Interactions between Landscape Structure, Vegetation Communities, and Range Health on Grassland Songbird Communities in the Complex Topography of the Foothills Fescue-Parkland Transition in Southern Alberta, Canada

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Abstract

Understanding how birds select their habitat in regionally specific ways is critical to effective conservation strategies. Considering the widely documented loss of native grasslands and declines of the songbirds that use these habitats, understanding avian habitat selection is particular important in on private lands managed simultaneously for cattle grazing and grassland biodiversity conservation. In this study, I propose to examine the impacts of cattle grazing, proxied by range health assessments, in interaction with landscape structure (amount, configuration, and composition of habitat types) and the composition and structure of local vegetation communities in the context of the complex topographic environment posed by the Foothills Fescue-Parkland Transition of southern Alberta, Canada. Throughout 2021 and 2022, I will conduct point counts, vegetation surveys, and burrow counts on Nature Conservancy of Canada conservation projects throughout this region and use Geographic Information Systems for spatial assessments of landscape structure. I will analyze these data using an information theoretic approach, as well as some additional correlative analyses. Results from this study will help to both elucidate the regionally specific mechanisms impacting grassland songbird populations at different spatial scales and provide regionally specific management recommendations benefiting grassland bird species.

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1 Introduction

1.1 Background

Grassland songbirds have had greater declines than the birds of any habitat in North America over the last 50 years (Rosenberg et al., 2019). With over 75% of grassland songbird species currently declining (Rosenberg et al., 2019), understanding effective management and securement of lands for grassland songbird conservation is paramount. As most remaining native prairie is on private land (Gauthier & Wiken, 2003), conservation of these lands in conjunction with traditional public conservation efforts is critical for protecting songbird habitat. While the grasslands these birds evolved on were historically disturbed by sporadic fire and Plains Bison (Bison bison) grazing (Knapp et al., 1999), commercial production of cattle are now the dominant disturbance factor maintaining these grasslands (Allred et al., 2011). These facts necessitate studying the impacts of cattle grazing on avian habitat use, specifically in the context of private land conservation. In this study, I propose to examine the impacts of cattle grazing as it interacts with other known factors in avian habitat selection. I will conduct this research in a high density of private conservation projects in an understudied region - the Foothills Fescue-Parkland Transition - on the western edge of Canadian Prairies. This work will highlight regionally specific trends in avian habitat selection and elucidate mechanisms impacting avian habitat selection in complex landscapes.

Multiple factors operating at different spatial scales contribute to avian habitat selection (Figure 1). At the local scale, vegetation communities serve as the primary determinant of habitat suitability for birds. The composition of plant species and the subsequent diversity of heights and covers impacts avian breeding success, foraging preferences, and protection from predators (Fisher & Davis, 2010), with predation being the largest cause of nest failure (Bleho et al., 2014). If

composition-mediated vegetation structure impacts foraging or breeding, a species-specific preference can occur for different types of grasslands such as native, bunch-grass dominated grasslands; grasslands dominated by non-native, agronomic grasses; or 'modified' grasslands where agronomic species have invaded native grasslands (Davis & Duncan, 1999; Gelbard & Harrison, 2003; Lloyd & Martin, 2005). At the regional scale, abiotic factors such as climate, topography, and geology filter the vegetation communities that can occur in an area (ex. Natural Regions Committee, 2006). Topographic variables are thus important determinants in habitat selection because preferred vegetation communities may be associated with aspect and elevation, in some cases mediating preferences for flatter areas (Gennet et al., 2017; Natural Regions Committee, 2006), or because flatter areas may be preferred for breeding (Pasinelli, 2016).

Between the local and regional scales, landscape structure – the amount, fragmentation, and composition of grasslands throughout a landscape – is a critical attribute of avian habitat selection. Landscape composition refers to what vegetation community types (native grasslands, modified grasslands, forests, etc.), are present and in a landscape and in what proportions to one another. Habitat amount (area of grassland habitat) affects key biological interactions including inter-specific and intra-specific competition (Sliwinski & Koper, 2012; Tscharntke et al., 2012). Reductions in the amount of habitat available (habitat loss) can result in population declines through direct losses of individuals and through changes in demographic parameters such as breeding or survival rates (Kurki et al., 2000; Zitske et al., 2011). Certain bird species are known to be area-sensitive and will not occur in patches below a threshold area, which can be closely linked to the total amount of habitat in the landscape (Davis, 2004; Ribic et al., 2009). Habitat fragmentation (amount of edge independent of the amount of habitat) is a landscape pattern describing the configuration of habitat throughout the landscape instead of how much is there

(Fahrig, 2003). As fragmentation increases in a given landscape, the total amount of edge habitat increases, patch size decreases, and distance between patches decreases (Fahrig et al., 2019). Fragmentation patterns can thus result in either positive or negative impacts on species, depending largely on the type of edge habitat (linked to the composition of the matrix), and the species' sensitivity to edge effects. Different edge types such as roads, water features, or forest affect habitat suitability for many bird species in different ways through altering biotic interactions like predation, competition, and brood parasitism, or by altering vegetation structure (Fletcher & Koford, 2003; Jones & White, 2012; Koper et al., 2009; Lockhart & Koper, 2018; Sliwinski & Koper, 2012). Landscape structure thus has many intricate impacts on avian populations relevant to regionally specific landscape composition, amounts of different habitats, and varying degrees of fragmentation.

Vegetation communities and landscape structure serve as the primary determinants of cattle management decisions including stocking rates, grazing duration, and seasonal timing of grazing (Adams et al., 2016). These aspects of cattle management then feedback to alter key aspects of vegetation communities and landscape structure, creating a cycle impacting habitat availability for birds. At the local scale, cattle grazing can directly impact birds through nest destruction, although this generally a small impact compared to the benefits provided through maintaining grassland habitats (Bleho et al., 2014). Cattle can also indirectly impact birds, largely through altering vegetation structure including plant height, litter retention, and levels of bare ground, all of which are critical attributes of avian habitat selection (Deutsch et al., 2010; Fisher & Davis, 2010; Harrison et al., 2011). Cattle-induced changes to vegetation structure can impact avian nesting success through increasing incidences of brood parasitism (Saab et al., 1995), reducing invertebrate prey availability (Sutter & Ritchison, 2005), and increasing rates of predation by

mammals or birds (Bylo et al., 2016; Renfrew & Ribic, 2003). At the landscape scale, disturbance from cattle grazing maintains grasslands and slows woody encroachment (Allred et al., 2011) and can alter plant species composition at the patch scale significantly (Herrero-Jáuregui & Oesterheld, 2018; Toledo et al., 2014). However, in general, avian responses to increases or decreases in cattle grazing are generally fast, on the order of a few years. Thus, management of cattle grazing remains a critical factor in determining avian habitat availability and usage, and also a tool able to alter habitats in multiple ways benefiting grassland birds.

An important management tool relating livestock grazing to the ecology of grasslands in Alberta, Canada, is range health assessment (Adams et al., 2016). Range health uses several metrics based on the composition and structure of the vegetation community to provide land managers with information regarding the ecological integrity of the grasslands in response to the cumulative impacts of cattle grazing. These assessments are combined with spatial ecosystem mapping to determine Ecologically Sustainable Stocking Rates for cattle (ESSRs; Adams et al., 2005; DeMaere et al., 2012). Range health has been linked as a predictor of several grassland songbird species in the Mixedgrass and Dry Mixedgrass Natural Subregions of Alberta (Dodd et al., 2016). However, the links between range health and grassland songbird communities in the Foothills Fescue-Parkland Transition have not been examined. If links between this commonly used management tool and the abundance of grassland birds can be elucidated in this region, it would facilitate communication of management recommendations benefiting birds specific to the study region.

Species-specific avian habitat selection varies in response to regional location, specifically regarding landscape structure and relative location within a species' range (Johnson & Igl, 2001). For example, the relative impacts of habitat amount and fragmentation on grassland birds in North

America has been shown to vary in different locations. In Wisconsin, the relative abundance of grassland birds was found to be determined more dependent on the composition of habitats in the landscape than by fragmentation (Renfrew & Ribic, 2008), whereas in Manitoba, the opposite was found (Lockhart & Koper, 2018). In this example, relative abundance in Wisconsin was highly correlated with the amount of wooded habitat in the landscape, while in Manitoba the larger impacts of fragmentation were likely due to increased nest predation near edges. Direct and indirect impacts of cattle on birds are also known to vary with regional context including topographic and climatic considerations (Bleho et al., 2014; Lipsey & Naugle, 2017). Therefore, to understand how vegetation communities, landscape structure, and cattle management impact avian habitat selection, these attributes must be studied in their regional context, especially at the edge of the range of many species as in this study.

The Foothills Fescue-Parkland Transition of Alberta is an understudied system where landscape structure, vegetation community type, and cattle grazing all interact in a complex topographic context. This area is characterized by rolling hills between the low-elevation grasslands, mid-elevation parkland savannas, and high-elevation montane ecosystems. Across this transitional area, fescue grasslands are present in mosaic landscapes with patches of open aspen forest and willow shrublands (Natural Regions Committee, 2006). Because of the regionally specific differences between this area and better studied grasslands, there are likely to be differences in the interactions between vegetation communities, landscape structure, and grazing that impact populations of grassland songbirds and are as yet not understood. Elucidating how complex landscapes interact with local habitat characteristics and cattle management in this understudied region will both assist in creating effective local management strategies and further theoretical understanding of concepts in landscape ecology.

1.2 Study Purpose & Objectives

In this study, I will conduct avian surveys and use statistical models to relate grassland songbird species abundances to four factors impacting avian habitat selection in the transition between the Foothills Fescue and the Foothills Parkland Natural Subregions in Alberta. Vegetation communities, the cumulative impacts of cattle grazing, landscape structure, and topographic characteristics all interact to influence avian habitat selection, but few studies have examined all these factors together and none have studied them in this unique, transitional region where these factors are likely to interact and impact birds differently than in other grassland regions. My study objectives are described in this section, my hypotheses are outlined in Section 3.8 following the literature review and methods, and the specific links between my hypotheses and my statistical methods are detailed in Table 3.

1.2.1 Landscape Structure

The Foothills Fescue-Parkland Transition presents a natural experiment to examine grassland fragmentation in a gradient of grassland to forest dominated landscapes. Some grassland songbird species have been shown to be area-sensitive (Ribic et al., 2009), and many have been shown to be affected by proximity to edges (Renfrew & Ribic, 2008). In the proposed study, I will attempt to discern between the effects of grassland amount and grassland fragmentation on grassland songbird communities in this mosaic landscape.

How does the complex landscape structure in the Foothills Fescue-Parkland Transition impact the abundance and diversity of obligate grassland songbirds?

1.2.2 <u>Vegetation Structure & Composition</u>

The vegetation communities in the Foothills Fescue-Parkland Transition are significantly different from other grassland regions in Alberta (Natural Regions Committee, 2006). Differences

in vegetation structure between native grasslands, modified grasslands, and non-native grasslands are known to impact avian habitat selection (Davis et al., 2013; Lloyd & Martin, 2005). The different vegetation community types in this region have been well documented from land management and cattle grazing perspectives (Adams et al., 2005; DeMaere et al., 2012), but habitat selection by grassland songbirds in these different community types has not been studied formally.

How does the type of vegetation community (native, modified, or tame pasture) compare with vegetation structure at smaller scales (cover, height, layering) to predict grassland songbird habitat selection in the Foothills Fescue-Parkland Transition?

1.2.3 Range Health

Range Health assessment for grasslands, forests, and tame pasture is a common management tool used throughout southern Alberta (Adams et al., 2016). It uses metrics based on the cumulative impacts of cattle on the vegetation community to inform what ecologically sustainable stocking rates for cattle are reasonable for the area. These metrics have been used in other grassland regions in Alberta to provide insight into habitat availability for grassland songbirds, particularly species-at-risk (Dodd et al., 2016), and I intend to examine if this commonly used assessment of grazing-induced vegetation changes can predict grassland songbird habitat selection in the Foothills Fescue-Parkland Transition. Using this common method will help to better communicate grassland songbird conservation issues to range managers working on the ground.

How do the cumulative impacts of cattle grazing, as they are represented by metrics used in range health assessments, influence grassland songbird communities in the Foothills Fescue-Parkland Transition?

1.2.4 <u>Topography & Elevation</u>

The Foothills Fescue-Parkland Transition is a complex region with large variation in topography moving from grasslands to montane environments. Topography is known to be a key determinant in biogeographic patterns of species composition (Natural Regions Committee, 2006), and studies have shown complex interactions between topography and local vegetation community composition, landscape structure, avian breeding territories, and livestock management (Gennet et al., 2017; Pasinelli, 2016; Reino et al., 2013; Rodríguez et al., 2018).

How does the complex topographic landscape posed by the Foothills Fescue-Parkland Transition interact with local and landscape attributes to influence obligate grassland songbird habitat selection?

1.2.5 Management Implications

This study will collect avian songbird data and relate it to landscape level metrics in an area with a high density of private conservation projects. The goals of these conservation projects have been largely based on conserving large, wide-ranging mammal species such as bears and large ungulates (McCue, 2016). Thus, little information on the success of these projects in conserving grassland bird species has been compiled. The information from the proposed study will have the ability to directly influence grassland songbird conservation through integration with the management efforts of the Nature Conservancy of Canada (NCC) and its partner land managers. These data will help to identify areas on existing NCC projects where species at risk are located, identify areas species at risk are likely to be located through models, provide management recommendations to benefit the conservation of grassland songbirds, and inform frameworks for securing new conservation projects.

2 Review: Grassland Songbirds in the Foothills Fescue-Parkland Transition

Grassland songbird habitat selection is dependent on several interacting factors. These factors include a wide breadth of concepts from landscape, population, and community ecology as well as aspects of land management and biological conservation. This information is divided here into six sections, each narrowing in on the avian communities in the grasslands of the Foothills Fescue-Parkland Transition. I first describe the study area with its complex topography, then the relationship between landscape structure and vegetation communities, and finally the effects of grazing on grassland songbird habitat selection in interaction with the other factors. For the avian community specifically, I summarize the predictions for various expected bird species in the area. A synthesis of major concepts is given in the final section of this chapter.

2.1 Defining the Foothills Fescue-Parkland Transition

Alberta is divided into ecological mapping units called 'natural regions' and 'natural subregions' that are used widely throughout conservation and landscape management (see McCue, 2016 for an example). The natural subregions are units within natural regions that are characterized by similar physical and biological traits including climate, soils, and vegetation communities (Natural Regions Committee, 2006). In the Grassland and Parkland Natural Regions of Alberta, natural subregions coincide largely with boundaries for 'ecoregions' used at the federal level within the Canadian Prairie Ecozone (Gauthier & Wiken, 2003). However, for conservation and management purposes, the provincially defined natural subregions serve as the dominant system for ecosystem classification through published series of reference communities called 'range community guides' and the Grasslands Vegetation Inventory (GVI; see Adams et al., 2005; DeMaere et al., 2012). Unless otherwise cited, I retrieved all information on the natural subregions presented in this section from information published by the Natural Regions Committee (2006).

The Foothill Fescue Natural Subregion lies on the western boundary of the Grassland Natural Region of Alberta within the foothills of the Canadian Rocky Mountains. It spans 13,623 km² and is bordered by the Mixedgrass Natural Subregion to the east, and sections of both the Foothills Parkland and the Montane Natural Subregions to the west. The Foothills Fescue differs from the Mixedgrass in that the former is at higher elevations (average 1100 MASL versus 975 MASL), is on average warmer in the winter (-9.7°C versus -10.2°C) and cooler in the summer (23.8°C versus 25.1°C), receives more precipitation annually (470mm versus 394mm), and has a shorter growing season (97-day versus 110-day frost-free period). The terrain is generally undulating with nutrient rich Black Chernozem soils. There is little open water or wetland cover. Fescue grasslands are among the most productive in North America and only a small proportion have not been anthropogenically altered (Shorthouse, 2010). Most remaining native grassland in the Foothills Fescue is in the south of the region and is dominated by Foothills Rough Fescue (*Festuca idahoensis*) with various interspersed forb species.

The Foothills Parkland Natural Subregion exists as a transition zone between the Grassland and Rocky Mountain Natural Regions in southern Alberta. It consists of two main patches: one bordering the northeast boundary of Waterton Lakes National Park (the south patch), and one near the boundary of Banff National Park (the north patch). Landscapes in these parkland areas differ from both grassland and montane ecosystems in that there are many open deciduous forests dominated by Trembling Aspen (*Populus tremuloides*) interspersed amongst a mosaic of fescue grasslands, willow shrublands, and intermittent streams. The Foothills Parkland differs from other parkland subregions in Alberta, namely the large-spanning Central Parkland, as the former is at higher elevations (average 1250 MASL versus 750 MASL), is on average warmer in the winter (- 9.6°C versus -14.7°C) and cooler in the summer (22.1°C versus 23.0°C), receives more precipitation annually (517mm versus 441mm), has a shorter growing season (76-day versus 102-day frost-free period), and is much smaller in area (3,921km² versus 53,706km²). The terrain varies from relatively flat areas to large slopes and has many interspersed wetlands but little open water.

The southern patch of Foothills Parkland present along the border of Waterton Lakes National Park exists within a larger conservation priority for the Nature Conservancy of Canada (NCC) called the Waterton Natural Area (McCue, 2016). NCC's Natural Areas are management units used to denote objectives for clusters of conservation projects (McCue, 2016). The Waterton Natural Area spans ~1100km² of Foothills Fescue, Foothills Parkland, and Montane habitats bordering Waterton Lakes National Park and Castle Wildlands Provincial Park. While this entire area is prioritized for protection under NCC's *Natural Area Conservation Plan*, NCC manages ~30 conservation easements working with private landowners to protect ~85km² and owns another ~100km² spread across ~40 other projects. All of these projects are within or bordering the southern Foothills Parkland patch. It is on these NCC projects that I intend to conduct my research.

Throughout this proposal, I refer to this study area cumulatively as the "Foothill Fescue-Parkland Transition". This is because the southern Foothills Parkland patch within NCC's Waterton Natural Area is relatively narrow, spanning only about 11km east to west (Figure 2). Towards its eastern boundary, the Foothills Parkland grassland habitats are more open and similar to those within the Foothills Fescue, while towards its western boundary forests begin to increase in area and density, and thus the Foothills Parkland resembles habitats of the Montane Natural Subregion (Tracy Rains, NCC Rangeland Resource Manager, *pers comm.*). Within the Foothills Parkland itself, the rolling topography creates microhabitats that can be more like either the Foothills Fescue or the Montane Natural Subregions. Thus, the narrow range and variable microhabitat structure of this region suggest that it should be studied as a continuum from 'Foothills Fescue' grassland into the 'Foothills Parkland' savannahs and ending in closed 'Montane' forests based on elevation, rather than as a single homogenous subregion.

2.2 Topography & Elevation

Topography represents an environmental cline mediating macro- and micro- habitats for birds through changes to vegetation communities at regional, landscape, and local scales. Large scale environmental filters imposed by variability in abiotic factors have been long implicated within niche theory (reviewed by Pocheville, 2015). At the regional scale, increases in elevation drive the changes in temperature, light availability, and geological conditions that create the transition between the grasslands of the Canadian Prairies to the forests of the Rocky Mountains (Natural Regions Committee, 2006). At local scales, topography can directly influence bird breeding territories (Pasinelli, 2016). Indirectly, topography has been found to be a predictor of plant species invasions in the Rocky Mountains, whereby middle-elevation ecosystems have higher proportions of non-native species, especially in productive, grass-dominated ecosystems (Averett et al., 2016). Such topography driven changes in vegetation community composition have been found to affect bird species habitat selection in California, where flatter areas were correlated with native vegetation and resulted in greater preference by grassland bird species (Gennet et al., 2017). Topography-driven effects on vegetation communities may also interact with other factors at the landscape scale including grassland fragmentation and livestock grazing to impact avian habitat usage (Reino et al., 2013; Rodríguez et al., 2018). Specifically, complex topographies may create grazing refugia where cattle either are not able to or do not readily access. The cross-scale impacts of topography on habitat selection and availability for birds necessitate their inclusion within the complex elevational continuum posed by the Foothills Fescue-Parkland Transition.

2.3 Landscape Structure

Birds have been shown to select their habitat based on characteristics at both local and landscape levels. While local habitat features remain a critical aspect of habitat selection (Fisher & Davis, 2010), the breeding success of birds can be influenced by factors at landscape scales an order of magnitude greater than individual breeding territories (Kurki et al., 2000). Indeed, grassland birds throughout the Canadian Prairies have been shown to select their habitat based on attributes of the landscape far outside of their local territories. Examples include studies looking at scales 0.4km to 1.2km beyond the parcels individual birds breed in (Davis et al., 2013; Renfrew & Ribic, 2008), 2.4km to 5km radii landscapes (Koper & Schmiegelow, 2006; Lockhart & Koper, 2018), and even levels of fragmentation throughout 100km² landscapes (Kurki et al., 2000). Because habitat selection is at least partially based on factors occurring at the landscape level, the importance of studying birds at multiple scales has been emphasized (Koper & Schmiegelow, 2006; Renfrew & Ribic, 2008).

The relative effects of landscape structure, specifically habitat amount and fragmentation, have been subjects of debate in discussing habitat fragmentation in recent literature. Throughout many landscape ecology studies, the amount of habitat in a landscape has been conflated with the configuration of habitat in studying the effects of habitat fragmentation (Fahrig, 2003, 2019). There is a general consensus that reductions in the amount of habitat through human land alteration has detrimental impacts on species, and that at a local scale, habitat edges can change the composition of biotic communities (Fahrig, 2017; Fahrig et al., 2019; Fletcher et al., 2018). However, local edge effects can either exacerbate or compensate for such habitat amount driven impacts on biotic communities at the landscape scale (Fahrig et al., 2019).

The amount of habitat in the landscape can be a critical feature in avian habitat selection. It has been reported that some obligate grassland species respond to higher covers of grasslands throughout landscapes (Renfrew & Ribic, 2008), generally corresponding with larger, contiguous stretches of grassland. As a corollary, many obligate grassland songbirds have been classified as woodland-sensitive, meaning that their use of habitats decreases as the amount of forest habitat in the landscape increases (Grant et al., 2004; Renfrew & Ribic, 2008). As the amount of habitat in the landscape decreases, population sizes shrink, increasing the importance of demographic stochasticity in population dynamics (Desharnais et al., 2006). Habitat loss has also been linked to reductions in individual survival rates and productivity (Kurki et al., 2000; Zitske et al., 2011).

Habitat fragmentation differs from habitat amount by considering how habitat is distributed throughout a landscape, instead of how much is present. Fragmentation at the landscape scale can be measured in a variety of ways, many of which provide an index of the cumulative impact of edge effects, and these edge effects can reduce grassland songbird habitat use by altering the core habitat available (ex. Koper et al., 2009). As the amount of grassland edge increases in the landscape, increased Brown-headed Cowbird (*Molothrus ater*) brood parasitism (Bernath-Plaisted et al., 2017), altered vegetation structure (Archer et al., 2017), and active edge avoidance in establishing territories (Fletcher & Koford, 2003) have been documented as mechanisms sometimes underlying these edge effects. However, increased risk of predation is likely the largest edge effect influencing habitat selection and nesting success, especially at grassland to forest ecotones (Hannon & Cotterill, 1998; Kurki et al., 2000; Renfrew et al., 2005; Renfrew & Ribic, 2003).

Acknowledging the differences between effects of habitat amount, fragmentation, and patch size is critical, particularly in grasslands. Some grassland bird species have been shown to be area

sensitive (Ribic et al., 2009). Fragmentation *per se* implies that as the number of patches in a landscape increases, average patch size decreases because the amount of habitat is held constant (Fahrig, 2017). Species-specific area sensitivity therefore interacts with the composition and fragmentation of the landscape, whereby different types of matrix can alter relationships between patch size and abundance (Renfrew & Ribic, 2008). In Savannah Sparrows (*Passerculus sandwichensis*), for example, density was shown to decrease with grassland core area in landscapes with low amounts of forest but increase with grassland core area in landscapes with high amount of forest (Renfrew & Ribic, 2008). Interactions between the amount of habitat and its fragmentation mean that even though there may be an appropriate amount of habitat for a given species at the landscape level, the fragmentation of the habitat may alter that species' usage. In some regions, grassland amount is more impactful than fragmentation (Renfrew & Ribic, 2008), and in others fragmentation is more impactful than amount (Lockhart & Koper, 2018). This inconsistency between regions highlights the necessity of studying the interactions between factors involved in avian habitat selection in a regional context (Johnson & Igl, 2001).

This discussion leads to the question of how local avian species diversity will respond to varying levels of habitat amount and fragmentation in grasslands. One theory, the *cross-habitat spill over hypothesis*, states that as landscape heterogeneity increases – meaning there are more types of habitat in the landscape – local diversity will increase as species begin to spill-over from their preferred into other habitat types (Tscharntke et al., 2012). This would be represented by higher species diversity with increasing edge in grasslands as the community shifts to being populated by both grassland obligate and grassland facultative species (Vickery et al., 1999). Given that grassland songbirds are imperiled as a group (Rosenberg et al., 2019), and that woody encroachment into grasslands represents a critical threat to grassland habitat (Archer et al., 2017),

an increase in diversity with increasing fragmentation *per se* would, in this case, be negative from a conservation context. Another theory, the *landscape species pool hypothesis* states that alphadiversity is mediated by gamma-diversity at the landscape level (Tscharntke et al., 2012). This implies that in landscapes with lower total species diversity, local species diversity may saturate, resulting in less impact of fragmentation patterns. In this study, if the diversity of the obligate grassland bird species pool is low at the landscape level, then there may be less evident impacts of fragmentation patterns.

In the study region, there are variably-sized patches of forest and grassland interspersed amongst one another (DeMaere et al., 2012; Natural Regions Committee, 2006). By selecting a broad distribution of landscapes with contiguous grassland habitat and landscapes with grassland fragmented by a matrix of forests, I will be able to address the relative impacts of the amount of grassland habitat and its fragmentation on individual species, obligate grassland birds as a group, and on the diversity of the entire avian community. Landscape structure may also interact with topography or conditions at the local habitat scale to influence diversity of different groups of avian species in the Foothills Fescue-Parkland Transition. As the subsequent sections will describe, I will examine landscape structure in the context of different vegetation communities and their disturbance through cattle grazing.

2.4 Vegetation Structure & Composition

A critical aspect of grassland songbird habitat selection is the vegetation community. Different vegetation communities provide different qualities of nesting habitat, protection from predators, and food sources (Fisher & Davis, 2010; Sutter & Ritchison, 2005). These vegetation communities can be examined in three broad attributes: composition, structure, and function (Noss, 1990). Vegetation structure is a particularly important factor for grassland songbird habitat selection (Davis, 2005; Fisher & Davis, 2010). Different species show preferences for varying levels of vegetation density, cover, bare ground, height, and litter depth (Fisher & Davis, 2010). The exact species composition of the vegetation community, however, has been thought to be less influential on grassland songbird habitat use than the changes to structure that compositional changes entail (Fisher & Davis, 2010). When considering impacts of vegetation on grassland songbird habitat selection, it is thus important to consider how vegetation composition results in structural changes.

When discussing changes in vegetation structure associated with composition, the impacts of anthropogenic land conversion become apparent. In the Canadian Prairies, conversion of native grasslands to 'cropland', areas cultivated for monocultures of agricultural species, has resulted in massive declines of grassland songbirds through the loss and fragmentation of native grasslands (Askins, 2002; Houston & Schmutz, 1999; Owens & Myres, 1973; Vickery et al., 1999). A related type of conversion common in western Canada is the clearing and reseeding of native grassland with non-native, agronomic grasses to produce 'tame pastures' and 'hay fields', the general difference between the two being whether the intended use is livestock grazing or hay harvesting (Adams et al., 2005, 2016). In the northern patch of Foothills Parkland in Alberta, it was estimated that 72% of native grasslands at lower elevations had been converted to cropland or tame pasture (Simonson & Johnson, 2005). These novel, anthropogenic ecosystems are generally homogenous, non-native vegetation communities that are structurally different from heterogeneous, native grassland ecosystems (ABMI, 2019; Hovick et al., 2015; Tews et al., 2004).

Anthropogenically altered vegetation communities differ structurally from native grasslands in several critical ways related to grassland birds. Tame pastures are managed to be static, consistently producing ecosystems characterized by dense, uniform cover of a one to few species (Adams et al., 2005). In contrast, native grasslands evolved with variable disturbance regimes from large ungulate grazing and fire resulting in a shifting mosaic landscape that supported diverse vegetation communities (Fuhlendorf et al., 2006; Hovick et al., 2015; Richardson et al., 2014). This native shifting mosaic can be characterized by spatial and temporal differences in vegetation density; amounts of bare ground; and layering of shrubs, grasses, and forbs (Adams et al., 2005). Furthermore, vegetation structure is mediated by species composition. Agronomic grasses are generally tall, perennial, rhizomatous grasses that form mats (Adams et al., 2005). Native grasslands, particularly those in the Foothills Fescue-Parkland Transition, are dominated by bunch grasses that leave gaps for a diversity of other plant species (Adams et al., 2005). Thus, in the novel ecosystems dominated by agronomic grasses, vegetation structural traits relevant to birds may be drastically different than native grasslands.

Responses of grassland songbird habitat selection to non-native vegetation communities is well studied in other regions, but not in the Foothills Fescue-Parkland Transition. In the Central Parkland of Alberta, grassland bird richness increased over time in former croplands seeded with agronomic species for dense nesting cover as grasslands matured (Prescott & Murphy, 1999). These results imply that non-native vegetation communities provide useful habitat for some grassland songbirds in aspen parkland grasslands, but it is also noted that this usage is species specific and dependent on constant anthropogenic maintenance (Prescott & Murphy, 1999). In a study in tallgrass prairie in Manitoba, native versus non-native grasslands were found to have similar total bird abundance, but different compositions based on species-specific preferences (Wilson & Belcher, 1989). Non-native grasslands in aspen parkland have been shown to have reduced bird species richness relative to non-native grasslands in mixedgrass prairie (McMaster & Davis, 2001), highlighting the regionally specific response of avian habitat selection to non-native vegetation. In a study conducted in Oregon, non-native vegetation cover was shown to affect neither food availability nor nesting success for grassland birds (Kennedy et al., 2009). However, in other cases, non-native vegetation communities have been shown to decrease nesting success in some species, even if the occurrence of species in these habitats does not change (Davis et al., 2016; Lloyd & Martin, 2005). Non-native vegetation thus provides habitat for some grassland songbirds, but the diversity of birds using them in aspen parkland may be reduced, management is required, and there is a possibility that the nesting success will also be reduced relative to native grasslands.

Agronomic grass species have additional impacts on vegetation communities through invasion into native grasslands, particularly in the Foothills-Parkland Transition. During the plant surveys conducted to develop the range community guides for this region, the non-native grasses Kentucky Bluegrass (*Poa pratensis*), Timothy (*Phleum pratense*), and Awnless Brome (*Bromus inermis*) occurred in 75%, 75%, and 21% of the 410 native grassland sample plots, respectively (Adams et al., 2005). The competitive ability and dominance of these non-native plants as they invade native communities depends largely on hydrology, topography, and anthropogenic disturbance levels, but once established, it is extremely difficult to revert the community to the native state (Adams et al., 2005; Dickson et al., 2012; Gelbard & Harrison, 2003; Lancaster et al., 2018; Toledo et al., 2014). These non-native, grass-dominated communities are generally referred to as 'modified grasslands' if they have greater than 75% non-native grass cover (Adams et al., 2005, 2016). These shifts in the composition of native grasslands have large corresponding impacts on vegetation structure and functioning that are relevant for grassland birds (Toledo et al., 2014), particularly near edges of tame pastures where propagules are highest.

Invasions of agronomic grasses into adjacent prairies can impact avian abundance and nesting success. In native mixedgrass prairies in Montana, the percent cover of non-native vegetation within 100m of avian point counts was shown to have a slightly negative impact on the abundance of several grassland songbirds, including Sprague's Pipits (*Anthus spragueii*) and Chestnut-collared Longspurs (*Calcarius ornatus;* Lipsey & Naugle, 2017). In native mixedgrass prairies in Alberta, brood parasitism of grassland songbirds by Brown-headed Cowbirds increased with cover of agronomic grasses as well as with vegetation height and proximity to roads (Bernath-Plaisted et al., 2017). This highlights that invasions of native grasslands by non-native vegetation can impact songbird habitat selection and nesting success, but also that these effects must be examined in a landscape context.

Avian habitat selection is affected by complex interactions between the type of vegetation community and the surrounding landscape. For example, in southern Saskatchewan, Bobolink (*Dolichonyx oryzivorus*) abundance was 20 times higher on non-native grasslands than on native grasslands, but abundance on non-native grasslands also increased as the cover of native grassland in the surrounding landscape increased, which implies that the two habitat types complemented the Bobolink populations at the landscape level (Davis et al., 2013). In the same study, Savannah Sparrow abundance was similar between native and non-native grasslands, but on native grasslands, abundance increased with the cover of native grassland in the surrounding landscape (Davis et al., 2013). When Savannah Sparrows were found on non-native grasslands, however, abundance decreased as the amount of native grassland in the surrounding landscape increased. Thus, Savannah Sparrow abundance increased as the landscape became dominated by the habitat type selected, whether that landscape was native or non-native grassland. These are two of several examples detailing the complex interactions between the habitat a species chooses and its location

in the landscape in addition to other aspects of grassland amount and fragmentation previously discussed. This information cumulatively highlights the need to examine habitat factors at multiple scales and in location-specific contexts when examining grassland bird habitat selection.

Species-specific habitat selection in relation to the type and structure of a grassland community is complex. Avian species show preferences for certain vegetation structures, but structure is mediated by whether the vegetation community is dominated by native bunch grasses; by agronomic, rhizomatous grasses; or by a mix of the two, as well as topography. Habitat selection is also influenced by the landscape context in which a given habitat occurs through interactions between the type of vegetation, its amount, and its fragmentation (Davis et al., 2013). As will be discussed in the next section, vegetation structure and composition is also dependent on the management of cattle-induced disturbance in grasslands. Without taking a holistic view regarding these interacting factors, critical nuances of habitat selection and their subsequent effects on community diversity will be missed.

2.5 Grazing & Range Health Assessment

While fire and Plains Bison (*Bison bison*) were historically the dominant disturbance regimes in the Canadian Prairies, they have been largely replaced by anthropogenically managed cattle (Fuhlendorf et al., 2010). Cattle grazing creates complex social-ecological systems that can benefit both humans and biodiversity by providing economic livelihoods and simultaneously maintaining grasslands on private land (McCue, 2016; Pogue et al., 2020). Although the exact impacts of cattle grazing on the landscape are slightly different than that of Plains Bison, these differences are more influenced by management than by intrinsic differences between species (Milchunas et al., 1998; Towne et al., 2005). Within grazing management, control of the amount of individual animals, their spatial distribution, seasonal timing, and allowing time for grasslands

to recovery following disturbance are key tenants of these socio-ecological grazing systems (Dodd et al., 2016).

Although the cumulative effects of livestock grazing in Canadian prairies are generally positive, grazing has been found to have minor negative impacts on nesting success directly through destroying nests (Bleho et al., 2014). Direct nest destruction in parkland transitions specifically were found to be 4.5 times higher than in prairie grasslands, suggesting differential impacts of grazing on songbirds in these regions (Bleho et al., 2014). Indeed, grazing pressure has more negative effects on the abundance of birds using dense grass structures in higher productivity grasslands, such as those in the Foothills Fescue-Parkland Transition, and more positive effects on the abundance of birds using sparse-grass structures in lower productivity grasslands (Lipsey & Naugle, 2017). In general, nest failure in grassland birds is much more commonly attributed to predators than to trampling by cattle (Bleho et al., 2014; Renfrew et al., 2005). However, cattle can also indirectly alter trophic interactions involving birds, their mammalian predators, and their invertebrate prey by altering vegetation structure (Harrison et al., 2011; Kerns et al., 2010; Sutter & Ritchison, 2005). Specifically, high intensity grazing has been shown to increase abundances of ground squirrels (Spermophilus spp.), an important nest predator for grassland birds, by altering vegetation structure to allow the ground squirrels to better see their own predators (Bylo et al., 2016; Renfrew & Ribic, 2003).

Impacts to vegetation structure by cattle grazing are numerous but dependent on the intensity of grazing. Higher intensities of grazing remove move vegetation litter, which is critical in avian habitat selection and also soil moisture retention (Deutsch et al., 2010; Fisher & Davis, 2010; Naeth et al., 1991). Grazing also decreases average vegetation height and increases amounts of bare ground (Harrison et al., 2011). In many cases, structural changes and their subsequent impacts on avian communities imposed by cattle grazing are reversible over periods of 1-4 years given time to recover (Fischer et al., 2020; Nelson et al., 2011). In some cases, however, higher grazing pressures can alter species composition significantly (Herrero-Jáuregui & Oesterheld, 2018) and these compositional shifts can lead to alterative stable states such as non-native grasslands (Toledo et al., 2014).

Range health assessment is a widely used protocol in Alberta that measures cumulative grazing-induced vegetation changes using standardized methods (Adams et al., 2016). The protocol is based on comparing the on-site conditions to documented reference plant communities (ie. Adams et al., 2005; DeMaere et al., 2012). The five categories assessed include ecological integrity based on vegetation composition, vertical vegetation structure, litter cover, bare ground, and noxious weed invasions (Adams et al., 2016). The scores of the five categories in comparison to the reference community are weighted, summed, and scored to produce a percent score that can be classified as unhealthy, healthy with problems, or healthy, and then used to advise cattle management (Adams et al., 2016). This method comparing in-field observations to reference communities remains the standard practice of cattle managers in Alberta and is relatively consistent with state-and-transition models, whereby community composition does not progress along a determined pathway to single climax, but can proceed to a number of stable states depending on disturbance and management (Fuhlendorf et al., 2012).

Range health has been used previously to understand habitat selection by bird populations. In the Central Parkland of Alberta, pastures with high range health had five times higher densities of waterfowl nests than pastures with low range health, though there were complex interactions between the densities of vegetation at the nest scale and the pasture scale (Warren et al., 2008). Metrics from range condition, a predecessor of range health, have been shown to be useful predictors of several birds in mixedgrass grasslands including Sprague's Pipit and Chestnutcollared Longspurs (Davis et al., 2014). Linkages between cattle grazing management, range health, and grassland birds in mixedgrass prairie in Alberta has also been explored in detail by the Multiple Species at Risk (MULTISAR) program run by the Alberta Conservation Association (Dodd et al., 2016).

Because of their widespread use, and because they have been linked to avian habitat use and breeding success in other areas, range health assessments will likely serve as a viable proxy of grazing disturbance in the Foothills Fescue-Parkland Transition as well. By examining how grazing-induced structural vegetation changes interact with the amounts and fragmentation of varying grassland types, one can begin to elucidate the mechanisms by which avian habitat selection is mediated at different spatial scales through grazing. Additionally, by using a management tool that is familiar to ranching communities, bird conservationists can better communicate such complex interactions to produce meaningful best management practises.

2.6 Avian Communities in the Foothills Fescue-Parkland Transition

This section details the likely bird communities in the Foothills Fescue-Parkland Transition. My expectations are based on a variety of sources, including technical resources, academic literature, and species observations from the area. Table 1 summarizes key species expected or plausibly within the study region, and their conservation statuses. Because details regarding species are summarized elsewhere (see Appendix B), accounts of species in this section focus specifically on their responses to the factors examined in this study.

2.6.1 Obligate Grassland Species

Obligate grassland birds are those that are reliant on grasslands for the entirety of their biological needs, using few, if any, other habitats (Vickery et al., 1999). Grassland birds have

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been noted as having the greatest declines of any habitat type since 1970 (Rosenberg et al., 2019), largely because of the widespread loss and fragmentation of native prairie (Vickery et al., 1999). Direct impacts of cattle grazing are 4.5 times greater in parkland transitions compared to prairie grasslands, but the largest losses to these populations are still predation by mesopredators (Bleho et al., 2014). Because the small grassland patch size in the Foothills Fescue-Parkland Transition reduces the relative abundance of area-sensitive species, and because obligate grassland birds have shown a strong negative response to habitat edges (Lockhart & Koper, 2018), I expect that the proportion of obligate grassland birds in this area will be most dependent on the fragmentation of grassland as mediated by edges. However, if local obligate grassland bird species saturates to landscape diversity levels, then the communities may show less response to fragmentation.

Chestnut-collared Longspurs and Sprague's Pipits are both listed as Threatened species in Canada (Canada, 2020; COSEWIC, 2010b, 2019). Both species have been shown to be area sensitive, requiring habitats greater than 39 and 145 hectares in size, respectively (Davis, 2004). Because of this area sensitivity, it is unlikely that they will be present in the study area except possibly in the northeastern-most habitats located in the Foothills Fescue Natural Subregion. ABMI (2019) predicts that the relative abundance of both these species throughout the study area is between 0 and 0.1. However, there are singular recorded observations for both species on NCC projects within the study area (NCC, 2020), and thus they may occur sporadically in large grassland patches.

The study region, however, has one of the highest predicted relative abundances of Bobolinks in Alberta (ABMI, 2019), which are also listed as a Threatened species in Canada (Canada, 2020; COSEWIC, 2010a). Bobolinks generally prefer hay fields and tame pasture habitat because of tall, dense vegetation structures but also benefit from native grassland in the landscape

(Davis et al., 2013). Bobolinks are sensitive to agricultural, forest, and road edges (Fletcher & Koford, 2003). Their territory size is dependent on an interaction between edge type and distance from edge but averages ~0.35 hectares (Fletcher & Koford, 2003). They have been found to occur less in landscapes with higher proportions of forest (Grant et al., 2004). Bobolinks are also sensitive to cattle grazing, as they prefer to nest in tall vegetation with high grass to forb ratios and deep litter (Grant et al., 2004; Schneider, 1998). Because of these factors, Bobolinks will likely be found more in modified grasslands and tame pastures with higher range health, and only in landscapes with low amounts of forest and patches large enough to support several mating pairs.

Savannah Sparrows are a common obligate grassland species found throughout the study area with flexible habitat selection. Different studies report that Savannah Sparrows were more abundant in non-native grasslands (Davis et al., 2013), more abundant in native grasslands (ABMI, 2019; Davis et al., 2016), or that there were no significant differences in abundance between these types of grassland communities (Davis & Duncan, 1999). Thus, Savannah Sparrow habitat selection is likely more dependent on specific vegetation structure than is captured by broad definitions of communities. Indeed, Savannah Sparrows have been shown to prefer dense, grassdominated habitats with high forb cover, low bare ground, and low shrub cover (Haegen et al., 2015; Lipsey & Naugle, 2017), which could correspond to either native or non-native grasslands depending on grazing pressures. However, when grasslands become too dense from lack of grazing, Savannah Sparrow abundance can decrease again (Prescott & Murphy, 1999; Ranellucci et al., 2012). Although grazing is required for Savannah Sparrows (Ranellucci et al., 2012), their specific structural preference is reflected by the species' negative association to intensive cattle grazing in productive grasslands (Lipsey & Naugle, 2017). Zachary Moore

Savannah Sparrow habitat selection is also dependent on landscape context. They have complex interactions between local vegetation community and the amount and type of grassland in the landscape (Davis et al., 2013). While Savannah sparrows are not area sensitive and have small territories (Davis, 2004), they are sensitive to edges (Lockhart & Koper, 2018). They have been found to have negative associations with agricultural edges, oil and gas infrastructure, and roads as well as positive associations with wetland edges (Sliwinski & Koper, 2012; Yoo & Koper, 2017). These edge effects have been linked to increased brood parasitism by Brown-headed Cowbirds causing decreased nesting success (Bernath-Plaisted et al., 2017). Savannah Sparrows have also been classified as sensitive to forest cover at the landscape level (Grant et al., 2004). As a result of these factors, in the Foothills Fescue Parkland Transition, Savannah Sparrows are likely to be found in most vegetation communities that meet their structural preferences but will be less abundant in landscapes with more edge, more Brown-Headed Cowbirds, and lower range health.

Vesper Sparrows (*Pooecetes gramineus*) are another common species in the study area. They have been noted to use both native and non-native grasslands (Davis & Duncan, 1999), but may have some preference for non-native grasslands (ABMI, 2019; Davis et al., 2016; Wilson & Belcher, 1989). Vesper sparrows show preference for tall, sparse vegetation with some shrub cover (Lipsey & Naugle, 2017) and have been noted to use grassland edges including aspen forest stands (Dechant et al., 2002; Johns, 1993). Vesper Sparrows are one of the few grassland obligate songbirds to have positive associations with forest amount at the landscape scale as well as different edge types (Grant et al., 2004; Sliwinski & Koper, 2012). The diversity of habitats used by Vesper Sparrows are likely to make them one of the few obligate grassland species to remain present in small, isolated patches of grassland in landscapes with high amounts of forest edge. The documented effects of grazing on Vesper Sparrows are complex and inconsistent. Vesper Sparrows were shown to have a mixed reaction to grazing in British Columbia, as they showed preference for nesting in both taller vegetation, which was associated with ungrazed areas, and areas with higher amounts of bare ground, which were associated with grazed areas (Harrison et al., 2010). However, although habitat selection was not influenced by alterations to vegetation structure by grazing, nesting success was shown to be lower in shorter vegetation, suggesting that grazing may indirectly impact Vesper Sparrow populations negatively by increasing nest predation (Harrison et al., 2011). In other cases, grazing has been shown to have beneficial (Owens & Myres, 1973), or neutral (Lusk & Koper, 2013; Ranellucci et al., 2012) impacts on Vesper Sparrows. It is likely that Vesper Sparrows will show a regional and vegetation community specific response to grazing.

Western Meadowlarks (*Sturnella neglecta*) are the final common grassland obligate species in the study area (NCC, 2020). They prefer native grassland communities and have been found to have reduced abundances in non-native grasslands (ABMI, 2019; Davis et al., 2013). They have been shown to have increases in abundance near wetland and agricultural edges (Sliwinski & Koper, 2012). Their abundance additionally decreases as the proportion of forested cover increases in the landscape (Grant et al., 2004). Like Vesper Sparrows, Western Meadowlarks were shown to prefer taller vegetation and higher amounts of bare ground, inconsistent with a standard response to grazing (Harrison et al., 2010). In one instance, they have been shown to have slightly increased abundance in grazed versus ungrazed grasslands (Ranellucci et al., 2012), but in general show a neutral response to grazing (Saab et al., 1995). It is likely Western Meadowlarks will be present throughout the study area, especially in lower lying, wetter areas.

In conclusion, examining the impacts of landscape structure, vegetation community, and grazing disturbance leads to predictions for the obligate grassland avian community across the spectrum of landscapes in the Foothills Fescue-Parkland Transition. Throughout the entirety of the study region, there will likely be Savannah Sparrows and Western Meadowlarks, although with higher abundances in native grasslands. In more open grasslands in the flatter, eastern end of the study region, the community may have Chestnut-collared Longspurs and Sprague's Pipits, although this is less likely. As grazing disturbance increases or the proportion of forested habitat in the landscape increases, the last remaining obligate songbird in small grassland patches will likely be the Vesper Sparrow. As even Vesper Sparrows become less abundant, any small grassland patches will likely only be occupied by facultative grassland species prospering in the forested and shrub-dominated areas.

2.6.2 Facultative Grassland Species

Facultative grassland birds are those which only partially rely on grasslands for their life cycles (Vickery et al., 1999). Examples of species common in the area include Clay-coloured Sparrow (*Spizella pallida*), Killdeer (*Charadrius vociferus*), Common Yellowthroat (*Geothlypis trichas*), and Wilson's Snipe (*Cardellina pusilla*). These are edge-specialist species that prefer either shrub or forest cover but use grasslands for part of their foraging or mating requirements. The presence of these species will likely increase as the amount of edge in the landscape increases.

Brown-headed Cowbirds are perhaps the most influential facultative grassland species in the area. They are brood parasites that lay their eggs in over 220 species' nests (Lowther, 1993 *in* Bernath-Plaisted et al., 2017). Brown-headed Cowbird abundance generally increases with cattle (Saab et al., 1995), although cattle exclusion in one instance was also shown to increase Brown-headed Cowbird abundance (Nelson et al., 2011). Brown-headed Cowbird abundance and rates of

brood parasitism are dependent on availability of perching structures, which generally correspond to grassland edges (Bernath-Plaisted et al., 2017; Johns, 1993; Sliwinski & Koper, 2012). Cover of non-native, agronomic grasses has also been associated with increased rates of brood parasitism (Bernath-Plaisted et al., 2017). Brown-headed Cowbird brood parasitism has been shown to have species specific impacts on nest survival rates, but is generally negative (Kerns et al., 2010).

2.6.3 <u>Non-grassland Species</u>

The proximity of this research to forested habitat presents opportunities for the relative abundance of non-grassland birds to be counted in this work. This proportion should be low, but based on my personal observations in the area, calls for the Western Wood Pewee (*Contopus sordidulus*), White-crowned Sparrows (*Zonotrichia leucophrys*), and Yellow Warblers (*Setophaga petechia*) are heard frequently from grassland bird counts. As the amount of the forest increases in the landscape, I expect that these species cumulatively may make up a higher relative abundance within the avian community as they spill over into grassland habitats.

2.7 Synthesis

In this project, I seek to gain a more holistic understanding of how interactions between local habitat characteristics and landscape structure influence the composition of grassland songbird communities in an understudied region. The relative influences of habitat amount and fragmentation have been debated, and the importance of more studies actively evaluating their relative importance has been highlighted (Fahrig, 2017; Fahrig et al., 2019; Fletcher et al., 2018). Even though it has been shown that habitat fragmentation is more important than grassland amount for some grassland species (Lockhart & Koper, 2018), species specific habitat selection has been shown to vary across regions (Johnson & Igl, 2001), and this may not be the case in the Foothills Fescue-Parkland Transition. Area sensitivity is a large factor determining habitat suitability for

some species (Davis, 2004; Koper et al., 2009), and thus the amount and fragmentation of grassland at the landscape scale will be a key determinant in the composition of grassland songbird communities in this region with limited grassland habitat. In addition, edges effects have been shown to be species-specific and to vary with different edge types (Fletcher & Koford, 2003; Sliwinski & Koper, 2012), but examination of how edge effects vary in different vegetation communities, including important structural differences in those dominated by native versus non-native grasses, has been less explored. The impacts of range health on grassland songbird habitat selection has been studied in mixedgrass grasslands (Dodd et al., 2016), but interactions between this common management tool and landscape structure has been less studied, and not at all in the context of this complex and topographically variable region.

In this study, I will test how the interactions between landscape patterns and local habitat characteristics influence species-specific habitat selection and local species diversity in the Foothills Fescue-Parkland Transition. Specifically, I will test these interactions as they relate to non-native vegetation communities and the cumulative impact of cattle grazing as measured by range health with the aim of improving best management practice recommendations for this region. For example, if landscape fragmentation is more detrimental to obligate grassland songbirds in native grasslands with low range health than in native grasslands with high range health, improving range health could decrease sensitivity to land-use patterns that are more challenging to alter. This is one of many possible findings of this study but highlights how the scaling of this work from local habitats to landscapes could interact with management recommendations and partnerships to improve conservation of grassland songbirds in this highly protected and unique region.

3 Methods

3.1 Study Area

This study will take place on Treaty 7 Territory in southwestern Alberta, Canada, the traditional territory of the Blackfoot Confederacy (Siksika, Kainai, Piikani), the Tsuut'ina, the Îyâxe Nakoda Nations, and the Métis Nation.

I will collect the data for this study from Nature Conservancy of Canada (NCC) projects bordering Waterton Lakes National Park in southern Alberta, Canada. The study region consists of all the properties within a management unit NCC calls the Waterton Natural Area containing >150 km² of protected aspen parkland and fescue grassland within or on the border of the Foothills Parkland Natural Subregion (Figure 2). These properties are a combination of fee-simple (NCCowned) and conservation easement (partner owned) properties. All are managed for biodiversity conservation and most have active livestock cattle grazing operations. The projects are situated within a landscape with variable topography across a gradient of open grassland to aspen forest in the Foothills Fescue-Parkland Transition (see Section 2.1).

3.2 Landscape Analyses & Site Selection

Most of the landscape data I will use in this project will come from two sources. The Grassland Vegetation Inventory (GVI) is an open access dataset produced by Alberta Environment and Parks. It combines information from various sets of data on soils types, topography, land cover, and anthropogenic land use to produce ecosystem polygons. It is a standard tool used in the assessment of land cover by conservation managers within southern Alberta. NCC has been using the GVI in conjunction with their own range health assessments and has added additional information on vegetation community and categorical range health classification for several of
their projects. For projects that do not have this updated GVI dataset, NCC generally has baseline ecosystem mapping data that I can start from to map grassland types.

Using these data, I will use Geographic Information Systems (GIS) to create a layer across all the NCC projects in this area that has ecosystem type mapped within the GVI. The ecosystem type categories will build off information collected by NCC for their ongoing range health assessment efforts. These include native grassland (<70% non-native species cover), modified grassland (<70% non-native species cover), tame pasture (grassland broken, seeded, and harvested for hay production), and forest (Adams et al., 2016).

I will use these mapped ecosystem types to assist in selecting sites for point counts. Throughout the study area, there are previously established range health assessment sites that have been assessed 2-4 times within the last 5-20 years by NCC. On projects where these sites are available, I will start site selection from these points because their locations have direct ties to the management of the properties. Where previous range health assessment sites are not available, I will establish new points in patches of grassland large enough to fit point counts within a patch of a single grassland type by randomly assigning points with non-overlapping 200-m-radius buffers. This process will allow me to conduct point counts across a range of landscape structures and grassland types to both compare among types and represent the natural variation across this region.

Each point count location will serve as a center-point for circular landscapes. The scales I will analyze include 400m, 800m, and 1600m radii. I chose these landscape scales because they provide scales nearly equivalent to the primary management units in the area (~800m x 800m quarter section of land or ~1600m x 1600m section; (McKercher & Wolf, 1986), and because they provide multiple scales for avian home ranges and habitat selection (see Koper & Schmiegelow, 2006; Renfrew & Ribic, 2008). These fixed radius landscapes will have minimal overlap at smaller

scales, but the proximity of points will result in more overlap at larger scales. Landscape overlap has often been thought to result in autocorrelation of results, but it has been found that autocorrelation will not necessarily occur with landscape overlap, nor is independence assured from a lack of overlap (Zuckerberg et al., 2012). I will therefore include latitude and longitude as fixed effects in my models to account for spatial autocorrelation.

Within each of the fixed-radius landscapes, I will calculate variables representing the amount and the fragmentation of habitat. For habitat amount, I will use a common metric, percent cover of each of the different ecosystem types (Lockhart & Koper, 2018). For the fragmentation of the habitat, I will use the Normalized Landscape Shape Index (nLSI). This metric standardizes the ratio of the amount of edge relative to the minimum and maximum amounts of edge given the area (ie. if the area of habitat were the simplest shape possible). nLSI will be calculated for each landscape according to Equation [1]:

$$nLSI = \frac{e - \min}{\max e - \min e} \quad [1]$$

where *e* is the length of edge, *max* and *min* respectively represent the maximum and minimum possible edge lengths, and *nLSI* ranges from 0 to 1 moving from minimum to maximum edge (Hesselbarth et al., 2019). I chose nLSI because it has been shown to be only weakly correlated with habitat amount although it is highly correlated with spatial aggregation of area (Wang et al., 2014). The weak correlation of nLSI with habitat amount will allow me to separate the effects of the amount of habitat from its fragmentation, providing a less biased interpretation of their relative effects (Wang et al., 2014). Within each landscape, I will also calculate the distance from the point count location to the nearest grassland habitat edge to provide an index of habitat selection responses at different spatial scales.

3.3 Topographic Variables

For each point count location, I will calculate three measures of topography at the local scale and one at the landscape scale. At the landscape scale, I will calculate the Coefficient of Variation (CV) for the transect passing through the middle of the landscape from end to end that represents the highest variation in elevation within the landscape. CV is the percent ratio of the mean to the standard deviation of a sample and will provide an estimate of the topographic variation in the landscape approaching 0 for flat landscapes and 1 when the standard deviation equals the mean. The CV in elevation will vary given the spatial scale examined but provides a landscape scale assessment of topographic variability necessary given the geology of working in the Rocky Mountain foothills. At the local scale, I will document site elevation using GIS, site slope using a clinometer in field, and site 'Northness' as a measure of the amount of incident sunlight according to Equation [2]:

Northness =
$$\cos\left(\frac{A\pi}{180}\right)$$
 [2]

where *A* is the aspect measured in degrees and *Northness* varies from -1 to 1 moving from south to north (as used in Gennet et al., 2017). This metric accounts for the levels of incident sunlight directly at the point count location, which can indirectly affect avian communities through vegetation structure and productivity (Gennet et al., 2017).

The Foothills Fescue-Parkland Transition is a narrow east to west belt ranging from flatter grasslands to complex montane topography. However, this is not a perfect gradient correlated with latitude, longitude, or distance from natural subregion boundaries, and there are many microhabitats within the undulating landscape not captured by such a simple gradient (see Section 2.1). Thus, I expect that the four topographic metrics detailed above will provide the best account

of the gradient of conditions present in the study region for comparison with the other variables of interest in this study.

3.4 Avian Point Count Surveys

I will measure the relative abundance of bird species at each survey location using multiple observations of fixed-radius point counts. At each of the chosen sites, I will conduct 5-minute, 100-m fixed-radius avian point counts to identify and count all birds seen or heard (Hutto et al., 1986). I will record the number of individuals in each species observed to form indices of relative abundance. I will attempt to survey each location 2-3 times throughout the breeding season (May 24 to July 5) between sunrise and 10:00am, on clear days without rain and wind <24km/h (Davis, 2003).

Methods designed to account for detectability often contain assumptions that are difficult to meet (Johnson, 2008; Rosenstock et al., 2002). However, during point counts, I will estimate distances and break sampling into minute intervals to allow for the potential of both distance and removal sampling. I will conduct point counts with an assistant using the double-independent-observer approach, whereby two observers independently document species observed in the same point count, and then detections are compared statistically (Alldredge et al., 2006). The double-independent-observer approach has been postulated to be effective in a two-stage sampling design, whereby species-specific detection probabilities are estimated for each observer to 'calibrate' truly independent observations later (Alldredge et al., 2006). At this point in time, I am considering this two-stage approach to increase sample sizes, but am concerned about balancing this with safety considerations, specifically the high density of bears in the study region. During the field season, I will have a better idea about the sample size versus safety tradeoff presented by converting from

the double-independent-observer approach to truly independent observations and would only do so after 60-80 observations under the original approach had been obtained (Buckland et al., 2004).

It is difficult to estimate what my sample size will be for this study. Based on my personal experience in the area throughout 2019 and 2020, wind will be a greater limiting factor than rain in conducting point counts. Wind in this region at the base of the mountains is often between 30 and 40 km/h, creating detectability issues for identifying birds by sound (Simons et al., 2007). Based on preliminary point counts conducted in summer 2020, I estimate I can complete between 7 and 15 counts per field day, depending on the distance between locations. Thus, depending on the proportion of field days in the 6-week breeding season suitable for counts, my sample size will vary. If I use the double-independent-observer approach for the whole breeding season, my sample size could be anywhere from 150 to 300 counts (50% to 75% suitable days, respectively, with an average of 10 counts per day) If I decide it is worth switching to truly independent observations later in the season, this may increase my sample size by an additional 50%.

3.5 Vegetation Surveys

I will conduct vegetation surveys within each of the 100m point count radii during the breeding bird season in May and June. Within each radius, I will establish four sampling locations at random distances from the point count centre in each of the four cardinal directions as determined with a random number table. At each of these four sampling locations, I will conduct structural assays using a Robel pole, recording the height on the Robel pole obstructed by vegetation from 4m away at an observation height of 1m (Robel et al., 1970). I will also establish 20x50-cm plots using portable frames and within each estimate the percent cover classes of grasses, forbs, shrubs, and bare ground, as well as litter depth and maximum vegetation height (modified from Daubenmire, 1959). This method used in transects has been found to underestimate

local species richness (Stohlgren et al., 1998), but as I am more interested in comparing structure than examining composition, and I am also conducting range health assessments, this should not be an issue. These are standardized methods with commonly used metrics consistently related to grassland songbird habitat selection (Coulloudon et al., 1999; Fisher & Davis, 2010). I will average each metric amongst the four plots in my analyses.

Following the breeding bird season, I will return to each site to conduct range health assessments at the same four locations surrounding each point count. I will follow the standardized range health assessments as detailed in Adams et al. (2016). From these, I will gather measures of the five range health metrics used, namely ecological integrity, number of vegetation layers present, estimate of litter present, amount of human caused bare ground and erosion, and the number and cover of listed invasive species. This procedure additionally requires more comprehensive examination of the composition of the vegetation community that may be used in subsequent analyses if required.

3.6 Burrow Surveys

I will conduct ground squirrel (*Spermophilus* spp.) burrow surveys concurrently with range health assessments following the breeding bird season. Surrounding each of the four locations used for vegetation surveys, I will conduct walkthrough surveys in a 5-m radius moving inward in 1m increments toward the centre point, counting all the burrows in the area. I will then average these four counts for statistical analyses.

While burrow counts do not provide an exact index of animal abundance, the burrows themselves are useful indicators of habitat usage by the species (Bylo et al., 2016). Other methods involving alarm playback have been shown to produce the most accurate abundance estimates for ground squirrels, but are required to be completed in the first three weeks of April (Downey et al.,

2006), limiting their applicability for this research. Still, because burrow counts provide an index of the relative activity of ground squirrels between point count locations, they will be a useful proxy for nest predation rates by ground squirrels in each site.

3.7 Statistical Analyses

3.7.1 Information Theoretic Approach

To analyze the large amount of information I will accumulate throughout this study, I will use Generalized Linear Mixed Models (GLMMs) and Akaike Information Criterion (AIC) comparisons (Burnham & Anderson, 2001). This method uses a suite of models comparing the same dependent variable with various combinations of independent variables. Each model combination is associated with a specific hypothesis, and then the fit of each model is compared via AIC values, the lowest of which represents the best fit and the hypothesis with the most support (Quinn & Keough, 2002). This approach has been used across many studies to examine the primary factors driving observed trends in grassland songbird communities. Other studies have used species occurrence, abundance, or nesting success as dependent variables in relation to landscape variables and vegetation characteristics including range health metrics (Davis et al., 2006, 2014; Lloyd & Martin, 2005).

Although the information theoretic approach provides a method of analyzing multiple hypotheses for complex data sets with many variables, there are a few associated issues. Generally, the most important model is interpreted as the one with the lowest AIC value (Burnham & Anderson, 2001). However, the number of variables in a model generally has a negative correlation with its AIC value (Arnold, 2010; Burnham & Anderson, 2001). Therefore, when two models are within the 2 AIC unit threshold difference used to determine best fitting models, the one with less variables will be used (Arnold, 2010). Secondly, there are many documented cases of 'data

dredging' using this approach to find significant results (Mundry, 2011). To avoid reporting unimportant and potentially incorrect interpretations of data using these analyses, it has been recommended to create *a priori* model suites with associated hypotheses and to avoid interpreting any compared models from a significance-based (frequentist) approach following the information theoretic approach (Mundry, 2011). By accounting for these general issues, the information obtained from this approach will provide a robust method of interpreting the complex data set I will collect for this study.

3.7.2 <u>Dependent Variables</u>

I will use two sets of dependent variables in my analyses. First, separate analyses will be conducted for each species that has enough data (criteria to be determined following data collection). The relative abundance will be used as the dependent variable in each analysis. In addition to conducting analyses for each species, I will also use grouped relative abundances and grouped species richness as dependent variables. The groups will follow previous distinctions of obligate grassland, facultative grassland, and non-grassland species (Ranellucci et al., 2012; Vickery et al., 1999). By looking at both species-specific and community level responses, I will be able to better examine how the key habitat selection variables measured in this study interact to influence grassland songbird communities.

3.7.3 Independent Variables

I will measure 29 independent variables for each point count location in this study. A complete list of the independent variables I will measure is shown in Table 2, including categories and how each will be derived. The variables fall across six categories: topography (aspect, slope, and elevation), landscape (cover of different habitat types and normalized landscape shape index), vegetation (community type and structure), range health (the final score as a percent), biotic

(abundances of species potentially driving habitat usage including brood parasites, predators, and competitors) and sampling variables (time of day, date, year, latitude, and longitude). During the analysis, I will check for correlations between my variables, and may adjust methods for those variables highly correlated together. Thus, while I will measure 29 independent variables, I will likely end up using less in my final models, impacting my required sample size.

3.7.4 <u>Random Variables</u>

If a landscape scale is later chosen to reflect individual parcels (ie. using a single quartersection with multiple point counts inside as the landscape unit), I will add random variables to nest point counts with a single landscape to circumvent issues of pseudoreplication (Quinn & Keough, 2002). I will then use AIC to determine which random variables to include in models.

3.7.5 <u>Model Suite & Hypotheses</u>

The *a priori* models I have chosen for comparison are shown in Table 3. Models will be compared based on computed AIC values and interpreted giving highest importance to those with the lowest AIC values, and those with the lowest number of variables when models are within 2 AIC units. (Arnold, 2010; Burnham & Anderson, 2001; Mundry, 2011). Each model will be run with only a single habitat type percent landscape cover (ie. habitat amount: native grassland, modified grassland, forest, etc.) as I expect these to be highly correlated. I will run each of the models with and without 'Sampling' variables to determine the relative effects of these incidental variables on my results. I will also use AIC to determine which of the 400m, 800m, or 1600m defined landscape scales is most relevant for the given species or group (*sensu* Brennan et al., 2002). Because of these factors, my model suite will be larger than as shown in Table 3, but this should not affect interpretation of results.

In the model suite, I have avoided including certain variables in the same model. Specifically, I have avoided combinations of the vegetation community, measures of vegetation structure, and the range health metrics because I expect them to be highly correlated. I am also more interested in which of them has the most predictive potential for the avian communities as this gives insight into the mechanisms influencing avian habitat selection. For example, if vegetation community type is the best predictor of the three, the variation within 'native' or 'modified' grassland communities is less important in habitat selection than variation between the types of grassland. Additionally, I expect that habitat amount will be correlated with topography as grasslands become less common at higher elevations. I have thus included interactions between habitat amount and topography in the global model only. Models containing biotic independent variables will not be used for the corresponding dependent variable (ie. will not check if Brownheaded Cowbird abundance is a function of Brown-headed Cowbird abundance).

3.7.6 Additional Tests

Several hypotheses outlined in Section 3.8 (below) and Table 3 require additional supporting evidence. In most cases, this support will be gained through simple comparisons such as correlation or regression. Correlation between independent variables will be important for determining which independent variables to include in my models but will also help so support hypotheses by providing alternative explanations for phenomena. Examples include the correlation of grassland type with topographic variables (*Flat Landscape Hypothesis*), correlation of shrub cover with distance to edge (*Fragmentation-Sensitive Species Hypothesis*), correlation of ground squirrel burrow abundance and range health (*Cattle-Mediated Habitat Selection Hypothesis*), or correlation of elevation and habitat amount (*Habitat Continuum Hypothesis*). I will also use simple regression to test the *Cross Habitat Spill-over Hypothesis* and the *Landscape Species Pool*

hypothesis by examining the relationship of obligate, facultative, and total grassland species richness to the amount of edge at the landscape scale.

3.8 Hypotheses

This section details my hypotheses for how topography, landscape structure, range health, and vegetation communities will interact to impact avian habitat selection and community composition in the grasslands of the Foothills Fescue-Parkland Transition. Each hypothesis corresponds to a specific model from the AIC model suite described in Table 3 and/or additional statistical test. In this way, statements referring to the "best model" indicate the best fitting model within the AIC model suite and references to correlation or regression will be accomplished through additional statistical tests. Due to the complexity of the models, some models will yield support for multiple hypotheses.

3.8.1 <u>Habitat Amount Hypotheses</u>

If the relative abundance of a species increases with the amount of a specific type of habitat:

- i. *because* the species uses a preferred grassland type *or* vegetation structure more with greater cover of a specific habitat type in the landscape, *then* the best fitting model for the species will include an interaction between the landscape cover of the habitat type and local grassland type.
 - a. *If* the landscape cover type *complements* the preferred local vegetation type, *then* the interaction will be positive, *and* the preferred local grassland type will differ from the landscape cover type.
- ii. *because* the species uses a preferred range health more with greater cover of a specific habitat type in the landscape, *then* the best fitting model for the species will include an interaction between the landscape cover of the habitat type and range health.

- iii. *because* the cover of a specific habitat type changes the occurrence of a preferred range health, *then* the best fitting model for the species will include the landscape cover of the habitat type and range health *without* an interaction.
- *iv.* because the cover of a specific habitat type increases the abundance of Brown-headed
 Cowbirds, *then* the best fitting model for the species will include the landscape cover
 of the habitat type and Brown-headed Cowbird relative abundance.
- *v. because* the cover of a specific habitat type increases the abundance of raptor and corvid predators, *then* the best fitting model for the species will include the landscape cover of the habitat type and the combined relative abundance of raptors and corvids.
- *vi. because* the cover of a specific habitat type increases the abundance of competing facultative grassland species, *then* the best fitting model for the species will include the landscape cover of the habitat type and the combined relative abundance of facultative grassland species.
- *vii. because* none of i-vi are true, *then* the best fitting model for the species will include the landscape cover of the habitat type only.

3.8.2 <u>Habitat Fragmentation Hypotheses</u>

If the relative abundance of a species declines in more fragmented landscapes:

- i. *because* the species uses a preferred grassland type *or* vegetation structure less near edges, *then* the best fitting model for the species will include an interaction between the normalized landscape shape index and local grassland type.
- ii. *because* the species uses a preferred range health less near edges, *then* the best fitting model for the species will include an interaction between the normalized landscape shape index and range health.

- iii. *because* habitat configuration changes the occurrence of a preferred range health,
 - a. *then* the best fitting model for the species will include the normalized landscape shape index and range health *without* an interaction.
 - *b. and* range health will be correlated with the normalized landscape shape index *or* distance to edge.
- *iv. because* edges increase the abundance of Brown-headed Cowbirds, *then* the best fitting model for the species will include habitat type and Brown-headed Cowbird relative abundance.
- *v. because* edges increase the abundance of raptor and corvid predators, *then* the best fitting model for the species will include the normalized landscape shape index and the combined relative abundance of raptors and corvids.
- *vi. because* edges increase the abundance of competing facultative grassland species, *then* the best fitting model for the species will include the normalized landscape shape index and the combined relative abundance of facultative grassland species.
- *vii. because* none of i-vi are true, *then* the best fitting model for the species will include the normalized landscape shape index only.

3.8.3 <u>Complex Landscape Structure Hypotheses</u>

If the relative abundance of a species declines in more fragmented landscapes *and* increases with the amount of a certain type of habitat, *then* the best fitting model for the species will include an interaction between the normalized landscape shape index and the landscape cover of the habitat type.

3.8.4 Edge Effects Vary with Degrees of Fragmentation Hypothesis

If the relative abundance of a species decreases closer to edges, especially in highly fragmented landscapes, *then* the best fitting model for the species will include an interaction between the normalized landscape shape index and distance to edge.

3.8.5 <u>Fragmentation Effects Vary with Elevation Hypothesis</u>

If the relative abundance of a species decreases closer to edges, especially at higher elevation, *then* the best fitting model for the species will include an interaction between the normalized landscape shape index and topographic variables.

3.8.6 <u>Edge-Sensitive Species Hypotheses</u>

If the relative abundance of a species decreases closer to edges:

- i. *because* brood parasites are more abundant near edges,
 - a. *then* the best fitting model for the species will include distance to edge and relative abundance of Brown-headed cowbirds,
 - b. *and* the best fitting model for Brown-headed Cowbirds will include normalized landscape shape index *or* distance to edge.
- ii. *because* avian predators are more active near edges,
 - a. *then* the best fitting model for the species will include distance to edge and the relative abundance of raptors and corvids,
 - b. *and* the best fitting model for raptors and corvids will include normalized landscape shape index *or* distance to edge.
- iii. *because* obligate grassland birds are outcompeted by facultative grassland birds,
 - a. *then* the best fitting model for the species will include distance to edge and the relative abundance of facultative grassland species,

- b. *and* the best fitting model for facultative grassland birds will include normalized landscape shape index *or* distance to edge.
- iv. *because* vegetation structure changes closer to edges,
 - a. *then* variation in abundance for the species will include distance to edge and vegetation structure,
 - b. *and* the percent cover of shrubs will increase with decreasing distance to edge.
- v. *because* edges alter cattle behaviour,
 - a. *then* the best fitting model for the species will include distance to edge and range health
 - b. *and* range health will decrease with decreasing distance to edge.
- vi. because of an undetermined mechanism,
 - a. then the best fitting model for the species will include distance to edge
 - b. *and* none of the additional variables in i-v.

3.8.7 <u>Topographic Variation (Flat Landscape) Hypothesis</u>

If the relative abundance of a species declines as variation in elevation at the landscape level increases:

- i. *because* the species preferentially selects flatter landscapes for breeding,
 - a. *then* the best fitting model for the species will include topographic variables,
 - b. *and* not grassland type or vegetation structure.
- ii. *because* the species preferentially selects flatter areas despite a preference for a certain vegetation community,
 - a. *then* the best fitting model for the species will include topographic variables,
 - b. and grassland type or vegetation structure,

- c. *and* topographic variables *will* interact with grassland type *or* vegetation structure.
- d. *and neither* grassland type *nor* vegetation structure will be spatially correlated with topographic variables.
- iii. *because* flatter areas are correlated with a preferred vegetation community or structure,
 - a. *then* the best fitting model for the species will include topographic variables,
 - b. and grassland type or vegetation structure,
 - c. *and* topographic variables *will not* interact with grassland type *or* vegetation structure,
 - d. *and either* grassland type *or* vegetation structure will be spatially correlated with topographic variables.

3.8.8 <u>Topographic Variation (Grazing Refugia) Hypothesis</u>

If the relative abundance of a species increases as variation in elevation at the landscape level increases *because* cattle do not graze on high slopes in landscapes with high elevational variation, *then* the best fitting model for the species will include topographic variables and range health *and* range health will increase as variation in landscape variation in elevation increases.

3.8.9 <u>Vegetation Community Preference Hypotheses</u>

- i. *If* the relative abundance of a species is influenced by the variation in structure between grassland types more than variation within a grassland type (habitat selection is at the patch scale), *then* the best fitting model for the species will include grassland type.
- ii. *If* the relative abundance of a species is influenced by the variation in structure within a grassland type more than variation between grassland types (habitat selection is at the

micro-site scale), *then* the best fitting model for the species will include vegetation structure.

- *If* the relative abundance of a species is influenced by the cumulative impacts on vegetation structure and composition represented by the weighted range health metrics (habitat selection is disturbance dependent), *then* the best fitting model for the species will include range health.
- *If* the relative abundance of a species is lower in a certain grassland type *or* vegetation structure *because* predation risk by ground squirrels is higher in the given grassland type *or* structure, *then* the best fitting model for the species will include grassland type *or* vegetation structure and the abundance of ground squirrel burrows.
- v. *If* the relative abundance of a species is lower in a certain grassland community *or* vegetation structure *because* brood parasites are more common in the given grassland type *or* structure, *then* the best fitting model for the species will include grassland type *or* vegetation structure and the abundance of Brown-headed Cowbirds.

3.8.10 <u>Cattle-Mediated Habitat Alteration Hypotheses</u>

If the relative abundance of a species decreases with decreasing range health,

- i. *because* brood parasites are more abundant in grasslands with lower range health,
 - a. *then* the best fitting model for the species will include range health and relative abundance of Brown-headed cowbirds,
 - b. *and* the best fitting model for Brown-headed Cowbirds will include range health.
- ii. because ground predators are more active in grasslands with lower range health,

- a. *then* the best fitting model for the species will include range health and the relative abundance of raptors and corvids,
- b. *and* the abundance of ground squirrel burrows will increase as range health decreases.
- iii. *because* of cattle-induced changes to vegetation structure or composition,
 - a. *then* the best fitting model for the species will include range health without the variables in (i) or (ii).

3.8.11 Cross-Habitat Spill-Over Hypothesis

If overall avian species richness increases in more fragmented landscapes *because* of cross-habitat spill over,

- a. *then* the diversity of facultative grassland species will increase as fragmentation increases,
- b. *and* the diversity of obligate grassland species will decrease as fragmentation increases,
- c. *and* the best fitting model for overall avian richness, obligate grassland species richness, and facultative grassland species richness will *all* include the normalized landscape shape index.

3.8.12 Landscape Species Pool Hypothesis

If overall avian species richness is constant across levels of landscape structure *because* local diversity saturates to the level of landscape species pools,

a. *then* the diversity of facultative grassland species will *not* vary with fragmentation,

- b. and the diversity of obligate grassland species will not vary with fragmentation,
- c. *and* the best fitting model for overall avian richness, obligate grassland species richness, and facultative grassland species richness will *not* include the normalized landscape shape index.

3.8.13 Habitat Continuum Hypothesis

If the relative abundance of obligate grassland songbird decreases moving from the east to the west boundary of the Foothills Parkland natural subregion *because* the region transitions from grassland to montane, *then* grassland amount at the landscape level will decrease as elevation increases.

3.9 Timeline

Following the revision of this proposal in April of 2021, I will complete this master's program entirely by December of 2022 (Figure 1). I will defend the proposal in April 2021 and complete the majority of field data collection in summer 2021. Throughout fall and winter 2021, I will analyze my data and write most of the thesis results. I have time and budget set aside for a second field season in 2022 to increase sample sizes for avian data collection. Following this second field season, I hope to complete and defend my thesis before December 2022.

3.10 Permitting

I have begun the process to obtain all relevant permits for this study. Required permits include a minimal animal use permit obtained from the University of Manitoba, and a research permit obtained from the Nature Conservancy of Canada (Appendix A). The research permit shown for the Nature Conservancy of Canada is from last year, but talks are in place to adjust the properties included in this research for the permit for this year. There is no reason this permit will be denied, but a delay is present in that the properties available for research are being determined by Nature Conservancy of Canada staff in conjunction with their partners. I contacted Environment and Climate Change Canada and Alberta Environment and Parks, and both institutions confirmed I did not need permits from them to conduct this research.

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5 Tables

Table 1: Relevant bird species with their grassland-relational categorization and conservation status by jurisdiction. Bolded species are those that are known to have insecure populations.

| Type ¹ | Common Name | Scientific Name ³ | National Status ² | Provincial Status ^{3, 4} | S-Rank (Regional) ⁵ |
|-------------------------|----------------------------|------------------------------|---------------------------------|--------------------------------------|-----------------------------------|
| Obligate Species | Bobolink | Dolichonyx oryzivorus | Threatened | Sensitive | S2B |
| | Chestnut-collared Longspur | Calcarius ornatus | Endangered | At Risk | S3S4B |
| | Savannah Sparrow | Passerculus sandwichensis | | Secure | S5B |
| | Sprague's Pipit | Anthus spragueii | Threatened | Sensitive | S3S4B |
| | Vesper Sparrow | Pooecetes gramineus | | Secure | S5B |
| | Western Meadowlark | Sturnella neglecta | | Secure | S5B |
| Facultative Species | Clay-coloured Sparrow | Spizella pallida | | Secure | S5B |
| | Killdeer | Charadrius vociferus | | Secure | S5B |
| | Wilson's Snipe | Gallinago delicata | | Secure | S5B |
| | Common Yellowthroat | Geothlypis trichas | | Secure | S5B |
| | Brown-headed Cowbird | Molothrus ater | | Secure | S5B |
| Non-Grassland Species | Western Wood Pewee | Contopus sordidulus | | May Be at Risk | S3S4B |
| | Yellow Warbler | Setophaga petechia | | Secure | S5 |
| | White-Crowned Sparrow | Zonotrichia leucophrys | | Secure | S5B |
| | Lincoln's Sparrow | Melospiza lincolnii | | Secure | S5B |
| | American Robin | Turdus migratorius | | Secure | S5B |

¹ Vickery et al., 1999

² Committee on the Status of Endangered Wildlife in Canada ranking (Canada, 2020), all species match with Species at Risk Act Schedule I listing except for Chestnut-Collared Longspurs, which are listed as Threatened.

³ Alberta Environment and Parks, wild species general listing (AEP, 2015)

⁴ No species listed have been assessed by the Alberta Endangered Species Conservation Committee (AESCC, 2017).

⁵ Alberta Conservation Information Management System (ACIMS, 2017)

Table 2: Independent variables to be used in information theoretic approach. Sources are denoted by superscripts. Measurements within

| Category | Subcategory | Scale | Short Name | Long Name | Туре | Description |
|-----------|---------------|-----------|------------|--|---------------------|---|
| Landscape | Amount | Landscape | FOR | Forest | Bounded, Continuous | The proportion of area within 400m, 800m, or 1600m landscape with forest cover (tree dominated) |
| | Amount | Landscape | MOD | Modified Grassland | Bounded, Continuous | The proportion of area within 400m, 800m, or 1600m landscape with modified grassland cover (>70% non- native plants) |
| | Amount | Landscape | NAT | Native Grassland | Bounded, Continuous | The proportion of area within 400m, 800m, or 1600m landscape with native grassland cover (<70% non-native plants) |
| | Amount | Landscape | ТАМ | Tame Pasture | Bounded, Continuous | The proportion of area within 400m, 800m, or 1600m landscape with modified grassland cover (Developed for/dominated by tame pasture species) |
| | Amount | Landscape | GEN | General Grassland | Bounded, Continuous | The proportion of area within 400m, 800m, or 1600m landscape with any grassland cover |
| | Fragmentation | Landscape | nLSI | Normalized Landscape Shape Index ¹ | Bounded, Continuous | LSI = edge/min edge; increases as irregularity or edge increases |
| | Fragmentation | Local | DIST | Distance to Edge (m) | Continuous | Distance in metres to the nearest grassland edge. |

the 100-m-radius fixed point count are "local" scale, and those at the 400m, 800m, and 1600m are "landscape" scale.

 \overline{I} (Hesselbarth et al., 2019; Wang et al., 2014)

Table 2 Continued.

| Category | Subcategory | Scale | Short Name | Long Name | Туре | Description |
|--------------|-------------|-----------|------------|---------------------------------|---------------------|---|
| Range Health | Score | Local | RH | Range Health Score ² | Bounded, Continuous | Weighted score of the 5 questions comparing reference site to plant community. Score <50 = Unhealthy, 50 to 75 = healthy with problems, >75 = healthy. |
| Topography | Exposure | Local | NORTH | Northness ³ | Bounded, Continuous | [-1,1]; = COS(PI*Aspect/180); degree to which site points South (-1) or North (1) |
| | Exposure | Local | SLOPE | Slope | Continuous | Slope as a percent. Determined in field |
| | Elevation | Local | ELEV | Elevation | Continuous | Elevation in metres above sea level (MASL). Determined through GIS/GPS |
| | Elevation | Landscape | ELEV_CV | Elevational Variation | Bounded, Continuous | Using a transect through the most variable topographic section of the 400m, 800m, or 1600m radius landscape, the mean elevation divided by the standard deviation in elevation (Coefficient of Variation) |
| Sampling | Year | Temporal | YEAR | Year Assessed | Categorical | Year of assessment, 2021 or 2022. |
| | Time of Day | Temporal | TOD | Time of Day | Bounded, continuous | Time of day in hours since sunrise (ie.0 = sunrise) |
| | Date | Temporal | DATE | Date Assessment | Bounded, continuous | Days into breeding season (ie. May $24 = 1$, Jul $5 = 42$) |
| | Location | Spatial | LAT | Latitude | Continuous | <i>Geographic coordinates of point</i> <i>count</i> |
| | Location | Spatial | LONG | Longitude | Continuous | Geographic coordinates of point count |

² (Adams et al., 2016) ³ (Gennet et al., 2017)

Table 2 Continued.

| Category | Subcategory | Scale | Short Name | Long Name | Туре | Description |
|------------|---------------------|-------|------------|--|---------------------|--|
| Vegetation | Composition | Local | TYPE | Vegetation Type ² | Categorical | Location of point count: Native Grassland (<70% non-native), Modified Grassland (>70% non- native), Tame Pasture (broken and seeded) |
| | Structure | Local | BARE_% | Percent bare ground ⁴ | Bounded, Continuous | Average of 4 survey plots within 100m point count. |
| | Structure | Local | FORB_% | Percent cover of forbs ⁴ | Bounded, Continuous | Average of 4 survey plots within 100m point count. |
| | Structure | Local | GRASS_% | Percent cover of grasses ⁴ | Bounded, Continuous | Average of 4 survey plots within 100m point count. |
| | Structure | Local | SHRUB_% | Percent cover of shrubs ⁴ | Bounded, Continuous | Average of 4 survey plots within 100m point count. |
| | Structure | Local | LITT_cm | Depth of litter layer measured in cm ⁴ | Ordinal | Average of 4 survey plots within 100m point count. |
| | Structure | Local | HEIGHT_R | Obstructed height from Robel pole assessment ⁵ | Ordinal | Average of 4 survey plots within 100m point count. |
| | Structure | Local | HEIGHT_M | Maximum vegetation height ⁴ | Bounded, Continuous | Average of 4 survey plots within 100m point count. |
| Biotic | Predation | Local | BURROW | Burrow Count Abundance | Bounded, Continuous | Average of 4 burrow counts within 100m point count. |
| | Predation | Local | RAP_COR | Relative Abundance of Raptor & Corvid Species | Ordinal | Relative abundance at point count of all raptor and corvid species identified |
| | Competition | Local | FAC_GR | Relative Abundance of Facultative Grassland Species | Ordinal | Relative abundance at point count of all facultative grassland species not including Brown- headed Cowbirds |
| | Brood Parasitism | Local | ВНСО | Relative Abundance of Brown-headed Cowbirds | Ordinal | Relative abundance at point count of Brown-headed Cowbirds |

² (Adams et al., 2016) ⁴ (Fisher & Davis, 2010) ⁵ (Robel et al., 1970)

Table 3: Model suite and hypotheses for information theoretic approach. All variables are described and categorized in Table 2. "+" indicates additive effects and "*" indicates interactions. Models will be run with and without 'Timing' variables to determine the influence of temporal variation. (COVER) indicates models will be run with each of 'NAT' 'MOD', 'TAM', 'GEN', and 'FOR' separately and at the most impactful scale (400m, 800m, or 1600m) as also determined through AIC. Additive effects of all 'Topography' variables, all 'Vegetation – Structure' variables, and all 'Biotic' variables are indicated by [TOPO], [STR], and [BIO], respectively. The "K" column indicates the maximum number of variables in the model not including 'Timing' variables or interactions. "K" may be lower after some variables are removed due to correlations with other variables. The "Hyp." column indicates to which hypothesis in Section 3.8 the model corresponds. For more complicated models, multiple hypotheses may be supported.

| Name | | Independent Variab | lependent Variables | | | | |
|--|---------|--------------------|---------------------|---|--------|---|-----------------|
| Null Model | | | | | | 0 | / |
| Amount Influences Use of Preferred Type | (COVER) | * | TYPE | | | 2 | 1.i |
| Amount Influences Use of Preferred Structure | (COVER) | * | [STR] | | | 8 | 1.i |
| Amount Influences Use of Preferred Type (Altered Parasitism) | (COVER) | * | TYPE | + | BHCO | 3 | 1.i, 9.v |
| Amount Influences Use of Preferred Type (Altered Predation) | (COVER) | * | TYPE | + | BURROW | 3 | 1.i, 9.iv |
| Amount Influences Use of Preferred Structure (Altered Parasitism) | (COVER) | * | [STR] | + | BHCO | 9 | 1.i, 9.v |
| Amount Influences Use of Preferred Structure (Altered Predation) | (COVER) | * | [STR] | + | BURROW | 9 | 1.i, 9.iv |
| Amount Influences Use of Preferred Health (Altered Structure) | (COVER) | * | RH | | | 2 | 1.ii, 10.iii |
| Amount Influences Use of Preferred Health (Altered Parasitism) | (COVER) | * | RH | + | BHCO | 3 | 1.ii, 10.i |
| Amount Influences Use of Preferred Health (Altered Predation) | (COVER) | * | RH | + | BURROW | 3 | 1.ii, 10.ii |

Table 3 Continued.

| Name | Independent Variables | | | | | | | | | | Hyp. |
|--|-----------------------|---|-----------|---|---|---|-------|---|---------|---|------------------|
| Amount Influences Preferred Health Behaviour | (COVER) | | | + | | | RH | | | 2 | 1.iii, 10.iii |
| Amount by Parasitism | (COVER) | | | + | | | | | BHCO | 2 | 1.iv |
| Amount by Predators | (COVER) | | | + | | | | | RAP_COR | 2 | 1.v |
| Amount by Competitors | (COVER) | | | + | | | | | FAC_GR | 2 | 1.vi |
| Amount by Unknown Mechanism | (COVER) | | | | | | | | | 1 | 1.vii |
| Fragmentation Influences Use of Preferred Type | | | nLSI | | * | , | ГҮРЕ | | | 2 | 2.i |
| Fragmentation Influences Use of Preferred Structure | | | nLSI | | * | | [STR] | | | 8 | 2.i |
| Fragmentation Influences Use of Preferred Type (Altered Parasitism) | | | nLSI | | * | , | ГҮРЕ | + | BHCO | 3 | 2.i, 9.v |
| Fragmentation Influences Use of Preferred Type (Altered Predation) | | | nLSI | | * | , | ГҮРЕ | + | BURROW | 3 | 2.i, 9.iv |
| Fragmentation Influences Use of Preferred Structure (Altered Parasitism) | | | nLSI | | * | I | [STR] | + | ВНСО | 3 | 2.i, 9.v |
| Fragmentation Influences Use of Preferred Structure (Altered Predation) | | | nLSI | | * | | [STR] | + | BURROW | 9 | 2.i, 9.iv |
| Fragmentation Influences Use of Preferred Health (Altered Structure) | | | nLSI | | * | | RH | | | 2 | 2.ii, 10.iii |
| Fragmentation Influences Use of Preferred Health (Altered Parasitism) | | | nLSI | | * | | RH | + | BHCO | 3 | 2.ii, 10.i |
| Fragmentation Influences Use of Preferred Health (Altered Predation) | | | nLSI | | * | | RH | + | BURROW | 3 | 2.ii, 10.ii |
| Fragmentation Influences Preferred Health Behaviour | | | nLSI | | + | | RH | | | 2 | 2.iii, 10.iii |
| Fragmentation by Parasitism | | | nLSI | | + | | | | BHCO | 2 | 2.iv |
| Fragmentation by Predators | | | nLSI | | + | | | | RAP_COR | 2 | 2.v |
| Fragmentation by Competition | | | nLSI | | + | | | | FAC_GR | 2 | 2.vi |
| Fragmentation by Unknown Mechanism | | | nLSI | | | | | | | 1 | 2.vii |
| Landscape Structure Interaction | (COVER) | * | nLSI | | | | | | | 2 | 3 |
| Edge Effects Vary with Degree of Fragmentation | | | nLSI*DIST | | | | | | | 2 | 4 |

Table 3 Continued.

| Name | | | | Inde | pendent Var | iables | | | | K | Нур. |
|---|---------|---|-----------|------|-------------|--------|-------|---|---------|----|--------|
| Fragmentation Effects Vary with Topography | | | nLSI | * | [TOPO] | | | | | 5 | 5 |
| Edge Sensitive by Parasitism | | | DIST | | | + | | | BHCO | 2 | 6.i |
| Edge Sensitive by Predation | | | DIST | | | + | | | RAP_COR | 2 | 6.ii |
| Edge Sensitive by Competition | | | DIST | | | + | | | FAC_GR | 2 | 6.iii |
| Edge Sensitive by Structure | | | DIST | | | + | [STR] | | | 8 | 6.iv |
| Edge Sensitive by Health | | | DIST | | | + | RH | | | 2 | 6.v |
| Edge Sensitive by Unknown | | | DIST | | | | | | | 1 | 6.vi |
| Topography | | | | | [TOPO] | | | | | 4 | 7.i |
| Topography Despite Type Preference | | | | | [TOPO] | * | TYPE | | | 5 | 7.ii |
| Topography Despite Structure Preference | | | | | [TOPO] | * | [STR] | | | 11 | 7.ii |
| Topography Influences Preferred Type | | | | | [TOPO] | + | TYPE | | | 5 | 7.iii |
| Topography Influences Preferred Structure | | | | | [TOPO] | + | [STR] | | | 11 | 7.iii |
| Topography Influences Health | | | | | [TOPO] | + | RH | | | 5 | 8 |
| Type Preference | | | | | | | TYPE | | | 1 | 9.i |
| Type Preference by Parasitism | | | | | | | TYPE | + | BHCO | 2 | 9.v |
| Type Preference by Predation | | | | | | | TYPE | + | BURROW | 2 | 9.iv |
| Structure Preference | | | | | | | [STR] | | | 7 | 9.ii |
| Structure Preference by Parasitism | | | | | | | [STR] | + | BHCO | 8 | 9.v |
| Structure Preference by Predation | | | | | | | [STR] | + | BURROW | 8 | 9.iv |
| Health by Parasitism | | | | | | | RH | + | BHCO | 2 | 10.i |
| Health by Predation | | | | | | | RH | + | BURROW | 2 | 10.ii |
| Health by Structure | | | | | | | RH | | | 1 | 10.iii |
| Global – Type | (COVER) | * | nLSI*DIST | * | [TOPO] | * | TYPE | * | [BIO] | 12 | / |
| Global – Structure | (COVER) | * | nLSI*DIST | * | [TOPO] | * | [STR] | * | [BIO] | 18 | / |
| Global – Health | (COVER) | * | nLSI*DIST | * | [TOPO] | * | RH | * | [BIO] | 12 | / |

6 Figures



Figure 1: Concept map detailing theorical considerations for study. Avian communities can be linked to several key mechanisms impacting habitat selection, each of which are affected by landscape structure, cattle management, and characteristics of vegetation communities as mediated by topography. Single directional arrows indicate one-way impacts, and double-directional arrows indicate both concepts influence one another.



Figure 2: Study area boundaries showing Alberta municipal boundaries (labelled), Alberta natural regions, and NCC's Waterton Natural Area. NCC Fee Simple properties denote the approximate span of the properties proposed for use in this study. NCC Conservation Easement projects are not shown due to privacy concerns. Inset map shows approximate location in southwest corner of Alberta. The entire "Parkland Natural Region" shown is the "Foothills Parkland Natural Subregion".



Figure 3: Proposed timeline for completion of research project between January 2021 and April 2022. Detailed descriptions of phases are available in the 'Timeline' section of this proposal. Dates are shown as Year-Month on the x-axis labels and as Date-Month in the data labels.

7 Appendix A – Permits

7.1 Minimal Animal Involvement – University of Manitoba

| ¥ Unive ∎Mani | rsity Itoba Research Ethics and Compliance | Animal Care & Veterinary Services 208-194 Datce Road Winnipeg, MB R3T 2N2 T: 204 474 6402 veterinaryservices@umanitoba.ca |
|------------------|---|---|
| 12 January | 2021 | |
| то: | Dr. N. Koper NRI/CHREER | 1.11 |
| FROM: | Dr. J. Treberg, Chair, Fort Garry Campus Animal | are Committee |
| RE: | Abbreviated protocol for minimal animal involvemer Relative Influences of Habitat, Landscape, and F Grassland Songbird Communities in the Foothil Alberta" | nt entitled "The Range Health on Ils Parkland of |

Please be advised that your Abbreviated Protocol for Minimal Animal Involvement as identified above has been reviewed by myself and Dr. Leo Kenny, Clinical Veterinarian, and has been approved for the period January 12 2021 – January 11 2025.

It is understood that these animals will be used only as described in your protocol. Should changes become necessary, very minor alterations can be made with the prior written approval of a university Veterinarian and written notification from the Chair of the Fort Garry Campus Animal Care Committee. More substantive changes may require submission to and assessment by the Fort Garry Campus Animal Care Committee.

JT/tvo

encls.

copy: Mrs. T. LaFleche, PAM

Mrs. S. Germscheid, Veterinary Services

A unit of the office of the Vice-President (Research and International)

umanitoba.ca/research

7.2 Research Permit – Nature Conservancy Canada



PERMIT TO CONDUCT RESEARCH

Project Lead: Zachary Moore

Permit Number: 2020-05

Interim and Final Report Timelines: Bird List following 2020 field season.

Permit Timeframe: May 31st 2020-July 15th 2020.

Properties Available for Access: Palmer, Jenkins, Olsen, Shoderee, Bruder L., Birdseye Ranch, West. Other properties may be accessed with permission from tony McCue prior to accessing the property.

General Purpose of Project: Point counts of grassland songbirds across NCC fee-simple properties.

Permit specific conditions:

-Discussions will occur with Tony McCue, leaseholders, and landowners prior to accessing properties (<u>tony.mccue@natureconservancycanada.ca</u>). -Access by foot only.

-Any observations of species that are documented while on the property will be shared with NCC following the site visit. At a minimum, observations should include: species name, date of observation, location (Latitude and longitude or LLD of the parcel), and observation notes.

Based on the information contained in the Application to Conduct Research, permission is granted to the above-named applicant(s) to conduct the research on the property(ies) outlined above, during the term, for the purpose(s), and subject to the terms and conditions described in the Application. NCC can terminate this permit at any time by providing notice to the permit holder(s). Access to NCC properties occurs at your own risk.

Dated at Calgary, Alberta, this 30th day of May, 2020.

NCC Approval Granted By: Name: Craig Harding Signature:

wing Hunding

Permit Contact Craig Harding, MSc Director of Conservation Science and Planning Nature Conservancy of Canada, Suite 830, 105 12th Avenue S.E., Calgary, Alberta T2G 1A1 T:403.515.6824 & C:403.852.9843 <u>craig.harding@natureconservancy.ca</u>

8 Appendix B - Existing Data Sources for the Study Region

Reviews of the grassland songbird communities in the Foothills Fescue-Parkland Transition were unavailable. I was not able to find any peer-reviewed academic articles specifically examining grassland avian communities in this region, although some were conducted in other aspen parkland habitats within Alberta (Johns, 1993; Prescott & Murphy, 1995, 1996, 1999). A comprehensive review of the ecology of each species in relation to landscape variables, habitat preferences, and land management in the Mixedgrass and Dry Mixedgrass Natural Subregions has been compiled by researchers at the MULTISAR (Multiple Species at Risk) program run by Alberta Conservation Association (Dodd et al., 2016). I spoke with the staff at MULTISAR creating these reports and they have little data and no similar reviews for the Foothills Fescue or Foothills Parkland Natural Subregions. Review documents for best management practises relevant to most grassland songbird species are also available free online from the Grasslands Ecosystem Initiative of the United States Geological Survey Northern Prairie Wildlife Research Centre but involve no information from the study region.

There are two large-scale modelling initiatives seeking to examine grassland songbird occurrences and distributions in Alberta. The first is by the Alberta Biodiversity Monitoring Institute (ABMI, <u>www.abmi.ca</u>) which has been established and visited monitoring sites annually throughout Alberta. Since 2007, they have compiled created spatial distribution models that predict the relative abundance in of many species throughout Alberta in 800m raster layers. This information is based on 1656 sampling locations spaced systematically across Alberta, one of which is located within the study region (ABMI, 2019). As of the time of this writing, however, this point has not yet been sampled for inclusion in the ABMI modelling initiative. This limits the ability to extrapolate these models to the Foothills Fescue-Parkland Transition, as habitat selection

from one area cannot always be extrapolated to another (Johnson & Igl, 2001). The second modelling initiative is by Dr. Barry Robinson, Grassland Songbird Biologist at Environment and Climate Change Canada. Dr. Robinson has compiled a database of point counts in the Canadian Prairie Ecozone from across Alberta, Saskatchewan, and Manitoba from various organizations and the Breeding Bird Atlas. He has used these to develop spatial models estimating the predicted density of males for 47 species across the Canadian Prairie Ecozone. Based on discussions with Dr. Robinson, these models include Breeding Bird Atlas points from areas just outside of the Foothills-Fescue Parkland, but none from within. It should be noted that the northern patch of Foothills Parkland in Alberta is within the definition of the Canadian Prairie Ecozone, and thus within the predictions of this model, but the southern Foothills Parkland patch focused on in this study is not. Discussions are underway to expand the models to the study area.

There are two other data sources I explored before concluding the necessity of this project. The Nature Conservancy of Canada has species observations on each of their projects going back to the securement of each project (the earliest of which in this area was secured in 1999). However, these are all incidental species observations collected in no systematic manner. Different observers would thus have different experience levels identifying birds, and some species may be over or under-represented in this data. The second source I explored was eBird (www.ebird.org). This is a citizen science platform that collects, houses, and displays transect and point count data from users. When visualizing 'hot spots' for public counts in this area, there are many high activity areas in Waterton Lakes National Park and some in Twin Butte, which are to the north and south of the proposed study area. However, because this area is largely privately owned land, there are very few observations throughout the proposed study region.

In conclusion, I examined several data sources in determining the necessity of the research outlined in this proposal. These included academic literature; technical reports, reviews, discussions with representatives from active monitoring initiatives; and various datasets for avian surveys within the Canadian Prairies. After exploring these data sources, it is clear there has been limited exploration or documentation of avian communities in this region, let alone documenting regionally specific avian habitat selection in the Foothills Fescue-Parkland Transition. This study will thus fill a knowledge gap essential to understanding grassland birds in Canada.

9 Submission Summary

Title: Interactions between Landscape Structure, Vegetation Communities, and Range Health on Grassland Songbird Communities in the Complex Topography of the Foothills Fescue-Parkland Transition in Southern Alberta, Canada

Author: Zachary Moore

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Version Notes:

None.

Version History:

- V1. 2020/11/26 'Short' draft, prepared for NRI7262 research seminar. Commented on by Glen Hostetler and John Sinclair.
- V2. 2021/02/28 'Long' draft, prepared for initial revisions prior to Committee Review.Commented on by Nicola Koper.
- V3. 2021/04/06 Revised long draft. Prepared for Committee Review and NCC. Commented on by Nicola Koper, Barry Robinson, Darcy Henderson, and Ryan Norris.