Improving Survey Methodology to Monitor Rare Grassland Birds in South Dakota

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IMPROVING SURVEY METHODOLOGY TO MONITOR RARE GRASSLAND BIRDS IN SOUTH DAKOTA

BY

KASSONDRA HENDRICKS

A thesis submitted in partial fulfillment of the requirements for the

Master of Science

Major in Wildlife and Fisheries Sciences

Specialization in Wildlife Sciences

South Dakota State University

2017
IMPROVING SURVEY METHODOLOGY TO MONITOR RARE GRASSLAND BIRDS IN SOUTH DAKOTA
KASSONDRA HENDRICKS

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

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Head, Department of Natural Resource Management

Dean, Graduate school
This thesis is dedicated to a black lab called Mudge.
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ABSTRACT

IMPROVING SURVEY METHODOLOGY TO MONITOR RARE GRASSLAND BIRDS IN SOUTH DAKOTA

KASSONDRA HENDRICKS

2017

Breeding Bird Survey (BBS) data for grassland bird species has shown the most rapid population decline of any other bird group. Current roadside survey techniques, however, may fall short of providing accurate numbers of rare grassland bird species such as chestnut-collared longspur (Calcarius ornatus), lark bunting (Calamospiza melanocorys), Sprague’s pipit (Anthus spragueii), and Baird’s sparrow (Ammodramus bairdii). Trends resulting from roadside data for grassland birds are oftentimes determined to be statistically insignificant because many grassland bird species occur on too few routes, occur in low numbers per route, and show high annual fluctuations in number. It is possible roadside surveys may be providing inaccurate assessments of population trends. The objectives of this study were to 1) determine if increasing the number of routes will increase detection, 2) determine if detection of grassland birds is different on paved versus gravel roads, 3) determine if grassland birds are more likely to occur along routes with more grassland cover, 4) determine if there is an interaction between grassland cover and road type on the occurrence of grassland birds, 5) and to determine if the occurrence of grassland birds is greater away from roads. We utilized BBS methodology to conduct roadside surveys and paired on and off-road surveys along new and existing BBS routes over three seasons (2013-15) in western South Dakota. We
used analysis of covariance to determine whether grassland birds were significantly affected by road type or percent grassland or differed between on and off-road surveys. The amount of grassland within point counts was the most significant variable effecting the abundance of grassland bird species. Higher percentages of grassland within a point count negated road effects for some species and resulted in an increase in abundance of focal bird species. Further, the inclusion of off-road point counts 800 m from roads increased abundance of two Species of Conservation Concern. Our findings suggest that increasing routes in areas with intact grassland habitat on gravel roads and incorporating off-road surveys at 800 m will allow for increased detection of focal grassland bird species which in turn can better advise conservation programs within South Dakota and beyond.
CHAPTER 1
THESIS INTRODUCTION AND LITERATURE REVIEW

Introduction

No other bird group in North America has experienced more significant or consistent declines than grassland birds. The decline of grassland passerine populations has been linked to habitat loss and fragmentation with populations of many species having concurrently exhibited decreasing population trends with increased habitat loss (Askins et al. 2007). Nationwide, grassland habitat losses total 99.9% for tall-grass and 70-80% for mixed-grass prairies, making grasslands of the Great Plains one of the most endangered ecosystems in North America (Samson et al. 2004, Askins et al. 2007). Since 2009, fifty-three million acres across the Great Plains alone were converted to cropland (Gage et al. 2016). As bird populations and grassland habitat continue to decline, it is important to develop survey methods to provide biologists with accurate indices of population trends. Current roadside survey techniques may fall short of providing accurate detection and numbers of rare grassland bird species such as chestnut-collared longspur (Calcarius ornatus), lark bunting (Calamospiza melanocorys), Sprague’s pipit (Anthus spragueii), and Baird’s sparrow (Ammodramus bairdii). The ability to accurately measure population trends of these species is necessary in the development of more effective conservation strategies with the goal of decreasing or reversing these declines.

Since 1966, the Breeding Bird Survey (BBS) has been the primary source for long-term data on population trends of North American birds. Run by the United States Geological Survey Biological Resource Division and the Canadian Wildlife Service, the BBS is the most extensive survey program in the world, encompassing over 4,000 survey
routes throughout the United States, Canada, and Mexico. Results of the BBS derive current population estimates and have driven and directed conservation strategies for many species in North America. However, roadside surveys have been scrutinized for their inability to accurately detect some species, especially grassland birds. Trends resulting from BBS data, particularly for grassland passerines with the greatest declines, are oftentimes determined to be statistically insignificant (Dale et al. 2005) because many grassland bird species occur on too few BBS routes, occur in low numbers per route, and show high year-to-year fluctuations in number. Roadside surveys can be biased in that roads occur non-randomly across landscapes and large tracts of grassland habitat and, oftentimes, areas with the highest grassland bird density are underrepresented. Studies have also indicated some species may exhibit an apparent aversion to roadside habitat. Grassland obligate avian species such as Sprague’s pipit, Baird’s sparrow, and chestnut-collared longspur have been shown to be as much as four times more abundant off-road than along roadsides in Southern Alberta (Wellicome et al. 2014). It is possible roadside surveys such as the BBS, in their current form, may not be the most appropriate method to assess population trends for these species.

South Dakota BBS trend data for Baird’s sparrow and Sprague’s pipit are classified as having low credibility due to a small sample size, low abundance, and imprecise results. Limited road access and volunteer recruitment make range coverage difficult and existing routes often go unsurveyed. Five South Dakota counties within the range of our focal species do not include BBS routes and BBS routes included in this study were otherwise unassigned. Many studies have suggested monitoring can be improved for more uncommon species with imperfect detectability by increasing the
percentage of area surveyed (Dale et al. 2005). This can be accomplished through a hybridized approach; increasing the number of roadside routes along gravel roads within the range of focal species and in areas with a greater percentage of grassland habitat, and the addition of surveys away from roadsides (Dale et al. 2005, Lawler and O’Connor 2004, McCarthy et al. 2012, Sanderlin et al. 2014, Van Wilgenburg et al. 2015, Wellicome et al. 2014). These methods are expected to increase the number of detections and improve coverage of these species ranges.

The purpose of this study was to identify methods to increase detections of grassland bird Species of Greatest Conservation Concern (SGCN) (chestnut-collared longspur, Baird’s sparrow, lark bunting, and Sprague’s pipit), as stated in the South Dakota Comprehensive Wildlife Conservation Plan (SDCWCP) (SDGFP 2005), as well as species listed as Level I priority grassland birds (grasshopper sparrow and western meadowlark) in the South Dakota All Bird Conservation Plan (SDGFP 2014). Chestnut-collared longspur, lark bunting, grasshopper sparrow, and Baird’s sparrow have shown annual nationwide declines of 4.2%, 3.9%, 2.5%, and 2% (between 1966 and 2015), respectively (Sauer et al. 2017). Even steeper declines have been detected in the Badlands and Prairie Region where annual declines for Sprague’s pipit, lark bunting, and Baird’s sparrow were 7.35%, 2.9% and 2.6% (between 1966 and 2015), respectively. Results of this study will be utilized in the development of a long-term grassland passerine monitoring program in South Dakota.

The objectives of this study were to 1) determine if the occurrence of grassland birds is greater away from roads, 2) determine if increasing the number of BBS routes will increase detection, 3) determine if detection of grassland birds is different on paved
versus gravel roads, 4) determine if grassland birds are more likely to occur along routes with more grassland cover, 5) and to determine if there is an interaction between grassland cover and road type on the occurrence of grassland birds.

**Literature Review**

**South Dakota Grassland Loss and Deterioration**

Following suit with the loss and degradation of grassland habitat throughout much of their range, grassland birds continue to decline significantly. No other bird group in North America has experienced more negative or consistent and widespread declines. Between 1966 and 2002, 17 of 28 species of grassland birds decreased significantly while only 3 of 28 increased significantly (Askins et al. 2007). Forty percent of species that made the Partners in Flight Landbird Watch List due to declining populations and/or high future threats occur in the Prairie Avifaunal Biome (Harris and Haskell 2007). Although these declines can be linked to habitat fragmentation, nest parasitism, pesticides, and invasion of woody vegetation, the underlying theme is the intensification of agriculture. Throughout much of their range, grassland birds must rely more and more upon marginal habitat and habitats under agricultural production.

During the late 2000s, cultivation of corn and soybeans in the United States reached record high levels following the biofuel boom (Lark et al. 2015). During this time, crop expansion resulted in substantial transformation of the landscape, including the conversion of long-term unimproved grasslands and land that had not been used for agriculture since the early 1970s. Grassland loss across the Great Plains has exceeded
70% with 13% of tallgrass prairie, 29% of mixed grass prairie, and 52% of shortgrass prairie remaining when compared to their historical extent as of 2003 (Samson et al. 2004). Since 2009, fifty-three million acres of grasslands across the Great Plains were converted to cropland, an area the size of Kansas (Gage et al. 2016). In one year alone (2014-2015), 3,686,960 acres were converted and continue to be at an average rate of 1% per year. Between 2008 and 2012, 77% or 5.7 million acres of new cropland originated from both native and planted grasslands (Lark et al. 2015). Although South Dakota holds the largest intact blocks of mixed-grass prairie in North America, 20% (1.4 million ha) were converted to cropland from 1980-2000 (Higgins et al. 2002) and the conversion of grassland to cropland has expanded westward at an accelerated rate (Wright and Wimberly 2013).

Although the continued loss of grassland habitat remains a considerable issue, loss of integrity of remaining habitat is also a substantial contributor to population declines of grassland birds. The disturbance and fragmentation of grasslands by agriculture have created a landscape mosaic of blocks of cropland, small patches of remnant prairie, and an interconnected network of narrow strip-cover habitats often seen along roadsides (Bergin et al. 2000). These alterations to the structure of the landscape have negatively affected grassland species diversity and abundance. Woody and exotic vegetation encroachment and agriculture reduces the area of grasslands, reducing patch size and increasing edge effects or the phenomena of avoidance, predation, competition, or brood parasitism that occur more frequently near a habitat edge (Bakker 2003). Driven by commodity prices, changes in crop types have contributed to a decrease in quality of wildlife habitat remaining on farmland while improvements in technology continue to
make farming in otherwise inaccessible land less risky, driving conversion westward (Higgins et al. 2002). While a lack of grazing can cause shading by taller grasses, which in turn deters growth of short grass species relied upon by some grassland birds, the conversion of grassland to cropland has increased grazing intensity on rangelands where cattle are now concentrated on smaller areas, further reducing variability in vegetation structure on any remaining tracts of habitat (Askins et al. 2007, Derner et al. 2009).

Remaining grassland habitat has also suffered through the loss of ecological drivers that historically shaped its composition. Natural regimes including drought on a broad scale and grazing and fire at landscape and local scales are integral to providing habitat for grassland avian fauna that are adapted to open grassland sustained by these dynamic ecosystems (Samson et al. 2004). Historically, interactions of large grazers, fire, a lack of or extreme variability in moisture, and prairie dogs created and maintained distinctly different plant communities in the western Great Plains resulting in a mosaic of vegetation structure and composition (Askins et al. 2007, Derner et al. 2009). A loss of these natural regimes has driven the invasion of exotic and woody vegetation into remaining breeding habitat, further degrading its quality. Species such as Kentucky bluegrass (*Poa pratensis*), crested wheatgrass (*Agropyron desertorum*), downy brome (*Bromus tectorum*), leafy spurge, Canada thistle (*Cirsium arvense*), yellow sweet clover (*Meillotus officinalis*), Eastern red cedar (*Junierus virginiana*), and Western snowberry (*Symphoricaropos occidentalis*) make habitat unsuitable for nesting grassland birds. Areas of suitable nesting habitat for birds have decreased by 16.4% while unsuitable habitats have increased 25.1% from 1992 to 1997 (Higgins et al. 2002). In Eastern Montana, Lloyd and Martin (2005) found chestnut-collared longspurs experienced lower
reproductive success in monocultures of invasive crested wheatgrass. The odds of a nest surviving a given day were 17% lower, nestlings grew more slowly, and had a lower final mass in the exotic habitat. The abundance of western meadowlark, upland sandpiper, Sprague’s pipit, Baird’s sparrow, and savannah sparrow was found to be negatively correlated with habitats dominated by exotic plants in Manitoba, Canada (Wilson and Belcher 1989). Grasshopper sparrows in Wisconsin were found in lower densities in areas that contained greater amounts of exotic vegetation (Ribic et al. 2009). When introduced forbs in western South Dakota increased in coverage from 0 to 50%, chestnut-collared longspur occurrence decreased from 25% to <1% (Greer et al. 2016). Lark bunting and western meadowlark occurrence were both negatively associated with the amount of introduced grass. When less than 5% of grassland habitat included introduced grass species, western meadowlark probability of occurrence was 80% and declined below 50% when introduced grass was present on greater than 80% of the habitat.

Increased woody vegetation within, surrounding, and near breeding habitat further reduces occurrence, density, and nesting success of many grassland bird species (Bakker 2003). Greer et al. (2016) found chestnut-collared longspurs, grasshopper sparrows, savannah sparrows, and western meadowlarks in central and western South Dakota were all negatively impacted by increasing amounts of wooded edge. An increase of wooded edge from 0 to 3.5% decreased chestnut-longspur occurrence by 50%, and in areas with any amount of woody edge the probability of occurrence was less than 30%. Grasshopper sparrow showed similar trends with less than 15% probability of occurrence when wooded edge was present on over 75% of habitat. Without the presence of wooded edge, grasshopper sparrow occurrence was greater than 75%. Western meadowlark occurrence
was found to be greater than 70% in areas where wooded edge was absent and declined to below 20% when woody species occupied 70% of the habitat. Grant et al. (2004) found the probability of occurrence for 11 of 15 grassland bird species decreased significantly as the percentage of woodland, tall shrub, or brush cover increased. If woody cover exceeded 25%, species such as Baird’s sparrow, Sprague’s pipit, grasshopper sparrow, and western meadowlark all declined in occurrence.

Roadside Surveys

The traditional method of monitoring passerine populations in North America is by roadside survey. The most recognizable of such surveys is the Breeding Bird Survey (BBS), coordinated by the United States Geological Survey Biological Resource Division and the Canadian Wildlife Service. Beginning in 1966, the goal of the program was to provide long-term data on population trends of bird species in North America. Today the survey occurs along over 4,000 routes in Canada, the United States, and Mexico. Surveys occur during peak breeding season (May-July). Routes are stratified by state or province and run for 40 km with three-minute point count stops every 0.8 km. It is considered to be the most extensive monitoring program for vertebrates in North America (Lawler and O’Connor 2004). BBS data, however, was never intended to be used in estimating the size of bird populations of which a number of assumptions are required, rather it was to be used in estimating the trends of abundant species populations (Twedt 2015). These trends are assumed to accurately represent the status of the actual population size and density.
Grassland Bird Road Avoidance

Surveys along roadsides are an efficient method to conduct point counts within a limited timeframe while accessing a broad array of habitat types. However, roads can increase edge effects, disturb birds through lights and motion, cause toxic effects from fumes, kill insect’s birds rely on, or cause direct mortality through collision (Summers et al. 2011). Traffic noise can interfere with communication by song upon which most species of birds depend to establish and maintain territories. Bird abundance, occurrence, and species richness have been found to be reduced near roads, especially where traffic levels are high. Grassland bird numbers were 20-50% lower within 100 m of gravel roads in Saskatchewan and Wyoming (Ingelfinger and Anderson 2004, Sutter et al. 2000). Reijnen et al. (1996) investigated the effects of traffic on breeding density of birds in deciduous and coniferous forests of the Netherlands. They found that of 43 species, 26 showed evidence of reduced density adjacent to roads and hypothesized that road noise was probably the most important cause of these observed reduced densities. Traffic noise can also increase vigilance for or make birds more vulnerable to predation, ultimately reducing foraging time and in turn reproductive rates (Summers et al. 2011). Pollution caused by vehicles can indirectly cause a reduction in density of breeding birds along roadsides by affecting abundance and size of insects adjacent to them. Birds that have a territory near roads experience higher mortality. Summers et al. (2011) investigated breeding bird occurrence and traffic noise along transects perpendicular to high-traffic roads and found bird species richness increased with distance from roads. Results indicated traffic noise was not the main cause of the negative relationship between bird species abundance and richness and proximity to roads. Nests built in proximity to roads
were more likely to fail at the chick stage and broods are significantly more likely to be lost completely with increased proximity to roads. Harris and Haskell (2007) found chestnut-collared longspurs may avoid areas with dense vegetation often associated with roadside ditches due to their preference for short, sparse to moderately vegetated native habitat for nesting and foraging.

Roadside sampling may also result in biased habitat representation, Keller and Scallan (1999) found greater urban area to occur along roadsides within 0-200 m than off-road areas along BBS routes in Maryland. Anthropogenic disturbances most frequently occur along roadsides and decrease with an increase in distance from the road (Van Wilgenburg et al. 2015). It is also likely different environments are sampled in differing intensities by the BBS which in turn may affect population estimates of some species when compared to others (Lawler and O’Connor 2004). A species whose primary habitat is sampled at lower intensity than its more marginal habitat which is in decline may experience more drastic decreases in population as birds move from marginal habitat into core habitat. Therefore, trend analyses for such a species would tend to overestimate the magnitude of declines and increases.

Roadsides produce edge effects and edge habitat supports a greater abundance and diversity of nest predators and edge loving birds. Small fragments along roadsides have a greater proportion of area close to the edge of a habitat in turn causing elevated frequencies of nest predation (Sutter et al. 2000). Edges can also support a large number of brood-parasitic brown-headed cowbirds (Molothrus ater). Roads on the landscape fragment grassland habitat in turn decreasing the suitable area available to nest. These
conditions may result in avoidance of roadsides by nesting or breeding birds that might have otherwise been detected during roadside surveys.

Many studies have shown area-sensitivity of grassland birds or a preference for large patches of grassland habitat (Ribic et al. 2009). Baird’s sparrow favor large patch sizes (Johnson and Igl 2001) with higher frequencies of occurrence in sites surrounded by more grassland habitat. They also tended to avoid areas with extensive woody vegetation or that occurred near roads (Madden 1996, Sutter et al. 2000). A greater amount of cropland typically occurs along roadsides than grassland in many areas that might fall within the range of grassland birds. Dale et al. (2005) found BBS routes in the Canadian prairie averaged 70% cropland. Landscapes with large grassland bird numbers also contained more grassland habitat than those with declining populations in the Midwest and Great Plains Regions (Veech 2006). Herkert (1994) found breeding bird richness patterns within 4.5 ha subsections of grasslands also significantly increased with fragment size in Illinois. Five area-sensitive species in the study even avoided small sections of fragmented habitat that might otherwise have been suitable. Johnson and Temple (1986 and 1990) found that western meadowlark and grasshopper sparrow were more likely to nest in large grassland fragments. An increase in nest predation on grassland birds was also detected in smaller fragments of grassland habitat. Further, Best et al. (2001) found grassland species occurred most commonly when the landscape contained more grassland block cover or grassland strip-cover and showed an aversion to landscapes dominated by intensive agriculture. Greer et al. (2016) showed the probability of occurrence of lark bunting was less than 10% when the landscape within 3200 m of the survey contained less than 40% grassland habitat. The probability of occurrence
increased however when grassland habitat made up more than 90% of the surrounding area. Western meadowlark density was found to be positively related to the amount of grassland in the surrounding habitat at 3200 m. Savannah sparrow occurrence and density at 3200 m were positively related to the amount of grassland on the landscape.

**Breeding Bird Survey Weaknesses**

Although the BBS has provided the only long-term dataset on breeding grassland birds in North American and is undoubtedly a convenient survey to incorporate in passerine monitoring regimes, it is not without its faults. Differences in observer detection rates, bias caused by analytical methods, and differences in land cover sampling are issues that have come up over the BBS’s lengthy existence.

In the development of the BBS, survey routes were located randomly within 1 degree blocks with 1 to 8 routes per block (Veech et al. 2012). Because routes are confined to secondary highways and do not cross regional boundaries, placement of routes is not completely random (Veech et al. 2006, McCarthy et al. 2012). Dependence on volunteers trends route establishment towards areas of high populace, or areas with the potential for a high density of volunteer observers. More populated states tend to have more BBS routes (Lawler and O’Connor 2004).

Roadside survey methodology does not typically include knowledge of the distance from observer to which a species is accurately detected nor the probability of detecting said species if present (Twedt 2015). The BBS requires an assumption that the probability of detection is the same for each data set being compared (Farnsworth et al. 2002). A number of birds detected in point count surveys can be affected by the time of
season and time of day presumably because of variations in singing frequency. Physical attributes of habitat such as foliage and density can also affect an observer’s ability to hear and identify bird song. Differences in detectability are also related to skill and experience of observers.

The BBS may not be adequately detecting changes in all bird populations. Differences in avian community composition between roadside and off-road surveys suggest that the use of BBS data to generate population trends may overestimate some common species and underestimate others of conservation concern (Harris and Haskell 2007). Roadside surveys are poor at documenting rare or endangered species, especially those that occupy habitat not sampled within roadside surveys while detection of edge species may be greater in roadside point counts than in off-road points (Bart et al. 1995, Harris and Haskell 2007, Keller and Fuller 1995). Many grassland birds occur on few BBS routes, occur in low numbers per routes or show high year-to-year fluctuation in numbers which can result in a low statistical power to detect any trend (Dale et al. 2005). Higher patchiness along BBS routes may lead to under sampling of grassland birds whose densities are negatively influenced by habitat fragmentation (Niemuth et al. 2007).

Improving Roadside Surveys

An important requirement of any monitoring program for any species is that it adequately samples its entire range. Sanderlin et al. (2014) found that it is more appropriate to survey more sites fewer times for rare species and that increasing the number of sample sites in a landscape improved bias and accuracy for species richness, occupancy probability, and detection probability estimates. Increasing route density in underrepresented environments and encouraging more consistent monitoring of routes
and environments farther from population centers might increase sampling of more rare species and their associated habitats (Lawler and O’Connor 2004, O’Connor et al. 2000). In Montana, managers struggled with low detection of Sprague’s pipit along BBS routes despite being in the highest density area of their range. With the addition of 42 new BBS routes, detections of Sprague’s pipit increased (Niemuth et al in print). Dale et al. (2005) found that increasing the number of BBS routes in areas with a higher percentage of grassland habitat resulted in a greater probability of detecting target grassland species, and it increased with each additional route surveyed. With the addition of these new routes, trends for Sprague’s pipit, Baird’s sparrow, and lark bunting were more negative. These differences in trends suggest that the BBS as is may not provide sufficient enough information to detect grassland species trends.

A number of studies have attempted incorporating point counts away from roadsides to improve detection of breeding birds and to cover a broader array of habitat (Dieni and Scherr 2004, Harris and Haskell 2007, Hutto et al. 1995, Keller and Fuller 1995, Rotenberry and Knick 1995, Wellicome et al. 2014). Harris and Haskell (2007) found that with the addition of off-road counts in eastern Tennessee, habitat away from roads was composed of more native grassland whereas roadside counts were dominated by land use associated with crop farming. The bird community associated with off-road counts was dominated by species found in grassland habitats and 17 of 39 species (44%) differed significantly in relative abundance and frequency of occurrence between on and off-road surveys. The authors suggested a hybrid approach, conducting surveys on and off-road in order to sample bird communities across a more representative section of the habitat. Wellicome et al. (2014) found off-road routes had more native grassland and
short shrubs and less fallow land and road area than roadside routes in Southern Alberta. Sprague’s pipit, Baird’s sparrow, and chestnut-collared longspur were as much as four times more abundant off-road than on and 17 of 30 species differed between on and off-road surveys. Keller and Fuller (1995) conducted on and off-road surveys in forested habitat at 200 and 400 m in Shenandoah National Park, Virginia. Roadside counts had a higher number of several edge species but did not show lower densities of non-edge forest species. More individuals occurred in roadside counts due to high incidence of edge-favoring species. Hutto et al. (1995) conducted 275 paired point counts in northern Montana within four distinct vegetation cover types. They found no difference between species detected on and off-road suggesting that restricted occurrences to either on or off-road were a result of a small sample size and not a product of habitat differences between on and off-road counts. There was however a difference between the number of species detected on and off-road which appeared to be a result of habitat changes associated with the presence of roads with such differences becoming less pronounced on more narrow roads. Due to the effect of road width on detection, the authors recommended restricting analysis to more narrow roads, combining roadside surveys with both on and off-road point counts, selecting roads with similar vegetation cover types within 100 m of either side, and adapting roadside survey methodology to the biology of target species. A study in shrubsteppe and grassland habitats in Southwestern Idaho showed that point counts conducted 400 m from roads in similar habitat resulted in no statistically significant differences in the number of individuals of a species between on and off-road surveys (Rotenberry and Knick 1995). Many of these roads however were unpaved and had very narrow rights-of-way. Dieni and Scherr (2004) established 162 paired point counts across
the Arrowwood National Wildlife Refuge in North Dakota at varying distances from roadsides. The number of bird species observed in these point counts tended to be greater along the road. The relative abundance of savannah sparrow, grasshopper sparrow, and western meadowlark were associated with distance from the road, but the effect was small. Van Wilgenburg (2015) suggested that much of the habitat bias associated with roadsides could be diminished by the addition of off-road sampling beyond 300-500 m from the road. Hanowski and Niemi (1995) suggested that some points should be placed off-road in habitats not sampled in roadside point counts. Habitat specific surveys may be preferable to increasing the number of randomly placed BBS routes for surveying under sampled habitats and species in the northern plains (Niemuth et al. 2007).
CHAPTER 2
STUDY AREA AND METHODS

Study Area

Fifteen counties were selected to be included in our study based on their occurrence within the range of our six focal species (2013-2015). These counties fall within the western and northcentral portions of South Dakota. This area, known as the Great Plains ecoregion (Bryce et al. 1998) comprises the western two-thirds of the state with the exclusion of the southwestern Black Hills falling between latitude 42° N and 46° N and longitude 98° W and 102° W (Greer et al. 2016). This region is characterized by a harsh, semiarid climate with hot summers and very cold winters (Hogan and Fouberg 40). Less than 50 centimeters of precipitation falls annually within the region, 80% of which comes from localized summer thunderstorms. Water and wind have shaped the buttes, terraces, badlands, and rolling hills that cover the landscape.

Grassland ownership in the U.S. portion of the Great Plains is estimated to be 84% private while the remainder falls within federal, state, municipal, county, or tribal jurisdiction (Askins et al. 2007). Agriculture historically has been limited due to the extreme climate and irregular precipitation. The predominant land use is grazing of livestock, largely cattle. Where tilling is possible, winter and spring wheat as well as sorghum are grown. As a result of the harsh climate and limited agriculture, the mixed grass prairie that characterizes the region has remained much intact. Short and mid grass steppe species such as blue grama (*Bouteloua gracilis*), buffalo grass (*Bouteloua dactyloides*), little bluestem (*Schizachyrium scoparium*), western wheatgrass (*Agropyron smithii*), green needleleaf (*Nassella viridula*), needle and thread (*Stipa comata*), forb
species including purple cone flower (*Echinacea angustifolia*) and American vetch (*Vicia Americana*) as well as shrubs such as fringed sagebrush (*Artemisia frigida*) are common throughout the area (Greer et al. 2016). In the portion of the study conducted east of the Missouri River, precipitation supports more crop varieties resulting in fragmented land and more prevalent agriculture (Niemuth et al. *in print*). Common crops include corn (*Zea mays*), wheat (*Triticum aestivum*), and soybeans (*Glycine max*) (Askins et al. 2007).

**Route Selection**

We included 28 routes within our study, 7 existing BBS routes and 21 new routes. All new routes were placed within the range of our focal species. New routes were added in counties where BBS routes did not exist, occurrences of focal species had been documented, road access was feasible, and in landscapes with varying amounts of grassland habitat. We allocated routes to include both paved and gravel roads. New routes were ground truthed prior to surveys to ensure access, habitat, and accuracy of maps.

**Methods**

**Preseason Training**

All technicians received annual training in late April and early May to ensure proficiency in the identification of grassland birds based on sight and sound, particularly focal species. In-phone apps such as BirdTunes (NatureSound Studio 2012) along with field guides were utilized in training to improve upon recognition and identification of species. We utilized practice routes prior to the official season to ensure technician aptitude in survey methods and grassland bird identification.
Roadside surveys

Surveys were conducted annually within 15 counties along 40 km predetermined routes (n=28), including 7 existing BBS routes and 21 new routes (Figure 2-1). Roadside surveys were conducted over three years following traditional BBS methodology (2013-2015). Surveys began in late May and extended into early July and occurred on days with no precipitation and winds <20 km/hr. We conducted surveys beginning half-an-hour before sunrise. Three-minute point counts occurred every 0.8 km (50 stops per route) where birds seen or heard within a 400 m radius were recorded. Percentage grassland cover, wind speed, temperature, vehicle noise and road type were recorded at each stop.

On and off-road surveys

Paired on and off-road surveys occurred over two years beginning in late May and extending into early July (2014-2015) utilizing methodology adapted from the Bird Conservancy of the Rockies field protocol (Hanni et al. 2015). Surveys began half-an-hour before sunrise, on days with no precipitation and when wind speed was less than 20 km/hr. We selected areas along the 28-predetermined routes with >70% grassland habitat within 1600 m and where permission was granted by landowners to conduct paired on and off-road point counts (n=131) (Appendix A). Counts were only conducted in areas where the off-road vegetation was of the same cover type and management regime as the on-road habitat. We conducted 6-minute point counts on-road and then immediately off-road at either 400 or 800 m and recorded birds seen or heard within a 400 m radius. We also recorded the method of detection (song, sight, flyover), distance from observer to bird, time until detection, and sex if possible. A rangefinder was utilized to determine
distance from observer to bird. Road type, wind speed, vehicle noise and temperature were also recorded.

Data Analyses

Roadside Surveys:

Data was analyzed using SYSTAT Version 13 (Systat Software, San Jose, CA). All statistical tests were considered significant at $P \leq 0.05$. Percentage grassland within 400 m was divided into three levels, <41%, 41-79%, and >80%, respectively. Division increments were biologically supported and supported by literature (Bakker 2000, Bakker et al. 2002). We used analysis of covariance to evaluate whether grassland cover and road type (gravel or paved) had a significant effect on individual species occurrence and abundance and grassland bird species richness and abundance. The Julian date of survey was used as a covariate to remove effects of the time of year from occurrence, abundance, and richness estimates. Analysis of variance was used to determine if increasing the number of roadside routes increased detection of focal species by comparing the frequency of occurrence of focal species on BBS routes with new routes.

On and Off-road Surveys:

On and off-road data was analyzed using SYSTAT Version 13 (Systat Software, San Jose, CA). We used analysis of covariance to determine whether grassland species richness, abundance, and individual species abundance differed between on and off-road surveys. The Julian date of survey was used as a covariate to remove effects of the time of year from abundance and richness estimates. A Tukey’s post hoc test was used to
determine where differences in species richness or abundance occurred between on-road surveys and off-road surveys at 400 or 800 m.
Figure 2-1. Map depicting South Dakota and the location of routes (n=28) surveyed annually 2013 through 2015. Stars depict the starting point of the Breeding Bird Survey routes (n=7) and circles depict starting point of new routes (n=21).
Figure 2-2. Map depicting South Dakota and the location of all Breeding Bird Survey routes within our study area (n=19). Stars indicate BBS routes (n=7) surveyed annually 2013-2015.
CHAPTER 3
RESULTS

Roadside Surveys

Routes

We conducted 1,981 point counts along 28 routes over three field seasons (2013-2015). Western meadowlark, grasshopper sparrow, and lark bunting were the most common species detected (Appendix A). Average percent grassland within point counts that occurred on paved roads (n=791) was 79.38 ± 0.99 and average percent grassland within point counts on gravel roads (n=1,190) was 79.43 ± 0.83. Mean vehicle occurrence along paved road point counts was 0.30 vehicles/stop and vehicle occurrence along paved road point counts was 0.08 vehicles/stop.

Focal Grassland Bird Species Richness

Focal species richness increased significantly with percentage grassland within the count (p<0.001) (Figure 3-1) and was significantly higher in point counts located on paved roads (p<0.001) than on gravel roads (Figure 3-2). The interaction between percentage grassland and road type was not significant (p=0.644). Date removed significant (p<0.001) amounts of variation in richness not accounted for by road type or landscape while year did not (p=0.547).

Focal Grassland Bird Species Abundance

Grassland bird focal species abundance increased significantly with percentage of grassland within the count (p<0.001) (Figure 3-3) and was significantly higher in point counts located on paved roads (p=0.001) than on gravel roads (Figure 3-4). The
interaction between percentage grassland and road type was also significant (p<0.001) (Figure 3-5). Year removed significant (p≤0.001) amounts of variation in abundance not accounted for by road type or landscape while date did not (p=0.565).
Figure 3-1. Grassland bird focal species richness in point counts (n=1,981) with three different levels of grassland habitat {(1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count) along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-2. Grassland bird focal species richness in point counts (n=1,981) located on different road types (1=paved and 2=gravel) in western and central South Dakota (2013-2015).
Figure 3-3. Grassland bird focal species abundance in point counts (n=1,981) with three different levels of grassland habitat {(1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count} along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-4. Focal grassland bird species abundance in point counts (n=1,981) located on different road types (1=paved and 2=gravel) in western and central South Dakota (2013-2015).
Figure 3-5. Grassland bird focal species abundance in point counts (n=1,981) located on different road types (1=paved, 2=gravel) with three different levels of grassland habitat \{(1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count\} along roadside survey routes in western and central South Dakota (2013-2015).
Chestnut-collared Longspur Abundance

Chestnut-collared longspur (CCLO) occurred in 4.34% of point counts (n=1,981). Abundance increased significantly with percentage grassland within the count (p<0.001) (Figure 3-6) and was significantly higher in point counts located on paved roads (p=0.002) than on gravel roads (Figure 3-7). The interaction between percentage grassland and road type was also significant (p<0.001) indicating CCLO abundance is higher on paved roads located in landscapes with >80% grassland (Figure 3-8). Date and year removed significant (p<0.001, p<0.001, respectively) amounts of variation in CCLO abundance not attributed to road type or landscape.

Sprague’s Pipit Abundance

Sprague’s pipit (SPPI) occurred in 1.61% of point counts (n=1,981). Abundance did not differ with percentage grassland within the count (p=0.754) but was significantly higher in point counts located on gravel roads (p=0.039) than on paved roads (Figure 3-9). The interaction between percentage grassland and road type was not significant (p=0.972). Date removed significant amounts of variation (p=0.002) in SPPI abundance not attributed to road type or landscape while year did not (p=0.132).

Lark Bunting Abundance

Lark Buntings (LARB) occurred in 39.02% of point counts (n=1,981). Abundance did not differ with percentage grassland within the count (p=0.546) or in point counts located on either paved or gravel roads (p=0.808). The interaction between percentage grassland and road type was not significant (0.074). Date and year removed significant
amounts of variation (p<0.001, p<0.001, respectively) not attributed to road type or landscape.
Figure 3-6. Chestnut-collared longspur abundance in point counts (n=1,981) with three different levels of grassland habitat {((1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count} along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-7. Chestnut-collared longspur abundance in point counts (n=1,981) located on different road types (1=paved and 2=gravel) in western and central South Dakota (2013-2015).
Figure 3-8. Chestnut-collared longspur abundance in point counts (n=1,981) located on different road types (1=paved, 2=gravel) with three different levels of grassland habitat { (1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count} along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-9. Sprague’s pipit abundance in point counts (n=1,981) located on different road types (1=paved and 2=gravel) in western and central South Dakota (2013-2015).
Baird’s Sparrow Abundance

Baird’s Sparrow (BAIS) occurred in 4.75% of point counts. Abundance increased significantly with percentage grassland within the count (p=0.043) (Figure 3-10) and was significantly higher on paved (p<0.001) than gravel roads (Figure 3-11). The interaction between percentage grassland and road type was also significant (p=0.011) (Figure 3-12). BAIS abundance was greater in point counts that occurred on paved roads in all grassland habitat amounts but the preference for paved roads was greatest in point counts with greater than 80% grassland habitat. Date and year removed significant amounts of variation (p=0.018, p<0.001, respectively) in BAIS abundance not attributed to road type or landscape.

Grasshopper Sparrow Abundance

Grasshopper sparrow (GRSP) occurred in 54.92% of point counts. Abundance increased significantly with percentage grassland within the point count (p<0.001) (Figure 3-13) but was not significantly different on paved versus gravel roads (p=0.701). The interaction between percentage grassland and road type was significant (p<0.001) (Figure 3-14). GRSP abundance was greater on paved roads in point counts with greater than 80% grassland habitat while abundance was greater in point counts with <80% grassland along gravel roads. Neither date or year accounted for significant amounts of variation (p=0.076, p=0.107, respectively) in GRSP abundance not attributed to road type or landscape.
Western Meadowlark Abundance

Western meadowlark (WME) occurred in 80.16% of roadside point counts. Abundance increased significantly with percentage grassland within the point count (p<0.001) (Figure 3-15) and was significantly higher on paved (p=0.009) than on gravel roads (Figure 3-16). The interaction between percentage grassland and road type was not significant (p=0.085). Date and year removed significant (p<0.001, p<0.001) amounts of variation not attributed to landscape or road type.
Figure 3-10. Baird’s sparrow abundance in point counts (n=1,981) with three different levels of grassland habitat {(1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count} along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-11. Baird’s sparrow abundance in point counts (n=1,981) located on different road types (1=paved and 2=gravel) in western and central South Dakota (2013-2015).
Figure 3-12. Baird’s sparrow abundance in point counts (n=1,981) located on different road types (1=paved, 2=gravel) with three different levels of grassland habitat {(1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count} along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-13. Grasshopper sparrow abundance in point counts (n=1,981) with three different levels of grassland habitat {1) ≤40% grassland, 2) >40-79% grassland, and 3) ≥80% grassland within the point count} along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-14. Grasshopper sparrow abundance in point counts (n=1,981) located on different road types (1=paved, 2=gravel) with three different levels of grassland habitat ((1) \leq 40\% grassland, (2) >40-79\% grassland, and (3) \geq 80\% grassland within the point count) along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-15. Western meadowlark abundance in point counts (n=1,981) with three different levels of grassland habitat {(1) ≤40% grassland, (2) >40-79% grassland, and (3) ≥80% grassland within the point count} along roadside survey routes in western and central South Dakota (2013-2015).
Figure 3-16. Western meadowlark abundance in point counts (n=1,981) located on different road types (1=paved and 2=gravel) in western and central South Dakota (2013-2015).
New Routes vs. BBS Routes

Grassland habitat along existing BBS routes ranged from 24.9-88.6% and averaged 65.5% within our study area (Sauer et al. 2017). Grassland habitat within point counts along new routes ranged from 5.3-99.7% and averaged 79.9%. Increasing the number of roadside survey routes located in high grassland landscapes along unpaved roads in western and central South Dakota resulted in an increased frequency of detection. Frequency of occurrence at all stops across all years along new versus existing BBS routes was higher on new routes for CCLS (0.6 to 7.8%), LARB (27.8 to 49.7%), SPPI (0.8 to 2.4%), BAIS (0.1 to 9.0%) and GRSP (46.8 to 61.8%). New routes included 1,152 point counts while 829 point counts occurred along old routes (Figure 2-1). Number of new routes (n=21) with ≥ 2 detections per route (necessary for analysis of BBS data) for CCLO, LARB, SPPI, BAIS and GRSP were 11, 20, 9, 10 and 21, respectively. Number of existing BBS routes within our study area (n=19) (Figure 2-2) with ≥ 2 detections per route between 2011-2015 for CCLO, LARB, SPPI, BAIS and GRSP were 12, 19, 0, 1 and 19, respectively (Sauer et al. 2017). Five new and 1 existing route had ≥2 detections of all 6 species.

On and Off-road Surveys

On and Off-Road Point Counts

I conducted 131 paired on and off-road point counts over two field seasons (2014-15) (Figure 2-2, Appendix B). Of these point counts, 87 were 400 m off-road and 44 were 800 m off-road. Western meadowlark, grasshopper sparrow, and chestnut-collared longspur were the most common species detected (Appendix A).
Focal Species Richness On vs. Off-Road

Focal species richness was significantly greater (p<0.001) (Figure 3-17) in point counts located at 800 m off-road than on-road point counts. Focal species richness was not significantly different between 400 m and on-road point counts (p=0.954). Focal species richness was lower at 400 m when compared to 800 m (p<0.001) from roadsides. Date removed significant (p<0.001) amounts of variation in richness not attributed to location of survey.

Focal Species Abundance On vs. Off-Road

Abundance of focal species was greater at point counts 800 m off-road than at point counts either 400 m (p=0.011) (Figure 3-18) off-road or on-road (p<0.001). Abundance was lower in on-road point counts when compared to off-road point counts at 400 m (p=0.009). Date removed significant (p=0.005) amounts of variation in focal species abundance not attributed to location of survey.

Chestnut-collared Longspur Abundance On vs. Off-Road

CCLO abundance was not significantly different in point counts at 400 m off-road when compared to on-road point counts (p=0.064) (Figure 3-19). Abundance was significantly greater in point counts that occurred at 800 m when compared to those that occurred on-road (p=0.015). Abundance did not differ significantly between point counts off-road at 400 and 800 m (p=0.621). Date removed significant (p<0.001) amounts of variation in CCLO abundance not attributed to location of survey.
Sprague’s pipit Abundance On vs. Off-road

SPPI abundance did not differ in point counts at 400 m off-road when compared to on-road point counts (p=0.746). Abundance did not differ in on-road point counts when compared to point counts that occurred at 800 m off-road (p=0.947). Abundance did not differ significantly between point counts off-road at 400 and 800 m (p=0.97). Date removed significant (p=0.001) amounts of variation in SPPI abundance not attributed to location of survey.

Lark Bunting Abundance On vs. Off-road

LARB abundance did not differ in point counts at 400 m off-road when compared to on-road point counts (p=0.492). Abundance did not differ in on-road point counts when compared to point counts that occurred at 800 m off-road (p=0.433). Abundance did not differ significantly between point counts off-road at 400 and 800 m (p=0.946). Date removed significant (p<0.001) amounts of variation in LARB abundance not attributed to location of survey.

Baird’s Sparrow Abundance On vs. Off-road

BAIS abundance did not differ in point counts at 400 m off-road when compared to on-road point counts (p<0.862). Abundance was lower in on-road point counts when compared to point counts that occurred at 800 m off-road (p<0.001) (Figure 3-20). Abundance was greater in point counts off-road at 800 m than 400 m (p<0.001). Date did not account for significant (p=0.380) amounts of variation in BAIS abundance not attributed to location of survey.
Grasshopper Sparrow Abundance On vs. Off-road

Abundance was greater in point counts located 800 m off-road than in roadside point counts (p=0.051) (Figure 3-21). GRSP did not differ in point counts at 400 m off-road when compared to on-road point counts (p=0.992). Abundance did not differ significantly between point counts off-road at 400 and 800 m (p=0.066). Date did not account for significant (p=0.858) amounts of variation in GRSP abundance not attributed to location of survey.

Western Meadowlark Abundance On vs. Off-Road

WEME abundance did not differ in point counts at 400 m off-road when compared to on-road point counts (p=0.401). Abundance did not differ between on-road point counts and point counts that occurred at 800 m off-road (p=0.573). Abundance did not differ significantly between point counts off-road at 400 and 800 m (p=0.10). Date removed significant (p<0.001) amounts of variation in WEME abundance not attributed to location of survey.
Figure 3-17. Grassland bird focal species richness in on/off-road paired point counts (n=131) in western and central South Dakota (2014-2015). On-road point counts were paired with a point count conducted either 400 (n=87) or 800 m (n=44) from the road.
Figure 3-18. Grassland bird focal species abundance in on/off-road paired point counts (n=131) in western and central South Dakota (2014-2015). On-road point counts were paired with a point count conducted either 400 (n=87) or 800 m (n=44) from the road.
Figure 3-19. Chestnut-collared longspur abundance in on/off-road paired point counts (n=131) in western and central South Dakota (2014-2015). On-road point counts were paired with a point count conducted either 400 (n=87) or 800 m (n=44) from the road.
Figure 3-20. Baird’s sparrow abundance in on/off-road paired point counts (n=131) in western and central South Dakota (2014-2015). On-road point counts were paired with a point count conducted either 400 (n=87) or 800 m (n=44) from the road.
Figure 3-21. Grasshopper sparrow abundance in on/off-road paired point counts (n=131) in western and central South Dakota (2014-2015). On-road point counts were paired with a point count conducted either 400 (n=87) or 800 m (n=44) from the road.
CHAPTER 4
DISCUSSION OF STUDY RESULTS

Discussion

The amount of grassland within a point count was the most important variable affecting the occurrence and abundance of our focal grassland bird species in roadside surveys. Focal species richness and abundance increased in point counts with greater percentage of grassland (≥80%). Individually, chestnut-collared longspur, Baird’s sparrow, grasshopper sparrow, and western meadowlark abundance was greater in point counts conducted in high grass landscapes (>80% grassland). Unfortunately, many existing BBS routes are dominated by cropland. The seven BBS routes included in our study averaged 62.3% (range 10.3-82.1%) grassland and only two of the seven were comprised of >80% grass. Similarly, Dale et al. (2005) found BBS routes in the Canadian prairie averaged 70% cropland and, with the addition of new grassland bird monitoring routes in grassland dominated landscapes, Baird’s sparrow, Sprague’s pipit, lark bunting, and western meadowlark occurred in greater numbers per stop when compared to existing BBS routes. These results indicate the addition of more routes in high grass landscapes will increase detection of grassland species of conservation concern (SGCN) in western and central South Dakota.

In our study, Sprague’s pipit and lark bunting abundance was not related to the amount of grassland in the point count. Interestingly Greer et al. (2016) showed that the probability of occurrence of lark bunting was less than 10% when the habitat within 3200 m of the survey contained less than 40% grassland habitat. The probability of lark bunting occurrence increased when grassland habitat made up more than 90% of the
surrounding area. A study that compared landscape composition of increasing, decreasing, and stable populations of grassland birds found that landscapes with more grassland habitat but less forest and urban land contained increasing populations of grassland birds in the Midwest and Great Plains Regions (Veech 2006). Additionally, BBS routes are more likely to include landscapes with anthropogenic impacts such as the presence of structures that are accessed by roads (Janousek et al. 2015). These studies suggest that the context of landscape surrounding point counts may be more influential than the amount of grass within point counts and that new routes should be placed in areas with the greatest intact grassland habitat as possible.

Chestnut-collared longspur, Baird’s sparrow, and western meadowlark were more abundant in point counts that occurred on paved roads when the point count had >80% grassland habitat. Road type was not a significant variable in the abundance of lark bunting or grasshopper sparrow. Rotenberry and Knick (1995) conducted paired on and off-road point counts along predominantly unpaved roads with very narrow rights-of-way. They suggested the lack of statistically significant differences in avian abundance on and off-road was due to a lack of road effect because the predominant type of roads surveyed are less disruptive of continuous grassland habitat. This theory might also apply to our own findings of an increase in focal species abundance on paved roads in western South Dakota where much of the habitat is still intact. The interaction between percentage of grassland and road type may also help to explain the increase in abundance of focal species along paved roads. Although focal species richness and abundance was greater overall on paved roads, abundance on paved or gravel roads changed as percentage grassland within a point count increased. In point counts that occurred in areas
with greater percentage of grassland, focal species abundance was greater on paved roads. In point counts that occurred in areas with lower percentage of grassland, focal species abundance was greater on gravel roads. This is a trend that continued to be demonstrated throughout our analysis of these variables with individual focal species.

Sprague’s pipit were the only focal species more abundant in point counts that occurred on gravel roads than on paved roads. Sensitive species, such as Sprague’s pipit, may be vulnerable to road effects even when habitat is excellent (>80%). Sutter et al. (2000) found that Sprague’s pipit occurred in lower abundance along roadsides and hypothesized that this may be attributed to the 20-30% reduction of suitable habitat associated with the road right-of-way within a point count in Saskatchewan. The interaction between habitat and road type was significant for chestnut-collared longspur, Baird’s sparrow, and grasshopper sparrow indicating some sort of habitat and road-type trade off. Grasshopper sparrow abundance was two times greater on paved roads in high grass point counts (>80%) than in low grass point counts (≤41%) where they were more abundant along gravel roads. These results suggest that road effects may become less important in areas with greater amounts of intact grassland habitat and more important when habitat is poor. Although not as obvious as grasshopper sparrow, Baird’s sparrow, and chestnut-collared longspur both indicate some road avoidance when less grassland habitat is available and an ability to tolerate paved roads in high grass landscapes.

Wellicome et al. (2014) found that grasshopper sparrow was negatively associated with human-modified type habitats and chestnut-collared longspur and Baird’s sparrow were less abundant along roads. Further, chestnut-collared longspur and Baird’s sparrow were found to be negatively associated with the human-modified habitat along roads.
suggesting that they tend to avoid establishing territories in roadside ditches (Dale et al. 2005).

The habitat and road type trade-off suggest that when selecting for new grassland bird monitoring routes in western South Dakota, road type may not be as important when routes are placed within intact landscapes. If the grassland habitat is poor (≤41%), it may be beneficial to select routes that include gravel roads to increase detections. Gravel roads tend to lack ditches, have less traffic, and occur in areas with less anthropogenic disturbances. Paved roads on the other hand often incur greater traffic and feature ditches that are heavily populated with invasive species of grasses. In western South Dakota, however, traffic encountered during surveys was very minimal and grass was continuous with fence lines. The main structures encountered were utility poles and buildings were a rare occurrence along routes. Never-the-less these results suggest that monitoring routes that include paved roads in western South Dakota are likely adequate in their detection of all focal species but Sprague’s pipit if located in high grassland landscapes.

The successful implementation of any monitoring program requires that it adequately samples the species entire range. Our results indicate increasing route density in underrepresented areas and encouraging more consistent monitoring of existing routes will increase sampling of more rare grassland birds. These are significant findings due to a lack of BBS routes within five counties within the range of SGCN in South Dakota (Butte, Campbell, Lyman, Walworth, and Ziebach), and because many existing BBS routes in western South Dakota go unassigned every year. Chestnut-collared longspur, Baird’s sparrow, lark bunting, Sprague’s pipit, and grasshopper sparrow had increased frequency of occurrence on new versus existing BBS routes. Similarly, Dale et al. (2005)
found that Sprague’s pipit, lark bunting, Baird’s sparrow, and western meadowlark were significantly greater on new grassland monitoring routes when compared to BBS routes in Canada. Sprague’s pipit, Baird’s sparrow, and lark bunting showed more dramatic declines with the inclusion of new routes in Canada when compared to BBS trends for the same period. In Montana, managers struggled with low detection of Sprague’s pipit along BBS routes despite being in the highest density area of their range (Niemuth et al. in print). By increasing the density of BBS routes, managers were successful at increasing detection. Sanderlin et al. (2014) suggested that rare species occupancy probability was influenced more by percentage of an area sampled than by the number of sampling occasions.

The focal grassland bird species that showed the greatest habitat and road type trade-off were also found in the greatest numbers in point counts conducted away from roadsides. Chestnut-collared longspur, Baird’s sparrow, and grasshopper sparrow were greatest in abundance at 800 m from roadsides than on roads. The majority of paired on and off-road surveys conducted occurred along one-lane gravel roads. Wellicome et al. (2014) found that the avian community associated with off-road routes was dominated by species more typical of native grassland habitats and that Baird’s sparrow and chestnut-collared longspur occurred as much as four times greater in number away from roadsides. Sutter et al. (2000) found that Baird’s sparrows were more abundant along trails (two-tracks lacking a ditch) when compared to roads and determined Baird’s sparrows are attracted to relatively dense habitat but tended to avoid the thick vegetation produced by smooth brome grass common in ditches. Chestnut-collared longspurs in the same study were 56% less abundant along roads suggesting that they tend not to establish territories
in proximity to roads because of the dense vegetation growing in ditches as they prefer short, sparse moderately vegetated habitat for nesting and foraging.

There was no significant difference in abundance of Sprague’s pipit or western meadowlark between on and off-road surveys. Our very low sample size for Sprague’s pipit may play some part in these results as South Dakota is on the edge of their range and, even within significant portions of their range, Sprague’s pipit are relatively uncommon. In the roadside survey portion of our study, abundance was greater on gravel roads which could suggest that there was no difference in abundance of Sprague’s pipit in point counts that occurred on-road versus those that occurred off-road because of a less severe road effect along gravel roads. Sutter et al. (2000) found that Sprague’s pipit occurred in lower abundance along roadsides and hypothesized that this may be attributed to the 20-30% reduction of suitable habitat associated with the road right-of-way within a point count of 100 m radius in Saskatchewan. Because Sprague’s pipit is a relatively rare species even within its range, off-road surveys may be too random and few in number to reliably increase detection. An increase in roadside routes along gravel roads would be more suitable to increasing detection. Conversely, western meadowlarks were one of the most abundant species in our study. Sutter et al. (2000) found no difference in abundance between western meadowlarks in point counts on roads versus those conducted along trails. Rotenberry and Knick (1995) noted fence lines along roadsides provide excellent perches for these birds which may contribute to the lack of difference in abundance of western meadowlark in point counts that occur on versus off-road in southwestern Idaho.

Past studies that compared on and off-road surveys and found no significant difference tended to have included off-road point counts ≤400 m from the roadside (Dieni
van Wilgenburg (2015) suggested that much of the habitat bias associated with roadsides could be diminished by the addition of off-road sampling beyond 400-500 m from the road. In our study, there was no significant difference in abundance of chestnut-collared longspur, Baird’s sparrow, grasshopper sparrow, and focal species richness in point counts that occurred along roadsides when compared to those that occurred at 400 m. The significant difference in abundance of focal species between roadside and off-road surveys at 800 m suggest that road effect in some areas may continue for some distance and off-road point counts conducted at distances less than 800 m may not accurately detect some focal species than roadside point counts. Further, point counts often limit counted birds to within a 200-400 m circular radius. Birds sensitive to road effects may not be present within this limited area although counting birds at a greater radius may substantially decrease detection and accuracy of identification. To increase the detection of relatively rarer grassland bird species such as chestnut-collared longspur and Baird’s sparrow, a hybrid approach of including point counts on-road and away from roads at a distance of at least 800 m could be included in the monitoring regime.

Summary

In western South Dakota, grassland habitat was the most important variable in determining occurrence and abundance of grassland birds. Focal grassland bird species abundance and richness, and chestnut-collared longspur, Baird’s sparrow, grasshopper sparrow, and western meadowlark individual abundances were all greater in point counts with greater than 80% grassland habitat. Higher percentages of grassland within a point count negated road effects that might be present for some birds along paved roads.
However, more sensitive species, such as Sprague’s pipit, may be vulnerable to road effects even when habitat is >80% grassland.

Increasing the amount of habitat surveyed with a greater number of grassland bird monitoring routes in areas of high grassland habitat appears to be the most beneficial method for increasing detection of grassland birds in South Dakota. Currently five of the counties within the range of our focal species do not contain BBS routes and many existing routes often go unsurveyed. Increasing coverage would also help to ensure that all land management types are equally surveyed. It is also important that any holes in coverage due to low volunteer recruitment are filled. A greater number of routes that are consistently surveyed on an annual basis will increase detections and would provide a more complete understanding of grassland bird populations across South Dakota.

The inclusion of off-road point counts along gravel roads, where road effect may be less, increased abundance of chestnut-collared longspur, Baird’s sparrow, and grasshopper sparrow within point counts. Further, some focal species that were more abundant in point counts off-road at 800 m were not significantly more abundant in point counts that occurred at 400 m. This finding suggests that increasing detection of grassland birds with the addition of off-road routes may not be beneficial unless point counts occur at as far as 800 m from roads. However, off-road surveys can be time consuming, expensive, and show a preference for public lands due to the difficulty of obtaining permission to survey lands under private ownership. This may create a bias towards certain land management regimes and not be financially feasible for some managers.
The amount of grassland along roadside routes was the most significant variable affecting the abundance of our focal species. Not only did higher percentages of grassland within a point count negate road effects that might be present for some birds along paved roads but it resulted in an increase in abundance of our focal species within point counts conducted on new routes with greater than 80% grassland habitat. Further, inclusion of off-road point counts away from roads increased abundance of two species of SGCN, chestnut-collared longspur and Baird’s sparrow, in South Dakota. Trends resulting from the BBS for grassland passerines with the greatest declines are often determined to be insignificant because many species occur on too few BBS routes, occur in low numbers per route, and show high year-to-year fluctuations in number (Dale et al. 2005). Our findings suggest increasing routes in areas with intact grassland habitat on gravel roads and incorporating off-road surveys at 800 m will allow for increased detection of SGCN in South Dakota. This, in turn, can better advise and improve upon conservation programs within the state and beyond. As grassland bird populations and their habitats continue to decline it becomes increasingly important to highlight the need for continued large-scale avian monitoring programs. Ensuring the accuracy of these programs ensures a more comprehensive understanding of avian populations throughout the state and better enables managers to direct conservation regimes to promote the continued existence of these populations and the habitat they so rely on.
CHAPTER 5
MANAGEMENT IMPLICATIONS AND FUTURE STUDY RECOMMENDATIONS

Management Implications

Surveys along roadsides are an efficient method to conduct point counts within a limited timeframe while accessing a broad array of habitat types. Roadside surveys may be, however, poor at documenting rare or endangered species, especially those that occupy habitat not sampled within surveys, while detection of edge species may be greater in roadside point counts than in off-road point counts (Bart et al. 1995, Harris and Haskell 2007, Keller and Fuller 1995). State BBS trend data for Baird’s sparrow and Sprague’s pipit are classified as having low credibility (describing a species with a very low sample size, low abundance, or imprecise results) suggesting improvement in data collection methodology or survey coverage are needed. Due to inconsistencies of BBS results for grassland passerines in South Dakota, it is important to develop new monitoring protocol that is adapted to the sensitivities of SGCN. As land conversion continues westward at an ever increasing rate, adequately monitoring the population trends of these species has never been more important and is vital to their continued existence.

An important requirement of any monitoring program for any species is that it adequately samples its entire range. Studies have suggested monitoring can be improved for more uncommon grassland species with imperfect detectability by increasing the percentage of area surveyed (Dale et al. 2005). Sampling should be representative of the species’ range and habitat across the landscape. Increasing the number of routes in landscapes with a greater amount of grassland habitat will increase detections of
grassland specialist species in point counts. If routes include greater than 80% habitat within point counts, road type is not important. If habitat is poor or patchy, selecting for routes where the majority of points fall on gravel roads may be more appropriate.

Grassland bird monitoring protocol should be developed with consideration of individual species possible aversion to roadsides. Sprague’s pipit was significantly more abundant on gravel roads and on new routes placed in intact landscapes than on existing BBS routes. Managers looking to improve detection of this species should consider increasing the number of routes to better encompass their range and to select for gravel roads located in intact grassland landscapes. Few studies that incorporated paired on and off-road surveys utilized point counts off-road at distances greater than 400 m. Based on our findings, differences in abundance of some grassland bird species was not present until 800 m from roadsides. Unfortunately, off-road point counts, especially those conducted at 800 m, are more time consuming and, thus, would result in less coverage of the landscape. An increase in coverage of grassland habitat with the inclusion of more bird monitoring routes provides for a more efficient method of increasing grassland passerine detection. If resources are not limited, increasing detections of SGCN could also be accomplished through a hybridized approach; increasing the number of roadside routes along gravel roads within the range of focal grassland bird species and in areas with greater percentage of grassland habitat, and the addition of surveys away from roadsides at least 800 m along these routes. Ensuring current BBS routes are surveyed annually would also be of benefit to all grassland species of western South Dakota. The BBS was created to develop long term population trends which in turn can identify species in need and drive conservation measures. With over 50 years of data it is
undoubtedly one of the most significant monitoring programs in the world. Being
volunteer dependent however limits habitat coverage in more rural areas such as western
South Dakota. Increasing the number of surveyed routes would be the most effective
strategy to ensuring its continued success. It is important to remember our findings may
differ from those in other parts of our focal species ranges, especially in areas in which
habitat has been significantly converted. Our results should be tested against similar data
from other parts of the Northern Great Plains Region.
Appendix A. Total number of each focal species detected along routes (n=28) on both roadside (2013-2015) and paired on and off-road surveys (2014-2015).

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<thead>
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<th>Species</th>
<th>Number detected</th>
<th>Roadside Surveys</th>
<th>On and off-road Surveys</th>
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<tr>
<td>Western meadowlark</td>
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</tr>
<tr>
<td>Grasshopper sparrow</td>
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<tr>
<td>Chestnut-collared longspur</td>
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<tr>
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<tr>
<td>Sprague's pipit</td>
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</tr>
<tr>
<td>Baird's sparrow</td>
<td>129</td>
<td>97</td>
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Appendix B. Location along routes of paired on and off-road surveys. Distance is the distance from the road the off-road survey was conducted. See figure 2-1 for map of routes.

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<thead>
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