EFFECTS OF LIVESTOCK GRAZING ON SCALED QUAIL AND GRASSLAND BIRDS IN THE MARFA GRASSLANDS, TEXAS

A Thesis

By

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Submitted to the College of Agricultural and Natural Resource Sciences of
Sul Ross State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2019

Major Subject: Range and Wildlife Management

EFFECTS OF LIVESTOCK GRAZING ON SCALED QUAIL AND GRASSLAND BIRDS IN THE MARFA GRASSLANDS, TEXAS

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ABSTRACT

High livestock stocking rates are partially responsible for reduced diversity and abundance of quail and grassland birds, especially in the Chihuahuan Desert Region of Texas. However, high-intensity/low-frequency grazing techniques have been implemented in some areas and are providing better habitat for birds. This research focused on comparing scaled quail (*Callipepla squamata*) and migratory grassland bird abundance and diversity, between a continuously grazed pasture and rotationally grazed pastures on a ranch in Marfa, Texas in 2017 and 2018. Scaled quail abundance data was collected via 72 spring call count surveys, and were analyzed using a Poisson regression. In 2017, an average of 1.06 and 3.00 scaled quail were heard in continuously and rotationally grazed pastures, respectively. In 2018, an average of 0.22 and 1.44 scaled quail were heard in continuously and rotationally grazed pastures, respectively. Quail detections were much greater in rotationally grazed pastures in both years. Grassland bird abundance and diversity was assessed by conducting 192 line transect surveys, where nearly 3,000 individuals from 43 species were observed. Simpson Diversity Index, Shannon-Weiner Index, evenness, and species richness were calculated and compared between grazing regimes. The rotationally grazed pastures had greater species richness, diversity, and evenness than the continuously grazed pasture. Finally, habitat for scaled quail and other grassland bird species were compared between grazing treatments. Vegetation data such as shrub density, shrub and grass height, ground cover (%), and dominant plant species were collected at 576 sampling points along bird survey transects. These data were used to examine any relationships in bird abundance and presence with potential habitat features within each season, using a generalized linear mixed model with AICc model selection. Results suggests that local scale habitat features have less to do with habitat use. Overall, high intensity/low frequency grazing provided habitat that allowed for a more diverse and abundant community of quail and grassland birds.

ACKNOWLEDGMENTS

I would first like to thank those who made this research possible, Borderlands Research Institute, the many organizations who awarded me scholarships, and all of my funding sources including Park Cities Quail, San Antonio Quail Coalition, and U.S. Fish and Wildlife Service. Also, the Dixon Water Foundation for land access and willingness to participate and support all of our research at the BRI.

I would also like to thank my advisor Dr. Ryan Luna for bringing me on as an undergraduate technician and allowing me to continue on this project for my graduate degree. Along with my committee members, Dr. Ryan O'Shaughnessy and Dr. Warren Conway, I appreciate all of the support and guidance along the way. I am especially thankful for the countless letters of recommendations written and questions answered in the past few years.

Lastly, I want to thank my parents, Chris and Kathy Williams, and my sister Kara for their support in me pursing my Master's so far from home. I also want to thank all of my friends at BRI who have made this process much more entertaining, especially Katie Sauer for being with me in the field all those early mornings. Also, all of the people who helped me in the field, fellow graduate students, undergraduate technicians, and BRI and TPWD employees.

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CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

Central North America was originally dominated by grassland ecosystems (Samson et al. 1998, Askins et al. 2007, Ribic et al. 2009). In the east was tallgrass prairies, dominated by bluestems (*Andropogon* spp.) and wheatgrass (*Agropyron* sp). Moving west, grasslands transitioned into the mixed-grass prairies which were home to a mixture of species from both tallgrass and short grass prairies. Shortgrass prairie in the west was dominated by blue grama (*Bouteloua gracilis*) and buffalograss (*Bouteloua dactyloides*, Samson et al. 1998, Askins et al. 2007, Ribic et al. 2009). However, since the mid-1800s, > 80% of North American grassland ecosystems have been lost or otherwise degraded due to urbanization, fire suppression, agriculture conversion, fragmentation, and overgrazing (Knopf 1994, Noss et al. 1995).

Historically, fire and grazing by prairie dogs (*Cynomys* spp.) and bison (*Bison bison*) played a crucial role in maintaining grassland ecosystems (Askins et al. 2007). During the last century, prairie degradation and destruction via land conversion to agriculture-dominated landscapes has eliminated essential breeding, migratory, and wintering habitat for grassland birds (Askins et al. 2007, Hill et al. 2014, Sadoti et al. 2018). Beyond outright destruction, prairie loss and ecosystem degradation has continued through overgrazing and brush encroachment where both have negatively impacted grassland habitat (Brennan and Kuvlesky 2005, Archer 2010, Bestelmeyer et al. 2018).

Grassland bird community abundance and composition throughout North America has been impacted among all seasons in the remaining North American grasslands. Overall,

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grassland birds are showing consistent declines (Sauer et al. 2013, Rosenberg et al. 2016). Saab et al. (1995) found that 17 of 43 grassland bird species responded negatively to grazing pressure, while 18 species had a neutral response and only 8 species responded positively. As shrub dominated ecosystems expand, grassland bird populations have declined in response (Saab et al. 1995). Studies hypothesize that unsustainable grazing, both current and historic, has led to homogenous habitat that does not provide complex grasslands, which is causing declines in grassland bird populations and degradation of North American grasslands (Saab et al. 1995, Davis et al. 2016).

In the Trans-Pecos Region of Texas, livestock overgrazing and fire suppression are hypothesized as reasons for receding desert grasslands and increases in woody encroachment (Richardson 2003). The Chihuahuan Desert is crucial for wintering grassland birds that breed in the western Great Plains, as well as important breeding bird habitat during summer (Askins et al. 2007). Recent studies show that 88% of grassland bird species breed in the Great Plains, and also 90% winter in the Chihuahuan Desert (Pool et al. 2014). This disproportionate use of the Chihuahuan Desert during winter amplifies the critical need to more clearly understand habitat use and bird composition patterns during winter, but also develop proper management and restoration strategies for what remains. Currently, ideal habitat for both wintering and breeding grassland birds in the Chihuahuan Desert is thought to be comprised of shortgrass prairie and desert grasslands dominated by low grasses and forbs with very little shrub cover (Bleho et al. 2015).

Although overgrazing has caused degradation of grasslands and greater shrub cover, sustainable livestock grazing can provide livestock management objectives simultaneously with suitable habitat for a diverse assemblage of grassland birds throughout the annual cycle (North

American Bird Conservation Initiative 2016). Studies show that preventing grassland degradation through shrub encroachment will contribute to the recovery of grassland bird populations (Coppedge et al. 2001). Sustainable grazing can be achieved through several different grazing systems commonly used in the United States, such as continuous, deferred-rotation, Merrill three-herd/four-pasture, and high intensity/low frequency (Holechek et al. 1998). Continuous grazing is the practice of grazing a specific area throughout the year, typically at a lower stocking rate (Holechek et al. 1998). Deferred-rotational grazing occurs when there are several pastures that each receive deferment (i.e., the delay of grazing until seed maturity every 2-4 years; Holechek et al. 1998). The Merrill three-herd/four-pasture grazing system rotates 3 herds throughout 4 pastures each year, and gives one pasture 4 months without grazing (Holechek et al. 1998). High intensity/low frequency grazing typically involves 3 or more pastures that are grazed for no more than 2 weeks, and are not grazed for at least 60 days (Holechek et al. 1998).

In this research, grassland birds refer to quail and migratory songbirds that rely on grassland habitat for all or part of their lifetime (Vickery et al. 1999). The Chihuahuan Desert in Texas is home to, both resident and migratory species, such as the game bird, scaled quail (*Callipepla squamata*); 4 winter resident species, Baird's sparrow (*Ammodramus bairdii*), chestnut-collared longspur (*Calcarius ornatus*), McCown's longspur (*Calcarius mccownii*), Sprague's pipit (*Anthus spragueii*); and 5 summer resident species, black-throated sparrow (*Amphispiza bilineata*), Cassin's sparrow (*Aimophilia cassinii*), Eastern meadowlark (*Sturnella magna*), lark sparrow (*Chondestes grammacus*), and Western meadowlark (*Sturnella neglecta*). Of these, Sauer et al. (2013) found that several were declining: scaled quail (3.1%/year), Sprague's pipit (3.5%/year), chestnut-collared longspur (4.3%/year), McCown's longspur

(5.3%/year), and Baird's sparrow (3.0%/year). Additionally, the health of those populations that occupy distinct habitats can be used to assess the overall health of the Chihuahuan Desert grassland ecosystem. The abundance and density of each species, as well as the overall diversity and evenness of all species across the grasslands, can be used to quantify grassland health. Habitat use of grassland bird species by season can be determined to see which habitat characteristics are being used and to determine which grazing regimes will best support scaled quail abundance and a diversity of grassland bird species, while allowing for a productive cattle grazing operation. The objectives of this study were to (1) evaluate differences in scaled quail relative abundance between grazing regimes, (2) examine differences in overall grassland bird diversity and richness between grazing regimes and season, and (3) evaluate habitat use in the Chihuahuan Desert for focal grassland bird species in the breeding and non-breeding seasons.

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CHAPTER II

LIVESTOCK GRAZING EFFECTS ON SCALED QUAIL AND SUMMER AND WINTER GRASSLAND BIRD DIVERSITY IN THE MARFA GRASSLANDS, TEXAS

Introduction

Historically, tallgrass and shortgrass prairies encompassed large portions of central North America, dominated by bluestems (*Andropogon* spp.), wheatgrass (*Agropyron* sp.), blue grama (*Bouteloua gracilis*) and buffalograss (*Bouteloua dactyloides*; Samson et al. 1998, Askins et al. 2007, Ribic et al. 2009). These grasslands were naturally managed through fires resulting from lightning strikes, grazing from migrating bison (*Bison bison*) herds, and cyclical drought which all contributed to maintain grass dominance in prairies and provided heterogeneity and diverse plant production (Samson et al. 1998, Askins et al. 2007, Ribic et al. 2009). However, native North American grasslands have been drastically reduced in function, quantity, and quality by > 80% since the mid-1800s (Knopf 1994, Noss et al. 1995). Grassland loss is attributed to agricultural conversion, overgrazing, fire suppression, and habitat fragmentation (Brennan and Kuvlesky 2005, Askins et al. 2007).

Livestock grazing can be used to manage grasslands similar to how bison and historic fire maintained these grassland ecosystems by controlling shrub densities. Grazing has historically been a favorite management tool for landowners, especially in western Texas as cattle ranches are prevalent across the Trans-Pecos and throughout the Chihuahuan Desert grasslands (Richardson 2003). Different grazing regimes can create and promote structural and habitat heterogeneity that increases abundance and diversity of vegetation species. Light to moderate grazing is typically considered a beneficial land management practice for the landscape, the cattle, and ranchers (Richardson 2003). In addition to reducing shrub encroachment, light to moderate grazing also benefits many species that rely on grassland habitats (Richardson 2003, Brennan and Kuvlesky 2005, Askins et al. 2007).

Historic grassland plant diversity and vast grasslands provided ample habitat for all grassland bird species. Resident game and migratory bird species historically used grasslands for breeding and wintering habitat, and relied upon medium to tall vegetation and low to moderate woody shrub cover within these grassland habitats throughout the annual cycle (Askins et al. 2007). However, land conversion to agriculture-dominated, overgrazed, and highly fragmented landscape is eliminating essential breeding, migratory, and wintering habitat for grassland birds, which are any species that is dependent on grassland habitats for survival (Brennan and Kuvlesky 2005, McCracken 2005). Decreasing habitat and declining populations make proper management of these existing grassland spaces imperative (Brennan and Kuvlesky 2005). Specifically, in the Trans-Pecos, overgrazing and fire suppression has led to an increase in woody shrub cover and a decrease in desert grasslands (Richardson 2003).

Historic overgrazing has caused an increase in shrub cover in the Chihuahuan Desert grasslands, however, sustainable grazing can provide proper habitat for a diversity of birds, as well as provide for the needs of a successful cattle operation (North American Bird Conservation Initiative 2016). This is important to achieve because preventing shrub encroachment and degradation of grasslands, will help the recovery of grassland bird populations (Coppedge et al. 2001). Sustainable livestock grazing can be achieved through several different manners: continuous, deferred-rotation, Merrill three-herd/four pasture, and high intensity/low frequency (Holechek et al. 1998). Specifically, on a ranch in west Texas, 2 grazing practices are in place: continuous grazing and high intensity/low frequency. The continuous grazing practice grazes one area through the year, typically at a lower stocking rate (Holechek et al. 1998). And, high intensity/low frequency utilizes multiple pastures grazed for less than 2 weeks, and not grazed for at least 60 days (Holechek et al. 1998). These grazing types on the same property offer a unique opportunity to research grassland bird population differences between the two grazing types.

According to the North American Breeding Bird Survey (BBS), many Chihuahuan Desert grassland bird species are experiencing population declines. Of the 37 grassland bird species monitored by the BBS, 32 species are declining (McCracken 2005, Sauer et al. 2013). Of these species, 90% use the Chihuahuan Desert grasslands for breeding or non-breeding habitat (Sauer et al. 2013, Pool et al. 2014). Each of these species are affected by different amounts of shrub cover, shrub species, and grazing pressure, making them useful for evaluating the effects of livestock grazing on grassland birds. However, little is known about grassland bird ecology, especially during winter in the Trans Pecos and Chihuahuan Desert, as very few studies have focused upon non-breeding grassland birds due to their cryptic nature and difficulty studying (Peterjohn 2003). This limited knowledge prevents researchers from effectively developing conservation or management plans that focus upon wintering grassland bird ecology (Peterjohn 2003, Smith et al. 2005).

This research I conducted in this study focused upon examining how livestock grazing affects Chihuahuan Desert grassland birds including the non-migratory game bird scaled quail (*Callipepla squamata*); 4 non-breeding migratory species, Baird's sparrow (*Ammodramus bairdii*), chestnut-collared longspur (*Calcarius ornatus*), McCown's longspur (*Calcarius mccownii*), Sprague's pipit; and 5 breeding migratory species, black-throated sparrow (*Amphispiza bilineata*), Cassin's sparrow (*Aimophilia cassinii*), Eastern meadowlark (*Sturnella* *magna*), lark sparrow (*Chondestes grammacus*), and Western meadowlark (*Sturnella neglecta*). My objectives were to (1) evaluate differences in scaled quail relative abundance between grazing regimes, and (2) examine differences in overall grassland bird diversity and richness between grazing regimes and season.

Study Area

This research was performed on the Mimms Ranch, owned and operated by Dixon Water Foundation, located just north of Marfa, Texas, in Presidio County. The Mimms Ranch encompasses 4,391 ha and is bounded by Highway 17 to the east and Highway 90 to the south (Figure 2.1). The Mimms Ranch is within the Trans-Pecos region of Texas, located within the Rio Grande River Basin, and is part of the Alamito Creek Watershed. The elevation of the ranch ranges between 1,349 m and 1,530 m. Loamy mixed prairie is the major ecological site which is dominated by grama (*Boutelua* spp.) grasses and mixed shrubs at low density.

The Mimms Ranch is managed using both rotational and continuous grazing. There are 30 pastures, averaging 104.5 ha that are rotationally grazed by 180-190 of cattle for 2 weeks, and are rested for a full year before being grazed again. There is one continuous grazing pasture (872.5 ha) which is subjected to grazing pressures from 30 cattle all year long. The region has a monsoonal annual precipitation pattern receiving about 40.2 cm of rain each year, the majority of which occurs July–September. The average yearly temperature in nearby Marfa ranges from 5.4-24.3 °C.

Study species

I chose 10 target study species, each of which occupy different habitats: non-migratory game species, scaled quail; and migratory songbirds, Baird’s sparrow, black-throated sparrow, Cassin’s sparrow, chestnut-collared longspur, Eastern meadowlark, lark sparrow, McCown’s

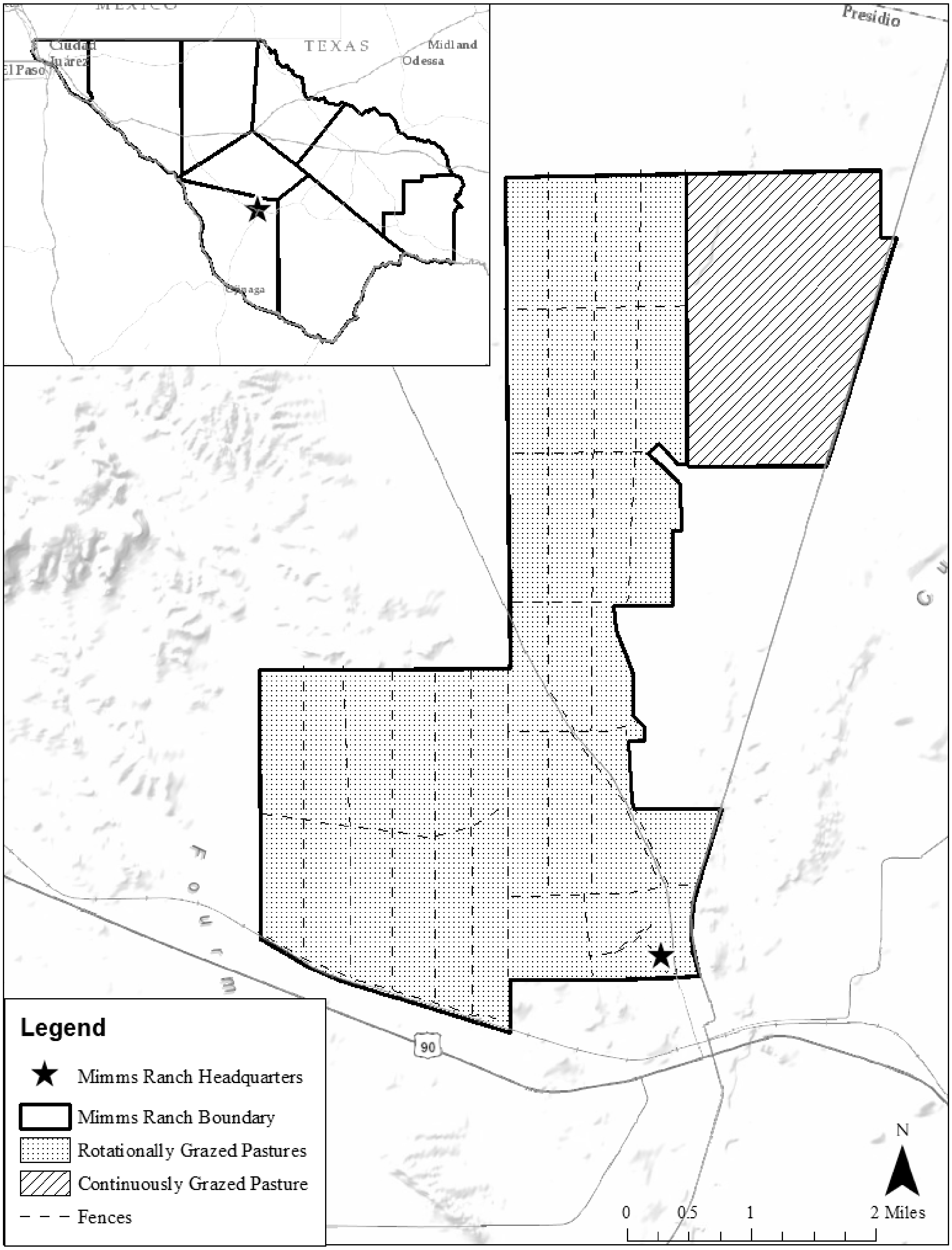

Figure 2.1. Location of the Mimms Ranch located west of Highway 17 and north of Highway 90 in Presidio County in the Trans-Pecos Region of Texas.

longspur, Sprague's pipit, and Western meadowlark. Focal species were selected because they inhabit different habitats present in the Chihuahuan Desert and therefore, were considered good indicators of large-scale ecosystem health. Summer study species are migratory species that reside, breed, and nest in the Chihuahuan Desert during summer. Winter study species are migratory species that breed elsewhere, and overwinter in the Chihuahuan Desert. Resident study species are either non-migratory, or migratory species whose winter and breeding ranges are in the Chihuahuan Desert. Each of these groups of species rely on grassland habitats differently; because of this, they provide a good overall assessment of grassland habitat health in the Marfa grasslands.

All quail species found in the Trans-Pecos are regionally important economically. As an important game species, scaled quail attract hunters to the Trans-Pecos. Their population is declining at 3.1% per year (Sauer et al. 2013). Scaled quail are found in grasslands with moderate shrub density and height that is used for cover, however scaled quail can be affected by vegetation changes by livestock grazing (Saiwana et al. 1998, Briristow and Ockenfels 2006).

Each focal species that overwinters in the Chihuahuan Desert is declining according to the Breeding Bird Survey (BBS) data (Sauer et al. 2013). The Sprague's pipit is declining ~4% per year and is considered Vulnerable by the International Union for Conservation of Nature (IUCN) Red List (McCracken 2005, BirdLife International 2018). Sprague's pipits typically are found in locations with short grass, void of woody shrub cover (Muller et al. 2018). Both the chestnut-collared longspur and McCown's longspur are grassland obligate species, and are declining (4.3%/year and 5.3%/year respectively; Sauer et al. 2013). Both longspur species are typically observed in areas with at least <10% shrub cover, usually in areas with <1% cover (Block and Morrison 2010). Baird's sparrow populations are also declining (3%/year), but have apparently stabilized in recent years according to BBS data (Sauer et al. 2013). Baird's sparrows have a very small winter range, and prefer tall dense grasslands with very little shrub cover (Macias-Duarte et al. 2009).

Birds that use the Chihuahuan Desert grasslands as breeding grounds have documented declining population numbers. For example, a grassland facultative species, the black-throated sparrow relies on grasslands that have more shrub cover than other species and are declining at about 1.8%/year (Sauer et al. 2013, Pool et al. 2014, Kozma et al. 2017). Black-throated sparrows are nesting site generalists and do not rely on grasslands as much as the other species in this study (Kozma et al. 2017). Cassin's sparrow and lark sparrow populations are slightly declining at 0.5%/year, 0.9%/year, respectively (Pool et al. 2014). During the breeding months, lark sparrows are found in areas with little to no grass cover, while Cassin's sparrows seem to be found in areas with more shrub cover (Best et al. 1997, Ruth 2000). According to BBS data, grassland-breeding species such as meadowlarks have well documented declines; the Eastern meadowlark is declining at 3.3%/ year and the Western meadowlark is declining slightly less at 1.3%/year (Pool et al. 2014, Sauer et al. 2013). Meadowlarks are documented as being a highly generalist species, in both breeding and wintering months. They are commonly found in areas with dense shrub cover, but also in areas with <10% shrub (Lawrence and Ballard 1999, Coffman et al. 2014).

Overall, all focal species selected for this study vary in habitat requirement, some relying on pure grasslands while others prefer shrubbier habitat. Most of these species are experiencing population declines, which makes monitoring population changes that much more important. Including species in this study that are resident and non-migratory, as well as migratory species that use the Chihuahuan Desert grasslands both in the winter and the summer, allows us to look at overall grassland health from a broader perspective.

Methods

All surveys were conducted in both the continuously and rotationally grazed pastures to compare between the 2 grazing types. However, since the continuously grazed portion of the ranch (872.5 ha) is much smaller in size than the rotationally grazed portion (3,533 ha), I did not conduct surveys in all of the rotationally grazed portions of the ranch. Using ArcGIS® 10.1 (Environmental Systems Research Institute [ESRI], Redlands, CA), I randomly selected pastures whose total acreage added up close to the acreage of the continuously grazed portion of the ranch. This resulted in sampling 9 pastures of the rotational grazing system (960.7 ha), to adjust accordingly (relative to acreage) to be comparable with the continuously grazed pasture.

Scaled quail call count survey methods

Call count surveys were used to estimate relative abundance of scaled quail to compare between the 2 grazing types (continuously and rotationally grazed). Such surveys are indirect counts which do not measure the total number of quail in an area; rather, they provide a relative index of abundance, and can be used to examine temporal trends. I used the Texas Quail Index (TQI) call count methods for scaled quail, following Rollins and Ruzicka (2015) for scaled quail surveys. Using ArcGIS® 10.1, I established 3 listening points in both grazing types, for a total of 6 listening stations. Listening stations were chosen along ranch roads at least 1.5 km apart to minimize the chance of double-counting individuals at successive listening stations (Rollins et al. 2005). I surveyed each listening point 3 times, each year, starting mid-April and ending 1 June in 2017 and 2018. This survey window coincides with the beginning of the breeding (i.e., calling) season for scaled quail in the Trans-Pecos (Rollins et al. 2005). Fall surveys were not conducted because scaled quail do not vocalize much during the fall covey period (Rollins et al. 2005).

Surveys were not performed when winds were >16 kph, as wind noise reduces ability to detect quail calls (Rollins et al. 2005). I conducted all surveys beginning at sunrise and continuing for 60-90 minutes after sunrise (Rollins et al. 2005). At each listening point, I turned off the vehicle and walked about 20 m away to avoid hearing engine cooling noise (Rollins et al. 2005). Weather data were collected before starting the survey, this typically took about 5 minutes to allow the birds to settle down from vehicle disturbance (Rollins et al. 2005). I listened for 5 minutes at each listening point, recording the location of each individual scaled quail heard, as well as a tally of the total number of calls heard at each survey point (Rollins et al. 2005). I compiled data in Microsoft Excel 2010 (Microsoft, Redmond, Washington) before transferring into IBM Statistical Package for Social Sciences (SPSS) version 22 statistical software (SPSS, Inc., Chicago, IL) for data analysis.

Line transect grassland bird survey methods

I conducted line transect surveys for both summer (July 1 to September 14) and winter (January 1 to March 14) grassland birds, in both 2017 and 2018. Starting points for line transects were randomly placed in each grazing type using the Random Point Generator in ArcGIS. Starting points were loaded onto a Garmin GPSMAP 64st Global Positioning System (GPS; Garmin International Inc, Olathe, KS). Each transect was 500 m long and was conducted from southeast to northwest based on a random azimuth. I conducted all transects in this manner, to ensure they were parallel, rather than spinning a random azimuth each time (Gregory et al. 2004). If a boundary fence was encountered along the 500 m transect, then I walked the transect in reverse from northwest to southeast. I conducted surveys on 3 transects per day, once a week, for both grazing regimes during winter and summer sampling seasons. Only 3 transect surveys could be completed each day due to the amount of travel time between starting points for transects. Limiting to 3 transects also allowed transects to fall within morning activity hours for the grassland birds. My goal was to complete 30 line transect surveys per grazing type, per season, for a total of 60 transects per season, and 120 per year.

I conducted line transect surveys beginning no later than 30 min after sunrise, then continued until 3 transects were complete, usually 3 hours after sunrise (Panjabi et al. 2006). All transects were walked at approximately 1km/hr, taking approximately 30 minutes per transect. Upon arrival at the starting point of each transect, I waited approximately 5 minutes until recording data to allow time for birds to settle down from the traveling disturbance caused by the observer (Hostetler and Main 2014). All birds observed or heard during the transect were identified and recorded. Birds were identified visually, by call or song, or if not identified to the species, then individuals were recorded to the genus level or as ‘unknown’ (Panjabi et al. 2010). I recorded the perpendicular distance (m) from the transect line to the initial detection of each bird using a Halo laser rangefinder Model number XRT7 (Wildgame Innovations, Grand Prairie, TX; Panjabi et al. 2010).

I also collected weather data during each survey morning in which transect surveys were performed. I used the Beaufort scale to categorize wind conditions at the start of each transect (Pool et al. 2012). Other recorded data included the following: temperature, wind speed and direction, barometric pressure (mmHg) using a handheld Kestrel weather meter, and cloud cover (%) which was estimated visually. I did not conduct transects on days with winds greater than a category 4 on the Beaufort scale (20-29 km/hr), or during any precipitation, as high winds would impair my ability to detect vocalizations, and precipitation and high winds alter bird behavior (Panjabi et al. 2010).

Data analysis

I analyzed quail call count survey data using a Poisson regression in IBM SPSS statistical software for 2017 and 2018 data. I chose a Poisson regression because these were count data, which tend to follow a Poisson distribution (Link et al. 2007, Spinola and Gates 2008). In this regression analysis, the dependent variable was the mean number of quail observed per listening station, and the independent variable was the measure of grazing density, which I calculated as cattle days/acre (number of cattle multiplied by the number of days on the pasture divided by the acreage of the pasture). This resulted in 5.2 cattle days/acre in the continuously grazed pasture, and 9.7 cattle days/acre in each rotationally grazed pasture.

I calculated species richness: Simpson diversity index, Shannon-Weiner diversity index, and evenness for transect survey data for each grazing type (continuous or rotational), and for each season (summer and winter), for each year (2017 and 2018). Species richness was calculated by summing total number of species identified in each grazing type, during each season (Rahmig et al. 2009, Bibi and Ali 2013).

The Simpson Diversity Index is the probability that two randomly selected individuals belong to the same species. This was calculated using $D = 1 – [\sum n (n – 1) / N (N – 1)]$ where n = the number of birds of a particular species, and N = the total number of birds off all species observed (Rahmig et al. 2009, Bibi and Ali 2013). A higher value of diversity (D) indicates a more diverse assemblage of bird species (Bibi and Ali 2013).

The Shannon-Weiner index can be used to compare diversity across different habitats, which is suitable for this study to compare diversity across grazing regimes. I calculated the

Shannon-Weiner Index for each grazing type and season using the following formula: $H = -[\sum P_i \ln(P_i)]$, where Pi = the proportion of each species observed relative to the total number of birds of all species observed (Rahmig et al. 2009, Bibi and Ali 2013). The Shannon-Weiner index (H) usually falls between 1.5 and 3.5, with higher values indicating that the number of individuals are more evenly distributed between all species (Bibi and Ali 2013).

The evenness will show how evenly distributed the individuals are across the species present in that grazing type. Evenness is an important component of each diversity index. I calculated evenness using $E = H / H_{max}$; where $H_{max} = \ln(N)$, and N = total number of species (Rahmig et al. 2009, Bibi and Ali 2013).

Results

Due to lack of observations and lack of detection, some species were not analyzed in the final analyses including *Ammodramus* sp. (*n* = 14 total observations; identified to genus level in the winter due to similarity between Baird's sparrows and Grasshopper sparrows), McCown's longspur (*n* = 0 observations), Sprague's pipit (*n* = 4 observations), and Western meadowlark (*n* = 1 observation).

Scaled Quail Surveys

I conducted a total of 72 call count surveys in 2017 (*n* = 36) and 2018 (*n* = 36), where 18 surveys were conducted in the continuously grazed pasture and the rotationally grazed pastures each year, respectively. Over the 2 years, I observed 103 scaled quail, 23 in the continuously grazed pasture and 80 in the rotationally grazed pastures.

In 2017, I observed a mean of 1.06 (SE = 0.25; SD = 1.06) scaled quail per listening station in the continuously grazed pasture, where a total of 19 quail were detected, with a range of 0 – 3 individuals observed per listening station. In the rotationally grazed pastures in 2017, I observed an average of 3.00 (SE = 0.45; SD = 1.91) scaled quail per listening station, where a total of 54 were observed, ranging from 0 – 7 individuals per listening station.

In 2018, I observed a mean of 0.22 (SE = 0.10; SD = 0.43) scaled quail per listening station in the continuously grazed pasture. Only 4 individuals were observed. In the rotationally grazed pastures in 2018, I observed an average of 1.44 (SE = 0.34; SD = 1.42) scaled quail per listening station, where a total of 26 were heard, and the number heard per listening station ranged from 0 – 4 individuals. In both 2017 and 2018, the number of scaled quail observed per listening station was significantly affected by cattle grazing density (cattle day/acre) (Table 2.1). In 2017, scaled quail observations increased by 25.5% with increase in grazing pressure and in 2018 scaled quail observations increased by 50.2% with increase in grazing pressure (Figure 2.2).

Diversity

During winter and summer of 2017 and 2018, I conducted 192 line transect surveys in the continuously (93 transects) and rotationally (99 transects) grazed pastures. I observed 2,994 birds of 43 different species. During winter 2017, I identified 13 different species in both the continuously and rotationally grazed pastures (Table 2.2). Simpson Diversity was lower in the continuously grazed pasture than in the rotationally grazed pastures. Similarly, the Shannon-Weiner Index was lower in the continuously grazed pasture compared to the rotationally grazed pastures. The rotationally grazed pastures had a more even distribution of birds across species than the continuously grazed pasture.

In summer 2017, I identified 25 species in the continuously grazed pasture, and 29 species in the rotationally grazed pastures. The Simpson Diversity Index was similar at 0.851 for the continuously grazed pasture and 0.883 for the rotationally grazed pastures. The Shannon-Weiner Index was slightly higher in the rotationally grazed pastures than in the continuously

Table 2.1. Parameter estimates for Poisson regression lines for scaled quail call count surveys from April-June in 2017 and 2018 in Presidio County, Texas

		Wald Chi Square	df	Sig.	Exp(B)	Lower 95% CI	Upper 95% CI
2017	Intercept	4.802	1	0.028	0.327	0.120	0.889
	Cattle day/acre	15.335	1	0.000	1.255	1.120	1.406
2018	Intercept	11.064	1	0.001	0.027	0.003	0.227
	Cattle day/acre	12.146	1	0.000	1.502	1.195	1.888

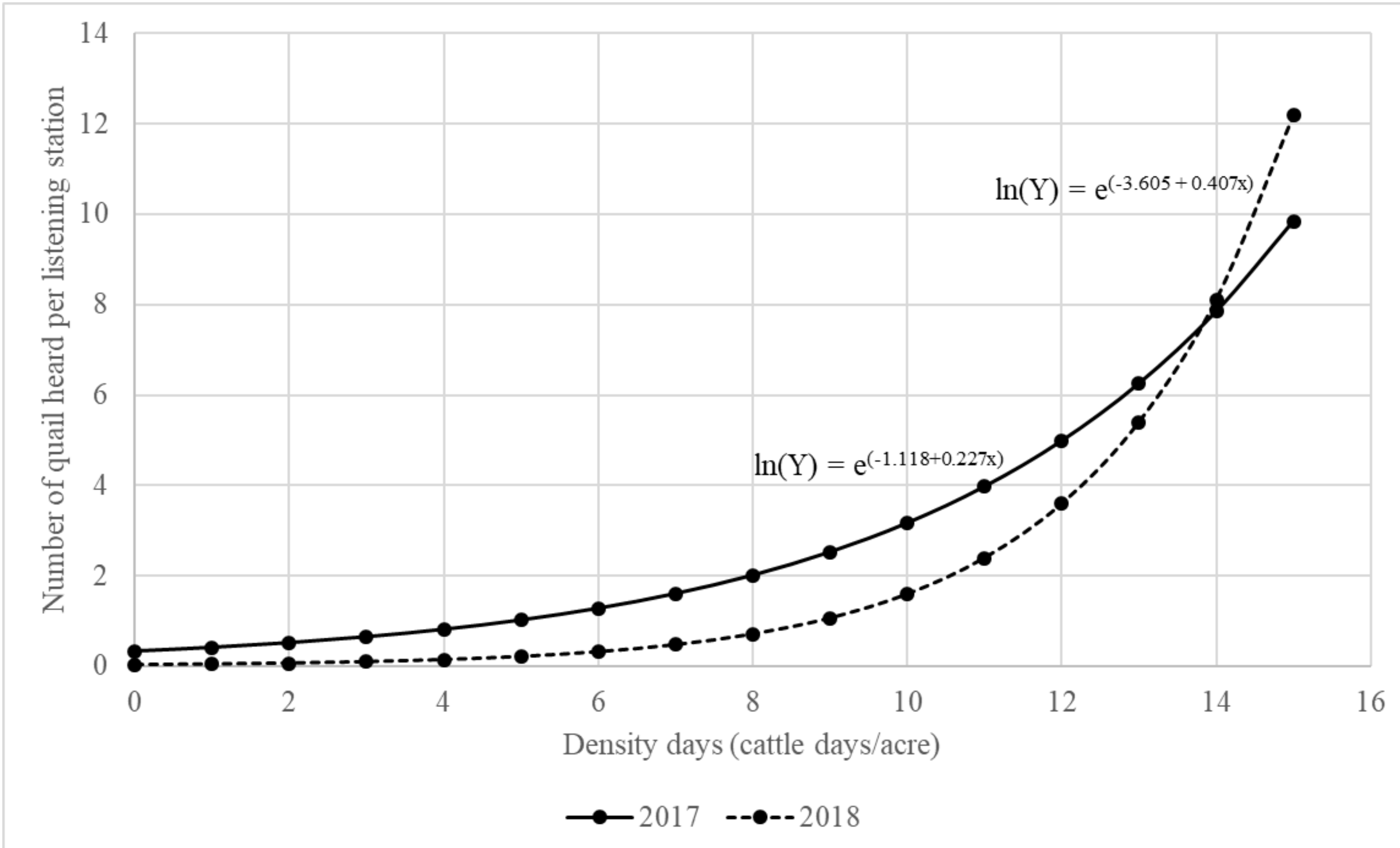

Figure 2.2. Poisson regression lines and equations for scaled quail call count surveys from April-June in 2017 and 2018 in the Trans-Pecos region of Texas showing the relationship between grazing density and number of quail observed.

Table 2.2. Diversity indices calculated for grassland bird species in the Trans-Pecos, Texas, in the winter and summer of 2017 and 2018 in a continuously grazed pasture and rotationally grazed pastures.

Year	Season	Grazing Type	Species Richness	Simpson Diversity Index (D)	Shannon-Weiner Diversity Index (H)	Evenness (E)
2017	Winter	Continuous	13	0.411	0.886	0.345
		Rotational	13	0.553	1.345	0.524
	Summer	Continuous	25	0.851	2.249	0.699
		Rotational	29	0.883	2.544	0.755
2018	Winter	Continuous	10	0.338	0.824	0.358
		Rotational	17	0.699	1.641	0.579
	Summer	Continuous	15	0.740	1.743	0.643
		Rotational	19	0.878	2.341	0.795

grazed pasture. The evenness was also slightly higher in the rotationally grazed pastures than in the continuously grazed pasture.

Richness and diversity estimates from winter 2018, were similar to those from winter 2017. Species richness was 10 in the continuously grazed pasture compared to 17 species in the rotationally grazed pasture. The Simpson Diversity Index was lower in the continuously grazed pasture at 0.338 compared to the rotationally grazed pasture at 0.699. The Shannon-Weiner index was also lower in the continuously grazed pasture at 0.824 and 1.641 in the rotationally grazed pastures. The continuously grazed pasture had a lower evenness than the rotationally grazed pastures.

Summer 2018 data were similar to summer 2017 data, where species richness was slightly greater in the rotationally grazed pasture at 19 species identified, compared to 15 species in the continuously grazed pasture. The Simpson Diversity Index was lower in the continuously grazed pastures ($D = 0.740$), while it was 0.878 in the rotationally grazed pastures. The Shannon-Weiner Index was also lower in the continuously grazed pasture than it was in the rotationally grazed pastures. Additionally, the continuously grazed pasture was less even than the rotationally grazed pastures. Overall, each diversity measure was greater in the rotationally grazed pastures, this suggests that rotational grazing is able to provide a more diverse and better habitat for many different bird species, both grassland obligate and grassland facultative species.

Discussion

In the Trans-Pecos region of Texas, grassland bird diversity measured by Simpsons Diversity Index, Shannon-Weiner Diversity Index, Evenness, and Species richness, were greater in the rotationally grazed pastures than the continuously grazed pasture, regardless of season or year. Similarly, scaled quail relative abundance estimates followed similar trends, where more were detected in rotationally grazed pastures than continuously grazed. Interestingly, this pattern was consistent regardless of year, where much fewer quail were detected in 2018 than 2017, and where the number of quail heard declined during the second sampling season in both grazing regimes. Now, although there were clear patterns of greater relative abundance in the rotationally grazed pastures, since observations decreased at approximately the same relative proportion, other factors might exert strong influences on scaled quail numbers more than cattle grazing pressure from year to year. This is most likely due to weather conditions such as precipitation timing and amounts which lead to differences in forage availability in the form of seeds and insects (Giuliano and Lutz 1993). This is not unexpected, as it is documented that quail population numbers tend to respond to seasonal and annual weather patterns (Giuliano and Lutz 1993). For example, Giuliano and Lutz (1993) found that in Texas, scaled quail abundance was sensitive to rainfall variations over winter, and Northern bobwhite (*Colinus virginianus*) abundance was mostly affected by precipitation during the prior breeding season (Giuliano and Lutz 1993).

However, the pattern relative to the grazing was the same from 2017 to 2018. In other words, the number of scaled quail observed in the rotationally grazed pasture was greater than the number observed in the continuously grazed pasture for both years. Therefore, a rotational grazing system appears to be more beneficial for scaled quail than a continuous grazing system in this particular ecoregion of Texas. The rotational grazing system allows recovery of plant species, but also grazes enough to provide some bare ground that is important for scaled quail habitat (Campbell-Kissock et al. 1984, Saiwana et al. 1998, Cantu et al. 2006). Most management recommendations suggest that moderate cattle grazing in a rotational system is beneficial to scaled quail which provides rest for the range, while increasing quail forage and cover (Cantu et al. 2006).

In this study, relative abundance of scaled quail increased with increased grazing pressure (9.7 cattle days/acre in the rotationally grazed pastures, which were grazed with 180 cattle, but for only 14 days a year, compared to 5.2 cattle days/acre in the continuously grazed pasture, which were grazed for 365 days per year, but with only 30 cattle); however, it is important to note, that the pastures with a higher grazing pressure were grazed at a shorter duration, and allowed to rest before being grazed again. These results are similar to other studies involving the number of scaled quail observed in relation to different grazing pressures. In southwest Texas, Campbell-Kissock et al. (1984) observed more scaled quail in short duration grazing pastures (n = 33) than in pastures that were grazed yearlong (n = 8). In southeastern Arizona, more scaled quail were observed in grazed pastures than in ungrazed pastures, and Saiwana et al. (1998) observed more quail in shrub-grass communities than grasslands (Bock et al. 1984). Collectively, these studies support the notion that some shrub cover is beneficial for scaled quail, and they do not rely on grasslands alone, as well as that some grazing (as opposed to none) and rotational grazing (as compared to continuous) are all good management strategies to improve scaled quail habitat.

Overall, bird diversity was greater in the rotationally grazed pastures in both winter and summer of 2017 and 2018 based on all diversity indices. Additionally, the rotationally grazed pastures had a more even distribution of birds across species than the continuously grazed pasture, similar to Bock et al. (1984) who observed greater total numbers of birds in grazed areas compared to non-grazed areas in summer. Grassland obligate species, such as grasshopper sparrows and Cassin's sparrows used ungrazed pastures more than grazed pastures in both the breeding and non-breeding seasons (Bock et al. 1984); however, I found that Cassin's sparrows used the continuously grazed pasture more and grasshopper sparrows used the rotationally grazed pastures more in the breeding season. Scaled quail and lark sparrows used the grazed areas more in the summer months (Bock et al. 1984), similarly, I observed more scaled quail and lark sparrows in the rotationally grazed pastures. Results from this study as well as others, indicate that grazing can be used to achieve a diverse habitat and that diversity of habitat will lead to a more diverse grassland bird community (Duchardt et al. 2016). The results of this study suggest a link between scaled quail numbers and other grassland bird numbers in the Trans-Pecos.

Management Implications

The results of this study suggest that healthy habitat for scaled quail is similar to healthy habitat for migratory grassland bird species. This habitat can be achieved through a high intensity-short duration grazing regime that elicits a diversity of grass and forb species, as well as controls shrub encroachment. These results allow researchers and managers to use a combination of stocking rate and grazing strategy to better manage for scaled quail habitat, and in turn, good habitat for migrating grassland birds. Additionally, the decrease in scaled quail observed in 2018 compared to 2017 is explained by something other than grazing. Further research can be done to analyze the timing of rainfall and the amount of rain in the winter or spring season. Grassland bird diversity and density can be further researched to determine why there is a lower number of species observed in the winter, and if it is potentially because of cryptic species that are not seen by observers. Also, grassland bird line transect surveys should be conducted at other grassland areas in the Chihuahuan Desert to see if similar trends are seen in other areas. These areas should be additional sites in Texas such as the Marathon and Alpine grasslands, also in New Mexico, and the Chihuahuan Desert region of northern and central Mexico in order to get a broader view of Chihuahuan Desert grassland bird habitat use and population health in the summer and winter.

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CHAPTER III

HABITAT USE BY SUMMER AND WINTER MIGRATORY GRASSLAND BIRDS IN THE MARFA GRASSLANDS, TEXAS

Introduction

The North American grassland ecosystem has been experiencing vast declines since the mid 1800's, with > 80% habitat loss (Knopf 1994, Noss et al. 1995). This habitat loss and fragmentation has caused population declines and decreases in species richness for many wildlife and plant species across North America (Hansen et al. 2005). This is especially true for grassland birds, which are declining more rapidly than any other group of birds (Knopf 1994, Sauer et al. 2013). Based on Breeding Bird Survey (BBS) data, 41 total species and 24 grassland obligate species show consistent declines, attributed to fire suppression, overgrazing, agriculture conversion, and urbanization (Askins et al. 2007, Sauer et al. 2013). All of these eliminate grassland habitat that both migratory and non-migratory grassland birds rely on for breeding, wintering, and year-round habitat (Askins et al. 2007). Rangeland deterioration is a major concern, and is continuing to expand through practices such as overgrazing which leads to shrub encroachment (Brennan and Kuvlesky 2005).

This increase in shrub cover is detrimental to grassland bird species, as it eliminates essential breeding and non-breeding habitat (Brennan and Kuvlesky 2005, McCracken 2005). Brush encroachment can be caused by overgrazing by domestic livestock that removes herbaceous plants and reduces competition for shrub species. Historic overgrazing in North America has caused increases in shrub cover in grasslands now, especially in the Chihuahuan Desert grasslands in the Trans-Pecos Region of Texas (Richardson 2003).

Chihuahuan Desert grasslands are important to many grassland bird species, both migratory and non-migratory birds. Non-migratory quail populations are affected by vegetation changes caused by livestock grazing (Saiwana et al. 1998). This makes it important to determine and characterize which habitat features quail are using in the breeding (summer) and non-breeding (winter) seasons. Nearly 90% of grassland obligate bird species in North America breed in the Great Plains and of these, 90% migrate and winter in the Chihuahuan Desert grasslands (Pool et al. 2014). In fact, most bird species that winter in the Chihuahuan Desert have experienced population declines since the 1970s, which highlights the importance of Chihuahuan Desert grasslands for conservation to continue providing proper habitat for these species (Sauer et al. 2013). Grassland birds tend to rely on slightly different habitats in the breeding vs. non-breeding season. However, very few efforts have been made to research wintering habitat for grassland birds.

This research focused on summer and winter habitat use in the Chihuahuan Desert by grassland birds, including non-migratory game birds, the scaled quail (*Callipepla squamata*); 4 wintering migratory species, Baird's sparrow (*Ammodramus bairdii*), chestnut-collared longspur (*Calcarius ornatus*), McCown's longspur (*Calcarius mccownii*), Sprague's pipit; and 5 summer migratory species, black-throated sparrow (*Amphispiza bilineata*), Cassin's sparrow (*Aimophilia cassinii*), Eastern meadowlark (*Sturnella magna*), lark sparrow (*Chondestes grammacus*), and Western meadowlark (*S. neglecta*). My objective for this study was to evaluate habitat use in the Chihuahuan Desert for focal grassland bird species in the summer and winter seasons, to identify crucial habitat features important to grassland birds in the Chihuahuan Desert.

Study Area

The Mimms Ranch is located in Presidio County, just north of Marfa, in the Trans-Pecos region of Texas (Figure 3.1). It has been privately owned and operated by Dixon Water Foundation since 2008. This 4,391-ha cattle ranch uses 2 different grazing regimes: continuous and rotational grazing. There is one continuously grazed pasture (875.5 ha) that has 30 cattle on it all year round. The remainder of the ranch is divided into 30 rotational grazing pastures, averaging 104.5 ha each. These pastures follow a low frequency, high intensity, short duration grazing system. Each of the 30 rotational pastures will have180-190 cattle for 2 weeks, and then are rested for a full year before being grazed again.

Mimms Ranch is located in the Marfa grasslands and receives about 402 mm of rain each year in a monsoonal pattern, and yearly temperature ranges from 5.4 - 24.3 °C. The elevation of the ranch ranges between 1,349 m and 1,530 m. Loamy mixed prairie is the major ecological site, which is dominated by grama (*Boutelua* spp.) grasses and mixed shrubs at low density.

Study species

Twelve study species were selected because they occupy distinct niches ranging from dense tallgrass to shrubby areas with bare ground; therefore, they appear to be good indicators of large-scale ecosystem health in the Chihuahuan Desert ecosystem. Study species are non-migratory game species, scaled quail (*Callipepla squamata*), and migratory songbirds: Baird's sparrow (*Ammodramus bairdii*), black-throated sparrow (*Amphispiza bilineata*), Cassin's sparrow (*Aimophilia cassinii*), chestnut-collared longspur (*Calcarius ornatus*), Eastern meadowlark (*Sturnella magna*), lark sparrow (*Chondestes grammacus*), McCown's longspur (*Calcarius mccownii*), and Sprague's pipit (*Anthus spragueii*), and Western meadowlark (*Sturnella neglecta*).

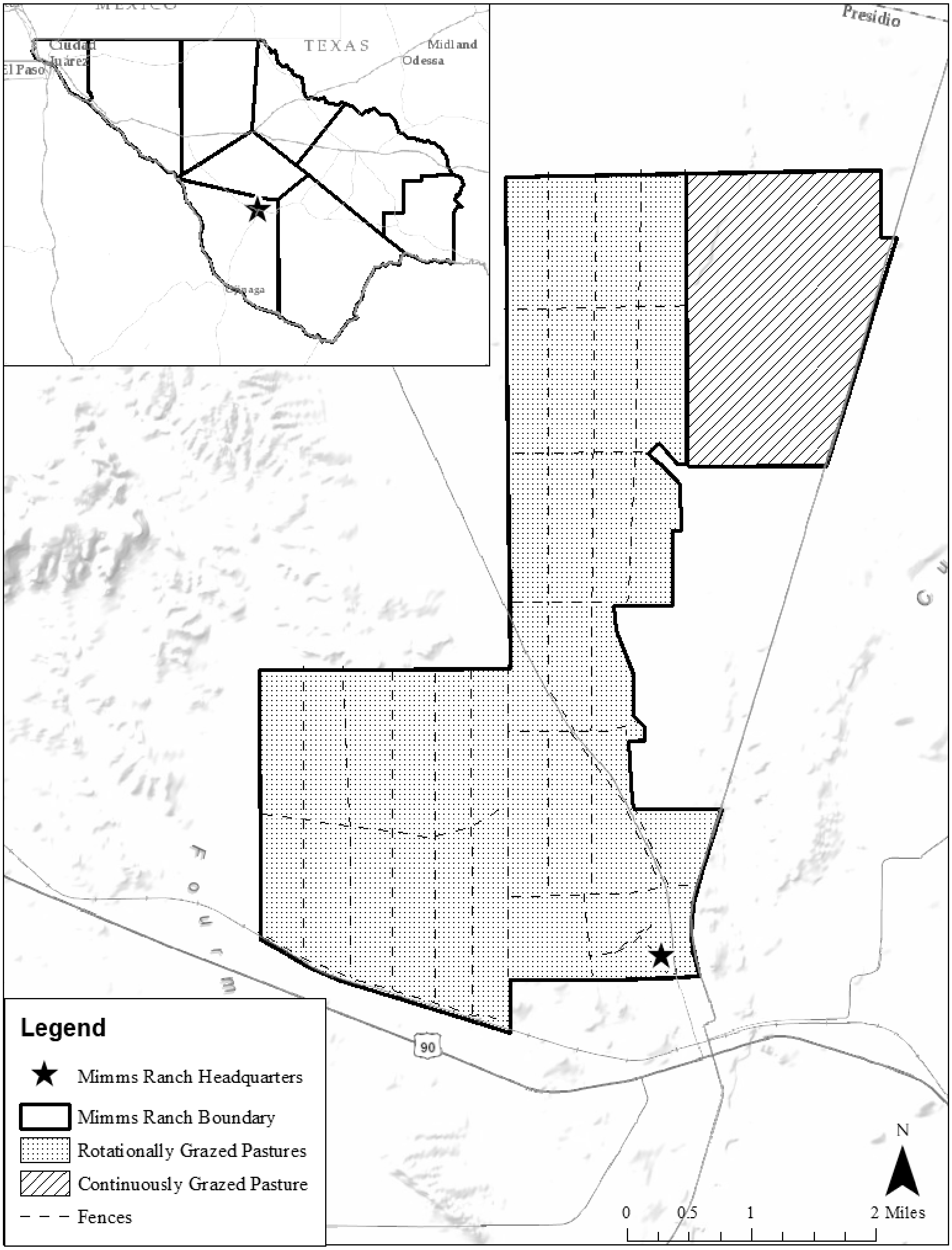

Figure 3.1. Location of the Mimms Ranch located west of Highway 17 and north of Highway 90 in Presidio County in the Trans-Pecos Region of Texas.

Scaled quail are economically and socially important for the region, as they attract hunters to the Trans-Pecos. Scaled quail are a species of conservation concern, and are declining at 3.1% per year (Sauer et al. 2013).

Winter study species are migratory species that overwinter in the Chihuahuan Desert during the non-breeding season. A notable winter species is the Baird's sparrow which is declining at a rate of 3.0 % per year, although it appears to be stabilizing in recent years (Sauer et al. 2013). The 2 longspur species in the Chihuahuan Desert, chestnut-collared and McCown's longspurs, are both grassland obligate species, and are both declining significantly at 4.3% per year and 5.3% per year, respectively (Sauer et al. 2013). The Sprague's pipit is declining at a rate of 4.4% per year and is considered "Vulnerable" by the International Union for Conservation of Nature (IUCN) Red List (McCracken 2005, BirdLife International 2018).

Summer study species are migratory species that reside in the Chihuahuan Desert during the breeding season. Grassland-breeding species such as meadowlarks have well documented declines: the Eastern meadowlark is declining at 3.3% per year and the Western meadowlark is declining slightly at 1.3% per year according to BBS data (Sauer et al. 2013, Pool et al. 2014). The Cassin's sparrow and lark sparrow have populations that are slightly declining at 0.5% per year, 0.9% per year, respectively (Pool et al. 2014). The black-throated sparrow is a grassland facultative species that selects grasslands with more shrubby components and is declining at about 1.8% per year (Sauer et al. 2013, Pool et al. 2014, Kozma et al. 2017).

Methods

Line transect grassland bird survey methods

To survey grassland birds in winter and summer, line transect surveys were conducted from January 1 to March 14 and July 1 to September 14 in 2017 and 2018, for a total of 4 sampling seasons. I used the Random Point Generator in ArcGIS® 10.1 (Environmental Systems Research Institute [ESRI], Redlands, CA) to place points at the beginning of each sample year; these points were loaded onto a Garmin GPSMAP 64st Global Positioning System (GPS; Garmin International Inc, Olathe, KS). These points served as the starting location of each 500 m transect. I surveyed each grazing type once per week, for 10 weeks during each sampling season. I conducted 3 line transect surveys per sampling day in each grazing type. Only 3 line transects were conducted each day to coincide with morning activity hours of grassland birds. My goal was to complete 30 line transect surveys per grazing type, per season, for a total of 60 transects per season, and 120 per year.

Surveys started no later than 30 min after sunrise, and all 3 surveys were completed within 3 hours of sunrise (Panjabi et al. 2006). I waited approximately 5 minutes after arriving at the starting point for each transect until I began recording bird observation data; this allowed time for the birds to acclimate from the traveling disturbance by the observer (Hostetler and Main 2014). Each transect was surveyed at 1 km/hr (500 m long) and took approximately 25-30 min to complete, walked at 1 km/hr. I conducted all transects running southeast to northwest, this was chosen based on randomly choosing an initial azimuth so that all transects were parallel to one another and not running along north/south fence lines (Gregory et al. 2004). If I expected to encounter a boundary fence during transects, then I walked the transect in reverse from northwest to southeast.

All birds observed during transects were identified and recorded. All birds were identified by sight, call, or song; if not identified to the species, individuals were recorded to the genus level, or as ‘unknown’ (Panjabi et al. 2010). I recorded the perpendicular distance (m) from the transect line to the initial detection of each bird using a Halo laser rangefinder Model number XRT7 (Wildgame Innovations, Grand Prairie, TX; ; Panjabi et al. 2010).

At the start of each transect, I collected weather data, such as air temperature, wind speed and direction, and barometric pressure (mmHg) using a handheld Kestrel weather meter(Nielsen Kellerman, Boothwyn, PA). I used the Beaufort scale to categorize wind conditions, and did not conduct transects when winds were greater than a category 4 on the Beaufort scale (20-29 km/hr) or during any precipitation (Panjabi et al. 2010, Pool et al. 2012).

Vegetation collection methods

I collected vegetation data along the line transect survey line to determine habitat use by the focal grassland bird species, using techniques modified from Panjabi et al (2010). Vegetation sampling was conducted at 3 locations, 0 m, 250 m, and 500 m, along each 500 m line transect. At each location within a 5 m radius circle, percent ground cover was estimated for each of the 5 categories: grass, forb, shrub, litter, and bare ground. Within this 5 m radius circle, the average height of grasses and forbs was visually estimated, and 3 dominant species were identified and recorded, as well as percentages within the circle. To survey shrub cover on a larger scale, the percentage of shrub cover was estimated within a 50 m radius circle from each of the 3 vegetation sampling locations. Additionally, average shrub height within the 50 m radius was estimated, and 3 dominant species were identified and recorded. Lastly, each line transect survey was broadly classified by topography (flat, foothills, hill, valley, or mountain) and habitat type (shrubland, grassland, pine/oak forest, riparian, or agriculture).

Data analysis

To determine habitat use for the focal grassland bird species, I analyzed bird sightings and vegetation data using IBM SPSS statistical software version 22(SPSS; SPSS, Inc., Chicago, IL). I performed a generalized linear mixed model using year as a random effect. However, year was removed as a random effect in some models due to convergence issues when there was 0 or low variance from 2017 to 2018. I tested 9 candidate models (Table 3.1) and used Akaike's Information Criterion (AICc) model selection to determine which habitat features are correlated and related to bird abundance and presence. Model averaging was performed when ΔAICc < 2. This in turn can be used to explain relative abundance of each focal bird species, and shows which habitat features are most important to the abundance of each species. In this paper, abundance refers to the number of individuals of a certain species observed per transect survey.

Results

Due to low sample size, survey data for some species were not used: Baird's sparrow (only identified to *Ammodramus* spp. during the winter; $n = 14$), McCown's longspur ($n = 0$), Sprague's pipit ($n = 4$), and Western meadowlark ($n = 1$).

Black-throated sparrow

During 2017 and 2018, I observed 38 black-throated sparrows. Most of these sightings occurred in the rotationally grazed pastures ($n = 29$), with only 9 sightings in the continuously grazed pasture. Thirty-four were observed during the summer, and only 4 were observed during winter. In summer, black-throated sparrows were observed in areas with an average of 16.8% shrub density and an average of 0.9 m shrub height, ranging from 3% to 40% shrub density and 0.4 m to 2.0 m shrub height. Average grass cover was 40%, and average grass height was 26 cm tall. Only summer black-throated sparrow sightings were used to determine habitat use due to low sample size in winter. The model that most explained summer black-throated sparrow abundance was the global model (Table 3.2 and 3.3).

Table 3.1. List of candidate models used in generalized linear mixed model analysis.

Model Name	Number of Parameters
Null	1
50 m Dominant Shrub Species	9
50 m % Shrub Cover × 50 m Average Shrub Height	42
5 m Dominant Species	11
5 m % Forb Cover	2
5 m % Bare Ground Cover	2
5 m Average Grass Height × 5 m % Grass Cover	4
Grazing Type	3
Global	29

Table 3.2. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of black-throated sparrow habitat use in summer 2017 and 2018 in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
Global	29	230.325	0	0.790
5 m Dominant Species*	11	232.974	2.649	0.210
50 m Dominant Shrub Species	9	275.802	45.477	0.000
50 m % Shrub Cover × 50 m Average Shrub Height*	4	295.399	65.074	0.000
5 m % Forb Cover*	2	302.812	72.487	0.000
Grazing Type	3	313.515	83.190	0.000
5 m % Bare Ground Cover	2	313.961	83.636	0.000
Null	1	314.212	83.887	0.000
5 m Average Grass Height × 5 m % Grass Cover*	4	321.877	91.552	0.000

*Denotes models where year was removed as random effect due to 0 variance from 2017 to 2018.

Table 3.3. Model results for the Global model in the analysis of black-throated sparrow habitat use in summer 2017 and 2018 in Presidio County, Texas.

Parameter	β	SE
Intercept	2.882	1.710
Continuous Grazing Pasture	-0.089	0.133
Rotational Grazing Pastures	0	0
50 m dominant: Acacia sp.	1.703	0.594
50 m dominant: Ephedra sp.	0.397	0.181
50 m dominant: Javelina bush	0.130	0.190
50 m dominant: Lotebush	0.513	0.652
50 m dominant: Mesquite sp.	1.723	0.379
50 m dominant: No shrub cover	0.324	0.362
50 m dominant: Prickly pear	0.338	0.600
50 m dominant: Yucca sp.	0	0
50 m % shrub cover	0.070	0.025
50 m shrub height	0.401	0.335
50 m % shrub cover × 50 m shrub height	-0.053	0.022
5 m % grass cover	0.027	0.019
5 m grass height	0.018	0.023
5 m % grass cover × 5 m grass height	-0.000	0.000
5 m % forb cover	0.040	0.018
5 m % bareground	0.031	0.014
5 m dominant: Black grama	-6.732	0.921
5 m dominant: Blue grama	-6.138	0.728
5 m dominant: Burrograss	-6.084	0.844
5 m dominant: Ephedra sp.	-4.762	0.970
5 m dominant: Grama sp.	-6.573	0.917
5 m dominant: Swallen's curly mesquite	-6.995	0.933
5 m dominant: Sideoats grama	-6.296	0.836
5 m dominant: Threeawn sp.	-6.201	0.882
5 m dominant: Whitethorn acacia	-6.571	1.095
5 m dominant: Woolly tidestromia	0	0

Cassin's sparrow

During 2017 and 2018, I observed 292 Cassin's sparrows. More Cassin's sparrows were observed in the continuously grazed pasture (*n* = 187) than in the rotationally grazed pastures (*n* = 105). All but 1 observation was in summer. In summer, Cassin's sparrows were observed in areas with an average shrub density of 8.8%, ranging from 0-75%, and an average shrub height of 0.6 m, but ranged from 0.1 m to 2.0 m. Average grass cover was 50%, and average grass height was 24 cm. Only summer Cassin's sparrow sightings were used in regression models to determine habitat use due to low numbers of observations in winter. Like the black-throated sparrow, the top model for the Cassin's sparrow was the global model (Table 3.4 and 3.5).

Chestnut-collared longspur

During winter 2017 and 2018, I observed 1,052 chestnut-collared longspurs. Most observations were in the continuously grazed pasture (*n* = 705), with 347 observations in the rotationally grazed pastures. All sightings occurred in winter. During winter, chestnut-collared longspurs were observed in areas with an average of 7% shrub density, ranging from 0-40%, and an average of 0.6 m shrub height, ranging from 0.2 m to 3.0 m shrub height. Average grass cover was 56%, and average grass height was 30 cm. The global model was the top model for the chestnut-collared longspur abundance (Table 3.6 and 3.7).

Eastern meadowlark

I observed 521 Eastern meadowlarks during 2017 and 2018. Sightings were almost equal in the continuously grazed pasture (*n* = 282) and in the rotationally grazed pastures (*n* = 239). The majority of observations were in summer (*n* = 368) with 153 observations in winter. During winter, Eastern meadowlarks were observed in areas with an average of 8.3% shrub density, ranging from 0-40%, and an average of 0.7 m shrub height, ranging from 0.3 m to 2.0 m shrub

Table 3.4. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of Cassin's sparrow habitat use in summer 2017 and 2018 in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
Global*	29	479.148	0	1.000
5 m Dominant Species	11	503.858	24.710	0.000
50 m Dominant Shrub Species	9	510.328	31.180	0.000
Grazing Type*	3	530.354	51.206	0.000
50 m % Shrub Cover × 50 m Average Shrub Height*	4	531.329	52.181	0.000
Null*	1	541.834	62.686	0.000
5 m % Forb Cover*	2	543.109	63.961	0.000
5 m % Bare Ground Cover*	2	547.624	68.476	0.000
5 m Average Grass Height × 5 m % Grass Cover*	4	559.444	80.296	0.000

*Denotes models where year was removed as random effect due to 0 variance from 2017 to 2018.

Table 3.5. Model results for the Global model in the analysis of Cassin's sparrow habitat use in summer 2017 and 2018 in Presidio County, Texas.

Parameter	β	SE
Intercept	0.349	7.318
Continuous Grazing Pasture	1.635	0.530
Rotational Grazing Pastures	0	0
50 m dominant: Acacia sp.	5.514	0.722
50 m dominant: Ephedra sp.	1.314	0.794
50 m dominant: Javelina bush	1.344	0.794
50 m dominant: Lotebush	-0.957	1.077
50 m dominant: Mesquite sp.	-1.798	1.170
50 m dominant: No shrub cover	1.822	1.430
50 m dominant: Prickly pear	3.416	0.822
50 m dominant: Yucca sp.	0	0
50 m % shrub cover	0.122	0.111
50 m shrub height	3.303	1.466
50 m % shrub cover × 50 m shrub height	-0.080	0.098
5 m % grass cover	-0.021	0.081
5 m grass height	0.090	0.076
5 m % grass cover × 5 m grass height	-0.001	0.001
5 m % forb cover	0.007	0.089
5 m % bareground	-0.070	0.066
5 m dominant: Black grama	-0.818	1.763
5 m dominant: Blue grama	1.612	1.733
5 m dominant: Burrograss	0.589	1.764
5 m dominant: Ephedra sp.	-1.013	2.230
5 m dominant: Grama sp.	0.712	2.751
5 m dominant: Swallen's curly mesquite	-1.186	1.885
5 m dominant: Sideoats grama	1.371	1.801
5 m dominant: Threeawn sp.	-0.249	1.954
5 m dominant: Whitethorn acacia	-5.627	2.266
5 m dominant: Woolly tidestromia	0	0

Table 3.6. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of chestnut-collared longspur habitat use in winter 2017 and 2018 in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
Global	29	587.598	0	1.000
50 m Dominant Shrub Species	11	662.251	74.653	0.000
5 m Dominant Species	9	690.872	103.274	0.000
50 m % Shrub Cover × 50 m Average Shrub Height	4	723.171	135.573	0.000
Grazing Type	3	749.239	161.641	0.000
5 m % Forb Cover	2	755.410	167.812	0.000
Null	1	757.359	169.761	0.000
5 m % Bare Ground Cover	2	758.093	170.495	0.000
5 m Average Grass Height × 5 m % Grass Cover	4	762.309	174.711	0.000

Table 3.7. Model results for the Global model in the analysis of chestnut-collared longspur habitat use in winter 2017 and 2018 in Presidio County, Texas.

Parameter	β	SE
Intercept	40,799.476	19,790.805
Continuous Grazing Pasture	2.115	6.398
Rotational Grazing Pastures	0	0
50 m dominant: Acacia sp.	12.497	14.262
50 m dominant: Allthorn sp.	14.954	17.550
50 m dominant: Beargrass	11.582	27.406
50 m dominant: Ephedra sp.	4.296	9.128
50 m dominant: Javelina bush	7.717	8.427
50 m dominant: Mesquite sp.	2.931	22.212
50 m dominant: No shrub cover	33.065	20.407
50 m dominant: Lotebush	5.840	23.863
50 m dominant: Oak sp.	10.595	20.863
50 m dominant: Yucca sp.	0	0
50 m % shrub cover	-1.585	1.279
50 m shrub height	-24.754	23.628
50 m % shrub cover × 50 m shrub height	1.505	1.547
5 m % grass cover	0.047	0.791
5 m grass height	1.144	1.346
5 m % grass cover × 5 m grass height	-0.012	0.023
5 m % forb cover	-0.138	0.669
5 m % bareground	-0.145	0.573
5 m dominant: Blue grama	-8.309	16.972
5 m dominant: Bluestem sp.	-13.374	28.600
5 m dominant: Broom snakeweed	-24.915	27.690
5 m dominant: Buffalo grass	-2.906	30.405
5 m dominant: Grama sp.	-26.726	20.390
5 m dominant: Swallen’s curly mesquite	-20.156	34.036
5 m dominant: Russian thistle	-31.138	23.789
5 m dominant: Threeawn sp.	0	0

in the continuously grazed pasture (n = 282) and in the rotationally grazed pastures (n = 239). The majority of observations were in summer (n = 368) with 153 observations in winter. During winter, Eastern meadowlarks were observed in areas with an average of 8.3% shrub density, ranging from 0-40%, and an average of 0.7 m shrub height, ranging from 0.3 m to 2.0 m shrub height. Average grass cover was 52%, and average grass height was 29 cm tall. During summer, Eastern meadowlarks were observed in areas with an average of 5.8% shrub density, ranging from 0-40%, and an average of 0.6 m shrub height, ranging from 0 m to 2.0 m shrub height. Average grass cover was 51%, and average grass height was 21 cm. Two analyses were conducted on Eastern meadowlark habitat use: one for winter and one for summer. The top model for Eastern meadowlark habitat use in the winter is the global model (Table 3.8 and 3.9). For summer habitat use, the global model was also the top model (Table 3.10 and 3.11).

Lark sparrow

I observed 17 lark sparrows during 2017 and no lark sparrows were observed in 2018. Thirteen observations were in the rotationally grazed pastures and 4 were in the continuously grazed pasture. During summer 2017, lark sparrows were observed in areas with an average of 7% shrub density, ranging from 0-30%, and an average of 0.6 m shrub height, ranging from 0 m to 1.9 m shrub height. Average grass cover was 37%, and average grass height was 21 cm. All observations were in the summer, as lark sparrows are migratory, so analysis consisted of summer observations. The top model for summer lark sparrow abundance is the 5 m dominant species (Table 3.12 and 3.13). This is showing a negative association with each vegetation species and abundance of lark sparrows.

Table 3.8. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of Eastern meadowlark habitat use in winter 2017 and 2018 in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
Global	29	340.012	0	1.000
50 m Dominant Shrub Species	11	360.506	20.494	0.000
5 m Dominant Species	9	368.924	28.912	0.000
Grazing Type	3	401.161	61.149	0.000
50 m % Shrub Cover × 50 m Average Shrub Height	4	403.836	63.824	0.000
Null	1	410.236	70.224	0.000
5 m % Forb Cover	2	413.262	73.250	0.000
5 m % Bare Ground Cover	2	415.298	75.286	0.000
5 m Average Grass Height × 5 m % Grass Cover	4	430.196	90.184	0.000

Table 3.9. Model results for the Global model in the analysis of Eastern meadowlark habitat use in winter 2017 and 2018 in Presidio County, Texas.

Parameter	β	SE
Intercept	15.554	6.964
Continuous Grazing Pasture	1.485	0.677
Rotational Grazing Pastures	0	0
50 m dominant: Acacia sp.	3.733	1.506
50 m dominant: Allthorn sp.	-1.362	1.856
50 m dominant: Beargrass	-1.515	2.905
50 m dominant: Ephedra sp.	-0.715	0.967
50 m dominant: Javelina bush	-1.690	0.891
50 m dominant: Mesquite sp.	0.529	2.354
50 m dominant: No shrub cover	0.963	2.155
50 m dominant: Lotebush	0.939	2.529
50 m dominant: Oak sp.	-1.082	2.194
50 m dominant: Yucca sp.	0	0
50 m % shrub cover	-0.242	0.135
50 m shrub height	-1.485	2.502
50 m % shrub cover × 50 m shrub height	0.221	0.165
5 m % grass cover	-0.106	0.084
5 m grass height	-0.060	0.142
5 m % grass cover × 5 m grass height	-0.000	0.002
5 m % forb cover	0.005	0.071
5 m % bareground	-0.101	0.059
5 m dominant: Blue grama	-0.915	1.797
5 m dominant: Bluestem sp.	-1.077	3.028
5 m dominant: Broom snakeweed	-7.283	2.934
5 m dominant: Buffalo grass	-1.923	3.223
5 m dominant: Grama sp.	-3.737	2.144
5 m dominant: Swallen’s curly mesquite	1.807	3.608
5 m dominant: Russian thistle	-5.769	2.521
5 m dominant: Threeawn sp.	0	0

Table 3.10. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of Eastern meadowlark habitat use in summer 2017 and 2018 in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
Global	29	508.691	0	0.929
5 m Dominant Species	11	513.837	5.146	0.076
50 m Dominant Shrub Species	9	525.471	16.780	0.000
50 m % Shrub Cover × 50 m Average Shrub Height	4	554.412	45.721	0.000
Grazing Type	3	558.910	50.219	0.000
Null	1	559.130	50.439	0.000
5 m % Bare Ground Cover	2	562.937	54.246	0.000
5 m % Forb Cover	2	562.992	54.301	0.000
5 m Average Grass Height × 5 m % Grass Cover	4	576.526	67.835	0.000

Table 3.11. Model results for the Global model in the analysis of Eastern meadowlark habitat use in summer 2017 and 2018 in Presidio County, Texas.

Parameter	β	SE
Intercept	-3.578	8.772
Continuous Grazing Pasture	-0.371	0.677
Rotational Grazing Pastures	0	0
50 m dominant: Acacia sp.	-1.134	3.049
50 m dominant: Ephedra sp.	-1.274	0.969
50 m dominant: Javelina bush	0.550	0.985
50 m dominant: Lotebush	-3.846	3.322
50 m dominant: Mesquite sp.	-2.193	1.941
50 m dominant: No shrub cover	0.604	1.846
50 m dominant: Prickly pear	0.017	3.065
50 m dominant: yucca	0	0
50 m % shrub cover	-0.067	0.129
50 m shrub height	0.498	1.712
50 m % shrub cover × 50 m shrub height	0.009	0.045
5 m % grass cover	0.098	0.097
5 m grass height	0.101	0.116
5 m % grass cover × 5 m grass height	-0.002	0.002
5 m % forb cover	0.042	0.093
5 m % bareground	0.004	0.070
5 m dominant: Black grama	3.319	4.688
5 m dominant: Blue grama	1.820	3.708
5 m dominant: Burrograss	0.881	4.330
5 m dominant: Ephedra sp.	3.426	4.957
5 m dominant: Grama sp.	3.593	4.666
5 m dominant: Swallen’s curly-mesquite	0.263	4.749
5 m dominant: Sideoats grama	8.049	4.257
5 m dominant: Threeawn sp.	2.844	4.490
5 m dominant: Whitethorn acacia	0.956	5.577
5 m dominant: Woolly tidestromia	0	0

Table 3.12. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of lark sparrow habitat use in summer 2017[a] in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
5 m Dominant Species	11	100.765	0	1.000
Global	29	161.799	61.034	0.000
50 m % Shrub Cover × 50 m Average Shrub Height	4	224.174	123.409	0.000
50 m Dominant Shrub Species	9	231.095	130.330	0.000
Null	1	232.802	132.037	0.000
Grazing Type	3	233.481	132.716	0.000
5 m % Forb Cover	2	233.834	133.069	0.000
5 m % Bare Ground Cover	2	239.265	138.500	0.000
5 m Average Grass Height × 5 m % Grass Cover	4	257.864	157.099	0.000

[a] No lark sparrows were observed in summer of 2018, analysis only has data for 2017 sightings.

Table 3.13. Model results for 5 meter Dominant Species in the analysis of lark sparrow habitat use in summer 2017 in Presidio County, Texas.

Parameter	β	SE
Intercept	5.931	0.383
Black grama	-5.863	0.532
Blue grama	-5.842	0.377
Burrograss	-6.000	0.457
Ephedra sp.	-5.000	0.528
Grama sp.	-5.931	0.459
Swallen's curly-mesquite	-6.000	0.528
Sideoats grama	-5.931	0.459
Threeawn sp.	-5.500	0.457
Whitethorn acacia	-5.863	0.532
Woolly tidestromia	0	0

Scaled quail

I observed 108 scaled quail during 2017 and 2018. More sightings were in the rotationally grazed pasture (*n* = 76) than in the continuously grazed pasture (*n* = 32). Sightings were similar in winter (*n* = 52) and summer (*n* = 56). During winter, scaled quail were observed in areas with an average of 15% shrub density, ranging from 0-30%, and an average of 0.7 m shrub height, ranging from 0.3 m to 3.0 m shrub height. Average grass cover was 51%, and average grass height was 30 cm. During summer, scaled quail were observed in areas with an average of 12% shrub density, ranging from 0-75%, and an average of 0.7 m shrub height, ranging from 0 m to 2.0 m shrub height. Average grass cover was 41%, and average grass height was 28 cm.

Separate analyses were conducted on scaled quail habitat use for winter and summer. In winter, there were 2 competing models that were averaged to produce a top model of 50 meter dominant shrub species and Global (Table 3.14 and 3.15). Scaled quail were negatively associated with all shrub species except for mesquite. This means that mesquite is beneficial for scaled quail abundance in winter. In summer, the 5 m dominant species model was the top for scaled quail abundance (Table 3.16 and 3.17). Each species was negatively associated with scaled quail abundance.

Discussion

For several species, the analysis results showed the global model as best model for assessing abundance. These results indicate that the vegetation characteristics measured, were all important in some way in predicting habitat use and abundance of these species. For example, black-throated sparrows are described as habitat generalists, especially during the summer season with nesting habitat (Kozma et al. 2017). Finding the global model as the top

Table 3.14. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of scaled quail habitat use in winter 2017 and 2018 in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
50 m Dominant Shrub Species*	11	346.038	0	0.663
Global*	29	347.541	1.503	0.313
5 m Dominant Species*	9	352.616	6.578	0.025
Grazing Type*	3	374.428	28.390	0.000
Null*	1	375.577	29.539	0.000
50 m % Shrub Cover × 50 m Average Shrub Height*	4	380.031	33.993	0.000
5 m % Forb Cover*	2	380.500	34.462	0.000
5 m % Bare Ground Cover*	2	381.729	35.691	0.000
5 m Average Grass Height × 5 m % Grass Cover*	4	396.616	50.578	0.000

*Denotes models where year was removed as random effect due to 0 variance from 2017 to 2018.

Table 3.15. Model averaging results (50 meter Dominant Shrub Species × Global) for the analysis of scaled quail habitat use in winter 2017 and 2018 in Presidio County, Texas.

Model	Parameter	β	SE
50 m Dominant Shrub Species	Intercept	-0.112	1.280
	Acacia sp.	-1.025	0.705
	Allthorn	-1.022	0.504
	Beargrass	-0.762	0.826
	Ephedra sp.	-0.106	0.960
	Javelina bush	-0.900	0.546
	Mesquite sp.	3.520	2.809
	No shrub species	-0.918	0.936
	Lotebush	-1.032	0.546
	Oak sp.	-0.699	0.710
	Yucca sp.	0	0
Global	Intercept	-0.112	1.280
	Acacia sp.	-1.025	0.705
	Allthorn	-1.022	0.504
	Beargrass	-0.762	0.826
	Ephedra sp.	-0.106	0.960
	Javelina bush	-0.900	0.546
	Mesquite sp.	3.520	2.809
	No shrub species	-0.918	0.936
	Lotebush	-1.032	0.546
	Oak sp.	-0.699	0.710
	Yucca sp.	0	0
	Continuous Grazing Pasture	-0.056	0.173
	Rotational Grazing Pasture	0	0
	50 m % shrub cover	0.026	0.044
	50 m shrub height	0.247	0.758
	50 m % shrub cover × 50 m shrub height	-0.034	0.066
	5 m % grass cover	0.011	0.013
	5 m grass height	0.009	0.024

Table 3.15 Continued.

Model	Parameter	β	SE
	5 m % forb cover	0.030	0.029
	5 m % bareground	0.002	0.008
	5 m dominant: Blue grama	0.322	0.185
	5 m dominant: Bluestem sp.	0.584	0.253
	5 m dominant: Broom snakeweed	-1.032	1.149
	5 m dominant: Buffalograss	0.241	0.349
	5 m dominant: Grama sp.	-0.460	0.311
	5 m dominant: Swallen's curly-mesquite	0.234	0.294
	5 m dominant: Russian thistle	-0.301	0.455
	5 m dominant: Threeawn sp.	0	0

Table 3.16. Model selection results, in compliance with Akaike's Information Criterion with small sample size corrections (AICc), for the analysis of scaled quail habitat use in summer 2017 and 2018 in Presidio County, Texas.

Model	k	AICc	ΔAICc	w_i
5 m Dominant Species	11	344.638	0	1.000
Global*	29	368.221	23.583	0.000
50 m % Shrub Cover × 50 m Average Shrub Height	4	387.669	43.301	0.000
50 m Dominant Shrub Species	9	392.894	48.256	0.000
5 m % Forb Cover*	2	400.623	55.985	0.000
Grazing Type	3	404.275	59.637	0.000
Null	1	405.873	61.235	0.000
5 m % Bare Ground Cover	2	412.449	67.811	0.000
5 m Average Grass Height × 5 m % Grass Cover	4	427.705	83.067	0.000

*Denotes models where year was removed as random effect due to 0 variance from 2017 to 2018.

Table 3.17. Model selection results for 5 meter dominant species in the analysis of scaled quail habitat use in summer 2017 and 2018 in Presidio County, Texas.

Parameter	B	SE
Intercept	8.788	1.277
Black grama	-8.576	1.781
Blue grama	-8.399	1.260
Burrograss	-9.000	1.530
Ephedra sp.	-7.000	1.767
Grama sp.	-8.788	1.534
Swallen's curly-mesquite	-9.000	1.767
Sideoats grama	-8.788	1.534
Threeawn sp.	-8.000	1.530
Whitethorn acacia	-6.576	1.781
Woolly tidestromia	0	0

model for this study makes sense because black-throated sparrows do not seem to specifically select for certain vegetation characteristics, which can explain why the global model was the best model for black-throated sparrow habitat use (Kozma et al. 2017).

Results for the habitat use by summer Cassin's sparrows were similar. The global model was the top model in the analysis, which again suggests that the habitat features measured in this study were all important in determining summer habitat use for Cassin's sparrows. However, looking at the parameters in this global model, there is a positive association between a few different features: mesquite shrub cover, acacia shrub cover, and 50 m shrub height. The results from this study, as well as results from other studies such as Ruth (2000) and Cooper et al.(2014), indicate that shrubs are important to Cassin's sparrow abundance. Many studies, including one in the grasslands of northwestern Oklahoma, indicate that increasing shrub cover corresponds with increasing abundance in breeding Cassin's sparrows (Cooper et al. 2014).

Additionally, the global model was the top model for the chestnut-collared longspur habitat use in the winter months. There was a strong negative correlation between shrub height and abundance, as well as shrub percentage. I observed longspurs in areas with an average of 7% shrub cover; this is similar to other studies that observed chestnut-collared longspurs at sites with less than 10% woody cover, and the most abundance observed <1% cover (Block and Morrison 2010).

The winter Eastern meadowlark analysis showed the global model as the best model. There did not seem to be many strong associations, either positive or negative, when looking into the parameters of this model. Eastern meadowlark winter habitat associations have been relatively unstudied, however the studies that have been done don't show definitive results as to what are important habitat characteristics. Eastern meadowlarks appear to be generalists in winter habitat as they can be found in areas heavily dominated by woody shrubs, but also in true grasslands with <10% shrub canopy cover (Lawrence and Ballard 1999, Coffman et al. 2014). Additionally, Eastern meadowlarks are often one of the most commonly sighted bird species in field studies, which further supports that they are habitat generalists, at least during the winter (Lawrence and Ballard 1999, Coffman et al. 2014).

The top model for Eastern meadowlark habitat use during summer was a combination of the 5 m dominant species model and the global model. The parameters for this combined model showed positive associations for all of the dominant plant species identified within 5 m of the transect lines; this was especially true for sideoats grama (*Bouteloua curtipendula*), a native grass. Other studies show increased use by Eastern meadowlarks in native grasslands than in monotypic habitats (Coppedge et al. 2001). While Eastern meadowlarks were found in areas varying in shrub density, that did not appear to affect their summer habitat use (Coffman et al. 2014).

During the summer months for the lark sparrow, the 5 m dominant vegetation species was the top model. However, every parameter in this model was negatively associated with lark sparrow abundance. This could be because most of the grasses observed are taller grasses, and lark sparrows prefer to nest in very short grasses or no grass cover (Best et al. 1997). Additionally, this analysis was done with only 17 observations in one summer season; larger sample sizes across more years could lead to different results.

Lastly in this study, scaled quail abundance during winter was best explained by the 50 m dominant shrub species model, where the only parameter with a positive association with scaled quail abundance was mesquite. This is similar to a study in southeastern Arizona that found that mesquite was the most common tree found at flush sites of scaled quail in fall and winter

(Bristow and Ockenfels 2006). During summer, scaled quail abundance was better explained by the 5 m dominant vegetation species. However, each parameter in this model was negatively associated with scaled quail abundance. This could be because quail typically use bunchgrasses for nesting sites (Cantu et al. 2006). Although there have been studies about nesting ecology of scaled quail, there is not much literature on general habitat use of scaled quail in the summer.

Management Implications

This study did not show definitive results for which habitat characteristics are important to each species in the summer and winter seasons. This could be because the variables measured were all important or that I did not have a high enough sample size. I think that further research should be conducted in several areas spread out across the Chihuahuan Desert grasslands to obtain a larger sample size of observations for these species to determine habitat use at a fine scale in the Marfa grasslands. Additionally, different statistical tests could be performed to potentially get better model outcomes. A binomial logistic regression could be used to look into use or non-use of habitat. A Principle Components Analysis (PCA) could also be performed to see which habitat features are used by different species. Takeaways from this study can rely on the observations of shrub density for each species to manage at a larger scale for certain species. These results can be used by ranch and land managers to continue a cattle operation, but also provide important wintering and summer habitat for declining migratory birds, as well as continue to provide good habitat for scaled quail.

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APPENDIX A

SCALED QUAIL DATA SHEET FOR 2017-2018 CALL COUNT SURVEYS IN THE TRANS-PECOS REGION OF TEXAS

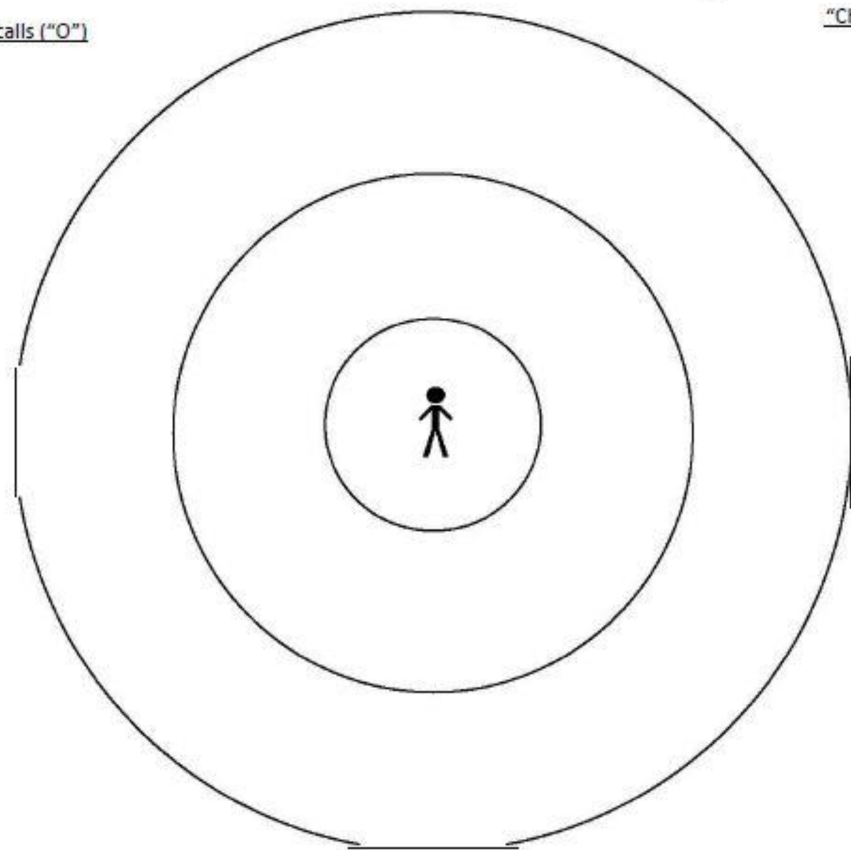
BRI Scaled Quail Call/Point Count Diagram

Mark an "O" for approximate location of 'whock' calls.
Mark an "X" at the approximate location of 'chekar' calls
Each ring represents a distance of about 200 yards.
Therefore, I am assuming a maximum of 600 yards is how far you will be hearing a quail calling.
Use a separate count plot for each of your stations.

Listening Station: ___________ Ranch: ------

Grazing Regime: _ _ _ _ Date:_______ North

"Whock" calls ("O") "Chekar" calls ("X")



Note: Your listening post should be located at the center of the first circle. This plot should help you keep track of multiple calling birds, and from year to year will give you an idea of locations of calling birds in different parts of your habitat.

of "Whock" calls # of quail # of "chekar" calls

APPENDIX B

ALL SPECIES OBSERVED DURING LINE TRANSECT SURVEYS IN 2017 AND 2018 IN THE CHIAHUAHUAN DESERT GRASSLANDS IN THE TRANS-PECOS REGION OF TEXAS

Species	Number observed
American avocet (*Recurvirostra americana*)	1
American kestrel (*Falco sparverius*)	3
Ammodramus sp. (*Ammodramus spp.*)	14
Barn swallow (*Hirundo rustica*)	179
Blue grosbeak (*Passerina caerulea*)	3
Black-throated sparrow (*Amphispiza bilineata*)	38
Burrowing owl (*Athene cunicularia*)	9
Cactus wren (*Campylorhynchus brunneicapillus*)	4
Cassin's sparrow (*Peucaea cassinii*)	292
Chestnut-collared longspur (*Calcarius ornatus*)	1,052
Chihuahuan raven (*Corvus cryptoleucus*)	5
Chipping sparrow (*Spizella passerina*)	13
Common nighthawk (*Chordeiles minor*)	17
Eastern meadowlark (*Sturnella magna*)	521
Golden eagle (*Aquila chrysaetos*)	1
Grasshopper sparrow (*Ammodramus savannarum*)	105
Horned lark (*Eremophila alpestris*)	142
Hummingbird species	1

Appendix B, Continued.

Species	Number observed
Lark bunting (*Calamospiza melanocorys*)	89
Lark sparrow (*Chondestes grammacus*)	17
Long-billed curlew (*Numenius americanus*)	12
Loggerhead shrike (*Lanius ludovicianus*)	33
Mourning dove (*Zenaida macroura*)	12
Northern harrier (*Circus hudsonius*)	18
Northern mockingbird (*Mimus polyglottos*)	1
Raven species (*Corvus* spp.)	20
Red-tailed hawk (*Buteo jamaicensis*)	8
Say’s phoebe (*Sayornis saya*)	1
Savannah sparrow (*Passerculus sandwichensis*)	48
Scott’s oriole (*Icterus parisorum*)	2
Scaled quail (*Callipepla squamata*)	108
Short-eared owl (*Asio flammeus*)	1
Sprague’s pipit (*Anthus spragueii*)	4
Swainson’s hawk (*Buteo swainsoni*)	5
Turkey vulture (*Cathartes aura*)	16
Unknown	72
Unknown sparrow	95
Unknown bird of prey	5
Upland sandpiper (*Bartramia longicauda*)	14

Appendix B, Continued.

Species	Number observed
Vesper sparrow (*Pooecetes gramineus*)	4
Western kingbird (*Tyrannus verticalis*)	5
Western meadowlark (*Sturnella neglecta*)	1
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	3

APPENDIX C

ALL SPECIES OBSERVED DURING LINE TRANSECT SURVEYS IN 2017 AND 2018 BY SEASON IN THE CHIAHUAHUAN DESERT GRASSLANDS IN THE TRANS-PECOS REGION OF TEXAS

Species	Winter	Summer
American avocet (*Recurvirostra americana*)	0	1
American kestrel (*Falco sparverius*)	1	2
Ammodramus sp. (*Ammodramus spp.*)	13	1
Barn swallow (*Hirundo rustica*)	0	179
Blue grosbeak (*Passerina caerulea*)	0	3
Black-throated sparrow (*Amphispiza bilineata*)	4	34
Burrowing owl (*Athene cunicularia*)	1	8
Cactus wren (*Campylorhynchus brunneicapillus*)	1	3
Cassin's sparrow (*Peucaea cassinii*)	1	291
Chestnut-collared longspur (*Calcarius ornatus*)	1,052	0
Chihuahuan raven (*Corvus cryptoleucus*)	5	0
Chipping sparrow (*Spizella passerina*)	3	10
Common nighthawk (*Chordeiles minor*)	0	17
Eastern meadowlark (*Sturnella magna*)	153	368
Golden eagle (*Aquila chrysaetos*)	0	1
Grasshopper sparrow (*Ammodramus savannarum*)	0	105
Horned lark (*Eremophila alpestris*)	96	46
Hummingbird species	0	1

Appendix C, Continued.

Species	Winter	Summer
Lark bunting (*Calamospiza melanocorys*)	0	89
Lark sparrow (*Chondestes grammacus*)	0	17
Long-billed curlew (*Numenius americanus*)	0	12
Loggerhead shrike (*Lanius ludovicianus*)	1	32
Mourning dove (*Zenaida macroura*)	0	12
Northern harrier (*Circus hudsonius*)	18	0
Northern mockingbird (*Mimus polyglottos*)	0	1
Raven species (*Corvus* spp.)	0	20
Red-tailed hawk (*Buteo jamaicensis*)	3	5
Say’s phoebe (*Sayornis saya*)	0	1
Savannah sparrow (*Passerculus sandwichensis*)	47	1
Scott’s oriole (*Icterus parisorum*)	0	2
Scaled quail (*Callipepla squamata*)	52	56
Short-eared owl (*Asio flammeus*)	1	0
Sprague’s pipit (*Anthus spragueii*)	4	0
Swainson’s hawk (*Buteo swainsoni*)	0	5
Turkey vulture (*Cathartes aura*)	0	16
Unknown	10	62
Unknown bird of prey	2	3
Unknown sparrow	75	20
Upland sandpiper (*Bartramia longicauda*)	0	14

Appendix C, Continued.

Species	Winter	Summer
Vesper sparrow (*Pooecetes gramineus*)	4	0
Western kingbird (*Tyrannus verticalis*)	0	5
Western meadowlark (*Sturnella neglecta*)	0	1
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	0	3
Total	1,547	1,447

APPENDIX D

ALL SPECIES OBSERVED DURING LINE TRANSECT SURVEYS IN 2017 AND 2018 BY GRAZING TYPE IN THE CHIAHUAHUAN DESERT GRASSLANDS IN THE TRANS-PECOS REGION OF TEXAS

Species	Continuous	Rotational
American avocet (*Recurvirostra americana*)	1	0
American kestrel (*Falco sparverius*)	1	2
Ammodramus sp. (*Ammodramus spp.*)	6	8
Barn swallow (*Hirundo rustica*)	68	111
Blue grosbeak (*Passerina caerulea*)	3	0
Black-throated sparrow (*Amphispiza bilineata*)	9	29
Burrowing owl (*Athene cunicularia*)	1	8
Cactus wren (*Campylorhynchus brunneicapillus*)	2	2
Cassin's sparrow (*Peucaea cassinii*)	187	105
Chestnut-collared longspur (*Calcarius ornatus*)	705	347
Chihuahuan raven (*Corvus cryptoleucus*)	0	5
Chipping sparrow (*Spizella passerina*)	6	7
Common nighthawk (*Chordeiles minor*)	8	9
Eastern meadowlark (*Sturnella magna*)	282	239
Golden eagle (*Aquila chrysaetos*)	0	1
Grasshopper sparrow (*Ammodramus savannarum*)	34	71
Horned lark (*Eremophila alpestris*)	31	111
Hummingbird species	0	1

Appendix D, Continued.

Species	Continuous	Rotational
Lark bunting (*Calamospiza melanocorys*)	49	40
Lark sparrow *Chondestes grammacus*)	4	13
Long-billed curlew (*Numenius americanus*)	2	10
Loggerhead shrike (*Lanius ludovicianus*)	14	19
Mourning dove (*Zenaida macroura*)	0	12
Northern harrier (*Circus hudsonius*)	9	9
Northern mockingbird (*Mimus polyglottos*)	0	1
Raven species (*Corvus* spp.)	1	19
Red-tailed hawk (*Buteo jamaicensis*)	2	6
Say’s phoebe (*Sayornis saya*)	0	1
Savannah sparrow (*Passerculus sandwichensis*)	27	21
Scott’s oriole (*Icterus parisorum*)	0	2
Scaled quail (*Callipepla squamata*)	32	76
Short-eared owl (*Asio flammeus*)	0	1
Sprague’s pipit (*Anthus spragueii*)	0	4
Swainson’s hawk (*Buteo swainsoni*)	1	4
Turkey vulture (*Cathartes aura*)	5	11
Unknown	35	37
Unknown bird of prey	0	5
Unknown sparrow	40	55
Upland sandpiper (*Bartramia longicauda*)	0	14

Appendix D, Continued.

Species	Continuous	Rotational
Vesper sparrow (*Pooecetes gramineus*)	4	0
Western kingbird (*Tyrannus verticalis*)	3	2
Western meadowlark (*Sturnella neglecta*)	1	0
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	2	1
Total	1,575	1,419

APPENDIX E

NUMBER OF STUDY SPECIES OBSERVED BY SEASON IN 2017 AND 2018 IN PRESIDIO COUNTY, TEXAS

Species	2017		2018		
	Winter	Summer	Winter	Summer	Total
Ammodramus sp. (*Ammodramus spp.*)	4	0	9	0	14
Black-throated sparrow (*Amphispiza bilineata*)	3	25	1	9	38
Cassin's sparrow (*Peucaea cassinii*)	0	163	1	128	292
Chestnut collared longspur (*Calcarius ornatus*)	623	0	429	0	1052
Eastern meadowlark (*Sturnella magna*)	116	259	37	109	521
Gambel's quail (*Callipepla gamelii*)	0	0	0	0	0
Lark sparrow (*Chondestes grammacus*)	0	17	0	0	17
McCown's longspur (*Calcarius mccownii*)	0	0	0	0	0
Montezuma quail (*Cyrtonyx montezumae)*	0	0	0	0	0
Scaled quail (*Callipepla squamata*)	16	47	36	9	108
Sprague's pipit (*Anthus spragueii*)	3	0	1	0	4
Western meadowlark (*Sturnella neglecta*)	0	1	0	0	1

APPENDIX F

NUMBER OF STUDY SPECIES OBSERVED IN 2017 AND 2018 IN CONTINOUSLY AND ROTATIONALLY GRAZED PASTURES IN PRESIDIO COUNTY, TEXAS

Species	Continuous	Rotational
Ammodramus sp. (*Ammodramus spp.*)	6	8
Black-throated sparrow (*Amphispiza bilineata*)	9	29
Cassin's sparrow (*Peucaea cassinii*)	187	105
Chestnut collared longspur (*Calcarius ornatus*)	705	347
Eastern meadowlark (*Sturnella magna*)	282	239
Gambel's quail (*Callipepla gamelii*)	0	0
Lark sparrow (*Chondestes grammacus*)	4	13
McCown's longspur (*Calcarius mccownii*)	0	0
Montezuma quail (*Cyrtonyx montezumae)*	0	0
Scaled quail (*Callipepla squamata*)	32	76
Sprague's pipit (*Anthus spragueii*)	0	4
Western meadowlark (*Sturnella neglecta*)	1	0

VITA

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