

**Effects of Twice-over Grazing on the Nesting Success of Grassland Songbirds
in Southwestern Manitoba**

by

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ABSTRACT

Rotational grazing is being promoted by some land managers, government agencies, and conservation groups as superior to season-long grazing for improving pasture and cattle production, and for grassland bird conservation; however, the assumed benefits have not been comprehensively studied. In 2011 and 2012, I examined the effects of twice-over rotational grazing on the nesting success of grassland songbirds in southwestern Manitoba, Canada. I monitored nesting attempts and collected structural vegetation data for five species of obligate grassland bird ($n=110$) and one shrub-nesting species ($n=41$). Nesting analyses were conducted using logistic exposure models. Twice-over grazing had a significantly negative effect on the nesting success of the ground nesting species, including Savannah sparrows (*Passerculus sandwichensis*). Grazing system did not have an effect on vegetation structure. The results are consistent with other rotational grazing studies, and suggest that twice-over rotational grazing does not benefit grassland songbirds in mixed-grass prairie habitats.

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1.0 INTRODUCTION

1.1 Background

Grassland ecosystems around the world have experienced some of the highest rates of destruction and degradation in comparison to any other type of ecosystem. The widespread conversion of grassland for agricultural is the primary cause of grassland reduction within the prairie biome (With et al. 2008). Considering the rate of prairie loss in North America, it is not surprising that the grassland bird populations have also drastically declined (Knopf 1996; With et al. 2008). One of the primary causes of prairie decline is loss of habitat through the conversion of prairie lands for agriculture and development (Brennan and Kuvlesky 2005). However, despite the reduction of agricultural conversion in the past 50 years, increased mechanization and more intensive management practices have further altered suitability of the remaining grasslands to support native species of both plants and animals.

Since the mid-1800s and the mechanization of agriculture, North American grassland ecosystems have been reduced by 80% of their original extent (Brennan and Kuvlesky 2005, Johnson et al. 2012). The mixed-grass prairie ecosystem in Manitoba has experienced an 82% area loss (Thorpe 2011), and has experienced the highest level of grassland loss and fragmentation among Canada's provinces (Roch and Jaeger 2014). Grasslands in Manitoba are under threat from further fragmentation and degradation, mainly in the form of agricultural conversion and energy development, and there is an urgent need to protect and manage these remaining areas.

The intact areas of mixed-grass prairie in south-western Manitoba are primarily grazed by cattle. Grazing activities can affect grassland birds by altering the vegetation structure and by creating disturbance during the nesting season (Paine et al. 1996, Ranellucci et al. 2012). It has been suggested that grazing management techniques may be a tool for conserving grassland

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bird populations by creating and maintaining specific habitat conditions (Holechek 1981, Derner et al. 2009). The majority of pastures used for grazing in southwestern Manitoba follow a season-long grazing pattern whereby cattle remain on the same pasture throughout the late spring and summer. A second system of grazing management promoted in southwestern Manitoba is twice-over rotational grazing. This system uses a three-to-six pasture rotation; each pasture is grazed twice per year, with strict timelines to promote grass production and allow for pasture rest periods. The twice-over system is thought to improve overall pasture and cattle health (Manske 2004), and it is also thought, despite the lack of evidence, that the twice-over grazing scheme may allow for an increased nesting success and nest survival of grassland birds by eliminating cattle activity during portions of the breeding cycle (OMAFRA 2012). In southwestern Manitoba, twice-over grazing is being promoted as a tool to “benefit livestock producers, wildlife and the land” (MHHC 2006, p28), and “result in an increase in the number of grassland birds on these pastures” (MHHC 2008, p27), under the Critical Wildlife Habitat Program. However, there is a lack of information for land managers and conservation organizations on the effects of different cattle grazing systems, particularly the twice-over rotational system, on the nesting success of native grassland songbirds. More information needs to be provided about grazing methods that are beneficial or non-destructive to native birds and wildlife.

1.2 Research Problem and Objectives

The overall goal of this project was to determine the effects of twice-over rotational grazing on the nesting success of native grassland birds in southwestern Manitoba. This was achieved by monitoring the outcome of nesting attempts by native grassland birds on twice-over rotationally grazed pastures in comparison with pastures grazed using a season-long

grazing system. For this study, nesting success is defined as one or more young fledging from the nest.

Objectives:

1. Determine the effects of grazing management on the nesting success of native grassland songbirds in the mixed-grass prairies of southwestern Manitoba.
2. Determine the species-specific effects of grazing management on two ground-nesters, (Savannah sparrow (*Passerculus sandwichensis*) and vesper sparrow (*Pooecetes gramineus*)), and a shrub-nester (clay-colored sparrow (*Spizella pallida*)).
3. Determine the effects of grazing management on the vegetation structure of the pastures.

1.3 Project Significance

There have been two studies evaluating effects of livestock grazing on the presence and abundance of grassland birds in southwestern Manitoba (Christie 1997, Ranellucci et al. 2012)). Christie's (1997) study was located northeast of my study area in the aspen parkland ecoregion of southwestern Manitoba, and evaluated the effects of managed grazing systems (deferred and twice-over combined) on the abundances of non-game birds. The study determined that managed grazing systems on average do not increase the abundance or species richness of non-game bird species when compared with season-long grazing (Christie 1997). Cristina Ranellucci evaluated effects of twice-over grazing on abundance of grassland birds in 2008 and 2009, in the same area of my study, and determined that avian species diversity and density were similar between twice-over and season-long grazed pastures (Ranellucci et al. 2012). A study by Davis et al. (2014) in south central Saskatchewan also found that grassland songbird abundance was not influenced by grazing system (rotational and season-long).

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Effects of grazing on the density and diversity of birds may differ from the effects of grazing on nesting success, because territory selection criteria (eg., vegetation structure and habitat size) are affected by different ecological conditions than those that influence nesting success (eg., predator abundance) (Ranellucci 2010). Several grassland and forest bird studies have suggested that density estimates may not effectively indicate habitat quality for successful nesting (Van Horne 1983, Winter and Faaborg 1999). Winter and Faaborg (1999) found that survey data are inadequate when describing grassland bird sensitivity to habitat fragmentation, and it is important to study nesting success. Johnson and Temple (1990) and Vickery et al. (1992) found that grassland bird density and nesting success are not correlated for a number of grassland bird species. In contrast, a review by Bock and Jones (2004) found that birds are usually more abundant in habitats where reproduction is highest, but that more research may be needed in disturbed habitats and in comparison to overall survival. Manitoba Habitat Heritage Corporation promotes twice-over grazing as a system that benefits grassland songbirds despite the evidence found in two studies on the effects of twice-over grazing on songbird presence and density. Given that population estimates based on presence and density alone do not necessarily reflect actual population trends in disturbed habitats, this study will use nesting success to add another layer of data to the question of how twice-over grazing is effecting grassland birds in southwestern Manitoba.

Livestock grazing is the most wide spread use of remaining native grasslands around the world (Fuhlendorf and Engle 2001). Yet, very few studies have been undertaken to evaluate the effects of grazing on the nesting success of the songbirds that require the grassland ecosystem for reproduction. This study complements research on effects of twice-over grazing on avian abundance (Ranellucci et al. 2012) and provides information for conservation organizations on the effectiveness of twice-over grazing as a grassland management technique, and may also be

useful for landowners who wish to develop grazing management plans that are ecologically beneficial to prairie ecosystems and their avian inhabitants.

1.4 Limitations

The landscape in southwestern Manitoba is a mixture of cropland, aspen forest, wetland, and mixed-grass prairie. There are many influences that could affect territory selection and nesting success of grassland songbirds. These influences include aspects of the habitat matrix surrounding grassland patches and areas of microhabitat (wetlands, forest stands, etc.) within grassland patches. To minimize these effects in this study, pastures and treatments were dispersed across the landscape and throughout the study site. Pastures of both grazing regimes were selected from each of the five separate rural municipalities to minimize potential bias that might result from regional differences in topography, geography and vegetation. However, in general, twice-over pastures in southwestern Manitoba have less core grassland habitat and more forest stands than season-long pastures (Ranellucci 2010). Thus, I cannot rule out the possibility that some differences between season-long and twice-over pastures could be caused by increased forest in the vicinity of grassland songbird nests.

Nesting success in this study is defined as any nesting attempt that fledges at least one host young from the nest, as determined by parental behaviour, chick age at previous visit, and the presence of fecal matter and feather scales in the nest (Davis 2005). There is potential for error determining nesting success this way; however, the alternative is to use costly nest cameras and/or tracking devices. Further, grassland passerine fledglings are still very vulnerable once they leave the nest, so determining a population's breeding success by fledging alone does not take into account the survivorship of fledglings to adults. A review of post-fledging studies found that the majority of mortality occurs in the first three weeks after fledging (Cox et al.

2014). Estimating a population's success rate in a habitat by number of nests that fledged at least one young could create an overestimation if in reality the post-fledge survivorship is low (Cox et al. 2014).

A note on the structure of the thesis:

This thesis has been set up as a sandwich style document. The questions being answered about twice-over grazing are not mechanistic but describe a pattern instead. Chapter 3 presents a manuscript for future publication on twice-over grazing, and chapter 4 presents management implications in regards to twice-over grazing and future research suggestions that will be useful for conservation organizations and land managers.

2.0 LITERATURE REVIEW

2.1 Grassland Loss

Grassland ecosystems around the world have experienced some of the highest rates of depletion and degradation compared to any other type of landscape. Grasslands continue to be one of the most threatened and least protected biomes (White et al. 2000, Hoekstra et al. 2005). The need to conserve the remaining prairies is critical.

Prior to European settlement, the North American Great Plains consisted of approximately 162 million ha of native prairie. The expansion of settlements and agriculture throughout this region has resulted in 80% loss of native prairie across the continent, and a 70% loss of mixed-grass prairie (Samson and Knopf 1994, White et al. 2000, Samson et al. 2004, Brennan and Kuvlesky 2005, Roch and Jaeger 2014). Considering the rate of prairie loss in North America it is not surprising that grassland bird populations have significantly declined, more so than any other group of terrestrial birds (Knopf 1994, With et al. 2008, Johnson et al. 2012). Despite the slowing rate of agricultural conversion in the past 50 years, increased mechanization and more intensive management practices have further altered the suitability of the remaining grasslands to support native species of both plant and animal (Donald et al. 2001, Roch and Jaeger 2014).

Grasslands are being destroyed directly by conversion for farmland and urban development, and indirectly through interference with the ecological processes that originally sustained the grasslands (Samson and Knopf 1994, Brennan et al. 2005, Askins et al. 2007, Roch and Jaeger 2014). The biggest threats to the remaining prairie are cultivation and development, the invasion of exotic species, woody vegetation encroachment, and improper grazing management (Samson and Knopf 1994, Davis 2004, Brennan and Kuvlesky 2005, With et al. 2008). Intensive agricultural activities have caused widespread fragmentation and deterioration

of the remaining grassland areas (Herkert 1994 and Knopf 1994, Roch and Jaeger 2014). Shifting beef and grain markets can lead to an over-use of pastures or to conversion of pastures to cropland (Gayton 1991). These economic fluctuations have been known to cause a shift away from multi-use farms towards large-scale monoculture cropping (Gayton 1991). Large farming operations change the landscape in a number of ways: they convert native prairie for growing crops; they replace native grasses in pastures with exotic grasses; they use more pesticides and herbicides; they remove natural field edges and wind-rows; and they drain wetlands and affect water flow over the land (Askins et al. 2007).

2.2 Declines of Grassland Songbirds

Grassland bird populations have declined since settlers reached the Great Plains. Murphy (2003) concluded that between 1980 and 1998, grassland bird population declines were highly correlated with changes in agricultural land use within their breeding habitats, particularly loss of rangeland and fragmentation. Data collected during the Breeding Bird Survey between 1970 and 2012 demonstrate that during this period, prairie bird populations in Canada declined by 40% on average (NABCI Canada 2012), and the population of 15 out of 22 recognized obligate grassland bird species has decreased annually (Environment Canada 2014).

There are multiple causes for the declines in grassland songbirds. Increasing applications of pesticides may have negative effects on breeding grassland birds through poisoning and by reducing important insect forage (Mineau and Whiteside 2013). Other human activities have been impacting bird breeding and wintering habitat directly and indirectly: directly, through the conversion of grassland to cropland and land development, and indirectly, by altering natural grazing patterns and suppressing fire on remaining grasslands (Askins et al. 2007). Converted and cultivated lands provide habitat for relatively few species, and those that attempt to breed

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in crop fields generally have lower reproductive success due to low pairing success and nest failure by farm machinery at harvesting (Askins et al. 2007). However, grassland bird declines have been less severe in areas that are dominated by cattle ranching than in areas that have a greater percentage of privately owned mixed cattle and grain farms (Askins et al. 2007). Cattle ranching plays a role in preventing some grassland areas from being converted; nonetheless, traditional rangeland management practices have been causing widespread deterioration of the remaining prairies through fragmentation, overgrazing, drought, fire suppression, woody plant encroachment, invasive species introduction, and loss of heterogeneity (Fuhlendorf and Engle 2001; Brennan and Kuvlesky 2005).

2.3 Manitoba's Mixed-Grass Prairies

Prior to European settlement, the North American Great Plains consisted of approximately 162 million ha of native prairie. Three of the most common types of prairie across the continent are tall-grass prairie, short-grass prairie, and mixed-grass prairie; each type is maintained by specific moisture conditions and soil type (NRC 2006). The mixed-grass prairie ecosystem encompasses native grass species that are found in both short-grass and tall-grass prairies. The native species commonly found within the study area include big bluestem (*Adropogon gerardii*), blue grama (*Bouteloua gracilis*), sedges (*Carex* spp.), salt grass (*Distichlis spicata*), spear grass (*Stipa comata*), northern wheatgrass (*Elymus lanceolatus*), slender wheatgrass (*Elymus trachycaulus*), switch grass (*Panicum virgatum*), western wheatgrass (*Pascopyrum smithii*), and little bluestem (*Schizachyrium scoparium*). Non-native grass species common to this area include crested wheatgrass (*Agropyron cristatum*), smooth brome (*Bromus inermis*), quack grass (*Elymus repens*) and Kentucky bluegrass (*Poa pratensis*) (USDA 2010). The mixed-grass prairie region of Manitoba also includes a variety of native and non-native forb and

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shrub species. The two most common shrubs on the study sites are wolf willow (*Elaeagnus commutate*) and western snowberry (*Symphoricarpos occidentalis*). Pasture sage (*Artemisia frigida*), pussytoes (*Antennaria* spp.), prairie crocus (*Anemone patens*), three-flowered avens (*Geum triflorum*), and vetchling (*Lathyrus* spp.) are common native forb species. A common invasive forb species was leafy spurge (*Euphorbia esula*) (USDA 2010).

Historically, the mixed-grass prairie stretched continuously from southern Manitoba and Saskatchewan to Texas and was bordered by the tall-grass prairie to the east and the short-grass prairie to the west (Samson and Knopf 1994). The northern portion of the prairies was formed by glacial deposits from the Wisconsin glacial period and is characteristically flat to rolling and dotted with wetlands. Within the northern prairies is the mixed-grass prairie of southwestern Manitoba, mixed into the aspen parkland forest transition zone (Askins et al. 2007). The mixed-grass prairie is characterized by varying amounts of mid-height and short grass species and a scattering of small shrubs (Askins et al. 2007, Samson and Knopf 1994). Historically, the mixed grass prairie was maintained by specific moisture and soil conditions that controlled vegetation type, in addition to natural grazing and fire that created a heterogeneous mosaic of grassland patches (Askins et al. 2007). After human settlement, the Manitoban prairies experienced the construction of pasture fences and increased livestock grazing. Over time the prairie ecosystem was fragmented into different land uses including cattle grazing, conversion to cropland, and oil and gas development (Askins et al. 2007). Today, the highest levels of grassland fragmentation in Canada are happening in the southwestern Manitoba uplands region and there is an urgent need to protect and manage the remaining grassland areas (Roch and Jaeger 2014).

2.4 Grazing History and Importance

The intact areas of mixed-grass prairie in southwestern Manitoba are characterized primarily by cattle grazing. Prior to the arrival of cattle, the prairie landscape supported an array of native grazers. The two most common grazers were plains bison and prairie dogs, whose populations were decimated by bison hunting and the persecution of prairie dogs because they competed with cattle for forage (Samson, Knopf 1994, Askin et al. 2007). These native grazers helped sustain the prairie landscape through a natural rotational disturbance (Brennan and Kuvlesky 2005). Grazing and naturally occurring fires maintained a plant community that had high heterogeneity and provided habitat for various prairie wildlife (Brennan and Kuvlesky 2005). The removal of bison and other native grazers from the prairies coupled with the addition of intensive cattle grazing operations had multiple negative effects on the prairie ecosystems of North America. The traditional cattle grazing of the past was driven by attempts to maximize livestock productivity and this quickly led to overgrazed pastures and plant loss that resulted in reduced biodiversity, soil erosion, increased runoff, and reduced groundwater accumulation (Brennan and Kuvlesky 2005; Fuhlendorf et al. 2006).

As damaging as overgrazing is to grassland ecosystems, it has been found that long-term idling of mixed-grass prairie is just as detrimental for maintaining grasslands and the habitat required by grassland birds (Askin et al. 2007, Ranellucci et al. 2012). Idle grasslands may have a relatively uniform vegetation structure but may also be impacted by woody plant encroachment (Ranellucci et al. 2012). In southern Manitoba, this type of habitat does not support a wide variety of prairie plants and wildlife.

A moderate amount of cattle grazing can produce some variety in patch conditions. Cattle are preferential grazers and will graze selectively for grasses and forbs that are more desirable in terms of nutrients and palatability (Fraser 2004). Cattle movement on a pasture are

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also affected by availability of water and shelter, and by learning behaviours from older members of the herd (Fraser 2004). This type of grazing can create an uneven distribution of cattle disturbance across a pasture resulting in heterogeneous vegetation structure and increased biodiversity (Howery et al. 1996; Fuhlendorf et al. 2006; Askins et al. 2007). The use of a variety of cattle stocking rates on a landscape can also increase vegetative heterogeneity on a larger scale. A common suggestion for reducing pasture degradation and to create predictable cattle gains is to use a moderate stocking rate (Biondini et al. 1998). However, the use of a moderate stocking rate throughout an area can create a homogenous vegetation structure at the landscape level that does not provide all of the habitat types preferred by those species that evolved with more diverse grazing intensities (Fuhlendorf and Engle 2001, Fuhlendorf et al. 2012, Lwiwski et al. 2015).

2.5 Livestock Grazing and Grassland Bird Nesting

The grassland habitat preferences of songbirds vary widely from tall and dense to short and sparse vegetation and managed grazing can be used as a conservation tool to create the required heterogeneous vegetation structure that is beneficial to multiple species (Fuhlendorf et al. 2006, Krausman et al. 2009, Bleho et al. 2014). However, the effect of cattle grazing on the nesting success of grassland songbirds has mixed results. Zimmerman (1996) found no effect of grazing on nest survival in the unburned tall-grass prairie of Kansas under moderate grazing pressure, and Klute et al. (1997) found no significant difference between the reproductive success of grassland birds on idle conservation reserve pastures versus grazed pastures. Similarly, two studies in the arid mixed-grass prairie of southern Canada found that grazing had little effect on the nest survival of grassland passerines (Koper and Schmiegelow 2007, Lusk and Koper 2013). Conversely, grasshopper sparrow nesting success in Kentucky was negatively

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affected by grazing when compared with ungrazed pastures (Sutter and Ritchison 2005). There is a multitude of ways that grazing can affect nesting grassland birds; grazing activities can indirectly affect grassland birds by altering the habitat and vegetation structure, and directly by creating disturbance during the nesting season (Paine et al. 1996, Milchunas et al. 2008, Johnson et al. 2012, Lusk and Koper 2013).

Direct disturbance by grazing cattle at nest sites of grassland songbirds can affect the overall success of a population. Cattle can directly affect nests by trampling (Paine et al. 1996, Fondell and Ball 2006), in some cases depredation (Nack and Ribic 2005), and by inducing abandonment (Bleho et al. 2014). The majority of cattle disturbances at a nest will result in nest failure, and include nests being crushed by hooves, noses, and during bedding, eggs and young kicked out by cattle movements, and nests being defecated on (Paine et al. 1996, Nack and Ribic 2005). Grassland passerines are at greater risk of nest destruction than the risk to ducks and shorebirds, perhaps because cattle see and avoid larger birds and nests (Bleho et al. 2014). Nest destruction by cattle is positively correlated with grazing pressure for several species (Fondell and Ball 2004, Bleho et al. 2014), and trampling rates are reduced with increasing vegetation density and percent cover; therefore, trampling rates can be greatly affected by the grazing system on a pasture (Paine et al. 1996). Cattle have been documented on camera to remove eggs and nestling from grassland songbird nests, and seem to be an opportunistic nest predator (Nack and Ribic 2005).

Indirectly, cattle grazing patterns can cause degraded grasslands, increased predator abundance and foraging efficiency, increased brood parasitism, and can increase the chance of nest discovery by removing nest cover (Dion et al. 2000; With et al. 2008, Bleho et al. 2014). Consistent high-intensity grazing creates too much disturbance and removes too much vegetation from grassland pastures to support high songbird diversity (Krausman et al. 2009).

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The sparse vegetation conditions left by overgrazing can reduce invertebrate biomass, provide inadequate nest cover, and allow an increased growth of woody plant material (Sutter and Ritchison 2005, Krausman et al. 2009). Heavily grazed native rangelands have also experienced a shift in plant species composition with an increase in less desirable forage plants and invasive plant species (Krausman et al. 2009).

Grazing can also affect nesting success indirectly by altering the vegetation that in turn can alter the predator community in an area (Klug et al. 2010). Nest predation is the most common cause of nest failure in the grasslands (Martin 1993), and the top predators of nests are small to medium-sized mammals: rodents, skunks, racoons, foxes, etc (Klett et al. 1988, Kuehl and Clark 2002). Each species of grassland bird is affected by grazing induced vegetation changes differently, based on their current activity requirements, including feeding, loafing, roosting, and nesting (Skinner 1975). The same can be said for the nest predators. For example, an increase in vegetation cover can lead to an increase in the abundance of some species of small mammals when large avian predators are present, but can lead to a decrease in small mammal abundances when larger mammalian mesopredators are present, due to the different prey search strategies of both groups of predators (Korpimaki et al. 1996). Depredation on grassland nests is thought to be mainly opportunistic (Vickery et al. 1992), and predator movements and foraging are thought to be in response to specific landscape features, which can include: habitat edges, water features, infrastructure, and vegetation structure (Dijak and Thompson 2000). Understanding how vegetation changes in response to grazing can affect predator abundance and movement in different landscapes could help manage grazing to reduce predator-related nest failures (Kuehl and Clark 2002).

Brown-headed cowbird (*Molothrus ater*) (hereafter, cowbirds) presence is highly correlated with livestock grazing activities (Goguen and Mathews 2001), and, for cowbirds,

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domestic livestock have proved to be a good replacement for the native ungulate grazers from the past (Mayfield 1965). Cowbirds prefer feeding in areas of short vegetation and remain close to the cattle to feed on the invertebrates that are kicked up by their movements across the pasture, and on the supplemental feed grains supplied at feed stations (Mayfield 1965, Goguen and Mathews 2001). An important habitat requirement for cowbirds is the presence of potential perch sites that exceed the average height of the surrounding vegetation, for displaying and singing, and for the females to use as observational points to watch host activity (Davis 1994, Shaffer et al. 2003). Historically, the brown-headed cowbird's population expanded and grew substantially following the development of agriculture across the Great Plains (Mayfield 1965). Increasing populations of cowbirds pose a threat to many host species because they reduce the host productivity by: 1) removing host eggs; 2) cowbird eggs have a relatively short incubation period so the cowbird often hatches first; 3) cowbird nestlings are generally larger than the host young; and 4) cowbird nestlings grow faster and out-compete the host young (Robinson et al. 1993). All of these factors can lead to decreased production of host young when cowbird nestlings are present (Robinson et al. 1993). Because the relationship between cowbirds and cattle is so significant, cattle grazing systems that create ideal habitat and vegetation conditions for cowbird breeding success could have a significant effect on the grassland nest production.

Livestock grazing may have significant effects on grassland bird populations because livestock grazing is perhaps the most pervasive land use in North America and the greatest limiting factor for wildlife production in the prairies (Fleischner 1994). Therefore, domestic cattle grazing can directly and indirectly affect the habitat needs of grassland birds, primarily food, cover and territory. Managing livestock in a way that also supports native wildlife comes down to finding a system that creates the habitat needed by the different wildlife by maintaining a varied structure in the native plant community (Krausman et al. 2009).

2.6 Rotational Grazing

Rotational grazing systems have been around since the end of the 18th century but widespread implementation was not popular until the 20th century (Biondini and Manske 1996). The general aim of rotational grazing systems is to increase overall production by providing forage plants with an opportunity to collect the resources (water, sunlight, and nutrients) needed to enhance growth by providing a cattle-free rest period. There are many types of rotational grazing patterns being practiced in North America, including rest-rotation, deferred-rotation and short duration/high intensity (Barker et al. 1990). The specific objectives of rotational grazing are to: 1) improve plant productivity and increase desirable species composition; 2) increase homogeneous grazing by utilizing higher stocking rates to reduce selective patch grazing; and 3) create a system of more uniform cattle distribution by improving water distribution and fencing (Briske et al. 2008). All of the above mentioned grazing systems aim to produce higher cattle yields by increasing the available forage on pastures (Briske et al. 2008). These systems are also hypothesized to benefit wildlife by minimizing disturbance during a portion of the growing season. For birds this coincides with the breeding season in May, June, and July (Barker et al. 1990, Ignatiuk and Duncan 2001). Rotational grazing systems also promote an increase in stocking rate (Briske et al. 2008), which could increase direct disturbance on nesting birds (Ranellucci 2010, Bleho et al. 2014), and an increase in homogenous pastures, which could reduce the desirability of the pasture as a nesting site (Cox et al. 2014). In addition, stocking density, or the number of cattle within a given area during the grazing period, is higher for rotational systems compared with season-long grazing, to allow for the required rest periods. This may increase disturbance to nesting birds during the grazing period.

Most published studies looking at rotational grazing have focused on plant productivity and animal performance, whereas only a few studies have looked at the potential effects of

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rotational grazing on wildlife (Brown and Kothmann 2009). Two of these studies found that the nesting success of ducks on rotationally grazed pastures did not significantly differ from the nesting success on season-long grazed pastures (Ignatiuk and Duncan 2001, Murphy et al. 2004). However, nesting success on grazed pastures was significantly higher than on ungrazed grasslands and cropland, suggesting that rotationally grazed pastures could be beneficial if they draw ducks away from unproductive habitats and preserve grasslands that would otherwise be converted to cropland (Ignatiuk and Duncan 2001). Rotational grazing seems to reduce the tall grasses that are preferred by some raptors and rodents (Saab et al. 1995), and in the grasslands of coastal California, rodent and raptor abundances decreased on the rotationally grazed pastures compared to the ungrazed pastures (Johnson and Horn 2008). A study of rotational grazing on Savannah sparrow and bobolink in Vermont found that nesting success and annual productivity varied annually, and that the number of female offspring produced was too low to provide stable populations based on reproductive rates (Perlut and Strong 2011). Christie (1997) also found that non-game bird productivity on rotational pastures varied between years; however, the overall results indicated that rotational grazing systems did not increase non-game bird abundance or richness in southwestern Manitoba. Rotational grazing in North Dakota had a negative effect on Savannah sparrow nest survival, a possible negative effect on clay-colored sparrow, and no effect on bobolink nest survival (Kerns et al. 2010). Temple et al. (1999) found that rotationally grazed pastures in Wisconsin had moderate diversities and densities of grassland birds but had the lowest nesting success and productivity when compared with continuously grazed and ungrazed pastures. In North Dakota, over a 5-year study, prairie-chicken (*Tympanuchus* spp.), and duck nesting densities were observed to follow the grazing rotation, seeking out the higher vegetation cover for nesting and brood rearing (Rice and Carter 1982). Ranellucci et al. (2012) found that only Savannah sparrows preferred twice-over

rotationally grazed fields and that the overall abundance of obligate grassland birds was higher on season-long grazed pastures than on twice-over.

Rotational grazing as a range management tool continues to be controversial among landowners, ranchers and scientists. A review of 60 years of research on rotational grazing studies by Briske et al. (2008) found that the majority of studies conducted to date have found little evidence that rotational grazing is beneficial for cattle productivity or habitat quality (Briske et al. 2008). The debate that arises from the varying results about the impacts of rotational grazing on grassland wildlife could be fueling further trials that use different systems of rotation, like the twice-over rotational system that is being used in southwestern Manitoba. This study has been set up to help answer whether this specific system follows the majority trend of being non-beneficial to grassland wildlife, specifically grassland songbirds.

2.7 Twice-over Rotational Grazing Systems

The majority of pastures used for grazing in south-western Manitoba follow a season-long grazing pattern. With this system cattle remain on the same pasture throughout the late spring and summer. In contrast, twice-over grazing uses a three to six paddock rotation with strict timelines to promote grass production and allow for pasture rest periods. Each paddock is grazed twice per season. The first grazing event occurs when grasses have reached the three-leaf stage and before flowering, to increase tillering (the production of more shoots and leaves). Secondary growth is then available for a second round of grazing. The twice-over rotation system requires landowners to follow a grazing schedule that optimizes the amount of time for both grazing and recovery, and thus is hypothesized to improve overall pasture and cattle health (Manske, 2004). The twice-over grazing system allows for 60 days of rest between grazing rotations and this leaves large areas of grassland cattle-free. It is thought that the twice-over

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grazing system could allow for an increase in nesting success of grassland birds by eliminating cattle activity during portions of the breeding cycle. A study looking at duck nesting in south central North Dakota found that nesting success on twice-over rotationally grazed pastures was significantly higher when compared with other grazing schemes and idle fields (Barker et al. 1990). Two studies that looked at twice-over grazing in Manitoba found that there is no benefit of the system over season-long grazing for grassland songbird abundance (Christie 1997, Ranellucci et al. 2012), and to my knowledge there has not been a study that has looked at this system in terms of the effect on grassland bird nesting success.

2.8 MHHC and Twice-over Grazing as Conservation Strategy

Manitoba Habitat Heritage Corporation (MHHC) was created in 1986 with a mandate to conserve and restore fish and wildlife habitat through working partnerships with landowners, conservation groups, corporations and government (MHHC 2005). MHHC's focus is on the agricultural regions of Manitoba and MHHC promotes conservation practices that enhance wildlife habitat while working with landowners to sustain and/or increase land productivity (MHHC 2005). MHHC has an ongoing project working on highlighting the benefits of prairie-friendly grazing systems for livestock producers throughout the mixed-grass prairie regions of Manitoba. This project includes providing cost-sharing incentives for landowners to set up twice-over grazing systems on their land. The twice-over system was brought back from North Dakota in the late 1990s, where the system was "producing impressive results for native grassland enhancement" (MHHC 2005 p. 33) and has shown to "benefit livestock producers, wildlife and the land" (MHHC 2006 p. 28). MHHC enters into 5-year agreements with private landowners to implement twice-over rotational grazing on native grassland pastures. As of 2012, there were

approximately 66 properties enrolled in the twice-over grazing demonstration project covering 24,500 acres (MHHC 2005 - 2012).

2.9 Flooding

During 2011, the Assiniboine and Souris river valleys in southwestern Manitoba experienced a 1 in 300-year flood event. The flood created a highly fragmented landscape of wet and dry patches. Typically, dry patches were narrow corridors or isolated islands surrounded by larger areas of flooded pasture. This may have influenced nest site selection and nesting success, as habitat patch shape plays a role in predicting nesting success (Walk et al. 2010). Similarly, nesting success may be lower in narrow strips of grassland habitat in comparison with larger blocks (Pasitschniak-Arts and Messier 1996), perhaps because narrow strips of habitat function as travel corridors for predators and improve a predator's search efficiency (Wall et al., 2010). These smaller, irregular shaped patches could also increase nest parasitism by creating more edge habitat and reducing the search area for the brown-headed cowbird (*Molothrus ater*) female (Robinson et al. 1993, Davis and Sealy 2000). Predator presence is greatest within small patches and corridors that are connected to larger grassland blocks, suggesting that these smaller areas expose nests to higher predation risk (Kuehl and Clark 2002).

To my knowledge, there are no previous studies that have looked at the effects of a significant, extreme flood event on the nesting success of grassland songbirds. However, a study by George et al. (1992) evaluated effects of another severe climatological event, drought, on the populations and nesting productivity of grassland birds in North Dakota. Densities of six of the eight common grassland species declined during the drought year, yet four of these species completely recovered the following year. Also, the overall bird density and species richness the year before the drought and the year after the drought did not differ significantly. During the

drought year the overall nesting success was significantly lower than the other years.

Considering the one-year drought had a minimal effect on multi-year demographics of the grassland bird populations in the study by George et al. (1992), a one-year flood could also have a limited effect on the grassland bird populations of southwestern Manitoba.

2.10 Natural History and Conservation Status of Study Species

Savannah sparrows (*Passerculus sandwichensis*) breed throughout most of Canada and into the central United States in a wide variety of open habitats (Wheelwright and Rising 2008). Preferred grassland habitat consists of short to intermediate vegetation height and density, limited bare ground, and a well-developed litter layer (Swanson 2002). Breeding territories for Savannah sparrows are small, ranging from 0.05 to 1.25 ha. Savannah sparrows prefer intact grassland with minimal tree and shrub cover, and generally nest in greater numbers moving away from grassland edges (Swanson 2002). Savannah sparrows in Manitoba begin nesting in late May and continue until late July, and clutch size is generally 4 or 5 eggs in a well concealed ground nest (Swanson 2002).

Vesper sparrows (*Pooecetes gramineus*) breed across the interior of Canada as far north as the southern Northwest Territories, and south to the central United States (Dechant et al. 2002). Vesper sparrows prefer open areas with short, sparse and patchy vegetation occurring in areas of native prairie, pasture, hayland, cropland, sage brush, shelterbelts, semidesert, and woodland edges (Jones et al. 2002). Song perches are an important characteristic for nesting territory, and can include any structure that is higher than the surrounding vegetation (Dechant et al. 2002). Nests are placed on the ground, generally tucked under dead stems or at the base of a small plant, beside areas of bare ground or sparse vegetation. A clutch consists of 4 or 5 eggs (Jones et al. 2002).

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Clay-colored sparrows (*Spizella pallida*) breed in shrubby grasslands and woody edges from the southern Northwest Territories south to the northern Great Plains, and from eastern British Columbia to Ontario and Wisconsin (Dechant et al. 2002). Clay-colored sparrows can nest on the ground; however, in Manitoba they nest almost exclusively in western snowberry (*Symphoricarpos occidentalis*) in areas adjacent to short vegetation of cropland or pasture, which are used for foraging (Knapton 1979, Dechant et al. 2002). Nesting territories are small, ranging from 0.04 to 0.5 ha, and territory arrangement is dependent upon shrub cover (Dechant et al. 2002, Grant and Knapton 2012). Nesting begins in late May and continues until late July, and a clutch consists of 4 eggs (Grant and Knapton 2012).

The western meadowlark (*Sturnella neglecta*) breeds in a variety of grassland habitats in southern Canada from Manitoba west to British Columbia, and south throughout the United States west of the Great Lakes (Dechant et al. 2002). Western meadowlarks use a wide range of vegetation heights and densities with low to moderate litter cover, and tend to avoid areas of sparse vegetation and dense woody cover (Dechant et al. 2002). Territory size within mixed-grass prairie can range from 2 to 7 ha, and territories are significantly more abundant within the interior of grassland areas than toward the edges (Dechant et al. 2002). Nesting generally occurs in Manitoba from mid-April to late July, and clutch size is 5 to 6 eggs (Davis and Lanyon 2008).

3.0 EFFECTS OF TWICE-OVER GRAZING ON SONGBIRD NESTING SUCCESS

3.1 Abstract

Rotational grazing is promoted as superior to season-long grazing for improving pasture and cattle production, and for grassland bird conservation, but the assumed benefits have not been comprehensively studied. In 2011 and 2012, I examined the effects of twice-over rotational grazing on the nesting success of grassland songbirds in southwestern Manitoba, Canada. I monitored nesting attempts and collected structural vegetation data for five species of obligate grassland bird ($n=110$) and one shrub nesting species ($n=41$). Nesting analyses were conducted using logistic exposure models. Twice-over grazing had a significantly negative effect on the nesting success of the ground nesting species, and Savannah sparrows (*Passerculus sandwichensis*) in particular. Grazing system did not have an effect on vegetation. The results are consistent with other rotational grazing studies, and suggest that twice-over rotational grazing does not benefit grassland songbirds in mixed-grass prairie habitats.

KEYWORDS: ground nesters, mixed-grass prairie, rangeland management, rotational grazing, season-long grazing, twice-over grazing

3.2 Introduction

Grasslands have undergone the highest rate of habitat conversion and degradation of any biome on earth (Hoekstra et al. 2005). Therefore, it is not surprising that grassland bird populations have also declined more than any other guild of terrestrial birds in North America (Askins 1993, Knopf 1996, Fuhlendorf and Engle 2001, With et al. 2008). Currently, prairie habitat decline is primarily caused by conversion for agricultural and urban development, and oil and gas extraction (Samson and Knopf 1994; Brennan and Kuvlesky 2005, Askins et al. 2007). In addition, the remaining prairies are being degraded by poor rangeland management practices,

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over-grazing, fire suppression, woody plant encroachment, and exotic species introduction (Brennan and Kuvlesky 2005, With et al. 2008).

Since the mid-1800s and the mechanization of agriculture, the extent of North American grassland ecosystems have been reduced by 80% (Samson and Knopf 1994, Brennan and Kuvlesky 2005) and the mixed-grass prairie ecosystem in Manitoba has experienced an 82% loss in area (Thorpe 2011). The remaining areas of intact mixed-grass prairie in southwestern Manitoba are fragmented and primarily grazed by cattle (Small and McCaughey 1999). Rangeland management techniques have traditionally been developed with the goal of increasing forage and livestock production; however, this approach may not meet the conservation objectives that have become more important over the last quarter-century (Fuhlendorf and Engle 2001). Although the condition of rangelands have been improving over the last half century, grassland bird populations have continued to decline, suggesting that rangeland management techniques may be inadequate to maintain the biological diversity of the grassland ecosystem (Fuhlendorf and Engle 2001, Samson et al. 2004). Habitat requirements of different grassland bird species vary greatly and may depend on having an interspersion of diverse habitat types throughout the landscape (Fuhlendorf and Engle 2001, Fondell and Ball 2003). There may be methods of managing rangeland and grazing activities to improve biodiversity and grassland bird habitat while still considering agricultural productivity (Herkert 1994, Fuhlendorf and Engle 2001, Johnson and Igl 2001, Derner et al. 2009), but currently there is a lack of adequate research to determine how this might be accomplished.

Traditional rangeland management focuses on managing grazing intensity and livestock distribution over space and time to increase production of the more palatable forage species for cattle and create a uniform grazing landscape (Holechek et al. 1998, Fuhlendorf and Engle 2001). Rotational grazing meets traditional rangeland management goals by using higher stocking

densities distributed over space and time to ensure uniform use of pastures by livestock (Holechek et al. 1998, Briske et al. 2008). Rotational grazing also provides pastures with periods of rest from cattle disturbance and it has been assumed that rested paddocks will allow for increased plant density, herbage production and improved nutrient quality, therefore improving animal performance (Manske 2004, MHHC 2010). It is also thought that the cattle-free, rested paddocks will allow for undisturbed nesting attempts and increased grassland bird production (Knopf 1996, Sutter 1997; MHHC 2010). Rotational grazing systems have been promoted by several rangeland scientists, government, university, and non-profit conservation agencies in Canada and the United States as being beneficial to both cattle producers and native prairie wildlife (Barker et al. 1990, Manske 2004, Krausman et al. 2009, MHHC 2010, Teague et al. 2013). However, the assumptions that rotational grazing is more beneficial than regular season-long grazing in terms of grassland habitat quality and/or cattle production is largely unproven in the majority of studies over the last 60 years (Christie 1997, Temple et al. 1999, Holechek et al. 1999, Briske et al. 2008, Kerns et al. 2010, Briske et al. 2011, Perlut and Strong 2011, Ranellucci et al. 2012).

While the majority of studies on rotational grazing have focused on plant productivity and cattle performance, there are a small selection that have looked at the potential effects of rotational grazing on wildlife (Brown and Kothmann 2009). White-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), Mearns' quail (*Cyrtonyx montezumae*), sharp-tailed grouse (*Tympanuchus phasianellus*), and greater (*Tympanuchus cupido*) and lesser (*Tympanuchus pallidicinctus*) prairie chickens can all be negatively impacted by rotational grazing systems that use heavy, short-term grazing intensities (Holechek et al. 1998). Rodent and raptor populations seem to be reduced on rotationally grazed pastures in comparison to idle grasslands (Saab et al. 1995, Johnson and Horn 2008). Two

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studies have looked at the effects of rotational grazing on duck nesting success and found that there is no difference in nesting success between rotationally grazed and season-long grazed pastures (Ignatiuk and Duncan 2001, Murphy et al. 2004). Similar results have been concluded from the studies that have looked at the effects of rotational grazing on grassland songbird populations (Christie 1997, Temple et al. 1999, Popp et al. 2004, Briske et al. 2008, 2011, Kerns et al. 2010, Perlut and Strong 2011, Ranellucci et al. 2012). The abundance and richness of grassland birds does not increase on rotationally grazed pastures (Christie 1997, Ranellucci et al. 2012), and grassland bird nesting success has not been increased on rotationally grazed pastures in several studies (Temple et al. 1999, Kerns et al. 2010, Perlut and Strong 2011). One study even found that rotational pastures attract grassland birds in higher densities, but the breeding productivity is low, suggesting that rotationally grazed pastures may be grassland bird population sinks (Temple et al. 1999). So, why are rotational systems still being promoted?

Rotational grazing can be applied in many different ways, and the handful of studies that have found positive results with an aspect of rotational grazing could be fueling the invention and testing of new systems, like the twice-over rotational system that has gained popularity in southwestern Manitoba during the last decade. The twice-over rotation grazing system has been growing in popularity across the Northern Great Plains, in part because it is hypothesized to improve habitat for wildlife (Biondini and Manske 1996, MHHC 2010). However, only a few studies have been done to test the effectiveness of this system for the conservation of grassland birds. Two previous studies that looked at the effects of twice-over rotational grazing on grassland songbirds in the northeastern mixed-grass prairie determined that obligate grassland birds had a significantly higher species richness and diversity on season-long pastures when compared with twice-over rotational pastures (Christie 1997, Ranellucci et al. 2012). These two studies did not compare the nesting success between the grazing systems, and the

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effects of twice-over grazing management on species richness and abundance may differ from effects on nesting success. This is an important determinant when looking at the demographics and factors affecting avian populations in a region (VanHorne 1983, Vickery et al. 1992), in particular when looking for conservation strategies.

To help further evaluate twice-over rotational grazing as a conservation strategy for declining grassland songbirds in northern mixed-grass prairies, I conducted a two-year study (2011-2012) comparing twice-over grazing versus season-long grazing on nesting success of mixed-grass prairie songbirds. To evaluate this I focused on the comparative nesting success results between twice-over grazed and season-long grazed pastures with specific focus on ground nesting and shrub nesting groups, individual species (Savannah sparrow, vesper sparrow, and clay-colored sparrow), and on vegetation structure. Additionally, I had the opportunity to observe the direct and indirect effects of a record flood event on nesting success within the area. The Assiniboine and Souris rivers experienced a 1-in-300-year flood event in 2011. The historic flood resulted in water inundating large areas of land. Flooding occurred because of: 1) high moisture levels (130% above normal) in the soil at freeze up during the previous autumn, and 2) above-normal (150%) winter snow pack and spring precipitation (200 to 300%), including severe storm events (Manitoba Government 2013). Major storms caused the Souris River to peak and overflow its banks four separate times between April and June. Within the rural municipalities of the study area, between 60 and 90% of cropland went unseeded due to flood conditions (WSRCD 2014). Grassland pastures also experienced high rates of flooding and water remained on the landscape for the majority of the breeding season. The following field season in 2012 did not experience any flooding, road access was fully open within the study area and farming and ranching operations proceeded as normal. This study has been set up to help

answer whether this specific system follows the majority trend of being non-beneficial to grassland wildlife, specifically grassland songbirds.

3.3 Methods

3.3.1 Study Sites

The study area was situated in the mixed-grass prairie region of southwestern Manitoba, within the boundaries of the West Souris River Conservation District, and was part of the Assiniboine and Souris River drainage basins. Nest survey sites were located between the Canada/USA border (48°59'59.9"N) to 120 km north (49°55'52.3"N), and between the Saskatchewan/Manitoba border (101°25'08.4"W) to approximately 70 km east (100°37'21.2"W) (Figure 1).

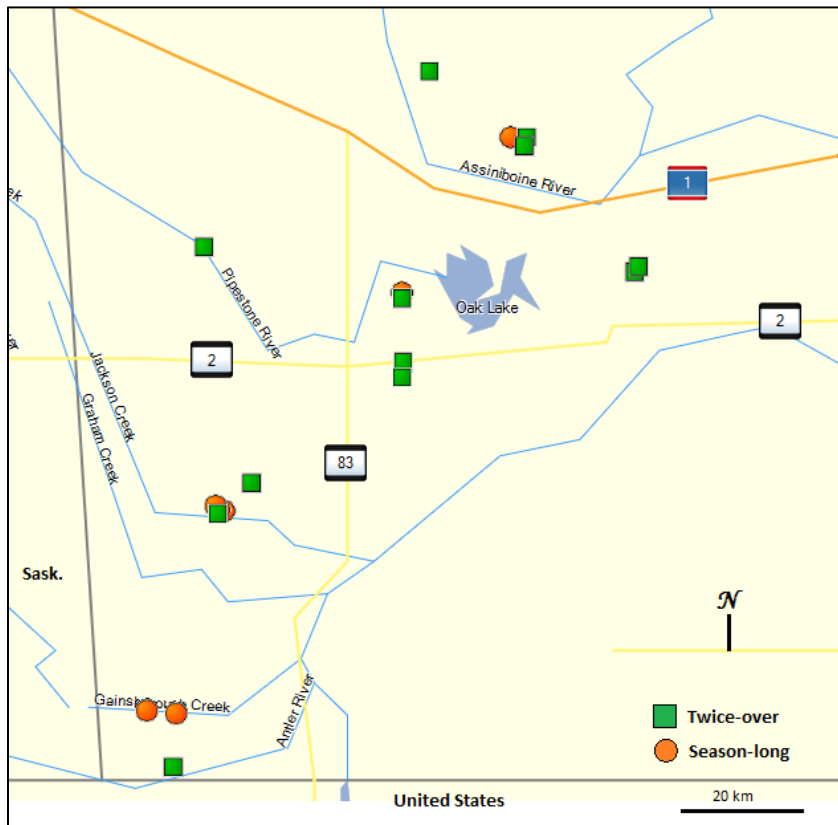


Figure 1: Study site locations in southwestern Manitoba for 2011 and 2012, identified by grazing treatment (map information from (1999-2010) Garmin Ltd.).

The study sites consisted of two cattle grazing management systems: twice-over rotation or season-long grazing. On season-long sites, cattle grazing was continuous between May and October, whereas on twice-over sites cattle were grazed rotationally between pastures starting June 1 and ending October 15 (MHHC 2002). In the northeastern Great Plains, the twice-over rotation system had landowners divide pastures into three to six paddocks and each paddock is grazed twice throughout the season. Cattle enter the first paddock on June 1, and are rotated through each paddock every 7 to 17 days. The number of days is determined by the number of paddocks in the rotation. The first rotation is typically complete by July 15, or after 45 days of grazing (Manske 2004). The second rotation on each paddock is double the number of days of the first rotation, and is typically completed by October 15. In a three-paddock system, this rotation allows for approximately 30 days of pasture rest during the first rotation, and 60 days rest for the second rotation. The average stocking rates (animal units grazed on an area during a month (AUM) divided by acre) for the study area were significantly higher ($p < 0.0001$) on season-long pastures (0.878 AUM/acre) than on twice-over pastures (0.757 AUM/acre) (Ranellucci et al. 2012). Fifteen sites were surveyed over two years: 9 twice-over grazed and 6 season-long grazed pastures.

3.3.2 Site Selection in 2011

The twice-over sites were selected based on years in the twice-over program (>3 yrs) and accessibility. Season-long sites were selected based on land owner volunteers and were approached through a contact with MHHC, or by referral from neighboring land owners already involved in the project. Pastures selected were only grazed by cattle that remained on the pasture from June 1 until mid October for both treatments. Study sites in 2011 were dispersed throughout the rural municipalities (RMs) of Albert, Edward, Pipestone, and Sifton, and ranged

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in size from 0.65 to 2 km². Thirteen sites were surveyed in the 2011 field season, 9 twice-over and 4 season-long. Flooding restricted access to all but these 13 sites. A greater number of twice-over sites were surveyed due to restricted access to season-long landowner volunteers. Each site was surveyed twice throughout the field season.

3.3.3 Site Selection in 2012

Nine of the 13 sites surveyed in 2011 were surveyed again in 2012. Four twice-over sites could not be sampled in 2012 due to changes in grazing management systems among years. Six new sites were added in 2012 (4 twice-over and 2 season-long). Four of the new sites were chosen from the RM of Woodworth, and 2 sites were chosen from the RM of Albert. Each site was surveyed twice throughout the field season.

3.3.4 Field Methods

Nest searching occurred from mid-May through mid-July in 2011 and 2012. One 9-ha search plot was selected per site and a minimum of two rounds of surveying for nests occurred within each plot throughout the breeding seasons in 2011 and 2012. In 2011, flooding reduced the amount of dry grassland habitat on all of the pastures. During the first visit to each site, researchers walked the area to determine the degree of flooding throughout the pasture and selected an area with minimal potential for flooding, generally encompassing all or almost the entire available unflooded upland habitat. Survey plots varied in shape depending on the landscape features at play in each site (excluding flooded areas and woodlots). Nest searching occurred between 0700hr and 1200hr and between 1600hr and 2000hr when it was not raining or windy (> 20 kph), as vegetation moving in high wind can visually obstruct a nest flush. Nest searching was not conducted between the hours of 1200hr and 1600hr when temperatures

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were highest and when adults are less likely to be attending nests (Winter et al. 2003). Nests were located using a rope drag, consisting of a 20 m rope with rock-filled cans attached every two feet, to flush incubating birds. I also located nests incidentally during field travel and nest monitoring. Once a nest was located, I recorded the species, stage of nesting, and the number of eggs and/or young. The nests were marked with bamboo stakes and flagging tape 10 m to the north and east, and I used a Global Positioning System to record location coordinates. Nests were re-visited every 2-4 days to record progress and the resulting success or failure (Winter et al. 2003). I classified a nest as successful if a minimum of one host young fledged. A successful fledge was characterized by the following cues: adults alarm calling near the empty nest, nestling age at previous visit, nests intact paired with the presence of fecal matter and feather scales in the nest, and/or fledglings observed in the vicinity (Davis 2003). Nestling age was visually determined by observing the developmental timing of feather tracts, timing of eye opening, and behavioural reactions to the observer (eg. begging for food vs. remaining motionless and quiet or looking jumpy) (Jongsomjit et al. 2007). Photographs were taken of nestlings each visit to reduce the time spent at the nest and provide a record for later confirmation. Nests of 7 species were monitored: chestnut-collared longspur (*Calcarius ornatus*), Savannah sparrow (*Passerculus sandwichensis*), vesper sparrow (*Pooecetes gramineus*), western meadowlark (*Sturnella neglecta*), clay-colored sparrow (*Spizella pallida*), Le Conte's sparrow (*Ammodramus leconteii*), and bobolink (*Dolichonyx oryzivorus*).

Upon completion of a nesting attempt, structural vegetation was measured using methods adapted from Wiens (1969). Samples were collected at each nest and for two random locations within 50 m of the nest; the random locations were selected using random numbers tables for both direction and distance. At each sample location two meter sticks were crossed and placed to create quadrats. A 1-m metal Wien's pole was dropped vertically using a

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stabilizing holder at the center of the sample and at each of the ends of the meter sticks. The Wien's pole is divided into 10 cm segments and vegetation pieces contacting the pole were counted in two categories, below 10 cm and above 10 cm. Only live vegetation that was in contact with the Wien's pole was counted. Litter depth and tallest vegetation were also recorded at each Wien's pole drop. Litter was defined as any horizontal dead vegetation that was no longer attached to the ground. The quadrats that were created by the crossed meter sticks were used to visually estimate the percentage cover of live grass, dead grass, forb, shrub, litter, bare ground, and cow excrement.

3.3.5 Data Analysis

Nesting success data were analyzed using logistic exposure modeling using PROC NLMIXED in SAS 9.3 (SAS Institute, Cary NC) to determine the effects of twice-over versus season-long grazing on the nesting success of grassland songbirds (Dinsmore et al. 2002; Shaffer 2004). The logistic exposure method reduces overestimation of nesting success that occurs because of the lack of detection of nests that fail during laying or early in the incubation stage (Mayfield 1961, Shaffer 2004).

Data collected on the flood-affected pastures that did not follow the twice-over rotation were not included in the grazing and nesting success analysis.

I ran preliminary models to determine whether seasonality (visit date) influenced daily nest survival and whether it should be included in the grazing models. I used a polynomial equation to describe the effects of visit date on nesting success, but the effect of visit date was not significant for any of the models and thus it was not included in subsequent models, to avoid overparameterization. Year was included in all models to account for the flood event in 2011 and other year effects.

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Nests were divided into two main groups: ground-nesting species ($n=110$) and shrub nesting clay-colored sparrows ($n=41$). Ground nesters and shrub nesters may be affected by different predator communities, and nesting success may be affected differently by grazing cattle (Dion et al. 2000). I also evaluated effects of twice-over and season-long grazing on three individual species, Savannah sparrows ($n=41$), vesper sparrows ($n=32$), and clay-colored sparrows ($n=41$), whose number of monitored nests with a confirmed outcome were greater than 20 nests (Hensler and Nichols 1981). The effect of year and the interaction between grazing treatment and year were also included in the nesting success analysis, to evaluate whether effect of grazing treatment differed between the flood year and normal water level year. However, the interaction between treatment and year was not significant for any of the four groups ($p > 0.3263$) and was removed to reduce collinearity (Quinn and Keough 2002). Whether nesting success varied with nest stage (incubation or nestling) was evaluated by adding the nuisance variable, nest stage, to the models. However, there was no effect of nest stage on nesting success ($p = 0.351$) and, therefore, the variable was removed for subsequent analysis to reduce overparameterization.

The effect of cattle being present in the same paddock as the nest was tested against visit fate by adding the variable, cattle presence, to the models. The cattle presence variable also had no significant effect on nesting success ($p=0.3486$), and was similarly removed from subsequent analyses. Following nesting guidelines by Ehrlich et al. (1988), twenty-three days of nest exposure was used for calculating nesting success for clay-colored sparrows, 26 days for Savannah sparrows, 25 days for vesper sparrows, and 26 days for ground nesters (averaged from the exposure days of all the ground nesting species: Savannah sparrow, vesper sparrow, western meadowlark, Le Conte's sparrow, and bobolink). Days of nest exposure included egg laying, incubation, and nestling days.

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To analyze effects of vegetation on nesting success, I first determined whether similar vegetation variables were correlated in order to reduce the number of variables in each test, and to avoid collinearity. There was a significant correlation between vegetation height and percentage live grass cover both at the nest ($p < 0.0001$, $r = 0.366$), and at random points ($p < 0.0001$, $r = 0.408$). I chose to use percentage live grass cover because its measurement was more consistent among years and observer. Litter depth and percentage dead grass cover was also significantly correlated at the nest ($p < 0.0001$, $r = 0.421$), and random points ($p < 0.0001$, $r = 0.567$). I chose litter depth as the variable to include in subsequent models because it is one of the top three consistent vegetation predictors used in the analysis of habitat use by grassland birds (Fisher and Davis 2010). I also evaluated effects of grazing on percentage bare ground cover at the nest and at random points.

Vegetation and nesting success

I used logistic exposure modeling in SAS (PROC NL MIXED; SAS Institute) to determine how litter depth, live grass cover, and bare ground cover, affected nesting success at the nest and within the available landscape on twice-over and season-long pastures.

Grazing system and vegetation

The effects of grazing system on vegetation structure were evaluated for three structural variables: litter depth, percentage live grass cover, and percentage bare ground cover. Data were analyzed using generalized linear models (PROC GENMOD; SAS Institute) to determine the distribution of best fit for the three vegetation variables. Diagnostic graphs and the deviance/df ratio suggested that residuals fit a negative binomial distribution. I used generalized linear mixed models (PROC GLIMMIX; SAS Institute) with a negative binomial distribution and maximum likelihood estimation to determine the effects of grazing treatment

on the three vegetation variables. The interaction between grazing treatment and year was not significant ($p > 0.7905$); it was removed for all models to reduce collinearity.

Data were analysed for brown-headed cowbird parasitism to look at the possible effect of grazing scheme on the parasitism rates using a chi-square test with parasitism events as the response variable and grazing scheme as the independent variable. I would have preferred to analyse parasitism rates for each species separately; however, there was an insufficient number of events (<5) for species individually to meet requirements of the chi-square test (Van Emden 2008).

For all analysis I used an alpha value of 0.1 to reduce the chance of making a type 2 error, a potentially significant problem in conservation biology (Taylor and Gerrodette 1993, Koper and Manseau 2009).

3.4 Results

3.4.1 Nest Monitoring

In 2011 and 2012, 175 nests of all species were located and monitored; 151 of the monitored nests were included in the analysis on effects of grazing treatment (Table 1). The twenty-four nests removed from nesting success analyses were those that occurred on pastures that were not rotated according to the twice-over grazing guidelines because pastures were flooded in 2011. Grazing treatment analysis included 60 nests from 2011, and 91 nests from 2012. There were 28 nest searches on twice-over pastures, and 20 nest searches on season-long pastures. Clay-colored sparrow (CCSP) and Savannah sparrow (SAVS) nests were the most frequently located (Table 1); vesper sparrow (VESP), western meadowlark (WEME), Le Conte's sparrow (LCSP) and bobolink (BOBO) made up the remainder of nests found and monitored (Table 1). Overall, the number of nests found per search effort between the grazing systems for ground nesters and clay-colored sparrows was not significant ($p=0.7367$).

TABLE 1. Number of nests and grazing scheme in 2011 and 2012 in southwestern Manitoba. Total nests $n=151$. Chi-square for the effect of grazing scheme on nests located per search (twice-over $n=28$, season-long $n=20$) for ground nesters and CCSP $p=0.7367$.

		Number of nests monitored						
	CCSP	Ground nesters	SAVS	VESP	WEME	LCSP	BOBO	Unk. sparrow
Twice-over	30 (1.1)	65 (2.3)	24 (0.9)	16 (0.6)	18 (0.6)	3	0	4
Season-long	11 (0.6)	45 (2.3)	17 (0.9)	16 (0.8)	7 (0.4)	4	1	0
Total	41	110	41	32	25	7	1	4

*Unk. Sparrow were those nests that failed between locating and first visit; identity could not be confirmed.

**Nests found per search on twice-over and season-long for each species are in parentheses.

Of 151 nests included in the grazing analysis, 37% successfully fledged at least one young (apparent nesting success). Clay-colored sparrows had the highest apparent nesting success at 59%, whereas western meadowlarks were the least successful, only producing young in 28% of nesting attempts. Nest predation was the leading cause of failure; 80% of failed nest

attempts were depredated (Table 2). The other causes of nest failure were trampling by livestock (8%), abandonment (6%), parasitism by brown-headed cowbirds (2%), and other causes (3%).

TABLE 2. Songbird nest fates in southwestern Manitoba in 2011 and 2012. Sample sizes represent the number of nests with known outcomes for each species or grouping. The numbers in parentheses are nest fates from the 24 nests where flooding prevented pastures from being grazed according to plan in 2011.

	Ground nesters+ <i>n</i> =110		Clay-colored sparrow <i>n</i> =41		Total <i>n</i> =151		Savannah sparrow <i>n</i> =41		Vesper sparrow <i>n</i> =32		Western meadowlark <i>n</i> =25	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Success	10	22	8	16	18	38	5	9	1	9	4	3
Failure	38	40	4	13	42	53	15	12	9	13	7	11
Depredated	28	35	3	10	31	45	10	10	7	11	5	11
Abandoned	3	2	1	0	4	(4) 2	0	1	2	0	0	0
Livestock	6	1	0	1	6	(2) 2	4	0	0	1	2	0
Parasitized	0	0	0	2	0	(1) 2	0	0	0	0	0	0
Other cause*	1	2	0	0	1	(2) 2	1	1	0	1	0	0

*2 nests were destroyed unintentionally by humans (landowner vehicle, field assistant), 1 unknown, (2) flooded.
+Ground nesters : Savannah sparrow, vesper sparrow, western meadowlark, Le Conte's sparrow, bobolink, unidentified sparrow.

Flood conditions may have negatively affected nesting success; 8 of the 10 nests trampled and 8 of the 10 abandoned nests occurred in 2011 (Table 2). Brown-headed cowbird parasitism was also higher in 2011; 25% of nests monitored from 2011 (*n*=60) were parasitized by cowbirds compared with 13% in 2012 (*n*=91). In 2011, 65% (*n*=13) of the parasitized nests occurred on twice-over pastures, whereas in 2012, only 42% (*n*=5) of parasitized nests occurred on twice-over (Table 3). Additionally, twenty-four nests were dropped from the 2011 analysis because the flooding prevented some pastures from being grazed according to grazing plan. Of the nests dropped, 70% (*n*=17) failed, with depredation causing only 47% (*n*=8) of the failures. The remaining causes of failure were abandonment (*n*=4), flooded (*n*=2), trampled (*n*=2), and cowbird (*n*=1) (Table 2).

3.4.2. Brown-headed cowbird parasitism

Brown-headed cowbirds were present throughout the study pastures, on both season-long and twice-over pastures (Appendix II). Cowbird parasitism events were higher in 2011 than in 2012 ($p=0.0693$), and clay-colored sparrow nests had the highest percentage (25%) of nests parasitized of the focal species (Table 3). However, there was no significant association between cowbird parasitism and grazing system ($p=0.1150$) or between cowbird parasitism and nesting success ($p=0.3046$).

TABLE 3. Brown-headed cowbird parasitism and grazing scheme by year and species during 2011 and 2012 in southwestern Manitoba. Chi-Square test for BHCO parasitism and grazing scheme $p=0.1150$, BHCO parasitism and overall nesting success $p=0.3046$, and BHCO parasitism and year $p=0.0693$.

Species	Nests Parasitized		Nests Monitored	Nests Parasitized		Nests Monitored	Total Nests (% Parasitized where $n > 30$)
	2011			2012			
	Season-long	Twice-over		Season-long	Twice-over		
CCLO	0	1	1	0	0	0	1
CCSP	1	3	15	6	1	29	44 (25%)
SAVS	2	5	25	1	1	21	46 (20%)
LCSP	1	0	3	0	1	4	7
VESP	2	0	12	0	2	22	34 (12%)
WEME	1	3	17	0	0	14	31 (13%)
Sparrow*	0	1	11	0	0	0	11
Year Totals	7	13	84	7	5	90	
Project Totals	Season-long =14	Twice-over =18	Total nests =174				

*Sparrow includes sparrow nests where the species could not be reliably identified before the nest failed. All sparrow nests were identified to species in 2012.

3.4.3 Nesting Success

Ground nesters. A significant effect of grazing scheme ($p=0.0186$) and year ($p=0.0091$) was detected for ground-nesting species. Nesting success probability was lower in twice-over rotationally grazed pastures for ground-nesting species compared with season-long pastures in

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both 2011 and 2012 (Figure 1). The probability of a nest succeeding on twice-over pastures ranged from 4 times lower in 2011 to 2.4 times lower in 2012, compared with nests in season-long grazed pastures.

Individual species. Clay-colored sparrow and vesper sparrow nesting success were significantly affected by year ($p = 0.0164$, $p = 0.0691$) but not by grazing scheme. The nesting success of Savannah sparrows was negatively affected by the twice-over grazing scheme ($p=0.0946$), but not by year ($p=0.1096$). The overall trend was that twice-over grazing had a negative effect on the probability of nesting success of all species monitored (Figure 1).

Year. Year had a significant effect on nesting success for all ground nesters collectively ($p=0.0091$), and for clay-colored sparrows ($p=0.0164$). Nesting success was greater in 2012 on both twice-over and season-long pastures.

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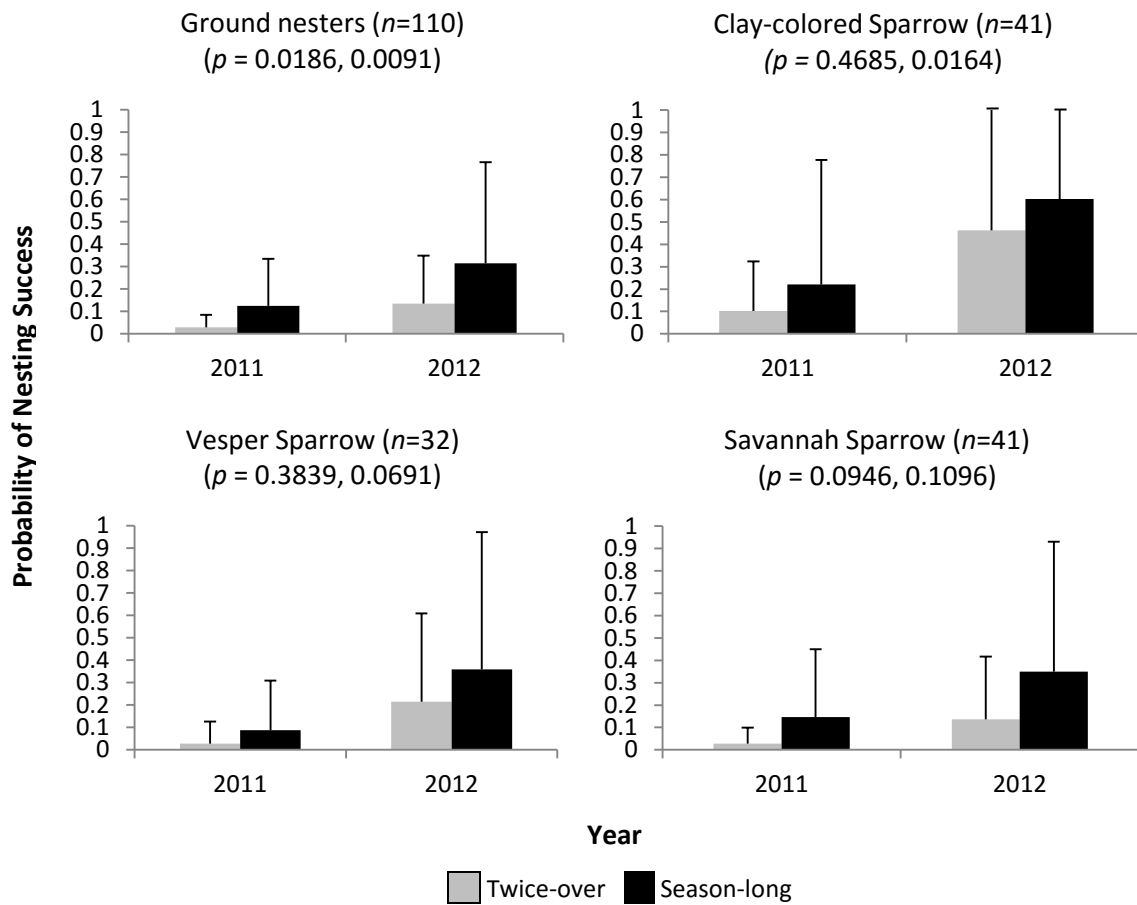


FIGURE 2. Probability and 90% upper confidence intervals of nesting success of grassland songbirds on twice-over rotationally grazed pastures versus season-long grazed pastures in 2011 and 2012 in southwestern Manitoba. *P*-values in parentheses show the effect of grazing treatment and year, respectively.

3.4.4 Vegetation results

Vegetation sampling was conducted around all 151 nests monitored. Overall, vegetation structure had little effect on nesting success at the nest site or within the available habitat ($p > 0.1$; Table 4). The only exception was that litter depth within the available habitat had a negative relationship on nesting success of ground nesting birds ($p = 0.0593$).

Grazing treatment did not have a significant effect on any of the vegetation variables analyzed, percentage living grass cover, percentage bare ground, or litter depth (Table 5). The

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effect of year was only significant for percentage of live grass cover ($p < 0.0001$), which can most likely be attributed to the increased moisture during the flooding of 2011.

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TABLE 4: Effects of vegetation structure on nesting success at the nest and within available habitat on the pastures. Alpha = 0.1.

	Litter depth (mm)						% Live grass cover						% Bare ground cover					
	Nest <i>p</i>	Est	Std error	Random <i>p</i>	Est	Std error	Nest <i>p</i>	Est	Std error	Random <i>p</i>	Est	Std error	Nest <i>p</i>	Est	Std error	Random <i>p</i>	Est	Std error
Ground	0.402	-0.104	0.124	0.059	-0.265	0.139	0.685	0.003	0.007	0.393	0.007	0.008	0.635	0.007	0.014	0.793	0.003	0.012
CCSP	0.840	0.035	0.173	0.373	-0.183	0.202	0.527	-0.008	0.012	0.519	0.010	0.016	0.987	0.001	0.057	0.216	-0.051	0.041
SAVS	0.977	-0.005	0.178	0.528	-0.139	0.218	0.891	0.002	0.012	0.495	0.009	0.013	0.595	0.014	0.023	0.597	0.012	0.022
VESP	0.746	-0.112	0.342	0.483	-0.181	0.255	0.148	-0.026	0.017	0.648	-0.008	0.017	0.433	-0.017	0.021	0.502	-0.014	0.021

TABLE 5: Effects of grazing system and year on vegetation structure at available habitat in southwestern Manitoba. Alpha = 0.1.

	Litter depth (mm)			% Live grass cover			% Bare ground cover		
	<i>p</i>	Est	Std error	<i>p</i>	Est	Std error	<i>p</i>	Est	Std error
Treatment	0.486	-0.1479	0.212	0.180	-0.129	0.096	0.187	0.463	0.350
Year	0.848	0.021	0.107	<0.0001	0.396	0.0583	0.579	0.099	0.179

3.5 Discussion

The results of this study suggest that grassland bird nesting success is negatively affected by twice-over grazing in southwestern Manitoba. Similar to the trend found by Temple et al. (1999) in the mid-western prairies of Wisconsin, where nesting success was also significantly lower on twice-over pastures compared to season-long grazed pastures. Ranellucci et al. (2012) and Davis et al. (2014) found that grazing system had no influence on the abundance of grassland songbirds, and that the birds seem to be attracted equally to the two grazing systems. The twice-over paddocks could be attractive to some species, such as Savannah and Le Conte's sparrows, because they have thick vegetation cover and limited disturbance early in the nesting season. However, during the grazing period of the rotational system, the probability of trampling and disturbance-based abandonment increases due to the high density of cattle in a relatively small paddock, and the probability of depredation increases when vegetation cover is removed (Temple et al. 1999, Ranellucci et al. 2012, Bleho et al. 2014). If rotationally grazed fields attract certain songbird species at a greater rate, such as Savannah sparrows (Ranellucci et al. 2012) as season-long but nesting success is lower, then this suggests that rotationally grazed pastures may be ecological traps for these grassland songbird populations in mixed-grass prairies (Temple et al. 1999).

The species-specific results in this study are consistent with results of the pooled grassland bird analyses. While nesting success was lower in twice-over pastures for ground-nesting species, nesting success of the only shrub-nesting species in this study, clay-colored sparrow, was the same, regardless of grazing system. Clay-colored sparrow nests were located almost exclusively in western snowberry in this study area (Knapton 1979, Dechant et al. 2002), which is common on both season-long and twice-over pastures in Manitoba. Habitat suitability for clay-colored sparrow seems to be affected more by the amount of shrub cover on a pasture

than by grazing system (Dechant et al. 2002, Davis et al. 2014). Cattle do not graze on snowberry and generally avoid thick shrub patches; therefore, clay-colored sparrow nests are infrequently trampled and vegetative nest cover for this species is rarely reduced by cattle (Bleho et al. 2014).

In mixed-grass prairie, Savannah sparrows are associated with tall grass cover, vegetation density, and litter depth (Swanson 2002), and they may be attracted to the taller vegetation that is found on rested paddocks. Ranellucci et al. (2012) found that Savannah sparrows were the only obligate grassland species that preferred twice-over grazing in one of the two study years. Similar to this study, Temple et al. (1999) found that nesting success of Savannah sparrows was lower in rotationally grazed pastures, further emphasizing the idea that rested rotational paddocks may attract birds to nest and the removal of vegetation by cattle later in the season may promote a lowered nesting success. By contrast, vesper sparrows prefer shorter, sparser vegetation than Savannah sparrows, and generally benefit from grazing (Dechant et al. 2002). Grazing system did not have an effect on vesper sparrow nesting success in this study. The sparsely vegetated sites they chose for nesting may not be drastically affected or altered by grazing activities over the season, as these areas are generally not high-traffic cattle areas. With a sample of only 34 vesper nests monitored, which was smaller than for the other species, the lack of an effect may have been due to low statistical power.

Trampling rates vary with species, grazing system, and grazing intensity. They typically have a minimal impact on nesting success in the northern mixed-grass prairie (Koper and Schmiegelow 1997, Bleho et al. 2014). However, higher cattle densities increase risks of trampling (Johnson et al. 2012, Bleho et al. 2014). Trampling rates in this study were higher than rates in several other grazing studies with similar moderate stocking rates; Kerns et al. (2010) found trampling affected only 3.2% (n=316), Johnson et al. (2012) found a trampling rate of

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1.5% ($n=131$) and Lusk and Koper (2013) and Ludlow et al. (2014) reported negligible trampling rates for nests monitored ($n=279$ and $n=332$, respectively). The higher trampling rate in this study (8%) may have been influenced by the increased stocking density of cattle both on the twice-over paddocks, and because of the reduced available dry land during the flood.

In addition to increased risks of trampling in grazing systems with higher densities of cattle (Bleho et al. 2014), grazing systems may affect depredation risk, which varies with amount of cover around nests perhaps because different grassland predators affect nests differently depending on vegetation characteristics (Bleho et al. 2014). I found little effect of vegetation structure on nesting success, with the exception of the negative effect of litter depth.

Depredation was the leading cause of nest failure in this study and depredation by small mammal predators could explain why litter depth had an effect on nesting success. Small mammal predators use the denser litter cover during travel for protection against aerial predators, and therefore may opportunistically encounter and consume more ground nests of those bird species that thoroughly conceal their nests (Dion et al. 2000). During rest periods on twice-over pastures, the vegetation and litter is thicker with fewer open patches (Ranellucci et al. 2012), which may attract the species of grassland birds that prefer more cover to nest, but may also provide cover and protection for small mammals and snakes that depredate nests (Weidinger 2002). During grazing of rotational paddocks, a different suite of nest predators could be affecting nesting success. Aerial predators that rely more on visual cues for detecting prey and nests tend to hunt in open areas and depredate more nests of those bird species that prefer sparse vegetation. Medium-sized mammals also prefer shorter, less dense vegetation that does not impede their movements (Dion et al. 2000). Twice-over grazing systems might compromise songbirds' strategies for avoiding locally common predators, because once cattle

are rotated onto the pasture, reducing vegetation density, depredation risk by medium-sized mammalian and aerial predators could be increased.

The frequency of brown-headed cowbird parasitism varies across the mixed-grass prairies. In central North Dakota, cowbirds are more abundant in areas that consist of vegetation cover made up of 30 – 80% western snowberry and wolf willow (*Elaeagnus commutata*) (Shaffer et al. 2003), the two prominent shrub species on the pastures in southwestern Manitoba. Cowbird parasitism in this study was higher in 2011, perhaps because flooding allowed cowbirds to locate more nests by reducing the search area to small islands of dry land within the pastures. Cowbird presence and abundance is directly related to the presence of cattle grazing (Goguen and Mathews 2001). Cattle create high-quality forage for cowbirds by creating areas of shorter vegetation, increasing invertebrate abundance, and flushing up invertebrates as they graze (Goguen and Mathews 2001). Cowbird parasitism rates are also higher in areas with abundant edge habitat and perches, including trees, shrubs, human infrastructure and fence lines at least 50cm high (Davis 1994, Shaffer et al. 2003). The grasslands of southwestern Manitoba are heavily fragmented with aspen and encroaching woody vegetation, and fence lines for managing livestock, all of which might help support regional cowbird populations.

Numerous differences among years were observed. For example, nesting success was significantly affected by year for the ground nesting group and for clay-colored sparrows and vesper sparrows individually. Apparent trampling, abandonment, and cowbird parasitism rates also seemed to be affected by year. The amount of live grass was significantly higher in 2011, which can most likely be attributed to the increased moisture during the flooding (Paine et al. 1996). It seems likely that the unusually high flood that occurred during the 2011 nesting season may have had direct and indirect impacts on nesting attempts. However, only two nests were

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confirmed destroyed by flooding: one nest at the egg stage, and one nest at the nestling stage. Thus, of greater impact was how the flooding may have affected nesting indirectly by changing the landscape, reducing high-quality nesting sites, and exposing nests to increased predator traffic, trampling, parental abandonment and parasitism. It seems likely that trampling rates were higher in 2011 because flooding fragmented the landscape and reduced the available dry land for both nesting and foraging cattle, which may have concentrated the locations of both taxa, and thus increased direct interactions between livestock and songbird nests (Nack and Ribic 2005). The flooding may have been a factor in the increased rate of nest abandonment, which may have been influenced by prolonged heavy rain events, and increased cattle disturbance around the nest.

Species respond to stocking rates differently (e.g., Bleho et al. 2014). Higher stocking rates may have a positive effect on the nesting success for species that prefer less dense vegetation (chestnut-collared longspur), and in the same pasture have a negative influence on a species that prefers more vegetative cover (Savannah sparrow) (Sliwinski and Koper 2015). The stocking rates for the season-long pastures in this study area are moderate and may not be high enough to cause direct destruction (Ranellucci et al. 2012, Bleho et al. 2014), particularly because more grassland obligate birds were present on season-long than on twice-over pastures (Appendix II, Ranellucci 2010). While the stocking rates in southwestern Manitoba were only slightly higher on the season-long pastures than on the twice-over pastures (Ranellucci 2012); the stocking density (animals per unit of land) between the two grazing systems is very different. Cattle on the season-long pastures have access to the entire pasture and can move around selectively, where the cattle on the twice-over pastures are concentrated on only one paddock, or approximately one-third of the entire pasture, and are forced to utilize less area per cow. Higher stocking densities can have an impact on grassland bird nesting by increasing cattle

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related nest disturbance (Johnson et al. 2012, Bleho et al. 2014), and could be one of the explanations for why twice-over grazing decreased nesting success. The two grazing systems in this study also did not have an effect on vegetation structure; so again, it is likely that the negative effects of twice-over grazing system were a result of grazing pattern (eg. high density of cattle during grazing rotation) than the resulting vegetation structure. Stocking rates may be used by conservation planners to create habitat for grassland species, but there is not a standard rate that will benefit all species, so a variety of different stocking rates applied regionally may provide the habitat needed to support a healthy diversity of grassland songbirds (Fuhlendorf et al. 2012, Sliwinski and Koper 2015).

In comparison to a heterogeneous landscapes, homogeneous grassland landscapes do not support as diverse a community of prairie plants and wildlife (Fuhlendorf et al. 2006; Briske et al. 2008), and may be leading to declining grassland bird populations (Samson and Knopf 1994, Brennan and Kuvlesky 2005). Twice-over rotationally grazed pastures in southwestern Manitoba have a more homogenous vegetation structure in comparison with season-long pastures (Ranellucci 2010), perhaps explaining why there is lower species richness and diversity of grassland birds on twice-over pastures (Ranellucci et al. 2012). The season-long pastures in this study also appeared to support a greater proportion of species at risk than the twice-over pastures (Appendix I and II). Fuhlendorf et al. (2006) determined that both plant and animal communities responded positively to heterogeneous landscapes, and that there was no difference in livestock performance between traditional homogeneous pasture management and heterogeneous patch style management. Responses of grassland birds to grazing will differ throughout the year depending on what their current resource requirements are. Lifecycle activities including foraging, roosting, courtship, and nesting have different resource needs (Saab et al. 1995). It is important to have a variety of vegetation communities within the

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landscape for all the different lifecycle activities and for the variety of different species (Cox et al. 2014). Therefore, grazing systems that create a more heterogeneous landscape are often better suited for creating breeding habitat for a wide array of grassland songbirds, while concurrently maintaining livestock production. My results suggest that in addition to homogenizing the prairie landscape (Ranellucci et al. 2012); twice-over grazing also decreases nesting success of some grassland songbirds. This supports earlier evidence (Ranellucci et al. 2012) that the twice-over rotational grazing system does not benefit grassland songbirds, at least in Manitoba, and should not be promoted as a conservation method for improving pasture land for conservation of grassland songbirds.

4.0 GENERAL CONCLUSION

4.1 Management Implications

The results of this study suggest that twice-over rotational grazing is not superior to season-long grazing for supporting the nesting success of grassland songbirds. Although the twice-over grazing system is valued by some rangeland managers and conservation organizations, this study, like others on rotational grazing, found no evidence supporting rotational grazing as an improved grassland management system over season-long grazing (Briske et al. 2008, 2011). Conservation managers intending to improve grassland bird habitat in Manitoba should re-evaluate the grazing management systems currently in place, in particular the twice-over grazing system.

Results of this study suggest that season-long grazing systems may be more beneficial for the conservation of grassland birds in southwestern Manitoba. The season-long grazing system and other management options that use less-intensive stocking rates and allow for the cattle to move freely over a large area may help create a grassland landscape that has a heterogeneous vegetative structure that is more beneficial to breeding grassland birds and other prairie wildlife (Fuhlendorf and Engle 2001, Askins et al. 2007, Coppedge et al. 2008, Horvick et al. 2015), while also keeping stocking densities low, to minimize direct effects on nests (Bleho et al. 2014). Season-long grazing systems also reduce the amount of edge habitat used by predators and cowbirds when compared to the twice-over system's design with cross fencing.

Grassland habitat loss is a main reason for associated bird declines throughout North America (Murphy 2003, Askins et al. 2007). There needs to be a focus on keeping remaining native grasslands intact, reducing further fragmentation, and improving pasture management.

Prairie conservation organizations may benefit from focusing less on the type of grazing system, and more on the influencing factors of these systems, stocking rates, seasonal timing, and frequency of grazing (Davis et al. 2014). The cattle industry is a key player in reducing further grassland loss (Fleischner 1994); any partnerships with ranchers should be cherished and utilized to the best of abilities and research. Even though twice-over grazing does not seem to benefit grassland birds over season-long, the land-agreements associated with the twice-over program may contribute to conservation by preventing some land parcels from being converted for crop land. Further, the twice-over program has enhanced connections among ranchers and land managers, conservation organizations, and scientists. These partnerships could be used to further open communication and in some cases reduce the divide between research and the users on land.

4.2 Future Research Considerations

This study demonstrated that twice-over rotational grazing does not benefit native grassland breeding birds when compared with season-long grazing. The findings of this study have lead to some general hypotheses, listed below, that could be explored in the future.

Rotational grazing systems operate on the basis of improving pasture forage conditions and promoting vegetation growth by providing cattle-free rest periods to pastures throughout different stages of the growing season (Manske 2004). While it has been thought that rotational grazing could benefit grassland birds by minimizing disturbance during a portion of the breeding season, it has also been suggested that the higher intensity cattle traffic during grazing periods is one of the reasons why breeding success is sometimes lower on rotational pastures (Bleho et al. 2014). If rested paddocks are attractive nest sites for grasslands birds, and there is a high nest failure rate once cattle are rotated onto paddocks, then rotational grazed pastures may act as a population sink for grassland nesting birds.

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Rotational grazing systems are designed to promote a homogenous grazing pattern and reduce selective grazing by cattle. However, homogenous landscapes have also been proven to be preferred by snakes and small rodents because they provide consistent cover for travel (Johnson and Temple 1990; Klug et al. 2010). If rotational grazing creates more homogenous landscapes and therefore promotes higher populations of small mammals, then this may lead to higher rates of nest depredation by snakes and small rodents on rotationally grazed pastures.

Twice-over rotational grazing systems require cross fencing to subdivide the pastures into paddocks. Fences have been shown to increase edge habitat, reduce core habitat, and attract edge predators and cowbirds (Renfrew and Ribic 2008). If the increased fencing on rotational pastures increases the abundance of edge predators, then I would predict depredation by these predators to be higher on twice-over grazed pastures than within other grazing systems that require less fencing.

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APPENDICES

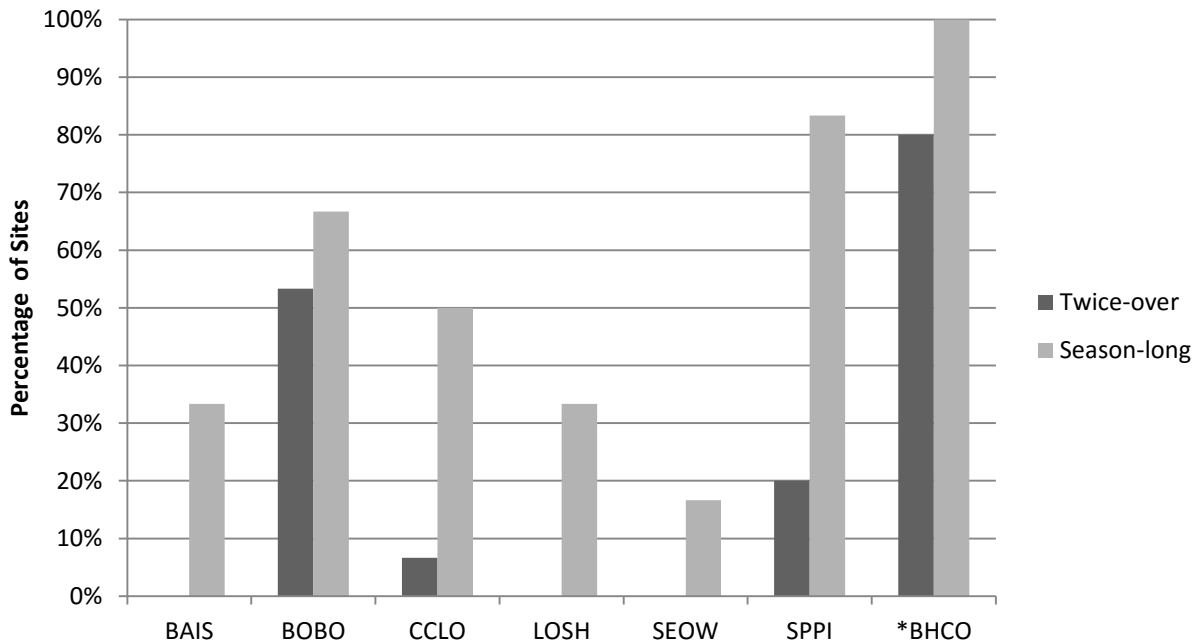
APPENDIX I – Presence of Species at Risk

Presence of Species at Risk (SAR) on twice-over and season-long pastures in southwestern Manitoba in 2011/2012.

	MB SAR Status*	Twice-over (13 sites)	Season-long (6 sites)
Baird's sparrow	Endangered	No	Yes (2 sites)
Bobolink	Special concern	Yes (9 sites)	Yes (5 sites)
Chestnut-collared sparrow	Endangered	Yes (2 sites)	Yes (2 sites)
Ferruginous hawk	Endangered	No	Yes (1 site)
Loggerhead shrike	Endangered	No	Yes (2 sites)
Short-eared owl	Threatened	No	Yes (1 site)
Sprague's pipit	Threatened	Yes (3 sites)	Yes (4 sites)
# of sites with SAR		10	6
# of sites with SAR excl. Bobolink		3	5

* (Bird Studies Canada 2012)

APPENDIX II – Study Sites with Species at Risk



The proportion of twice-over and season-long sites with species at risk present.

APPENDIX III - Grassland Bird Species in Southwestern Manitoba

Obligate and facultative grassland bird species present during the study (2011/2012) (Vickery et al. 1999, Ranellucci 2010).

Species
<i>Obligate Grassland Birds</i>
*Baird's sparrow (<i>Ammodramus bairdii</i>)
*Bobolink (<i>Dolichonyx oryzivorus</i>)
*Chestnut-collared longspur (<i>Calcarius ornatus</i>)
Grasshopper sparrow (<i>Ammodramus savannarum</i>)
Horned lark (<i>Eremophila alpestris</i>)
Le Conte's sparrow (<i>Ammodramus leconteii</i>)
Savannah sparrow (<i>Passerculus sandwichensis</i>)
*Sprague's pipit (<i>Anthus spragueii</i>)
Upland sandpiper (<i>Bartramia longicauda</i>)
Vesper sparrow (<i>Poocetes gramineus</i>)
Western meadowlark (<i>Sturnella neglecta</i>)
<i>Facultative Grassland Birds</i>
Brewer's blackbird (<i>Euphagus cyanocephalus</i>)
Brown-headed cowbird (<i>Molothrus ater</i>)
Clay-colored sparrow (<i>Spizella pallida</i>)
Eastern kingbird (<i>Tyrannus tyrannus</i>)
Killdeer (<i>Charadrius vociferous</i>)
Lark sparrow (<i>Chondestes grammacus</i>)
*Loggerhead shrike (<i>Lanius ludovicianus</i>)
Nelson's sharp-tailed sparrow (<i>Ammodramus nelsoni</i>)
Red-winged blackbird (<i>Agelaius phoeniceus</i>)
Sedge wren (<i>Cistothorus platensis</i>)
Western kingbird (<i>Tyrannus verticalis</i>)

*Species at risk

APPENDIX IV - Odds of Nesting Success

Odds ratios for the effects of grazing system and year on the nesting success of grassland songbirds in southwestern Manitoba in 2011 and 2012. 90% upper and lower confidence intervals.

	Ground nesters $n=110$ (Grazing $p=0.0186$, year $p=0.0091$)			CCSP $n=41$ (Grazing $p=0.4685^*$, year $p=0.0164$)			SAVS $n=41$ (Grazing $p=0.0946$, year $p=0.1096^*$)			VESP $n=32$ (Grazing $p=0.3839^*$, year $p=0.0691$)		
	β	upper	lower	β	upper	lower	β	upper	lower	β	upper	Lower
Grazing Value	-0.0565	-0.1708	-0.9590	-1.4272	0.5456	-1.400	-0.6574	-0.0106	-1.3042	-0.4174	0.3747	-1.2096
Odds	0.5684	0.8430	0.3832	0.6523	1.7257	0.2466	0.5182	0.9885	0.2714	0.6588	1.4546	0.2983
%	43	16	62	35	73	75	48	1	73	34	45	70
Year Value	0.6070	0.9889	0.2251	1.1174	1.8798	0.3551	0.6186	1.2547	-0.018	0.8901	1.6944	0.0858
Odds	1.8349	2.6883	1.2525	3.0569	6.5523	1.4263	1.8563	3.5068	0.9827	2.4354	5.4434	1.0896
%	83	169	25	206	555	43	86	251	2	144	444	9

*Results based on an alpha value of 0.1

The odds of a ground nesting species being successful on twice-over pasture is 43% less than on season-long pasture.