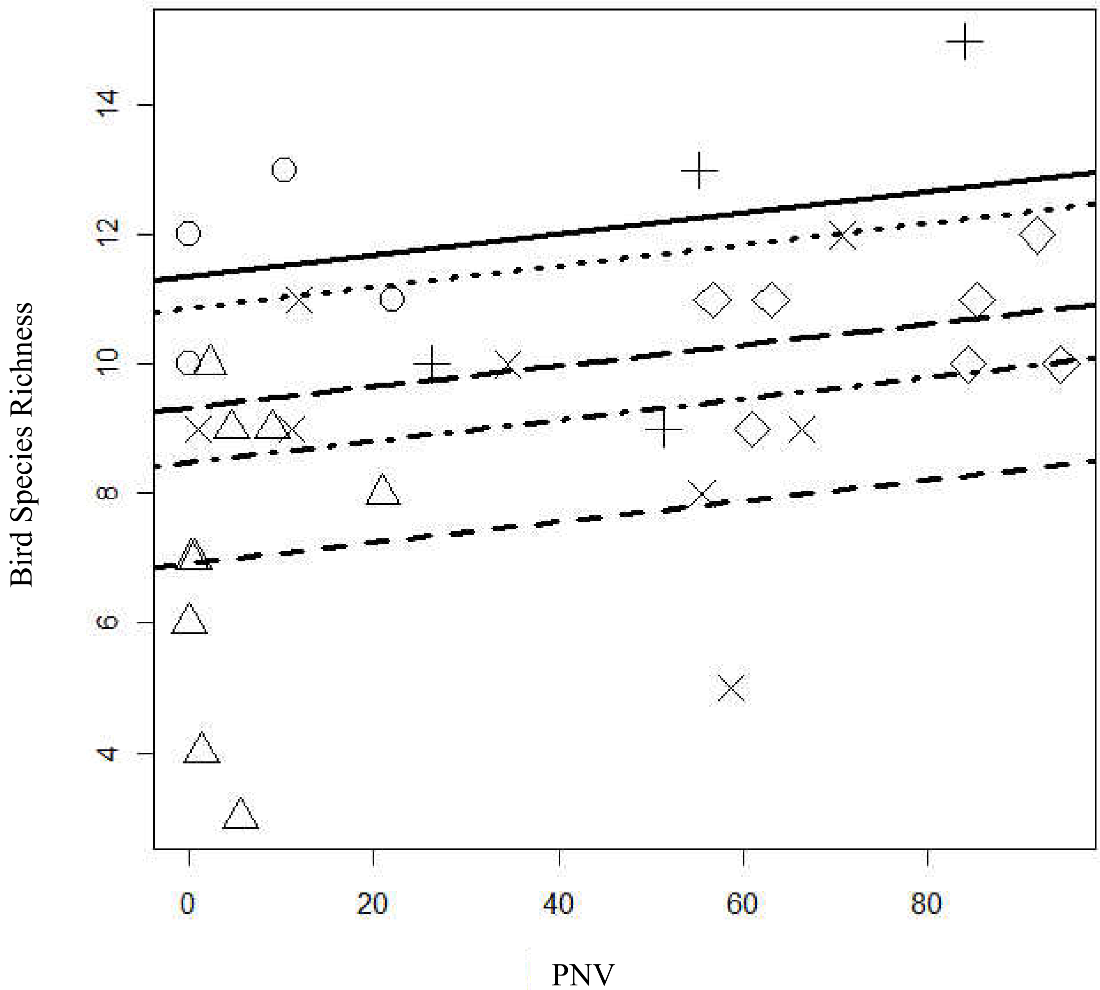

Figure 5. Influence of the percent native vegetation on bird species richness. Solid line and O represent DNC, dashed line and Δ represent ONC, dotted line and + represent MSN, dot-dash line and X represent REM, and long dashed line and ◊ represent WSN grassland types.

CHAPTER III

ASSESSMENT OF LANDSCAPE LEVEL INFLUENCES ON GRASSLAND BIRDS USING GIS TECHNIQUES

Abstract

The loss of remnant prairie can be linked to agricultural intensification, especially in North Dakota. Increasing development, reduced fire frequency, reduced grazing, increasing shelterbelts, and increasing plant invasion all negatively impact native bird populations through changes in quality and composition of habitats in the landscape. These land use practices reduce the size of viable habitat patches and changes the landscape matrix (the areas of the landscape between habitat patches). The primary methods for grassland conservation in the eastern mixed-grass prairie portion of North Dakota are grassland reconstruction and protection of the remaining remnant prairies. Within northeastern and east-central North Dakota, five grassland types (REM, MSN, WSN, ONC, and DNC) were investigated for grassland bird species richness. Point counts were conducted on sites composed of the above mentioned grassland types (n = 32) to monitor grassland bird species richness. These sites are contained within a fragmented landscape. Five landscape variables, grassland/herbaceous cover, open water cover, woody vegetation cover, emergent aquatic vegetation cover, and row crop cover, were measured within 2 km of each study site to determine the influence of the surrounding landscape on bird occupancy. Twenty grassland obligate, grassland user, and

wetland bird species were observed during the course of this study (2008-2011). Based on statistical support in a multi-model analysis, grassland type (which was forced into all models), the percentage of woody vegetation and the percentage of open water within the surrounding landscape influenced grassland bird species richness on the sampled sites.

Introduction

Populations of grassland dependent birds have undergone significant declines in North America, most notably due to the loss and degradation of remnant prairie (Sugden and Beyersbergen 1984, Batt et al. 1989, Johnson and Schwartz 1993, Peterjohn and Sauer 1993, Herkert 1994, Knopf 1994, Dale et al. 1997, Sauer et al. 1999, McMaster et al. 2005, Dahl 2006, Askins et al. 2007). The loss of remnant prairie can be linked to agricultural intensification, especially in North Dakota (Askins et al. 2007), along with increasing urban development, reduced fire frequency, reduced grazing, increased planting of shelterbelts, and increasing plant invasion all negatively impact native bird populations through changes in quality and composition of habitats in the landscape (Knopf 1994, Peterjohn and Sauer 1999, Giuliano and Daves 2002, Grant et al. 2004, Hamer et al. 2006).

The aforementioned land use practices reduce the size of habitat patches and change the landscape matrix (the areas of the landscape between habitat patches; Vittorio 2002). As a result of habitat loss and alteration of the landscape, several species of grassland birds have recently been classified as species of high conservation concern in North Dakota (Hagen et al. 2005). Conservation efforts in response to grassland bird declines have been to preserve remnant prairie patches and construct new grasslands.

This puts habitat back on the landscape, but typically does not take into consideration the composition of the surrounding landscape of the reconstruction sites.

With the continued decline of many grassland bird species, there have been many studies investigating the influence of local factors on grassland bird species richness and occupancy (e.g., Wiens 1969, Whitmore 1979, Rotenberry and Wiens 1980, Madden et al. 2000, Johnson and Igl 2001, Grant et al. 2004, Koper and Schmiegelow 2006, Fisher and Davis 2010). More recently, there has been an increase in studies investigating the influence of landscape factors on grassland bird species richness and occupancy (Dunning et al. 1992, Bakker et al. 2002, Fletcher and Koford 2002, Bender and Fahrig 2005, Cunningham and Johnson 2006, Winter et al. 2006, Ribic et al. 2009, Davis et al. 2013). These studies identified that both local and landscape factors influence grassland bird species. Therefore, studies should include both local and landscape factors when determining what is influencing grassland bird species richness.

Response to landscape level factors, the spatial scale of the landscape level effects, and the response to local factors may differ among avian species (Michaels and Cully 1998, Bakker et al. 2002). Species that forage further from their territories are influenced by the landscape composition at distances of 0-600 or 0-1000 m whereas species that forage near their territories are influenced by the landscape composition at distances of 0-100 or 0-300 m (Soderstrom and Part 2000). Grassland bird species richness has been shown to depend not only on site characteristics, but also on the surrounding landscape characteristics (Knick and Rotenberry 1995, Bakker et al. 2002, Fletcher and Koford 2002). Habitat requirements of 17 of 19 grassland bird species were best explained by models that included both local and landscape scale factors (Cunningham and Johnson 2006). Understanding the influence of local and landscape level factors at varying distances from survey sites on grassland bird species richness will allow for more effective management and conservation by prioritizing sites for grassland reconstruction based upon the composition of the surrounding landscape (Bakker et al. 2002, Cunningham and Johnson 2006).

Previous research has identified that the amount and location of woody vegetation influences many grassland bird distributions, where an abundance of woody vegetation results in reduced bird abundance (e.g., Soderstrom and Part 2000, Best et al. 2001, Coppedge et al. 2001, Ribic and Sample 2001, Fuhlendorf et al. 2002, Niemuth 2003). Considerable amounts of cropland in the landscape have also been shown to influence grassland birds in a negative manner (O'Connor et al. 1999, Brennan and Kuvlesky 2005). The opposite appears to hold true for the amount of grassland in the surrounding landscape. Ribic and Sample (2001) observed that certain species had higher densities at sites with greater amounts of grassland in the surrounding landscape. Additionally, Davis et al. (2013) found that the amount of grassland within 400 m of the study site influenced grassland passerine abundance. Neotropical migrants were also more abundant in landscapes with a greater amount of wetland habitats (i.e., open water and emergent vegetation; Flather and Sauer 1996).

This research is focused on understanding the influence of the surrounding landscape at varying distances (scales) from the study sites on grassland bird use of reconstructed and remnant prairie sites. Landscape composition was examined within gradually increasing radius circles surrounding each study site: 250 m, 500 m, 1000 m, 1500 m, and 2000 m. Previous studies have found that landscape factors from 200 m to 1600 m influence grassland birds (e.g., Bergin et al. 2000, Soderstrom and Part 2000, Ribic and Sample 2001, Bakker et al. 2002). Examining the influence of landscape factors on remnant and reconstructed grassland use by grassland birds is necessary for managing lands in agricultural landscapes (Davis et al. 2013).

Methods

Study Area

The Devils Lake Wetland Management District (WMD), as delineated by the United States Fish and Wildlife Service (USFWS), was established in 1962 to manage important upland and wetland habitat needed by waterfowl and other wildlife. The Devils Lake WMD encompasses eight counties (Benson, Cavalier, Grand Forks, Nelson, Pembina, Ramsey, Towner, and Walsh; see Figure 1) totaling 26,524 square kilometers in northeastern North Dakota. To provide this crucial habitat for waterfowl and other wildlife, the Devils Lake WMD manages 222 WPAs, 4 NWRs, and 2,809 easements that cover 103,416 hectares of wetland and upland habitat. The Arrowwood WMD, established in 1961, encompasses the counties of Eddy and Foster in east-central North Dakota (Figure 1). Arrowwood WMD manages 28 WPAs, 1 NWR, and 318 easements that cover 10,202 hectares of wetland and upland habitat.

The Devils Lake and Arrowwood WMDs are located within the tallgrass and mixed-grass prairies within the Drift Prairie physiographic region (Bluemle 1991). Tallgrass prairie is specifically located within the Red River Valley physiographic region in the eastern portion of the Devils Lake WMD, while the mixed-grass prairie is situated throughout the remaining portion of the study area. The Drift Prairie physiographic region of North Dakota is classified in the wheatgrass-bluestem-needlegrass (*Agropyron-Andropogon-Stipa*) category as delineated by Kuchler 1964. Plant species that historically dominated the landscape in this region consist of cool- and warm-season grasses such as western wheatgrass (*Pascopyron smithii*), slender wheatgrass (*Elymus trachycaulus*), green needlegrass (*Nassella viridula*), prairie Junegrass (*Koeleria macrantha*), needle and thread (*Hesperostipa comata*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), big bluestem (*Andropogon gerardii*), and little bluestem (*Schizachyrium scoparium*; Kuchler 1964). Native forbs found in this region are comprised of fringed sage (*Artemisia frigida*), white sage (*Artemisia ludoviciana*), white prairie aster (*Symphyotrichum falcatum*), purple coneflower (*Echinacea purpurea*), blazing star species (*Liatris* spp.), silver-leaf scurf pea (*Psoralea argophylla*), prairie rose (*Rosa arkansana*), Missouri goldenrod (*Solidago missouriensis*), and soft goldenrod (*Solidago mollis*; Kuchler 1964).

The Drift Prairie physiographic region is located within the prairie pothole region (PPR) of North America. The PPR of North America covers approximately 715000 square kilometers and encompasses Iowa, North Dakota, South Dakota, Minnesota, Montana, Saskatchewan, Manitoba, and Alberta (Euliss et al. 1999). The PPR is made up of many shallow wetlands, tall-grass prairie, mixed-grass prairie and shortgrass prairie (Euliss et al. 1999). These areas contain highly productive soils. As a result, many wetland and remnant prairie areas have been converted to agricultural production (Tiner

1984, Dahl 1990, Dahl and Johnson 1991, Samson and Knopf 1994, Noss et al. 1995). This has created a fragmented landscape of grassland, wetland, and agricultural areas.

Study Site Selection

Between 2008-2011 (Table 2), I surveyed five types of grasslands for grassland birds: 1) multi-species natives (MSN) - areas seeded with a mixture of 12-30 native grasses and forbs, 2) warm-season natives (WSN) - areas seeded with three to four warm-season grasses and not more than six forbs, 3) dense nesting cover (DNC) – areas seeded with a wheatgrass (*Thinopyrum)* species, alfalfa (*Medicago sativa)*, and yellow sweetclover (*Melilotus officinalis*) mixture within the last 15 years, 4) old dense nesting cover (ONC)– areas seeded with a form of dense nesting cover (i.e., non-native grasses, such as smooth brome (*Bromus inermis*)) ≥ 15 years ago, and 5) remnant prairie (REM) - areas that have never been plowed (see Appendix A for site specific seed mixtures). All sites were on WPAs, NWRs, and a private grassland easement within the Devils Lake and Arrowwood WMDs, located in Cavalier, Benson, Ramsey, Towner and Eddy counties, northeastern and east-central North Dakota, USA (Figure 1; Table 3).

Sites were selected for the five grassland types described above from available habitat within the mixed-grass prairie across the Devils Lake and the Arrowwood WMDs. MSN, WSN, and DNC sites are uncommon in this study area as these seed mixtures are either new reconstruction practices (MSN and WSN) or age restricted (DNC), which limited available sites. To qualify as a study site, the species seeded for a particular grassland type had to make up > 50 percent of the study site. REM sites were selected based on historical land use records rather than vegetation cover. The ONC sites were selected based on time since seeding (i.e., these sites were seeded ≥ 15 years ago).

Using the qualifiers described above, 32 sites were chosen among the five grassland types (Table 4). The median site size (n = 32) for the study period, 2008-2011, was 88 ha. The maximum site size was 264 ha (Haven WPA), while the minimum site size was 32 ha (Stinkeoway WPA).

Nearly all of the study sites selected contained a single grassland type surrounded by an agricultural matrix. However, to obtain a large enough sample size, two of the WPAs contained multiple grassland types no nearer than 1.61 km of each other. A minimum distance of 1.61 km between sites was chosen to try and ensure that the multiple grassland types within a WPA were not adjacent to each other allowing them to be considered separate sites. The Martinson WPA contained WSN and MSN grassland types and the Register WPA contained DNC and MSN grassland types. Both WPAs were categorized as two separate sites. Register WPA was split into the sites Register 1 and Register 2, while Martinson WPA was split into sites Martinson 1 and Martinson 2.

Bird Survey Methods

Survey points were distributed within each site in proportion to the amount of habitat available within the five grassland types (Table 5). Each survey point was placed in accordance to the restrictions described below. The number of survey points per grassland type reflects differences in size of available habitat and the amount of hectares contained within each site. Survey points were placed in a restricted randomization design (random locations with restrictions on placement) within the 32 sites. I used 'Geospatial Modeling Environment' ('Hawth's Analysis Tools') in ArcMap™ 9.3.1 (Environmental Systems Research Institute, Redlands, CA), to place survey points within the boundaries of each WPA, NWR, or grassland easement. To meet sampling restrictions, points were repositioned if placed within a wetland, < 100 m from a site edge, and/or < 300 m from another point.

The Register 1 and Register 2 sites contained eleven survey points in total. Two observers were required to complete the survey of the WPA in a single day. The primary observer trained the secondary observer on survey protocol prior to performing surveys. A "practice point" was surveyed by both observers simultaneously and observer results were compared. Upon completion of the "practice point," the primary and secondary observers surveyed their portion of the eleven survey points within the Register site.

Throughout the course of the study (2008-2011), one survey point was eliminated and two survey points were excluded for a year. In 2010 a DNC survey point was removed from the Tarvestad WPA because of rising water. Langley WPA and Haven WPA were added in 2010 to increase the number of survey points within REM.

Survey points and sites were uploaded into a Trimble® GeoXT™ GPS Unit (Trimble Navigation Limited, Sunnyvale, CA) upon completion of making a map in ArcMap™ 9.3.1. Survey sites were located using a Trimble® GeoXT™ GPS Unit and identified a day in advance to ensure survey locations were accessible. Each bird survey point was surveyed twice per field season using a 100 m fixed-radius survey method to catch the peak breeding season for grassland birds, which begins early-May and ends mid-July (Stewart 1975, Winter et al. 2004). Point counts with a 100 m fixed radius may be the most appropriate for bird surveys in open habitats, such as grasslands (Cyr et al. (1995, Savard and Hooper 1995). The first round of surveys began no earlier than 15 May and finished no later than 18 June. The second round of surveys began immediately after the first round was completed and continued until July. All surveys were completed by 08 July each year (Table 2). Surveys started with the southernmost sites and worked north, which ensured the breeding birds had arrived at their breeding sites. The order of sites stayed consistent from the first round of surveys to the second. The same points were surveyed each year with additional sites and survey points added in 2010 to obtain a larger sample size (Table 4). An additional grassland type was also added in 2010 (Table 4).

Surveys took place between sunrise and 1030 Central Standard Time (CST) with four to seven points surveyed per person per day. Surveys ceased when wind speed exceeded 24 km/h based on a Kestrel® 4500/4500 NV Weather Meter™ (Kestrel® Sylvan Lake, MI) or if precipitation exceeded a drizzle (adapted from protocols in Anderson and Ohmart 1977; Robbins 1981; and Ralph et al. 1995). A single observer recorded data at each survey point with two single observers during the full study period (2008-2011). Each survey was conducted over a 12-minute period, which included a two-minute cool down stage upon arrival at the point. This resulted in 10 minutes of actual survey time within a 100 m fixed-radius. The cool down stage ensured the birds became acclimated to observers' presence and behaved as naturally as possible (Bollinger et al. 1988). Singing male birds within the 100 m fixed-radius were recorded after identification (song or sight). This gave singing male densities at each point. Double counting and overestimating the number of individuals at each point was avoided by spacing survey points by a distance of > 300 m (Ralph et al. 1995). Birds that flew over the 100 m fixed-radius survey area without landing were only recorded if they were using the habitat for acts such as displaying or aerial feeding (Johnson and Igl 2001). Data from the first and second round of surveys in each year were pooled to get a representation of all the birds observed at a point. If a site contained multiple points, all points were pooled to determine the site-level species composition (see Appendix B for site specific avian observations). I calculated bird species richness of grassland obligate, grassland user, and wetland species for each study site surveyed (n = 32).

Landscape Classification

Aerial photographs (National Agriculture Imagery Program; NAIP) were obtained of the landscape in and around each WPAs, NWRs, and grassland easements surveyed for grassland birds from the Department of Geography at the University of North Dakota. The NAIP aerial photographs were digitized in ArcMap 9.3 and ArcMap 10.1 to classify landscape characteristics. The photographs were taken in 2009 by the United States Department of Agriculture: Farm Service Agency (USDA: FSA 2009).

For each site surveyed, landscape characteristics were classified at scales up to 2 km from the site (Figure 6). Habitat classification as defined by the 2001 National Land-Cover Database (Homer et al. 2004) which was modified and used to categorize the landscape in northeastern and east-central North Dakota into five cover types: 1) grassland/herbaceous; 2) row crop; 3) open water; 4) emergent vegetation; 5) woody vegetation (Figure 7, Table 14).

Statistical Analyses

I hypothesized that the amount of grassland/herbaceous, row crop, open water, emergent aquatic vegetation, and woody vegetation coverage could influencing bird species richness. I also hypothesized that the impact of the various cover types on species richness may occur at different landscape scales. I calculated bird species richness of grassland obligate, grassland user, and wetland species for each study site surveyed (n = 32).

Multi-model inference was used to construct multiple regression models predicting bird species richness from a local variable, grassland type, as well from landscape variables, the percentage of each of the five described above (Table 15, Table 16, Table 17, Table 18, Table 19), at multiple scales from the sites (e.g., 250 m, 500 m, 1000 m, 1500 m, and 2000 m). All assumptions (normality, linearity, random samples, homogeneity of variance, and x obtained without error) were tested and met. Grassland type was forced into all models as it showed a significant influence on bird species richness (see Chapter II). Due to the large number of variables, models were constructed in a multi-step approach. First, for each of the five landscape variables independently, multi-model inference was utilized to determine which scale or scales had statistical support (e.g., delta AIC < 2) for influencing bird species richness. Secondly, any landscape variables at the scale or scales that had statistical support were combined into an overall model and further investigated through multi-model inference to determine which models had support (Mazerolle 2006). All possible models nested in the global model were obtained using the function *dredge* in the library *MuMIn* (Barton 2011). At all steps of the process, the models were limited to five predictor variables due to the limitations of the sample sizes.

Results

Twenty grassland obligate, grassland user, and wetland bird species were observed during the course of this study within the five grassland types (2008-2011). The multi-model analysis of each land cover type found support for the influence of percentage of open water and woody vegetation on grassland bird species richness at multiple scales (Table 11, Table 12). The amount of open water within the landscape surrounding the surveyed sites for grassland birds resulted in a mostly negative influence on bird species richness; while the amount of woody vegetation within the landscape resulted in a combination of both a negative and positive influence on bird species richness (Table 11, Table 12). The percentage of grassland/herbaceous, row crop, or emergent vegetation did not influence bird species richness as all models resulted in delta AIC > 2. The overall model had many models with support when predicting bird species richness (Table 13). Both the percentage of woody vegetation and the percentage of open water had positive and negative effects on bird species richness depending on the other terms in the models (Table 11, Table 12). When further investigated in an overall model, the percentage of open water and the percentage of woody vegetation had some support for predicting bird species richness, but did not have as much support as grassland type (Table 13).

Discussion

In agreement with my predictions, I found that the percentage of woody vegetation and the percentage of open water within the landscape up to 2000 m from the study sites had statistical support when determining influence on bird species richness (Table 11, Table 12). However, there was no support for the influence of the percentage of grassland/herbaceous cover, the percentage of row crop cover, or the percentage of open water cover at any spatial scale on bird species richness. These results suggest minimal influence of the surrounding landscape on bird species richness. It was also found that grassland type had a significant influence on bird species richness (Chapter II).

Due to the complexity of the landscape matrix, landscape variables contained within 2000 m from study sites are influencing the bird species richness. However, the level of significance did not prove to have much support, if any, for the landscape variables measured within this study. The percentage of woody vegetation within the surrounding landscape resulted in a minimal amount of support suggesting both negative and positive influences on bird species richness. Similar results were found by Kahl et al. (1985), Sample (1989), and Ribic and Sample (2001). Kahl et al. (1985) and Sample (1989) both found that select bird species used woody vegetation as singing perches while Ribic and Sample (2001) found that select species avoid areas containing woody vegetation in the surrounding landscape. The percentage of open water within the surrounding landscape also resulted in a minimal amount of support suggesting a negative influence on bird species richness. This may be a result of the open water cover type not acting as a usable form of habitat for grassland birds.

This research project had a few limitations that may have impacted the significance of the results. The distance to which the landscape variables were analyzed (0–2000 m) may not have been large enough to observe a significant landscape level influence on bird species richness. There have been other studies that have shown landscape effects at larger scales than ours (e.g., Winter 1998). Additionally, the landscape variables investigated may have been inappropriate to measure at such a scale or they may not have been delineated into specific enough categories to observe a more significant influence on bird species richness. Separating the grassland/herbaceous and row crop cover types into more specific categories may have resulted in different findings. Lands such as pasture and hay lands were included within the grassland/herbaceous cover type (Table 14). Lands such as wheat were included within the row crop cover type (Table 14). Had there been separate cover types for these categories, the analysis may have resulted in different findings. Pasture and hay lands may have different disturbances than idle grassland and wheat fields may provide different habitat than fields of corn. Since landscape variables were not considered beyond 2000 m, it is unclear how much farther from the study sites landscape level influences would be observed.

In conclusion, I can suggest that the amount of woody vegetation in the landscape should be identified in the surrounding landscape matrix prior to choosing sites for grassland reconstruction or conservation. The amount of open water should be identified as well. I did not find the amount of grassland in the surrounding landscape was important. However, previous research suggests that the amount of grassland in the surrounding landscape has a significant influence on bird abundance. Therefore, the amount of grassland in the surrounding landscape should also be identified prior to choosing sites for grassland reconstruction and conservation.

Identifying the amount of these landscape variables in the surrounding landscape prior to choosing sites for grassland reconstruction may result in sites that are more beneficial for grassland obligate, grassland user, and wetland avian species. Understanding which sites that may be more beneficial to these species in terms of the surrounding landscape variables will be important as land managers reconstruct formerly cropped areas to multiple grassland types that vary in terms of price/acre (Table 1).

Table 11. Multi-model inference investigating the influence of the percentage of open water and grassland type on grassland bird species richness. All possible combinations of the percentage of open water at varying distances (250 m, 500 m, 1000 m, 1500 m, and 2000 m) from the sites were included in each model. Grassland type was fixed to be included in each model. All models were limited to five predictor variables due to sample size. Water250 = percentage open water within 250 m from site, Water500 = percentage open water within 500 m from site, Water1000 = percentage open water within 1000 m from site, Water1500 = percentage open water within 1500 m from site, Water2000 = percentage open water within 2000 m from site. GrasslandType = REM, MSN, WSN, DNC, and ONC grassland types.

Model Number	Model	delta AIC	R Squared	Model Weight	Coefficient
1	GrasslandType	0.0000	0.4840	0.1110	
2	GrasslandType +	0.0158	0.5344	0.1100	
	Water500				-0.0506
3	GrasslandType +	0.1153	0.5826	0.1040	
	Water1000 +				-0.4388
	Water1500				0.3552
4	GrasslandType +	0.2153	0.5813	0.0990	
	Water1000 +				-0.3287
	Water2000				0.2445
5	GrasslandType +	0.7836	0.5231	0.0750	
	Water1000				-0.0504
6	GrasslandType +	1.0270	0.5195	0.0660	
	Water250				-0.0389
7	GrasslandType +	1.7440	0.5086	0.0460	
	Water1500				-0.0361

Table 12. Multi-model inference investigating the influence of the percentage of woody vegetation and grassland type on grassland bird species richness. All possible combinations of the percentage of woody vegetation at varying distances (250 m, 500 m, 1000 m, 1500 m, and 2000 m) from the sites were included in each model. Grassland type was fixed to be included in each model. All models were limited to five predictor variables due to sample size. Woody250 = percentage woody vegetation within 250 m from site, Woody500 = percentage woody vegetation within 500 m from site, Woody1000 = percentage woody vegetation within 1000 m from site, Woody1500 = percentage woody vegetation within 1500 m from site, Woody2000 = percentage woody vegetation within 2000 m from site. GrasslandType = REM, MSN, WSN, DNC, and ONC grassland types.

Model Number	Model	delta AIC	R Squared	Model Weight	Coefficient
1	GrasslandType	0.0000	0.4840	0.1300	
2	GrasslandType +	0.3103	0.5301	0.1110	
	Woody250				0.1462
3	GrasslandType +	0.8764	0.5218	0.0840	
	Woody500				0.1410
4	GrasslandType +	0.9679	0.5713	0.0800	
	Woody250 +				0.6563
	Woody1500				-0.9985
5	GrasslandType +	1.1490	0.5689	0.0730	
	Woody250 +				1.4970
	Woody500				-1.4470
6	GrasslandType +	1.3350	0.5149	0.0670	
	Woody1000				0.1849
7	GrasslandType +	1.5830	0.5111	0.0590	
	Woody2000				0.2135
8	GrasslandType +	1.7970	0.5078	0.0530	
	Woody1500				0.1984
9	GrasslandType +	1.9720	0.5577	0.0480	
	Woody250 +				0.6782
	Woody1000				-0.8411

Table 13. Overall model investigating the influence of two landscape variables, percentage of open water and percentage of woody vegetation, which showed support (e.g., delta AIC < 2) from the global models. Grassland type was fixed to be included in all models. All models were limited to five predictor variables due to sample size. Water250 = percentage open water within 250 m from site, Water500 = percentage open water within 500 m from site, Water1000 = percentage open water within 1000 m from site, Water1500 = percentage open water within 1500 m from site, Water2000 = percentage open water within 2000 m from site. Woody250 = percentage woody vegetation within 250 m from site, Woody500 = percentage woody vegetation within 500 m from site, Woody1000 = percentage woody vegetation within 1000 m from site, Woody1500 = percentage woody vegetation within 1500 m from site, Woody2000 = percentage woody vegetation within 2000 m from site. GrasslandType = REM, MSN, WSN, DNC, and ONC grassland types.

Model Number	Model	delta AIC	R Squared	Model Weight	Coefficient
1	GrasslandType	0.0000	0.4840	0.0290	
2	GrasslandType +	0.0158	0.5344	0.0290	
	Water500				-0.0506
3	GrasslandType +	0.1153	0.5826	0.0270	
	Water1000 +				-0.4388
	Water1500				0.3552
4	GrasslandType +	0.2153	0.5813	0.0260	
	Water1000 +				-0.3287
	Water2000				0.2445
5	GrasslandType +	0.3103	0.5301	0.0250	
	Woody250				0.1462
6	GrasslandType +	0.7836	0.5231	0.0200	
	Water1000				-0.0504
7	GrasslandType +	0.8764	0.5218	0.0190	
	Woody500				0.1410
8	GrasslandType +	0.9149	0.6214	0.0180	
	Water500 +				-0.0510
	Woody250 +				0.6959
	Woody1500				-1.1090
9	GrasslandType +	0.9679	0.5713	0.0180	
	Woody250 +				0.6563
	Woody1500				-0.9985
10	GrasslandType +	0.9861	0.5711	0.0180	
	Water500 +				-0.0459
	Woody250				0.1311
11	GrasslandType +	1.0270	0.5195	0.0170	
	Water250				-0.0389

Table 13 Cont.

Model Number	Model	delta AIC	R Squared	Model Weight	Coefficient
12	GrasslandType +	1.1490	0.5689	0.0160	
	Woody250 +				1.4970
	Woody500				-1.4470
13	GrasslandType +	1.1910	0.5683	0.0160	
	Water1000 +				-0.0498
	Woody250				0.1448
14	GrasslandType +	1.2550	0.6174	0.0160	
	Water1000 +				-0.0549
	Woody250 +				0.7032
	Woody1500				-1.0940
15	GrasslandType +	1.3350	0.5149	0.0150	
	Woody1000				0.1849
16	GrasslandType +	1.4900	0.5643	0.0140	
	Water500 +				-0.0467
	Woody500				0.1261
17	GrasslandType +	1.5600	0.6622	0.0130	
	Water1000 +				-0.3333
	Water2000 +				0.2435
	Woody250 +				0.7375
	Woody1500				-1.3010
18	GrasslandType +	1.5600	0.6137	0.0130	
	Water500 +				-0.0554
	Woody500 +				0.9379
	Woody1500				-1.4720
19	GrasslandType +	1.5830	0.5111	0.0130	
	Woody2000				0.2135
20	GrasslandType +	1.7200	0.6118	0.0120	
	Water250 +				-0.0427
	Woody250 +				0.7320
	Woody1500				-1.1850
21	GrasslandType +	1.7440	0.5086	0.0120	
	Water1500				-0.0361
22	GrasslandType +	1.7760	0.5604	0.0120	
	Water1000 +				-0.0501
	Woody500				0.1401
23	GrasslandType +	1.7970	0.5078	0.0120	
	Woody1500				0.1984

Table 13 Cont.

Model Number	Model	delta AIC	R Squared	Model Weight	Coefficient
	GrasslandType +	1.8100	0.6595	0.0120	
	Water1000 +				-0.4453
24	Water1500 +				0.3558
	Woody250 +				0.7235
	Woody1500				-1.3010
	GrasslandType +	1.8160	0.5598	0.0120	
25	Water1500 +				-0.0397
	Woody250				0.1545
	GrasslandType +	1.9720	0.5577	0.0110	
26	Woody250 +				0.6782
	Woody1000				-0.8411
	GrasslandType +	1.9940	0.5574	0.0110	
27	Water500 +				-0.0468
	Woody1000				0.1605

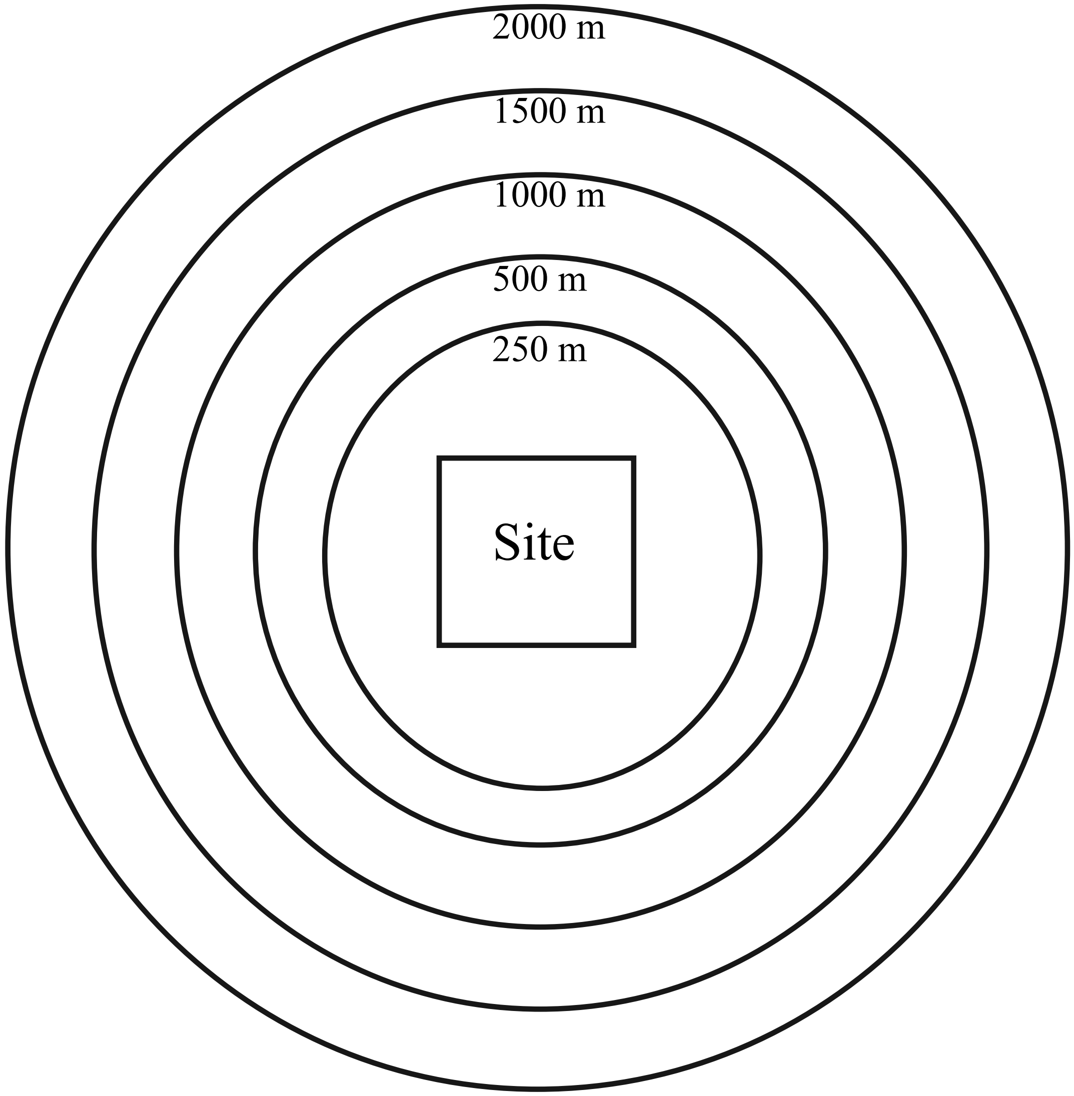

Figure 6. Landscape characteristics were classified within 2 km of each site.

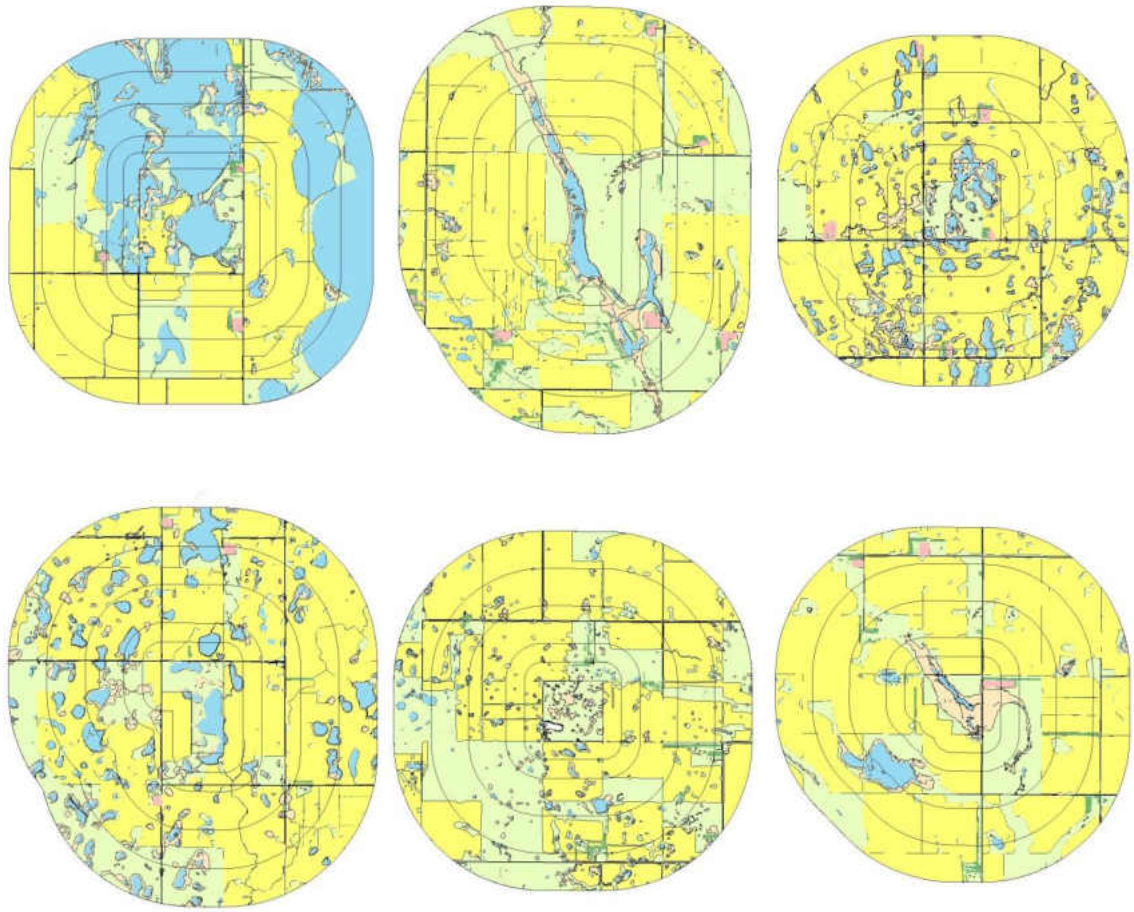

Figure 7. Landscapes in northeastern and east-central North Dakota categorized within 2000 m from each site into five cover types: 1) grassland/herbaceous; 2) row crop; 3) open water; 4) emergent vegetation; 5) woody vegetation.

Table 14. Five landscape variables used to classify areas surrounding surveyed sites.

Land Cover Classes	Land Cover Description
Grassland/Herbaceous	Areas dominated by herbaceous vegetation, generally greater than 80% of total vegetation. This class also includes alfalfa and all hay lands.
Row Crops	Areas used for the production of annual crops. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes small grains (e.g., wheat) and all land being actively tilled.
Open Water	All areas of open water, generally with less than 25% cover of vegetation or soil.
Emergent Vegetation	Areas where perennial herbaceous vegetation occupies periodically saturated or permanent wetlands.
Woody Vegetation	Areas characterized by tree and shrub cover.
	Developed from Homer et al. 2004

Table 15. The percentage of the grassland/herbaceous cover type within scales up to 2000 m from each site surveyed for grassland birds. Grass250 = percentage grassland within 250 m from site, Grass500 = percentage grassland within 500 m from site, Grass1000 = percentage grassland within 1000 m from site, Grass1500 = percentage grassland within 1500 m from site, Grass2000 = percentage grassland within 2000 m from site, REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native.

Site	Grassland Type	Grass250	Grass500	Grass1000	Grass1500	Grass2000
Avocet Island	WSN	16.96	16.75	19.81	21.14	19.19
Breakey	WSN	38.39	36.57	32.25	32.52	32.61
Deep Valley	REM	50.54	47.90	38.75	35.00	35.86
Edwards	ONC	15.58	11.15	10.15	12.07	12.05
Elias	WSN	15.48	12.99	12.86	12.79	13.76
Freund	ONC	62.29	55.88	62.23	68.97	72.35
Grassland Easement	REM	54.64	49.04	42.86	40.28	39.53
Halvorson	WSN	76.52	76.39	76.99	76.71	74.59
Haven	REM	71.05	63.52	59.57	62.05	66.28
Hofstrand	MSN	32.47	32.15	34.64	34.85	32.73
Howes	ONC	26.48	23.02	18.56	15.59	16.25
Lake Alice	MSN	11.18	17.61	22.79	16.30	15.16
Langley	REM	61.79	56.07	51.07	54.27	54.08
Lone Tree	REM	41.03	39.54	39.64	40.41	46.14

Table 15 Cont.

Site	Grassland Type	Grass250	Grass500	Grass1000	Grass1500	Grass2000
Martinson 1	WSN	15.04	17.23	20.86	20.65	21.92
Martinson 2	MSN	40.12	38.76	37.07	38.89	36.45
Melass	REM	51.16	46.85	41.81	39.97	35.94
Native Prairie Unit	REM	72.40	74.66	71.66	66.74	64.79
Phil Aus	DNC	14.59	10.62	10.95	11.79	15.00
Pintail	ONC	33.61	27.71	24.39	17.82	19.21
Putman	ONC	15.07	19.82	18.96	18.58	23.17
Register 1	DNC	87.42	80.47	72.19	68.44	66.43
Register 2	MSN	52.75	53.09	54.35	55.23	55.68
Rolling Rock	WSN	26.40	29.09	33.88	34.05	34.84
SBA	WSN	56.91	48.99	45.23	44.23	42.43
Solberg	ONC	23.14	19.86	22.72	25.37	28.95
Stephens	DNC	29.41	28.78	30.16	36.46	41.85
Stinkeoway	ONC	31.15	28.79	27.38	27.29	26.72
Tarvestad	DNC	6.32	8.96	14.61	16.96	16.05
Tweten	ONC	19.92	27.09	34.79	24.98	24.65
Waltz	ONC	25.73	22.37	26.74	26.77	25.03
Ziegler	REM	14.23	13.46	12.13	16.68	20.49

Table 16. The percentage of the open water cover type within scales up to 2000 m from each site surveyed for grassland birds. Water250 = percentage open water within 250 m from site, Water500 = percentage open water within 500 m from site, Water1000 = percentage open water within 1000 m from site, Water1500 = percentage open water within 1500 m from site, Water2000 = percentage open water within 2000 m from site, REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native.

Site	Grassland Type	Water250	Water500	Water1000	Water1500	Water2000
Avocet Island	WSN	36.61	36.81	28.69	31.81	34.99
Breakey	WSN	4.29	3.78	4.72	5.20	6.20
Deep Valley	REM	3.23	1.79	2.91	1.88	1.56
Edwards	ONC	2.71	2.66	2.74	2.62	2.89
Elias	WSN	12.97	9.74	5.85	4.61	4.67
Freund	ONC	15.57	19.25	11.42	8.50	7.68
Grassland Easement	REM	4.89	6.27	5.76	4.56	3.68
Halvorson	WSN	1.58	1.34	1.95	1.69	2.16
Haven	REM	0.36	0.92	1.13	1.63	2.14
Hofstrand	MSN	3.88	3.46	3.96	2.89	2.49
Howes	ONC	3.20	3.59	5.08	5.35	5.04
Lake Alice	MSN	46.33	41.33	31.15	35.50	38.03
Langley	REM	4.07	1.71	0.71	0.65	1.79
Lone Tree	REM	10.51	5.20	2.91	2.50	2.56
Martinson 1	WSN	17.89	16.55	10.21	7.20	6.07
Martinson 2	MSN	4.94	5.59	9.42	8.24	8.09
Melass	REM	13.95	13.18	12.96	10.49	9.04
Native Prairie Unit	REM	3.58	2.58	6.98	11.74	12.70
Phil Aus	DNC	7.29	4.88	3.09	1.99	2.06
Pintail	ONC	2.46	1.78	1.58	1.86	1.55
Putman	ONC	8.56	7.30	5.91	7.19	7.46
Register 1	DNC	4.72	6.28	5.38	5.05	5.06
Register 2	MSN	5.38	4.87	4.49	5.97	6.45
Rolling Rock	WSN	2.80	1.84	1.65	1.35	1.55
SBA	WSN	0.41	0.17	0.19	3.01	3.39
Solberg	ONC	2.48	2.57	5.62	6.33	7.83
Stephens	DNC	1.47	1.02	0.89	1.24	1.21
Stinkeoway	ONC	6.02	5.17	5.17	4.57	5.18
Tarvestad	DNC	39.96	44.70	52.26	58.23	60.59

Table 16 Cont.

Site	Grassland Type	Water250	Water500	Water1000	Water1500	Water2000
Tweten	ONC	0.83	1.22	3.21	2.85	1.91
Waltz	ONC	12.20	9.84	8.56	8.36	8.32
Ziegler	REM	44.31	27.26	18.04	15.76	13.60

Table 17. The percentage of the emergent vegetation cover type within scales up to 2000 m from each site surveyed for grassland birds. Emergent250 = percentage emergent vegetation within 250 m from site, Emergent500 = percentage emergent vegetation within 500 m from site, Emergent1000 = percentage emergent vegetation within 1000 m from site, Emergent1500 = percentage emergent vegetation within 1500 m from site, Emergent2000 = percentage emergent vegetation within 2000 m from site, REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native.

Site	Grassland Type	Emergent 250	Emergent 500	Emergent 1000	Emergent 1500	Emergent 2000
Avocet Island	WSN	2.01	2.78	2.49	2.49	2.74
Breakey	WSN	11.75	10.59	10.39	10.78	11.41
Deep Valley	REM	5.38	6.91	6.30	4.83	3.90
Edwards	ONC	14.22	20.44	15.25	13.68	13.03
Elias	WSN	20.50	18.90	10.03	8.53	8.02
Freund	ONC	13.93	12.67	9.60	9.74	8.79
Grassland Easement	REM	10.05	10.96	8.96	8.75	8.45
Halvorson	WSN	5.42	6.13	6.51	6.24	7.05
Haven	REM	2.49	1.78	1.86	1.74	1.65
Hofstrand	MSN	9.37	9.06	7.45	6.45	5.79
Howes	ONC	7.76	8.39	8.33	7.81	7.80
Lake Alice	MSN	7.99	8.42	6.39	5.15	4.01
Langley	REM	2.85	2.81	1.29	0.79	0.87
Lone Tree	REM	10.77	9.63	5.73	3.65	2.61
Martinson 1	WSN	16.26	18.16	13.09	9.67	8.86
Martinson 2	MSN	6.98	7.66	9.83	9.74	10.40
Melass	REM	12.29	12.40	9.43	8.14	7.20
Native Prairie Unit	REM	0.90	0.87	0.90	1.41	1.42

Table 17 Cont.

Site	Grassland Type	Emergent 250	Emergent 500	Emergent 1000	Emergent 1500	Emergent 2000
Phil Aus	DNC	7.06	5.37	3.18	2.99	3.01
Pintail	ONC	7.79	9.32	7.15	5.99	5.42
Putman	ONC	5.48	7.53	6.49	6.81	6.53
Register 1	DNC	7.86	9.75	9.25	9.50	9.18
Register 2	MSN	8.29	9.25	7.48	7.81	8.09
Rolling Rock	WSN	3.60	3.64	2.66	1.99	2.21
SBA	WSN	17.48	25.69	15.46	11.68	9.25
Solberg	ONC	11.98	13.18	14.59	15.63	16.24
Stephens	DNC	6.86	5.14	4.91	4.87	6.57
Stinkeoway	ONC	10.21	8.55	7.87	8.24	8.23
Tarvestad	DNC	8.35	9.59	9.79	8.02	7.91
Tweten	ONC	17.84	11.72	6.21	4.00	2.65
Waltz	ONC	19.63	22.88	17.13	17.04	16.08
Ziegler	REM	1.63	2.98	3.47	5.38	5.17

Table 18. The percentage of the row crop cover type within scales up to 2000 m from each site surveyed for grassland birds. Crop250 = percentage row crop within 250 m from site, Crop500 = percentage row crop within 500 m from site, Crop1000 = percentage row crop within 1000 m from site, Crop1500 = percentage row crop within 1500 m from site, Crop2000 = percentage row crop within 2000 m from site, REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native.

Site	Grassland Type	Crop250	Crop500	Crop1000	Crop1500	Crop2000
Avocet Island	WSN	43.53	43.23	48.42	44.15	42.69
Breakey	WSN	45.56	50.06	52.43	51.27	49.53
Deep Valley	REM	39.52	42.51	50.86	56.93	57.28
Edwards	ONC	66.59	68.71	71.35	71.26	71.54
Elias	WSN	49.79	60.85	70.93	73.68	73.19
Freund	ONC	7.38	11.93	15.12	11.33	9.98
Grassland Easement	REM	29.38	33.98	41.81	45.49	47.34
Halvorson	WSN	14.45	14.95	12.72	13.62	14.42
Haven	REM	25.93	32.97	35.07	32.03	27.63
Hofstrand	MSN	53.63	55.62	53.26	55.21	58.19
Howes	ONC	62.56	65.47	66.90	70.09	69.88
Lake Alice	MSN	34.51	33.15	39.23	42.70	42.33
Langley	REM	31.30	38.97	46.10	42.50	40.44
Lone Tree	REM	35.64	44.86	49.86	52.08	47.23
Martinson 1	WSN	50.41	50.17	54.94	61.85	62.68
Martinson 2	MSN	46.80	48.03	43.43	42.96	44.86
Melass	REM	22.26	28.65	34.79	39.48	45.86
Native Prairie Unit	REM	0.00	0.00	4.97	6.94	7.82
Phil Aus	DNC	71.06	79.41	82.65	82.59	79.21
Pintail	ONC	55.33	61.28	66.19	73.83	72.98
Putman	ONC	70.55	65.57	68.40	67.14	62.54
Register 1	DNC	0	4.37	13.13	16.81	18.91
Register 2	MSN	33.26	33.14	33.08	30.39	29.23
Rolling Rock	WSN	66.00	64.21	60.74	61.29	60.41
SBA	WSN	24.79	29.73	38.29	40.16	43.89
Solberg	ONC	62.39	65.93	57.07	52.63	46.90
Stephens	DNC	62.01	64.73	63.38	56.88	49.89
Stinkeoway	ONC	51.57	57.69	59.34	59.69	59.68
Tarvestad	DNC	45.15	37.07	22.78	16.22	15.01

Table 18 Cont.

Site	Grassland Type	Crop250	Crop500	Crop1000	Crop1500	Crop2000
Tweten	ONC	58.51	59.09	54.35	67.05	69.51
Waltz	ONC	41.38	48.71	47.29	47.62	50.42
Ziegler	REM	39.84	56.39	66.37	61.76	59.96

Table 19. The percentage of the woody vegetation cover type within scales up to 2000 m from each site surveyed for grassland birds. Woody250 = percentage woody vegetation within 250 m from site, Woody500 = percentage woody vegetation within 500 m from site, Woody1000 = percentage woody vegetation within 1000 m from site, Woody1500 = percentage woody vegetation within 1500 m from site, Woody2000 = percentage woody vegetation within 2000 m from site, REM = remnant prairie, ONC = old dense nesting cover, WSN = warm-season native, DNC = dense nesting cover, and MSN = multi-species native.

Site	Grassland Type	Woody 250	Woody 500	Woody 1000	Woody 1500	Woody 2000
Avocet Island	WSN	0.89	0.50	0.59	0.41	0.38
Breakey	WSN	0.00	0.00	0.20	0.23	0.24
Deep Valley	REM	1.34	1.32	1.18	1.35	1.39
Edwards	ONC	0.90	0.51	0.51	0.37	0.49
Elias	WSN	1.26	0.51	0.32	0.38	0.37
Freund	ONC	0.82	1.70	1.62	1.45	1.21
Grassland Easement	REM	1.03	0.84	0.60	0.91	1.01
Halvorson	WSN	2.03	1.55	1.82	1.74	1.77
Haven	REM	0.18	0.84	2.37	2.55	2.31
Hofstrand	MSN	0.65	0.46	0.69	0.59	0.79
Howes	ONC	0.00	0.19	1.13	1.16	1.03
Lake Alice	MSN	0.00	0.14	0.44	0.36	0.47
Langley	REM	0	0.51	0.84	1.79	2.83
Lone Tree	REM	2.05	1.62	1.86	1.37	1.46
Martinson 1	WSN	0.41	0.68	0.90	0.62	0.47
Martinson 2	MSN	1.16	0.51	0.26	0.17	0.20
Melass	REM	0.33	0.29	1.01	1.93	1.95
Native Prairie Unit	REM	23.12	21.89	15.50	13.17	13.27
Phil Aus	DNC	0.00	0.00	0.13	0.64	0.71
Pintail	ONC	0.82	0.71	0.69	0.49	0.83
Putman	ONC	0.34	0.29	0.23	0.29	0.30
Register 1	DNC	0.00	0.00	0.05	0.21	0.42

Table 19 Cont.

Site	Grassland Type	Woody 250	Woody 500	Woody 1000	Woody 1500	Woody 2000
Register 2	MSN	0.32	0.42	0.59	0.61	0.59
Rolling Rock	WSN	1.20	1.34	1.08	1.32	0.99
SBA	WSN	0.41	0.68	0.83	0.91	1.04
Solberg	ONC	0.00	0.00	0.00	0.03	0.09
Stephens	DNC	0.25	0.57	0.66	0.56	0.47
Stinkeoway	ONC	1.05	0.47	0.24	0.22	0.19
Tarvestad	DNC	0.23	0.51	0.56	0.57	0.44
Tweten	ONC	2.91	2.09	1.44	1.11	1.28
Waltz	ONC	1.06	0.47	0.29	0.2	0.16
Ziegler	REM	0.00	0.00	0.00	0.41	0.79

CHAPTER IV

CONCLUSIONS

Grassland birds are a suite of species that depend on remnant prairie and grassland for breeding sites; however, the grassland cover type has declined extensively, resulting in a decline in grassland birds throughout North America. The remaining grasslands are often encompassed within a fragmented landscape that includes varying landscape variables, some of which negatively influence bird species richness. This has resulted in many grassland bird species being identified as species of conservation concern. Identifying desirable habitat and landscape factors will be beneficial for land management.

This research was the first to address the use of grassland obligate, grassland user, and wetland avian species on five grassland types within a fragmented landscape in northeastern and east-central North Dakota. Results of this work indicate that these bird species inhabited the MSN and DNC grassland types more over the other three (ONC, REM, and WSN). In addition, my research shows that the amount of woody vegetation as well as the amount of open water had some support for predicting local bird species richness. It is important for future studies to investigate detailed landscape level effects at further scales on grassland obligate, grassland user, and wetland avian species since this study failed to detect significance of many variables examined. This will allow for the proper management for the success of these species. This study provides important information to land managers for the management of grassland obligate, grassland user, and wetland avian species. Additional research in northeastern and east-central North Dakota is needed to determine the impacts of landscape variables at larger spatial scales from the study sites. This will allow for better determination in grassland reconstruction site selection.

APPENDICES

Appendix A

Site Specific Seed Mixtures

DNC

Plant Species			Sites			
Family	Scientific Name	Common Name	Register 1	Phil Aus	Tarvestad	Bull Moose
Fabaceae	*Medicago sativa*	Alfalfa	X	X	X	X
	Melilotus officinalis	Yellow Sweetclover	X	X	X	X
Poaceae	*Thinopyrum ponticum*	Tall Wheatgrass	X	X	X	X
	Thinopyrum intermedium	Intermediate Wheatgrass		X	X	X
	Pascopyrum smithii	Western Wheatgrass	X			
	Panicum virgatum	Switchgrass				X

MSN

Plant Species			Sites			
Family	Scientific Name	Common Name	Register 2	Hofstrand	Lake Alice	Martinson 2
Asteraceae	*Echinacea angustifolia*	Purple Coneflower		X	X	X
	Gaillardia aristata	Blanket Flower	X	X	X	X
	Helianthus maximilianii	Maximilian Sunflower		X	X	X
	Liatris ligulistylis	Meadow Blazingstar	X			
	Liatris pycnostachya	Prairie Blazingstar		X		
	Ratibida columnifera	Prairie Coneflower		X		X
	Rudbeckia hirta	Black-eyed Susan	X	X	X	X
	Solidago rigida	Stiff Goldenrod	X			
Fabaceae	*Amorpha canescens*	Leadplant		X		
	Astragalus canadensis	Canada Milkvetch	X		X	

Appendix A: MSN Cont.

Plant Species			Sites			
Family	Scientific Name	Common Name	Register 2	Hofstrand	Lake Alice	Martinson 2
	Dalea candida	White Prairie Clover	X			
	Dalea purpurea	Purple Prairie Clover	X	X	X	X
	Vicia americana	American Vetch	X			
Lamiaceae	*Monarda fistulosa*	Wild Bergamot	X	X		
Linaceae	*Linum lewisii*	Lewis Flax		X	X	X
Poaceae	*Pascopyrum smithii*	Western Wheatgrass	X	X	X	X
	Elymus trachycaulus	Slender Wheatgrass	X	X	X	X
	Andropogon gerardii	Big Bluestem	X	X		X
	Andropogon scoparius	Little Bluestem	X		X	
	Bouteloua curtipendula	Sideoats Grama	X	X	X	X
	Bouteloua gracilis	Blue Grama		X		X
	Elymus canadensis	Canada Wildrye	X	X	X	X
	Nassella viridula	Green Needlegrass	X	X	X	X
	Panicum virgatum	Switchgrass	X	X	X	X
	Sorghastrum nutans	Indiangrass	X	X	X	X
	Hesperostipa comata	Needle and thread	X			
	Hesperostipa spartea	Porcupine grass		X		
Roasaceae	*Rosa arkansana*	Prairie Rose	X			
Scrophulariaceae	*Penstemon grandiflorus*	Shell-leaf Penstemon		X		X

WSN

Plant Species			Sites						
Family	Scientific Name	Common Name	Martinson 1	Rolling Rock	Avocet Island	Breakey	Elias	Halvorson	SBA
Apiaceae	*Zizia aurea*	Golden Alexander				X	X		
Asteraceae	*Cirsium arvense*	Canada Thistle				X			
	Helinathus annuus	Wild Sunflower				X	X		
	Liatris spp.	Blazingstar spp.				X	X		
	Solidago rigida	Stiff Goldenrod				X	X		
Fabaceae	*Astragalus canadensis*	Canada Milkvetch	X						
	Medicago sativa	Alfalfa	X	X	X				
	Melilotus officinalis	Yellow Sweetclover				X	X	X	X
Poaceae	*Pascopyrum smithii*	Western Wheatgrass						X	X
	Elymus trachycaulus	Slender Wheatgrass						X	X
	Andropogon gerardii	Big Bluestem	X	X	X			X	X
	Andropogon scoparius	Little Bluestem				X	X	X	

Appendix A: WSN Cont.

Plant Species			Sites						
Family	Scientific Name	Common Name	Martinson 1	Rolling Rock	Avocet Island	Breakey	Elias	Halvorson	SBA
	Bouteloua curtipendula	Sideoats Grama				X	X		
	Calamovilfa longifolia	Prairie Sandreed						X	
	Elymus canadensis	Canada Wildrye				X	X		
	Panicum virgatum	Switchgrass	X	X	X	X	X	X	
	Sorghastrum nutans	Indiangrass	X	X	X	X	X		X
	Spartina pectinata	Prairie Cordgrass				X	X		
	Sporobolus heterolepis	Prairie Dropseed				X	X		
Ranunculaceae	*Thalictrum pubescens*	Tall Meadowrue				X	X		
Rubiaceae	*Galium boreale*	Northern Bedstraw				X	X		

ONC

Plant Species			Site								
Family	Scientific Name	Common Name	Waltz	Solberg	Stinkeoway	Freund	Tweten	Pintail	Howes	Edwards	Putman
Fabaceae	*Medicago sativa*	Alfalfa		X	X	X			X	X	X
	Melilotus officinalis	Yellow Sweetclover	X	X	X	X	X	X	X	X	X
Poaceae	*Agropyron elongatum*	Tall Wheatgrass		X	X				X	X	
	Thinopyrum intermedium	Intermediate Wheatgrass		X	X				X	X	
	Pascopyrum smithii	Western Wheatgrass			X			X			
	Elymus trachycaulus	Slender Wheatgrass			X			X			
	Bromus inermis	Smooth Bromegrass	X			X	X				X
	Nassella viridula	Green Needlegrass			X			X			
	Phalaris arundinacea	Reed Canarygrass						X			

Appendix B

Site Specific Avian Observations

DNC

Avian Species			Sites			
Family	Scientific Name	Common Name	Register	Phil Aus	Tarvestad	Bull Moose
Emberizidae	*Ammodramus leconteii*	Le Conte's Sparrow	X	X	X	X
	Ammodramus nelsoni	Nelson's Sparrow	X	X	X	X
	Ammodramus savannarum	Grasshopper Sparrow	X			
	Melospiza melodia	Song Sparrow	X			
	Passerculus sandwichensi	Savannah Sparrow	X	X	X	X
	Spizella pallida	Clay-colored Sparrow	X	X	X	X
Fringillidae	*Spinus tristis*	American Goldfinch		X		
Icteridae	*Agelaius phoeniceus*	Red-winged Blackbird	X	X	X	X
	Dolichonyx oryzivorus	Bobolink	X	X	X	X
	Molothrus ate	Brown-headed Cowbird	X	X	X	X
	Sturnella neglecta	Western Meadowlark	X	X		
	Xanthocephalus xanthocephalus	Yellow-headed Blackbird		X	X	
Parulidae	*Dendroica petechia*	Yellow Warbler			X	
	Geothlypis trichas	Common Yellowthroat	X	X	X	X

Appendix B: DNC Cont.

Avian Species			Sites			
Family	Scientific Name	Common Name	Register	Phil Aus	Tarvestad	Bull Moose
Scolopacidae	*Bartramia longicauda*	Upland Sandpiper		X		
	Gallinago delicata	Wilson's Snipe				X
Troglodytidae	*Cistothorus platensis*	Sedge Wren	X	X	X	X
Tyrannidae	*Tyrannus tyrannus*	Eastern Kingbird	X			
	Tyrannus verticalis	Western Kingbird				X

MSN

Avian Species			Sites			
Family	Scientific Name	Common Name	Register	Hofstrand	Lake Alice	Martinson
Alaudidae	*Eremophila alpestris*	Horned Lark	X			
Charadriidae	*Charadrius vociferus*	Killdeer		X		
Colimbidae	*Zenaida macroura*	Mourning Dove			X	
Emberizidae	*Ammodramus leconteii*	Le Conte's Sparrow	X	X	X	X
	Ammodramus nelsoni	Nelson's Sparrow	X	X	X	X
	Ammodramus savannarum	Grasshopper Sparrow	X		X	
	Melospiza melodia	Song Sparrow		X	X	X
	Passerculus sandwichensi	Savannah Sparrow	X	X	X	X
	Pooecetes gramineus	Vesper Sparrow	X			
	Spizella pallida	Clay-colored Sparrow	X	X	X	X
Icteridae	*Agelaius phoeniceus*	Red-winged Blackbird	X	X	X	X

Appendix B: MSN Cont.

Avian Species			Sites			
Family	Scientific Name	Common Name	Register	Hofstrand	Lake Alice	Martinson
	Dolichonyx oryzivorus	Bobolink	X	X	X	X
	Molothrus ate	Brown-headed Cowbird	X	X	X	X
	Sturnella neglecta	Western Meadowlark	X	X		
	Xanthocephalus xanthocephalus	Yellow-headed Blackbird		X		
Parulidae	*Dendroica petechia*	Yellow Warbler				
	Geothlypis trichas	Common Yellowthroat	X	X	X	X
Scolopacidae	*Gallinago delicata*	Wilson's Snipe				
Scolopacidae	*Limosa fedoa*	Marbled Godwit	X			
Troglodytidae	*Cistothorus platensis*	Sedge Wren	X	X	X	X
Tyrannidae	*Tyrannus tyrannus*	Eastern Kingbird	X	X		
	Tyrannus verticalis	Western Kingbird				

WSN

Avian Species			Sites						
Family	Scientific Name	Common Name	Martinson	Rolling Rock	Avocet Island	Breakey	Elias	Halvorson	SBA
Charadriidae	*Charadrius vociferus*	Killdeer			X				
Columbidae	*Zenaida macroura*	Mourning Dove							
Emberizidae	*Ammodramus leconteii*	Le Conte's Sparrow	X		X	X	X	X	X

Appendix B: WSN Cont.

Avian Species			Sites						
Family	Scientific Name	Common Name	Martinson	Rolling Rock	Avocet Island	Breakey	Elias	Halvorson	SBA
	Ammodramus nelsoni	Nelson's Sparrow	X		X	X	X	X	X
	Ammodramus savannarum	Grasshopper Sparrow						X	
	Melospiza melodia	Song Sparrow	X		X		X	X	
	Passerculus sandwichensi	Savannah Sparrow	X	X	X	X	X	X	X
	Spizella pallida	Clay-colored Sparrow	X	X	X	X	X	X	X
Hirundinidae	*Tachycineta bicolor*	Tree Swallow						X	
Icteridae	*Agelaius phoeniceus*	Red-winged Blackbird	X	X	X	X	X	X	X
	Dolichonyx oryzivorus	Bobolink	X		X	X	X	X	X
	Molothrus ate	Brown-headed Cowbird	X	X	X	X	X	X	X
	Quiscalus quiscula	Common Grackle		X			X		
	Sturnella neglecta	Western Meadowlark		X				X	

Appendix B: WSN Cont.

Avian Species			Sites						
Family	Scientific Name	Common Name	Martinson	Rolling Rock	Avocet Island	Breakey	Elias	Halvorson	SBA
	Xanthocephalus xanthocephalus	Yellow-headed Blackbird	X	X	X	X	X		
Parulidae	*Dendroica petechia*	Yellow Warbler					X	X	
	Geothlypis trichas	Common Yellowthroat	X	X	X	X	X	X	X
Scolopacidae	*Bartramia longicauda*	Upland Sandpiper				X			
	Gallinago delicata	Wilson's Snipe		X			X		
Troglodytidae	*Cistothorus platensis*	Sedge Wren	X	X	X	X	X	X	X
Tyrannidae	*Tyrannus tyrannus*	Eastern Kingbird				X		X	X

ONC

Avian Species			Sites								
Family	Scientific Name	Common Name	Waltz	Sol-berg	Stinke-oway	Freund	Tweten	Pintail	Howes	Edw-ards	Putman
Emberizidae	*Ammodramus leconteii*	Le Conte's Sparrow	X	X	X		X			X	
	Ammodramus nelsoni	Nelson's Sparrow	X	X	X			X	X	X	X

Appendix B: ONC Cont.

Avian Species			Sites								
Family	Scientific Name	Common Name	Waltz	Sol-berg	Stinke-oway	Freund	Tweten	Pintail	Howes	Edw-ards	Putman
	Passerculus sandwichensi	Savannah Sparrow	X	X	X	X	X	X	X	X	X
	Spizella pallida	Clay-colored Sparrow	X	X	X	X	X	X	X	X	X
Icteridae	*Agelaius phoeniceus*	Red-winged Blackbird	X		X		X	X	X		
	Dolichonyx oryzivorus	Bobolink	X	X	X	X	X	X		X	X
	Molothrus ate	Brown-headed Cowbird	X	X	X		X	X	X		
	Quiscalus quiscula	Common Grackle	X						X		
	Sturnella neglecta	Western Meadowlark	X								
	Xanthocephalus xanthocephalus	Yellow-headed Blackbird		X				X			
Parulidae	*Geothlypis trichas*	Common Yellowthroat		X				X	X		
Troglodytidae	*Cistothorus platensis*	Sedge Wren	X	X	X		X	X	X	X	
Tyrannidae	*Tyrannus tyrannus*	Eastern Kingbird	X								

REM

Avian Species			Sites							
Family	Scientific Name	Common Name	Deep Valley	Grassland Easement	Lone Tree	Melass	Native Prairie Unit	Ziegler	Langley	Haven
Columbidae	*Zenaida macroura*	Mourning Dove					X			
Emberizidae	*Ammodramus leconteii*	Le Conte's Sparrow			X		X			
	Ammodramus nelsoni	Nelson's Sparrow						X		
	Ammodramus savannarum	Grasshopper Sparrow	X	X	X		X		X	X
	Melospiza melodia	Song Sparrow			X		X	X	X	X
	Passerculus sandwichensi	Savannah Sparrow	X	X	X	X	X	X	X	X
	Pooecetes gramineus	Vesper Sparrow		X						
	Spizella pallida	Clay-colored Sparrow	X	X	X	X	X	X	X	X
Fringillidae	*Spinus tristis*	American Goldfinch			X					
Icteridae	*Agelaius phoeniceus*	Red-winged Blackbird	X	X	X	X	X	X	X	X
	Dolichonyx oryzivorus	Bobolink	X	X	X	X	X	X	X	X
	Icterus spurius	Orchard Oriole					X			

Appendix B: REM Cont.

Avian Species			Sites							
Family	Scientific Name	Common Name	Deep Valley	Grassland Easement	Lone Tree	Melass	Native Prairie Unit	Ziegler	Langley	Haven
	Molothrus ate	Brown-headed Cowbird		X	X	X	X	X	X	X
	Quiscalus quiscula	Common Grackle		X					X	
	Sturnella neglecta	Western Meadowlark		X			X			X
	Xanthocephalus xanthocephalus	Yellow-headed Blackbird	X	X				X		
Mimidae	*Dumetella carolinensis*	Gray Catbird					X			
Parulidae	*Dendroica petechia*	Yellow Warbler			X		X			
	Geothlypis trichas	Common Yellowthroat	X		X		X		X	X
Scolopacidae	*Bartramia longicauda*	Upland Sandpiper	X	X						
Troglodytidae	*Cistothorus platensis*	Sedge Wren					X	X	X	
Tyrannidae	*Empidonax traillii*	Willow Flycatcher					X			
	Tyrannus tyrannus	Eastern Kingbird	X	X	X		X	X		X

Appendix B: REM Cont.

Avian Species			Sites							
Family	Scientific Name	Common Name	Deep Valley	Grassland Easement	Lone Tree	Melass	Native Prairie Unit	Ziegler	Langley	Haven
	Tyrannus verticalis	Western Kingbird	X				X			

Appendix C

North Dakota Plant Associations – Belt Transect Method (Grant et al. 2004b)

Belt Transect Codes

Shrub and Tree Types

Low shrub (generally <1.5 m tall)

11 snowberry dense; other plants few or none
12 snowberry; remainder mostly native grass-forb types
13 snowberry; remainder mostly Kentucky bluegrass
14 snowberry; remainder mostly smooth brome (or quackgrass)
15 silverberry; add modifier 15[2] = native grass-forb, 15[3] = Kentucky bluegrass, 15[4] = smooth brome, 15[5] = crested wheatgrass
16 snowberry; remainder mostly crested wheatgrass
18 meadowsweet; add modifier as above 18[2], 18[3], 18[4], or 18[5]
19 other low shrub (user defined – add modifier as above)

Tall shrub/tree (generally ≥ 1.5 m tall)

21 native shrub (chokecherry, buffaloberry, hawthorn, willow, etc.)
22 shrub-stage aspen
23 introduced shrub (caraganna, Russian olive, etc.)
31 aspen
33 shade-tolerant woodland tree (green ash, box elder, American elm, etc.)
34 oak
35 introduced tree (Siberian elm, juniper, spruce, etc.)

Native Grass-Forb and Forb Types (>95% dominance by native herbaceous plants, including forbs)[a]

41 dry cool season (sedges, green needlegrass, needle-and-thread, wheatgrass species, prairie junegrass, forbs)
42 dry warm season (little bluestem, prairie sandreed, blue gramma, forbs)
43 mesic cool-warm mix (big bluestem, switchgrass, porcupine grass, prairie dropseed, forbs)
46 meadow (fowl bluegrass, foxtail barley, northern reedgrass, fine-stem sedge species, baltic rush, prairie cordgrass)

47	wetland; robust emergent vegetation or open water (cattail, river bulrush, bur-reed, common reed grass, manna grass)
48	clubmoss/lichen
49	forb
51	Kentucky bluegrass >95% (or >50% if mixed with other non-natives)
52	Kentucky bluegrass and native grass-forbs, Kentucky bluegrass 50-95%
53	native grass-forbs and Kentucky bluegrass, Kentucky bluegrass 5-50%
61	smooth brome >95% (or >50% if mixed with other non-natives)
62	smooth brome and native grass-forbs, smooth brome 50-95%
63	native grass-forbs and Smooth brome, smooth brome 5-50%
71	crested wheatgrass >95% (or >50% if mixed with other non-natives)
72	crested wheatgrass and native grass-forbs, crested wheatgrass 50-95%
73	native grass-forbs and crested wheatgrass, crested wheatgrass 5-50%
74	quackgrass >95% (or >50% if mixed with other non-natives)
75	quackgrass and native grass-forbs, quackgrass 50-95%
76	native grass-forbs and quackgrass, quackgrass 5-50%
77	reed-canary grass
78	tall, intermediate, or pubescent wheatgrass
79	other introduced grass (user defined)
Introduced Weed Types	
81	leafy spurge
85	Canada thistle
87	absinthe wormwood
88	other induced weeds (user defined)
98	tall introduced legume: sweetclover or alfalfa
Other	
91	barren/unvegetated (e.g., rock, anthill, bare soil); dead vegetation
99	other – user defined

[a]Prairie rose, bearberry, winterfat, and cactus are considered a native forb with respect to these categories

Appendix C: Belt Transect Codes Cont.

In the event of an apparent equal mix of Kentucky bluegrass and smooth brome – consider as code 61 or 62

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