OVERWINTER SURVIVAL AND HABITAT SELECTION OF BAIRD’S AND
GRASSHOPPER SPARROWS IN THE MARFA GRASSLANDS, TEXAS

Approved:

______________________________
Louis A. Harveson, Ph.D., Co-Chair

______________________________
Mieke Titulaer, Ph.D., Co-Chair

______________________________
Maureen Correll, Ph.D.

______________________________
Bonnie J. Warnock, Ph.D.

Approved:

______________________________
Robert J. Kinucan, Ph.D., Associate Provost of Graduate Studies
ABSTRACT

Over the past four decades grassland birds have become one of the bird groups in steepest decline in North America. This may be related to habitat loss in their breeding and wintering areas. Most of the studies related to this guild of birds have been conducted on the breeding grounds. To better understand grassland bird population declines, it is important to study their whole annual cycle, including their wintering grounds. In addition, the study of grassland birds in the southern United States is very limited. Baird’s Sparrow (Centronyx bairdii) and grasshopper Sparrow (Ammodramus savannarum) have lost between 70–80% of their total population since 1966. I monitored these species over the winters of 2016-2017 and 2017-2018 in order to better understand the winter ecology of both species in Marfa, Texas. The objectives of this project were to, 1) monitor winter survival rates of Baird’s and grasshopper sparrows in the Marfa Grasslands, 2) determine home ranges for both species, and 3) explore habitat selection in both species. I deployed 144 transmitters using a figure-eight leg loop harness on these species throughout both winters to track and locate birds 1×/day. I then obtained visual estimates of ground cover within 5 m radius circular plots of 20 radiotelemetry locations per bird. I also collected habitat data across a grid of points spaced every 100 m within the study area. The mean home range (fixed kernel utilization distribution at 95%) for Baird’s and grasshopper sparrow was $6.58 \pm 1.30$ ha and $4.74 \pm 1.21$ ha, respectively, for both seasons combined. Baird’s sparrow selected areas with less bare ground, shrub height, forb cover and Russian thistle (Salsola spp.), while grasshopper sparrow selected areas with less bare ground and taller grasses. Winter survival estimates for Baird’s sparrow were 100% for the first winter and 70.24% for the second winter, and survival estimates for grasshopper sparrow were 77.67% and 44.42% for the first and second winter, respectively. The main cause of mortalities was depredation by diurnal raptors and
loggerhead shrikes (*Lanius ludovicianus*). I also explored microclimate in bird and random locations. I found that vegetation had an effect on minimum and maximum temperatures with short grass reaching the lowest temperatures. This information contributes to a growing knowledge base of the wintering ecology of Baird’s and grasshopper sparrows available to managers and researchers to support thriving grassland bird populations within the region.
DEDICATION

I dedicate this thesis to my parents Josefina and Manuel Perez that have supported me on every stage of my life and are my inspiration to follow my dreams. To my sister Monica, my brother Manolo, my sister in law Yessica, and my two nieces Mariana and Jimena. Without them and their unconditional support, I could not have done it. To them, I give all my love and effort to this thesis.

Dedico esta tesis a mis padres Josefina y Manuel Perez que me han apoyado en cada etapa de mi vida y son mi inspiración para seguir mis sueños. A mi hermana Mónica, mi hermano Manolo, mi cuñada Yessica y mis dos sobrinas; Mariana y Jimena. No hubiera podido hacer esto sin ellos y su apoyo incondicional. A ellos todo mi amor y esfuerzo de esta tesis.
ACKNOWLEDGEMENTS

To Dr. Louis A. Harveson for being such a good advisor, who believed in me and gave me the opportunity to be part of Borderlands Research Institute and work on this project. To my advisor Dr. Mieke Titulaer for guiding me and helping me innumerable times, and being patient with me. I am so honored by being your first student; you are already a great advisor. To Dr. Bonnie Warnock for all your knowledge and your willingness to help and give me your time whenever I needed it. To Dr. Maureen Correll, thank you for making me think out of the box, all your advice and dedication to my project. To all my committee, each of you are an inspiration to me.

To Fabiola Baeza for being the best research partner I could ever have asked for. To my technicians, Ernesto Garcia-Ortega, Collette Lauzau, Alana Boise, Megan Pasternak and Sebastian Orue-Herrera that gave their 110% to the project and the birds. Thank you for making field work more fun and much easier; definitely I could not have done this without you. You guys are awesome!

I would like to thank Dixon Water Foundation that generously let me stay and do research at one of their properties. To Robert Potts, Casey Wade, and Jonathan Baize for all their hospitality, assistance, and patience. To the Wade family for being such good neighbors and sharing good moments, and their back yard with me and my crew. To “mi amiguito” Bo Crees for sharing good moments and a field house with us.

Thank you to the funders, Texas Parks and Wildlife Department, especially Russell Martin and all staff that got to help me in captures. Thank you for all your interest and support. To the Bird Conservancy of the Rockies for sharing all your knowledge, particularly to Arvind Panjabi,
Greg Levandoski, and most of all Erin Strasser, for teaching me all I needed to know in order to start a new site.

To all of the 130 volunteers that helped me to capture birds throughout the 2 winter seasons, all my gratitude and admiration, it was a pleasure to meet each one of you. Thank you for all your support and patience moving nets and making circles over and over. You all made these hard days much easier and interesting.

To my fellow graduate students that made this journey so much enjoyable, for all your friendship, advise and being there when I need it the most. To BRI/SRSU staff, especially Julie Rumbelow and Dana Karelus, for all your technical support.

Lastly, I would like to thank my family, Manuel Perez, Josefina Perez, Monica Perez, Manuel Perez, Yessica Elizondo, Mariana Perez, Jimena Perez and my boyfriend Enrique Prunes. Thank you all for being by my side and all your support, and for encouraging me to stay on this journey to the end.
TABLE OF CONTENTS

ABSTRACT ......................................................................................................................... iii
DEDICATION ........................................................................................................................ v
ACKNOWLEDGEMENTS ...................................................................................................... vi
TABLE OF CONTENTS ...................................................................................................... viii
LIST OF FIGURES ............................................................................................................ x
LIST OF TABLES ................................................................................................................ xii

CHAPTER

I  INTRODUCTION ................................................................................................................ 1
   Study Species .................................................................................................................. 2
   Literature Cited ............................................................................................................ 9

II  HOME RANGE AND HABITAT SELECTION OF BAIRD’S AND
    GRASSHOPPER SPARROWS IN THE MARFA GRASSLANDS,
    TEXAS .......................................................................................................................... 13
   Introduction .................................................................................................................. 13
   Study area .................................................................................................................... 16
   Methods ....................................................................................................................... 18
   Results ........................................................................................................................ 28
   Discussion ................................................................................................................... 44
   Management Implications ......................................................................................... 46
   Literature Cited .......................................................................................................... 48

III  WINTER SURVIVAL OF BAIRD’S AND GRASSHOPPER SPARROWS
    IN THE MARFA GRASSLANDS, TEXAS ................................................................. 54
   Introduction .................................................................................................................. 54
   Study area .................................................................................................................... 56
   Methods ....................................................................................................................... 57
   Results ........................................................................................................................ 64
   Discussion ................................................................................................................... 72
   Management Implications ......................................................................................... 76
   Literature Cited .......................................................................................................... 77
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Distribution of Baird’s sparrow in North America (BirdLife International 2016)</td>
<td>4</td>
</tr>
<tr>
<td>1.2</td>
<td>Annual index of relative abundance of Baird’s and grasshopper sparrows from 1966 to 2015, estimated as yearly predicted abundances from the hierarchical model analysis (Sauer et al. 2017)</td>
<td>5</td>
</tr>
<tr>
<td>1.3</td>
<td>Distribution of grasshopper sparrow in North America (BirdLife International 2018)</td>
<td>7</td>
</tr>
<tr>
<td>2.1</td>
<td>Location of Mimms Ranch, Presidio County, Texas</td>
<td>17</td>
</tr>
<tr>
<td>2.2</td>
<td>Capture areas inside Mimms Ranch, Presidio County, Texas</td>
<td>19</td>
</tr>
<tr>
<td>2.3</td>
<td>Example of formation for captures, and recaptures. The left drawing explains the captures, making a semi-circle to drive birds into the net and the drawing to the right explains recaptures, placing the net over the bird</td>
<td>20</td>
</tr>
<tr>
<td>2.4</td>
<td>Example of a mean home range size obtained for both sparrows (5.87 ha ± 0.93). Locations (n =46) of Baird’s sparrow (ID number: 24782) followed from 15 December, 2016 to 31 January, 2017 with a home range size of 5.73 ha</td>
<td>31</td>
</tr>
<tr>
<td>2.5</td>
<td>Maximum home range size obtained for both sparrows (54.91 ha). Locations (n =34) of Baird’s sparrow (ID number: 39920) followed from 26 January 2017 to 9 March 2017</td>
<td>32</td>
</tr>
<tr>
<td>2.6</td>
<td>Minimum home range size obtained of both sparrows (0.80 ha). Locations (n =76) of grasshopper sparrow (ID number: 39954) followed from 1 December 2017 to 4 March 2018</td>
<td>34</td>
</tr>
<tr>
<td>2.7</td>
<td>Difference between grazing systems and type of point in the Mimms Ranch using descriptive statistics. The variables compared in these charts are variables of importance obtained in habitat selection</td>
<td>41</td>
</tr>
<tr>
<td>3.1</td>
<td>Winter survival and confidence intervals of winters 2016-2017 and 2017-2018 for Baird’s and grasshopper sparrows in the Marfa grasslands, Texas</td>
<td>66</td>
</tr>
</tbody>
</table>
3.2 Pooled temperature distributions from 10 February 2018 to 3 March 2018 for bird (Baird’s and grasshopper sparrows) and random locations at the Marfa Grasslands, from 0000 to 2350 hours. Bars represent measurements that are 10 min. apart and indicate the mean temperature (ºC) ± 95% CI. ............................................................... 70

3.3 Average mean, minimum, and maximum daily temperatures (ºC) from 10 February 2018 to 3 March 2018 for the three different vegetation classes. Bars are means ± 95% CI. ........................................................................................................................................................................................................................................... 71

3.4 Minimum daily temperature at the Marfa grasslands form December 14 to March 10 of the winters 2016-2017 and 2017-2018 ....................................................................................................................................................................................... 75
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Candidate models used to explain home range size during winters 2016-2017 and 2017-2018 of Baird’s and grasshopper sparrows in the Marfa grasslands, Texas</td>
<td>25</td>
</tr>
<tr>
<td>2.2</td>
<td>Candidate models used to explain habitat selection during winters 2016-2017 and 2017-2018 of Baird’s and grasshopper sparrows in the Marfa grasslands, Texas</td>
<td>27</td>
</tr>
<tr>
<td>2.3</td>
<td>Home range and core area size by species (BAIS = Baird’s sparrow, GRSP = grasshopper sparrow) of the winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas</td>
<td>30</td>
</tr>
<tr>
<td>2.4</td>
<td>Rank of parametric home range size of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas</td>
<td>35</td>
</tr>
<tr>
<td>2.5</td>
<td>Model averaging of the regression coefficients, beta estimates, and 95% confidence intervals of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Asterisks indicate variables for which the 95% CI of the estimates did not include zero.</td>
<td>36</td>
</tr>
<tr>
<td>2.6</td>
<td>Values of mean, minimum, maximum, and standard deviation for selected (Baird’s and grasshopper sparrows) and available habitat during the winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas</td>
<td>38</td>
</tr>
<tr>
<td>2.7</td>
<td>Rank of models to explain habitat selection of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas</td>
<td>39</td>
</tr>
<tr>
<td>2.8</td>
<td>Model beta estimates and 95% confidence intervals of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Asterisks indicate variables of Baird’s sparrow for which the 95% CI of the estimates did not include zero. X indicates variables of grasshopper sparrow for which the 95% CI of the estimates did not include zero.</td>
<td>40</td>
</tr>
<tr>
<td>3.1</td>
<td>Candidate models used for Baird’s sparrows and grasshopper sparrows, separately, to explain survival during the winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas</td>
<td>63</td>
</tr>
</tbody>
</table>
### TABLE

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2</td>
<td>Rank of models explaining survival of both species with ΔAICc value lower than 2, during winters 2016-2017 and 2017-2018 in the Marfa Grasslands, Texas</td>
</tr>
<tr>
<td>3.3</td>
<td>Model averaged regression coefficients (beta estimates) and 95% confidence intervals for the variables in the top models (ΔAICc &lt; 2) for Baird’s sparrow and grasshopper sparrow during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Asterisks indicate variables for which the 95% CI of the estimates did not include zero.</td>
</tr>
<tr>
<td>3.4</td>
<td>Number of loggers in the three different vegetation categories in bird and random locations during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Parentheses indicate the expected cell counts under the null hypothesis of independence.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
</tr>
<tr>
<td>69</td>
</tr>
<tr>
<td>73</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION

The Chihuahuan Desert grasslands are shared by Mexico and the United States. Over time, these grasslands have been considerably degraded through mismanaged grazing and conversion to cropland, resulting in habitat fragmentation and increasing aridity in the region (Pidgeon et al. 2002, Agudelo et al. 2008, Pool et al. 2014). As a consequence, the Chihuahuan Desert grasslands are now extremely threatened in both countries. A substantial portion of the historic grasslands in the Chihuahuan Desert have also been lost and replaced by less productive shrublands (Van Auken 2000, Pool and Panjabi 2011, Pool et al. 2014). The northern part of the Chihuahuan Desert, where the Marfa Grasslands occur, is comprised of 25% grassland, but it may have once supported up to 50% more grassland than it does today (Dinerstein et al. 2000).

Grassland ecosystems have an important economic value, providing land for cattle grazing. This ecosystem also acts as an important carbon sink, water catchment, and habitat for numerous plants and wildlife, including many species of birds (Samson and Knopf 1994).

The Chihuahuan Desert grasslands are critical wintering areas for migratory grassland birds and are important for their survival. About 90% of the grassland bird species that breed in the western U.S. and Canada overwinter in the Chihuahuan Desert grasslands (Panjabi et al. 2010, Pool et al. 2014). Populations of grassland birds that winter in northern Mexico and southern United States are one of the bird groups with the steepest declines in North America (Samson and Knopf 1994, Sauer and Link 2011). Increasing evidence suggests that factors limiting populations of this guild of migratory birds at their wintering grounds play a vital role

This thesis follows the style of Journal of Wildlife Management.
in their population declines (Morrison et al. 2013, Macias-Duarte and Panjabi 2013). For example, previous research suggests that shrub encroachment degrades grassland quality, making it unsuitable for open grassland bird species (Agudelo et al. 2008, Panjabi et al. 2010; i.e., creating more potential perches for predators). Also, parts of the Chihuahuan Desert grasslands are extremely threatened; nearly 50% of grasslands of Valles Centrales, Chihuahua have been converted from grasslands to croplands (Pool et al. 2014), consequently eliminating important wintering habitat. Therefore, the diversity and abundance of grassland bird specialists can be affected.

Grassland birds are good indicators of the ecosystem integrity and are useful for monitoring changes within these systems (Grageda-Garcia 2011). In order to conserve both grasslands and grassland birds, we need more information on the factors driving their population declines. Information on survival estimates and habitat selection during the winter is important to understand the factors contributing to grassland bird population declines during the nonbreeding season. Unfortunately, studies of these birds in the southern United States are very limited and no research on the demographics of grassland birds has been conducted in west Texas, making this study integral to developing conservation goals for the region.

**Study Species**

Baird’s sparrow (*Centronyx bairdii*) and Grasshopper sparrow (*Ammodramus savannarum*) are 2 grassland bird species that migrate to the Chihuahuan Desert to spend the winter. Both species are considered sedentary due to their fixed home ranges (Gordon 2000), making them more susceptible to habitat fragmentation. They are considered grassland obligate species (Vickery et al. 1999) and occupy habitat consisting of dense patches of tall grass.
(Macías-Duarte et al. 2009), and almost no shrubs (Macías-Duarte et al. 2017). These grasses offer cover for their protection from predators, habitat structure, as well as food sources for these 2 species during the winter (Pulliam and Mills 1977, Gordon 2000). Throughout the non-breeding season, both species eat a diversity of seeds, primarily of the Poaceae family (Titulaer et al. 2017). Both species are of conservation concern by US Fish and Wildlife Service (USFWS 2008), Texas Parks and Wildlife (TPWD 2012), and Rio Grande Joint Venture (Rosenberg 2016). They are also considered a tri-national concern species for the United States, Canada, and Mexico (Woiderski et al. 2017).

**Baird’s sparrow**

Baird’s sparrow is a small sparrow of about 12 cm in length, flat-headed, looking mostly brownish with some yellow on its head. It has a white chest with a streaky breast. It is distinguished by the 3 dark spotted marks on the auriculans. Sexes are without dimorphism. Baird’s sparrow is considered a rare bird and only locally abundant within grasslands in good condition (Green el al. 2002). This species breeds in the northern Great Plains in North Dakota, Montana, and the Canadian provinces of Saskatchewan, Alberta, and Manitoba. This species spends the winter in Arizona, New Mexico, Texas, and the Mexican states of Chihuahua, Durango, Coahuila, and Sonora (Green el al. 2002) (Figure 1.1). Its population has declined 2.17% annually since 1966 (Sauer et al. 2017) (Figure 1.2). Typically, Baird’s sparrow eludes predators by running and hiding in the grass rather than flying away (Pulliam and Mills 1977).

**Grasshopper sparrow**

The grasshopper sparrow is a small sparrow of around 11 cm in length, with a heavy bill, and a flat-headed appearance (Vickery 1996). It is mostly brownish with a white and buffy
Figure 1.1 Distribution of Baird’s sparrow in North America (BirdLife International 2016).
Figure 1.2 Annual index of relative abundance of Baird’s and grasshopper sparrows from 1966 to 2015, estimated as yearly predicted abundances from the hierarchical model analysis (Sauer et al. 2017).
chest, distinctive bright yellow at lore and the edges of the wing. Grasshopper sparrows do not show sexual dimorphism. This species maintains a wider distribution globally than the Baird’s sparrow, but is also locally dispersed and uncommon within its range (Vickery 1996). Its breeding range is mostly throughout the eastern United States and it is partially resident in small parts of Arizona, Texas (including Marfa Grasslands), Mississippi, Alabama, Georgia, North Carolina, South Carolina, and Florida. It winters from the south of the US, to El Salvador in Central America (Figure 1.3). The grasshopper sparrow population is declining 2.52% per year since 1966 (Sauer et al. 2017; Figure 1.2). Like the Baird’s sparrow, the grasshopper sparrow also presents cryptic behavior, eluding people and predators by hiding and running in the tall and dense grass.

In the winter of 2012-2013 Bird Conservancy of the Rockies (BCR) initiated a study on overwinter survival and habitat use of these species in Janos, Chihuahua, Mexico, and added additional sites in the Mexican states of Durango (2013-2014) and Coahuila (2014-2015) to understand the factors limiting the overwinter survival of Baird’s and grasshopper sparrows. The work described in the next 2 chapters, is an addition of a fourth site to this project in the Marfa Grasslands of Texas, USA, in 2016. I investigated demographic parameters and habitat use of Baird’s sparrow and grasshopper sparrow during two consecutive winter seasons (2016-2017, 2017-2018).

The main objectives of this research project were the following: 1) monitor daily movements of Baird’s and grasshopper sparrows in the Marfa grasslands to estimate local winter survival for both species, 2) estimate local home ranges for the 2 species, 3) conduct vegetative sampling to calculate habitat metrics for the study site, and 4) determine their habitat selection by comparing
Figure 1.3 Distribution of grasshopper sparrow in North America (BirdLife International 2018).
vegetation structure in bird location to the overall study site.

The specific objectives of my thesis were as follows:

Chapter 2

1. Estimate home range and core area size for Baird’s and grasshopper sparrows
2. Identify which habitat characteristics influence home range size and movement patterns
3. Evaluate the influence of landscape variables potentially influenced by grazing practices on habitat selection by Baird’s and grasshopper sparrows
4. Compare differences in objectives 1-3 between species

Chapter 3

1. Estimate winter survival rates of Baird’s and grasshopper sparrows
2. Identify factors (vegetation characteristics, weather, microclimates) that influence overwinter survival of these birds
3. Determine how vegetation cover affects microclimate conditions (temperature) that may have an impact on survival.
LITERATURE CITED


Accessed 9 November 2018.

Austin, Texas, USA.


CHAPTER II
HOME RANGE AND HABITAT SELECTION OF BAIRD’S AND GRASSHOPPER SPARROWS IN THE MARFA GRASSLANDS, TEXAS

Introduction

The grasslands of the Chihuahuan Desert are an important wintering region for many avian species (Macías-Duarte and Panjabi 2013a). These grasslands are very susceptible to anthropogenic change (Pool et al. 2014) that can also alter bird species populations (Sadoti et al. 2018). In particular, the Marfa Grasslands situated in the Chihuahuan Desert are considered a Grassland Priority Conservation Area (GPCA) by the Commission of Environmental Cooperation (Pool and Panjabi 2011). These grasslands, which are mixed prairies with a diversity of wildlife and vegetation, are suitable winter habitat for Baird’s sparrow (*Centronyx bairdii*) and grasshopper sparrow (*Ammodramus savannarum*).

Baird’s and grasshopper sparrows are long-distance migrants, are considered grassland habitat specialists (Vickery et al. 1999, Correll et al. 2019), and therefore depend on wintering places like the Marfa Grasslands. They are granivorous during winter (Titulaer et al. 2018), evade predators by seeking refuge in nearby vegetative structures (Pulliam and Mills 1977), and are associated with dense, tall grasses, and little shrub cover (Macías-Duarte et al. 2009, Martínez-Guerrero et al. 2011).

Both sparrows are listed as species of conservation need by Texas Parks and Wildlife Department (TPWD) (TPWD 2012) because their populations have decreased more than 70% over the last 50 years (Sauer et al. 2017). Their decline is likely related to habitat loss and fragmentation (Herkert et al. 2003), exotic invasive species (Saalfeld et al. 2016), oil and gas development (Van Wilgenburg et al. 2013), shrub encroachment, overgrazing, and the
conversion of grassland to croplands on both the breeding and wintering grounds (Macías-Duarte and Panjabi 2013b, Pool et al. 2014). For example, due to historical overgrazing, droughts, and fire suppression (USDA-NRCS 2012), Texas has already lost 30% of its mixed grass prairies (Samson and Knopf 1994), which is the main winter habitat of Baird’s and grasshopper sparrows in the Marfa Grasslands. Both grasshopper and Baird’s sparrows are better understood on their breeding grounds, partially due to their secretive behavior during winter, which makes them harder to study in the nonbreeding season.

To manage habitat for Baird’s and grasshopper sparrows and sustain their populations, it is essential to understand the habitat use and preferences, and space requirements for both species in breeding and nonbreeding areas. These species use habitat differently depending on seasons and activities, for example seeking refuge from predators, nesting, foraging, and roosting (Manly et al. 2002). It is therefore important to understand the habitat requirements of a species in the context of movement patterns both within and across seasons. Movement patterns are an important element for gene flow, habitat selection, foraging behavior (Gordon 2000) and for defining an animal’s home range (i.e., the cognitive map of the environment where an animal resides) (Powell and Mitchell 2012). There are many other definitions of the term home range, but for the purpose of this paper, I will use Worton’s (1987) definition: “home range is a fixed 95% region of the location of an animal over time based on a relative frequency distribution, called utilization distribution.” Movement patterns and home ranges can vary depending on habitat structure, food availability, and protection from predators (Ginter and Desmond 2005). Studying home range size and habitat of Baird’s and grasshopper sparrows is challenging because they are difficult to see and therefore track in the winter. In addition, an affordable technology for tracking small birds such as these sparrows (15 to 23 g Baird’s sparrow, and 14.5
to 20 g grasshopper sparrow; Green et al. 2002, Vickery 1996) that lasts for long periods of time (i.e. the whole winter season or longer) does not exist. Therefore, little work has been done to quantify home range on their wintering grounds (although exceptions exist; e.g. Strasser et al. 2018). Regardless, Very High Frequency (VHF) transmitters are small enough to deploy on adult grassland sparrows and can provide valuable information about their movements and the true locations of individuals, especially in such cryptic species over shorter time periods (± 45 days), with significant field effort (Bridge et al. 2011).

While one study of grasshopper sparrows showed high within-season dispersal rates during the breeding season (Williams and Boyle 2017), one of the few studies on wintering Baird’s and grasshopper sparrows suggests that both species are inclined to stay within fixed home ranges during the nonbreeding season (Gordon 2000), suggesting that their movements are restricted to a small area relative to their ability to travel a given distance. Little is known about Baird’s and grasshopper sparrow home range size, but overall, among grassland sparrow species there appears to be substantial variability in wintering home range size. Strasser et al. (2018) reported a home range size of 5.52 ha for Baird’s sparrows and 3.59 ha for grasshopper sparrows in Janos, Chihuahua. Henslow’s sparrow (Centronyx henslowii), the most closely related sparrow to the Baird’s sparrow (Zink and Avise 1990), has a winter home range between 0.009 to 1.50 ha with a mean estimate of 0.30 ha in southeastern Louisiana (Bechtoldt and Stouffer 2005). Another closely related species, Le Conte sparrows (Ammospiza leconteii), has an average home range of 10.31 ha during winter in southeast Texas (Baldwin et al. 2010). A similar study with vesper sparrows (Poecetes gramineus) in the Chihuahuan Desert reported an average home range of 32.68 ha in 2010 (Macías-Duarte and Panjabi 2013b). Ginter and Desmond (2005) estimated a mean home range of 9.1 ha for Savannah sparrows (Passerculus sandwichensis), for 38 birds
during the winter in south Texas. Because of this variability in home range size across related grassland bird species, it is important to obtain estimates for Baird’s and grasshopper sparrows in order to understand their space requirements.

I studied winter home range and habitat use of Baird’s and grasshopper sparrows using VHF telemetry to provide information on the wintering ecology of these species that can be used to develop management guidelines for these species. Because both species are grassland specialists (Vickery et al. 1999) that depend on grass cover for protection, I hypothesized that both species would use areas with denser patches of grass, taller grass, and less shrubs than what was available on the landscape. In addition, I hypothesized that there is a negative relationship between percentage of vegetative cover and home range size (i.e., if there is less cover, birds need to travel more to find food and protection), and that both species have similar space requirements because of their similar size and behavior (i.e., diet and foraging behavior, predator avoidance behavior).

**Study Area**

The study site is located in the Marfa Grasslands GPCA in west Texas, USA, that are mainly used for commercial cattle grazing and hunting. This site is part of a property owned and operated by Dixon Water Foundation since 2008, called the Mimms Ranch. The property is located just on the north edge of Marfa (30°19 N, 104°01 W), in Presidio County, Texas (Figure 2.1). The Mimms Ranch encompasses 4,390 ha with an elevation from approximately 1,350 m to 1,530 m. The ranch is actively managed with 2 different grazing systems: 30 pastures of about 100 ha where 80–100 cattle are moved every day, and an 858-ha pasture that is moderate, continuously grazed year-round by about 30 cattle. It also has 19 half ha enclosures throughout the entire ranch with no grazing.
Figure 2.1 Location of Mimms Ranch, Presidio County, Texas.
These grasslands have a semi-arid climate and get approximately 402 mm of rain per year, displaying a monsoonal annual rain pattern with most of this precipitation falling from July to September. Annual temperature averages 14.85°C (max = 24.3°C, min = 5.4°C), with December and January being the coldest months (US climate data 2018). The area comprises mainly of loamy mixed prairie, shallow mixed prairie, and igneous hills and mountain mixed prairie (USDA-NRCS 2012). The site is dominated by mid-grasses; mainly grama grasses (Bouteloua spp.), threeawn grasses (Aristida spp.) and Swallen’s curly mesquite (Hilaria swallenii). The Marfa grasslands are abundant in wildlife such as kit fox (Vulpes macrotis), golden eagle (Aquila chrysaetos), pronghorn (Antilocapra americana), mule deer (Odocoileus hemionus), black-tailed jackrabbits (Lepus californicus), kangaroo rats (Dipodomys spp.), rattlesnakes (Crotalus spp.), scaled quail (Callipepla squamata), burrowing owl (Athene cunicularia), Sprague’s pipit (Anthus spragueii), as well as other grassland birds including the 2 study species.

Methods

Capture and recapture

I collected data in 2 consecutive winters, 2016-17 and 2017-18. I had 3 main capture sites within the ranch: 2 at the rotational pasture (HEQU and BADA; both winters), and 1 at the continuous pasture (CONT; 2017-18; Figure 2.2). To capture Baird’s and grasshopper sparrows I placed a straight line of 2 to 4 mist nets (12.0 x 2.0 m long) strategically located in patches of dense and tall grass. Later, I spaced 7 to 15 people evenly in a semicircle around the nets and walked slowly, hitting the ground and grass to flush birds into the nets (Figure 2.3).
Figure 2.2 Capture areas inside Mimms Ranch, Presidio County, Texas.
Figure 2.3 Example of formation for captures and recaptures. The left drawing explains the captures, making a semi-circle to drive birds into the net and the drawing to the right explains recaptures, placing the net over the bird.
Once captured, I banded each individual with a unique aluminum federal band and took the following morphometric measurements: wing, tail, culmen and tarsus length, weight, and molt. I determined age for Baird’s sparrows by feather shape and wear in retrices, and color and shape in greater coverts. It was not possible to age grasshopper sparrows because of its complete preformative molt and absence of obvious clues during winter. I then fitted captured sparrows with 0.59 g VHF radio-transmitters PicoPip Ag379 (Biotrack Ltd, Dorset, UK), using a figure-8 harness with a 1-mm cord (Rappole and Tipton 1991) where transmitter weight did not exceed 5% of body weight (i.e., > 15.5 g) to reduce adverse effects of transmitters on individual birds. I then released every bird at its original capture location.

I attempted to recapture tagged birds in the middle of the season (early-mid January) to replace the transmitters because transmitter batteries last between 45 to 50 days. I also made an effort to recapture tagged birds one week before the end of the season (early March) to remove radio-transmitters and avoid extra weight during migration. To recapture birds, I radio-tracked each individual to identify its specific location in the area without flushing the bird. Once located I made a semicircle around the bird to flush the individual into the net. Another methodology used to recapture birds was using active netting by laying 2 mist nets over the located bird. Two technicians made the best triangulation possible to locate the bird, then 2 groups of 2 people holding a mist net each slowly approached the bird’s location with one net parallel to the other. Once both nets were close to the location, technicians placed the nets over the bird (Figure 2.3). All netting, banding, and sampling were performed under the requisite of Sul Ross State University (SRSU) Animal Care and Use Committee, Texas Parks and Wildlife Department (permit number SPR-1216-286), and U.S. Fish and Wildlife Service (permit number 22415).


**Monitoring**

I monitored birds over 2 winters from 15 December 2016 to 9 March 2017 (first winter) and 14 December 2017 to 8 March 2018 (second winter). I tracked every tagged bird once a day using a receiver Biotracker (Loteck Wireless Inc. Newmarket, Ontario) or R4000 (Advanced Telemetry Systems, Isanti, NM) and a directional yagi antenna with three-elements (Advanced Telemetry Systems, Isanti, NM). To avoid correlation in locations due to time of day, I tried to track at different times of the day between 0730 to 1800 hours. Towards the end of each study season, I occasionally tracked birds twice a day with at least 1 hour between observations to obtain the minimum number of points needed for statistical analysis (see below). In order to take an accurate location and avoid disrupting the birds, I located each bird by triangulation. I first walked slowly in a circular pattern, taking bearings from the strongest signals at multiple locations. Once I identified the probable general location of the bird, I walked faster to make the birds flush. Once the bird flushed, I marked a point with a global positioning unit (GPS), 3-meter accuracy, Garmin Oregon 650t (Garmin Ltd., Olathe, KS) to record the exact location on the landscape. For each location I recorded whether the bird was detected by sight or by signal, and if the bird moved from its previous location before it was seen. I also recorded the status of the bird as either good condition (when birds flew well or with normal behavior), bad condition (when birds flew oddly or were not able to fly), bird biting transmitter, radio fell off, or dead bird. Locations were uploaded to a database to join with the recorded information.

**Vegetation survey**

I conducted vegetation surveys within the study site along a grid of points spaced every 100 m, and at ≥20 locations for every individual tagged. At each vegetation survey point I made visual estimates of ground cover in a 5-m radius circular plot. I estimated percentage of forbs,
shrubs, grasses, Russian thistle (*Salsola* spp.), other cover, and bare ground, as well as shrubs, forbs and grass height (cm). This ocular estimation shows a strong linear correlation (*r* = 0.92) with sampling ground-cover photo estimates (Macías-Duarte et al. 2018), and is more time efficient than measuring every variable. To avoid observer bias in the vegetation estimates, technicians were trained and calibrated with each other at the beginning of the season, and one more time at the middle of the season.

**Analysis**

**Home Range**

Kernel estimators calculate the probability of occurrence at each location and as a result determine the utilization distribution for an animal (Worton 1989). Values are higher where there is more concentration of locations, and lower where the concentration of locations is lower. I estimated home ranges at 95% and core area at 50% of the utilization distribution (Worton 1987) using the fixed kernel density estimator with least square cross validation as a smoothing parameter. Home ranges were calculated with Program R (R Core Team 2016, www.r-project.org, accessed 13 May 2018) package adehabitatHR (Calenge 2006). I analyzed radio-tagged birds with >30 tracking locations as suggested by Seaman et al. (1999). I then used additive linear regression models with base R in program R (R Core Team 2016) to determine which variables contributed to the variation in home range and core area size. I log-transformed *home range* and *core area* (dependent variables) to fulfil model assumptions. To avoid multicollinearity, I eliminated the variables *bare ground* and *other* that were highly correlated (*|r|* >0.6) with grass cover and grass height, respectively, and also with each other. I built 7 hypothesis-driven models including a combination of the following variables: year, species, grass cover, grass height, and shrub cover. To be able to directly compare the estimates of the
regression coefficients of every variable, I scaled all variables using the “scale” function in 
R. I included YEAR and SPECIES as factors in a subset of models to account for any effects of 
anual variation or differences across species. I included grass cover and grass height in a 
subset of models because of exhibited positive association with both species (Macías-Duarte et 
al. 2009), and shrub cover for its similar negative association (Ruth et al. 2014, Agudelo et al. 
2008). The full model included all 5 variables. For the second model, I decided to exclude 
shrub cover due to the small percentage of shrub cover present at the study site. In the third 
model I considered YEAR, SPECIES, and grass cover because of the bird’s preference for dense 
grass. The fourth model included YEAR, SPECIES, and grass height because of the association 
of the species with tall grass. In the fifth model I considered only YEAR and SPECIES to 
determine if vegetation plays any role at all in determining home range size. For the sixth model 
I excluded YEAR and considered only grass height and grass cover to see if those two variables 
only could explain variability of home range without considering between year variation. And 
lastly, I considered a model with only YEAR as the null model because of the denoted difference 
of home range sizes between years (Table 2.1).

I used an information-theoretic approach and the Akaike Information Criterion corrected 
for small sample size (AICc) to evaluate the relative goodness-of-fit, and compare and select the 
best model containing the most informative variables (Burnham and Anderson 2002). Then I 
used the model averaged 95% confidence intervals for inference.

Habitat selection

To estimate the bird’s habitat selection for vegetation characteristics per species, I used 
logistic regression (Manly et al. 2002) to compare vegetation data gathered at the bird locations
Table 2.1 Candidate models used to explain home range size during winters 2016-2017 and 2017-2018 of Baird’s and grasshopper sparrows in the Marfa grasslands, Texas.

<table>
<thead>
<tr>
<th>Model</th>
<th>Model Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>loghr~ year + species + grass cover + grass height + shrub cover</td>
</tr>
<tr>
<td>2</td>
<td>loghr~ year + species + grass cover + grass height</td>
</tr>
<tr>
<td>3</td>
<td>loghr~ year + species + grass cover</td>
</tr>
<tr>
<td>4</td>
<td>loghr~ year + species + grass height</td>
</tr>
<tr>
<td>5</td>
<td>loghr~ year + species</td>
</tr>
<tr>
<td>6</td>
<td>loghr~ grass height + grass cover</td>
</tr>
<tr>
<td>7</td>
<td>loghr~ year</td>
</tr>
</tbody>
</table>
I used a generalized linear mixed-effect model (glmer), for each species separately, with package lme4 (Bates et al. 2015) in program R (R Core Team 2016). The global model included all uncorrelated vegetation variables as fixed effects and bird ID as a random effect. To each grid point, I assigned a random individual ID number of the bird points stratified by capture site (BADA, HEQU, CONT) and year (season 1 and season 2), to add individual as a random effect in the model. I calculated the Pearson correlation coefficient for all pairs of independent variables to eliminate variables with a correlation higher than |r| >0.6. I found a strong correlation of -0.78 between bare ground and grass cover. I then compared 2 univariate models each containing one of the two variables and the random effect, and compared these two models using AIC (Burnham and Anderson 2002). The model with bare ground performed better than the model with grass cover (ΔAIC= 23.4). Therefore, I eliminated grass cover and left bare ground in the global model. To be able to directly compare the estimates of the regression coefficients of every variable, I scaled all variables using the “scale” function in base R.

I built 9 hypothesis-driven models where I included combinations of the following variables: bare ground, grass height, shrub cover, shrub height, forb cover, forb height, Russian thistle, and other (Table 2.2). The full model included all 8 variables and the random effect, and null model included only the random effect. All other models were constructed based on the hypotheses that habitat selection of the birds is determined by grass and or shrub cover, grass and or shrub height, vegetative cover or vegetation height. I used an information-theoretic approach and the Akaike Information Criterion corrected for small sample size (AICc) to evaluate the relative goodness-of-fit, and compare and select the best model containing the most informative variables (Burnham and Anderson 2002). Then I used the model averaged 95%
Table 2.2 Candidate models used to explain habitat selection during winters 2016-2017 and 2017-2018 of Baird’s and grasshopper sparrows in the Marfa grasslands, Texas.

<table>
<thead>
<tr>
<th>Model</th>
<th>Model Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Null) 1</td>
<td>presence~bird ID</td>
</tr>
<tr>
<td>2</td>
<td>presence~bird ID+bare ground</td>
</tr>
<tr>
<td>3</td>
<td>presence~bird ID+shrub cover+shrub height</td>
</tr>
<tr>
<td>4</td>
<td>presence~bird ID+bare ground+shrub cover</td>
</tr>
<tr>
<td>5</td>
<td>presence~bird ID+bare ground+grass height</td>
</tr>
<tr>
<td>6</td>
<td>presence~bird ID+grass height+forb height</td>
</tr>
<tr>
<td>7</td>
<td>presence~bird ID+bare ground+grass height+shrub cover+shrub height</td>
</tr>
<tr>
<td>8</td>
<td>presence~bird ID+bare ground+shrub height+forb cover+Russian thistle+other</td>
</tr>
<tr>
<td>(Global) 9</td>
<td>presence~bird ID+bare ground+grass height+shrub cover+shrub height+forb cover+forb height+Russian thistle+other</td>
</tr>
</tbody>
</table>
confidence intervals to determine which variables were related to bird presence (i.e. whose CI do not include 0).

The model that I used for habitat selection is a model that includes all data of both years and grazing systems together. However, because grazing regime potentially influences the habitat characteristics that birds select for, I explored the difference between grazing systems using descriptive statistics. I did not analyze the effects of grazing with ANOVAs or GLMs that would allow for the inclusion of grazing system as independent variable and each vegetation variable as dependent, because the vegetation cover data in percentages did not meet the assumptions of these models. I did not add grazing system to the logistic regression model because I assumed that birds select their habitat based on vegetation and not on grazing regime directly, and because the continuously grazed site was only monitored in 2017-18, and in that year birds were divided by grazing system which does not allow for a comparison between grazing system within species (i.e., there was only one Grasshopper Sparrow in the continuous pasture in 2017-2018).

Results

I tagged a total of 66 birds, 40 Baird’s sparrows (BAIS) and 26 grasshopper sparrows (GRSP) in the winter of 2016-2017, and a total of 78 birds (48 BAIS, 30 GRSP) in the winter of 2017-2018. I recorded a total of 4,176 bird locations from the 144 captured sparrows (88 BAIS, 56 GRSP): 1,855 in the winter of 2016-2017 and 2,321 in the winter of 2017-2018. In the winter of 2017-2018, I captured 2 grasshopper sparrows that were previously banded. One had been captured and banded in another study at the same site during the previous summer, and the second bird was banded and tracked by me during the winter of 2016-2017.
**Home ranges**

I calculated home range and core area for 76 individuals that had ≥30 locations per bird, including 24 Baird’s and 14 grasshopper sparrows in the first season, and 24 Baird’s and 17 grasshopper sparrows from the second season. These home ranges were calculated from 3,409 GPS points.

The mean of the 50% fixed kernel utilization distribution for core area size for Baird’s and grasshopper sparrows combined (n = 76) across the whole study site was 1.16 ha ± 0.18 (min 0.15, max 11.46; Table 2.3). The mean 95% fixed kernel utilization distribution for home range size for BAIS and GRSP together (n = 76) across the study site was 5.87 ha ± 0.93 (min 0.80, max 54.91) (Table 2.3) (Figure 2.4). For the 2 seasons combined, Baird’s sparrow obtained a home range of 6.58 ha ± 1.30 ha and core area of 1.34 ha ± 0.268 ha and grasshopper sparrow obtained a home range of 4.74 ha ± 1.21 ha and core area of 0.87 ha ± 0.19 ha.

Both core areas and home ranges seemed larger in the winter of 2016-2017 (core area: 1.52 ha ± 0.33 ha; home range: 7.59 ha ± 1.65 ha) than in the winter of 2017-2018 (core area: 0.80 ha ± 0.12 ha; home range: 4.17 ha ± 0.79 ha). Some of the birds were difficult to locate; I found a number of them far from their capture location, and others were not found. Birds that moved more than 200 m from their capture location were called floaters (Strasser and Panjabi 2016). In season one I found more floaters than during the second season, which explains why home ranges and core areas were larger in season 1. The bird that moved the most and had the largest home range (core area: 11.46 ha; home range: 54.91 ha) moved to a site approximately 720 m east from its capture location, and later moved again 1.5 km west until finally it established 5.5 km away from its capture site (Figure 2.5). The bird that moved the least was a
Table 2.3 Home range and core area size by species (BAIS = Baird’s sparrow, GRSP = grasshopper sparrow) of the winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas.

<table>
<thead>
<tr>
<th>Species</th>
<th></th>
<th>Descriptive Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
<td>Min</td>
</tr>
<tr>
<td>BAIS</td>
<td>Home Range 95%(ha)</td>
<td>47</td>
<td>6.58</td>
</tr>
<tr>
<td></td>
<td>Core Area 50% (ha)</td>
<td>47</td>
<td>1.34</td>
</tr>
<tr>
<td>GRSP</td>
<td>Home Range 95%(ha)</td>
<td>29</td>
<td>4.74</td>
</tr>
<tr>
<td></td>
<td>Core Area 50% (ha)</td>
<td>29</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Figure 2.4 Example of a mean home range size obtained for both sparrows (5.87 ha ± 0.93).
Locations ($n$ = 46) of Baird’s sparrow (ID number: 24782) followed from 15 December, 2016 to 31 January, 2017 with a home range size of 5.73 ha.
Figure 2.5 Maximum home range size obtained for both sparrows (54.91 ha). Locations (n =34) of Baird’s sparrow (ID number: 39920) followed from 26 January 2017 to 9 March 2017.
grasshopper sparrow that was found frequently in the same place (core area: 0.18 ha, home range: 0.80 ha) (Figure 2.6)

I found 3 top models explaining variation in home range size (ΔAICc values lower than 2; Table 2.4). The top model for predicting home range size indicates that the combination of year and species explained the most variation in home range size (Model 5; Akaike weight = 0.338). The second model with ΔAICc < 2 suggests that home range size varies by year only and received almost the same support as the top model (Model 7; Akaike weight = 0.274). The third model with ΔAICc < 2 suggests HR size varies by year, species, and grass cover (Model 3; Akaike weight = 0.157).

To determine the effect of the predictors in the top models, I averaged the regression coefficients and 95% CI of year, species, and grass cover based on the three top models (Table 2.5). Among the 3 variables, the most influential variable that predicted home range was year, which was the only variable for which the 95% CI did not include zero (Table 2.5).

**Habitat Selection**

Over the two winters, the average cover in Baird’s sparrow locations was 45% grass cover, 0.6% forb cover, 0.1% shrub cover, 40% bare ground, 0.5% Russian thistle, and 13% other cover. Average grass height was 19.11 cm, forb height 21.6 cm, and shrub height 47.06 cm. Grasshopper sparrow locations had a mean of 42.0% grass cover, 1.0% forb cover, 0.2% shrub cover, 43.0% bare ground, 1.0% Russian thistle, and 13.0% other cover. Average grass height was 21.51 cm, forb height 23.49 cm and shrub height 57.49 cm. On average, grid locations had less grass cover (37%), a similar percent of forb and shrub cover than grasshopper sparrow with 1% and 0.2% respectively. Also grid locations had more bare ground than both sparrows (50%), more Russian thistle than Baird’s sparrow but less than Grasshopper sparrow
Figure 2.6 Minimum home range size obtained of both sparrows (0.80 ha). Locations (n =76) of grasshopper sparrow (ID number: 39954) followed from 1 December 2017 to 4 March 2018.
Table 2.4 Rank of parametric home range size of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas.

<table>
<thead>
<tr>
<th>Model</th>
<th>loglik</th>
<th>ΔAICc</th>
<th>df(K)</th>
<th>AICc weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 5: year + species</td>
<td>1.8</td>
<td>0</td>
<td>4</td>
<td>0.338</td>
</tr>
<tr>
<td>Model 7: year</td>
<td>0.5</td>
<td>0.4</td>
<td>3</td>
<td>0.274</td>
</tr>
<tr>
<td>Model 3: year + species + grass cover</td>
<td>2.2</td>
<td>1.5</td>
<td>5</td>
<td>0.157</td>
</tr>
<tr>
<td>Model 4: year + species + grass height</td>
<td>1.8</td>
<td>2.3</td>
<td>5</td>
<td>0.108</td>
</tr>
<tr>
<td>Model 6: grass height + grass cover</td>
<td>0.0</td>
<td>3.6</td>
<td>4</td>
<td>0.055</td>
</tr>
<tr>
<td>Model 2: year + species + grass cover + grass height</td>
<td>2.2</td>
<td>3.9</td>
<td>6</td>
<td>0.049</td>
</tr>
<tr>
<td>Model 1: year + species + grass cover + grass height + shrub cover</td>
<td>5.6</td>
<td>5.6</td>
<td>7</td>
<td>0.021</td>
</tr>
</tbody>
</table>
Table 2.5 Model averaging of the regression coefficients, beta estimates, and 95% confidence intervals of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Asterisks indicate variables for which the 95% CI of the estimates did not include zero.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimate (β)</th>
<th>Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2.5%</td>
</tr>
<tr>
<td>Year*</td>
<td>-0.480</td>
<td>-0.93</td>
</tr>
<tr>
<td>Species</td>
<td>-0.360</td>
<td>-0.81</td>
</tr>
<tr>
<td>Grass cover</td>
<td>-0.08</td>
<td>-0.31</td>
</tr>
</tbody>
</table>
(0.8 %), and fewer other cover with 10%. Average grass and forb height obtained the lowest means of 18.37 cm and 19.68 cm respectively, and shrubs (49.92 cm) were taller than in Baird’s sparrow locations, but lower than in Grasshopper sparrow locations (Table 2.6).

I found 2 top models explaining habitat selection of Baird’s sparrows (ΔAICc values lower than 2; Table 2.7). The top model included bare ground, forb cover, other cover, Russian thistle, and shrub height (Model 8: Akaike weight = 0.607) and the second model with ΔAICc < 2 was the global model which included bare ground, grass height, shrub cover, shrub height, forb cover, forb height, Russian thistle, and other cover (Model 9: Akaike weight = 0.393). After averaging both models, there were 4 influential predictors of Baird’s sparrow habitat selection (95% confidence intervals did not include 0): bare ground (95%CI = -0.45, -0.21), shrub height (95%CI = -0.33, -0.12), forb cover (95%CI = -0.29, -0.07), and Russian thistle (95%CI = -0.34, -0.08), indicating that Baird’s sparrow selected areas with less bare ground, forb cover, Russian thistle, and lower shrub height (Table 2.8).

Grasshopper sparrow had only one top model (ΔAICc values lower than 2; Table 2.7) that included bare ground and grass height (Model 5: Akaike weight = 0.805). Both variables were influential predictors of habitat selection where 95% confidence intervals did not include 0: bare ground (95%CI = -0.50, -0.23), and grass height (95%CI = 0.37, 0.69), indicating that grasshopper sparrow selected areas with less bare ground, and taller grass (Table 2.8).

Although I was not able to formally analyze the effects of grazing systems on home ranges and habitat selection in my study species, I was able to describe both grazing systems through the vegetation points collected in each plot. Vegetation grid points at the rotational pasture obtained the highest percentage of bare ground (60.3 %), however Baird’s (46.8 %) and grasshopper (50.1 %) sparrows obtained the lowest percentage on the rotational (Figure 2.7).
Table 2.6 Values of mean, minimum, maximum, and standard deviation for selected (Baird’s and grasshopper sparrows) and available habitat during the winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Selected Baird's Sparrow</th>
<th>Selected Grasshopper Sparrow</th>
<th>Available Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Grass Cover (%)</td>
<td>45.47</td>
<td>6</td>
<td>94</td>
</tr>
<tr>
<td>Grass Height (cm)</td>
<td>19.11</td>
<td>6</td>
<td>42</td>
</tr>
<tr>
<td>Forb Cover (%)</td>
<td>0.61</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Forb Height (cm)</td>
<td>21.60</td>
<td>1</td>
<td>64</td>
</tr>
<tr>
<td>Shrub Cover (%)</td>
<td>0.13</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Shrub Height (cm)</td>
<td>47.06</td>
<td>1</td>
<td>135</td>
</tr>
<tr>
<td>Bare Ground (%)</td>
<td>40.17</td>
<td>0</td>
<td>90.5</td>
</tr>
<tr>
<td>Russian thistle (%)</td>
<td>0.50</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Other (%)</td>
<td>13.12</td>
<td>0</td>
<td>67</td>
</tr>
</tbody>
</table>
Table 2.7 Rank of models to explain habitat selection of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas.

<table>
<thead>
<tr>
<th>Model</th>
<th>loglik</th>
<th>ΔAICc</th>
<th>df(K)</th>
<th>AICc weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baird’s sparrow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 8: bare ground + shrub height + forb cover + Russian thistle + other</td>
<td>-1411.83</td>
<td>0.000</td>
<td>7</td>
<td>0.607</td>
</tr>
<tr>
<td>Model 9 (Global): bare ground + grass height + shrub cover + shrub height + forb cover + forb height + Russian thistle + other</td>
<td>-1409.24</td>
<td>0.868</td>
<td>10</td>
<td>0.393</td>
</tr>
<tr>
<td>Model 7: bare ground + grass height + shrub cover + shrub height</td>
<td>-1424.44</td>
<td>23.209</td>
<td>6</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 4: bare ground + shrub cover</td>
<td>-1430.51</td>
<td>31.337</td>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 5: bare ground + grass height</td>
<td>-1433.82</td>
<td>37.959</td>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 2: bare ground</td>
<td>-1434.85</td>
<td>38.010</td>
<td>3</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 3: shrub cover + shrub height</td>
<td>-1450.70</td>
<td>71.721</td>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 6: grass height + forb height</td>
<td>-1457.05</td>
<td>84.419</td>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 1 (Null)</td>
<td>-1464.87</td>
<td>96.052</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Grasshopper Sparrow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 5: bare ground + grass height</td>
<td>-1227.59</td>
<td>0.000</td>
<td>4</td>
<td>0.805</td>
</tr>
<tr>
<td>Model 7: bare ground + grass height + shrub cover + shrub height</td>
<td>-1227.18</td>
<td>3.208</td>
<td>6</td>
<td>0.162</td>
</tr>
<tr>
<td>Model 9 (Global): bare ground + grass height + shrub cover + shrub height + forb cover + forb height + Russian thistle + other</td>
<td>-1224.72</td>
<td>6.348</td>
<td>10</td>
<td>0.034</td>
</tr>
<tr>
<td>Model 6: grass height + forb height</td>
<td>-1245.07</td>
<td>34.950</td>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 2: bare ground</td>
<td>-1268.14</td>
<td>79.101</td>
<td>3</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 4: bare ground + shrub cover</td>
<td>-1268.04</td>
<td>80.900</td>
<td>4</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 8: bare ground + shrub height + forb cover + Russian thistle + other</td>
<td>-1267.17</td>
<td>85.204</td>
<td>7</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 1 (Null)</td>
<td>-1295.51</td>
<td>131.819</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 3: shrub cover + shrub height</td>
<td>-1294.68</td>
<td>134.171</td>
<td>4</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Table 2.8 Model beta estimates and 95% confidence intervals of Baird’s and grasshopper sparrows during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Asterisks indicate variables of Baird’s sparrow for which the 95% CI of the estimates did not include zero. X indicates variables of grasshopper sparrow for which the 95% CI of the estimates did not include zero.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baird’s sparrow</th>
<th>Grasshopper sparrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>0.008</td>
<td>-0.383</td>
</tr>
<tr>
<td>Bare Ground*</td>
<td>-0.329</td>
<td>-0.337</td>
</tr>
<tr>
<td>Grass Height x</td>
<td>0.093</td>
<td>0.477</td>
</tr>
<tr>
<td>Shrub Cover</td>
<td>-0.033</td>
<td>NA</td>
</tr>
<tr>
<td>Shrub Height*</td>
<td>-0.224</td>
<td>NA</td>
</tr>
<tr>
<td>Forb Cover*</td>
<td>-0.182</td>
<td>NA</td>
</tr>
<tr>
<td>Forb Height</td>
<td>-0.069</td>
<td>NA</td>
</tr>
<tr>
<td>Russian thistle*</td>
<td>-0.21</td>
<td>NA</td>
</tr>
<tr>
<td>Other</td>
<td>0.037</td>
<td>NA</td>
</tr>
</tbody>
</table>
Figure 2.7 Difference between grazing systems and type of point in the Mimms Ranch using descriptive statistics. The variables compared in these charts are variables of importance obtained in habitat selection.
Figure 2.7 Continued.
Whereas the continuously grazed pasture had more similar percentages of bare ground in all points (Baird’s sparrow = 51.9%, grasshopper sparrow = 55.6%, grid = 53.9%). Mean grass height was similar within species across grazing system (Figure 2.7). In agreement with the results from the habitat selection model, it can be seen that grasshopper sparrows were in areas with taller grasses (CON = 23.4 cm, ROT = 23.5 cm) than Baird’s sparrows (CON = 20.6 cm, ROT = 20.3 cm) or grid points (CON = 18.8 cm, ROT = 19.0 cm). Nevertheless, Baird’s sparrows appear to be found in taller grasses compared to the grid points in both grazing systems. Shrub cover was recorded in the points of only 7 grasshopper sparrows. For these 7 sparrows, I obtained the highest mean of shrub height of all point types at the rotational grazed pasture (60.2 cm) and the lowest mean shrub height of all point types in the continuous grazing system (36.5 cm). It should be noted that most grasshopper sparrows in 2017-2018 were caught in the rotational pastures. Baird’s sparrows obtained lower means in shrub height than the grid points in both grazing systems (CON = 46.6 cm, ROT = 41.9 cm) (Figure 2.7). The continuously grazed pasture had higher percentages of forb cover (BAIS = 0.41 %, GRSP = 0.88 %, GRID = 0.36 %) than the rotational pasture (BAIS = 0.16 %, GRSP = 0.31 %, GRID = 0.27 %). I found more Russian thistle across the rotational pasture (0.69 %) than the continuous pasture (0.32%). As previously found, Baird’s sparrow had the lowest percentages of Russian thistle in both pastures (CONT = 0.18 %, ROT = 0.09 %) and grasshopper sparrow the highest percentage of all at the rotational pasture (1.20%). Information about forb cover and Russian thistle must be considered cautiously because their percentages are less than 2% of the total cover.
**Discussion**

This study is the first to document Baird’s and grasshopper sparrow home range and habitat selection in West Texas. I found that the mean home range size was not different between Baird’s and grasshopper sparrows at the Marfa grasslands, but there was a lot of variability across individuals and years. Both species combined obtained a mean home range size of 5.87 ha. The results of habitat selection revealed that both species selected areas with less bare ground, and Baird’s sparrow selected areas with less forb cover, Russian thistle, and lower shrub height, whereas grasshopper sparrows selected areas with taller grasses.

In agreement with Strasser et al. (2018), I obtained similar results and larger mean of home range in Baird’s sparrow than grasshopper sparrow; nevertheless, I did not find significant difference between species. While home ranges of Baird’s and grasshopper sparrows were larger than home ranges of their relatives the Henslow’s sparrows (Bechtoldt and Stouffer 2005), home ranges were smaller than those of other sparrows during winter like Savannah sparrows (Ginter and Desmond 2005), Le conte’s sparrows (Baldwin et al. 2010), and vesper sparrows (Macías-Duarte and Panjabi 2013b). This result was expected because of their behavior of hiding and walking, and in agreement with Gordon (2000) who suggests that both species are inclined to have a fixed home range during winter. However, comparisons of home range sizes across studies should be taken with caution. Although most home ranges sizes are estimated with kernel density estimators, the estimates can vary substantially depending on the smoothing parameter used (Seaman et al. 1999).

Although most of the birds remained within a fixed home range, some of the birds moved far from their original area of capture, including one Baird’s sparrow with a home range area 8 times larger than the mean. Further, some birds disappeared from their capture site and moved...
so far that I could not relocate them. This might have led to an underestimation of the mean home range size for these birds. Williams and Boyle (2017) also found large distance movements of grasshopper sparrows within the breeding season. Likewise, Baldwin et al. (2010) found Leconte’s sparrows disappearing and others moving from their original capture area.

Out of the 7 linear regression models we tested to identify vegetation characteristics that influence home range size, the variable $\text{YEAR}$ provided the strongest predictor for variation in home range size. Although the top models indicate some support for an influence of species and grass cover, the 95% confidence intervals of their estimates included zero. It is possible this indicates that home range size is associated with other variables I did not consider, such as weather, food availability, bird density, and abundance or even presence of predators. For example, in Arizona, summer rainfall is negatively correlated with movement patterns of Baird’s and grasshopper sparrows (Gordon 2000), and this can be one variable that may affect variation in home range size. Seed abundance can be another variable influencing home range size. Although Ginter and Desmond (2005) did not find a relationship between home range size and seed abundance for Savannah sparrows, Benkman and Pulliam (1988) suggest that sparrows are restricted to areas of dense seed concentration, restricting their areas of movement.

The 4 most influential parameters in my habitat selection model of Baird’s Sparrow were bare ground, shrub height, forb cover, and Russian thistle. These results are in agreement with the findings of Henderson and Davis (2014) who found a decreased abundance of Baird’s sparrows with an increase in bare ground, and an increased abundance with vegetation volume. Also, my results agree with Macias-Duarte et al. (2009) that found an increased occurrence of Baird’s sparrows in areas with higher grass cover, which is negatively correlated with bare ground in their study. Macias-Duarte et al. (2009, 2017) also reported Baird’s sparrow avoids
tall shrubs, which is probably related to the increase of perches for their predator, the loggerhead shrike. I found that Baird’s sparrows selected for less forb cover, whereas Martinez-Guerrero et al. (2011) found that Baird’s sparrow abundance was positively correlated with forb cover in Cuchillas de la Zarca, Durango, Mexico. This could be related to a considerably higher percentage of forb cover in Cuchillas de la Zarca that Baird’s sparrow could be using as shelter, or a specific forb that this species could be consuming.

Grasshopper sparrow had the 2 most influential parameters in habitat selection: bare ground and grass height. My results support Ruth et al. (2014) results of a negative association of bare ground with grasshopper sparrows. Similarly, Macias-Duarte et al. (2009) reported preference of areas with dense grass cover and taller grass. Grasshopper sparrows were in areas with taller grasses in both grazing systems. Such similarities of this study with previous studies indicates that both sparrows stay for the most part within a fixed home range in winter in the Marfa grasslands compared to other sparrows in other study sites, and are clearly selecting areas with more vegetative cover (less bare ground).

Management implications

I found that both species of sparrow selected areas with less bare ground. In addition, grasshopper sparrow selected taller grasses, and Baird’s sparrow also selected smaller shrubs, less forbs, and Russian thistle. These habitat characteristics that Baird’s and grasshopper sparrows selected for are also associated with the ideal environment for cattle grazing (Holecheck 1991). Grazing and grassland birds are not necessarily rivals; moderate continuous grazing or rotational grazing systems appear to be if not favorable at least not detrimental for both species (Holechek 1991). I suggest that more research should be done in this regard so grazing can be used as a tool to maintain preferable habitat for grassland birds.
Although the results of the study showed the preferable habitat and home ranges of these species, I was not able to track all individuals, which may have affected home range size estimation. More information is needed to explain the location and movements of the missing birds. Putting more effort on finding birds that have gone missing from their capture area, and later with better and affordable technology, could fill a gap in information and give valuable information to better understand these species.

Sedentary birds like Baird’s and grasshopper sparrows can suffer a population decline when their preferred habitat is limited (Gordon 2000). Therefore, the habitat selection results of this study can be helpful for selecting areas with suitable habitat within the region to preserve (i.e., areas with dense grass cover, tall grass, and absence of shrubs). Moreover, this information can help managers to make decisions on which habitat characteristics to promote in habitat restoration efforts. Managers need to consider creating more of favorable habitat for grassland birds (i.e., more soil cover, taller grass, less shrub cover) by restoration of degraded areas. Shrub removal in encroached areas, prescribed fire, and reseeding can be used in order to create these habitat requirements (USDA-NRCS 2012).
LITERATURE CITED


Range Size and Movement Patterns of Savannah Sparrows Wintering in South Texas. 

117:748–759.

Sparrow (Centronyx bairdii). A. F. Poole and F.B. Gill, Editors. The Birds of North 


Robinson. 2003. Effects of Prairie Fragmentation on the Nest Success of Breeding Birds 

Rangelands 13:115–120.

Macías-Duarte, A., A. B. Montoya, C. E. Méndez-González, J. R. Rodríguez-Salazar, W. G. 
Hunt, and P. G. Krannitz. 2009. Factors Influencing Habitat Use by Migratory Grassland 

Macías-Duarte, A., and A. O. Panjabi. 2013a. Association of habitat characteristics with winter 
survival of a declining grassland bird in Chihuahuan Desert grasslands of Mexico. The 
Auk 130:141–149.


Strasser, E. H., and A.O. Panjabi. 2016. Identifying limiting factors for grassland birds wintering


CHAPTER III

WINTER SURVIVAL OF BAIRD’S AND GRASSHOPPER SPARROWS IN THE MARFA GRASSLANDS, TEXAS

Introduction

Grassland migratory birds are experiencing one of the fastest population declines in North America (Sauer et al. 2017). Baird’s sparrow (Centronyx bairdii) and grasshopper sparrow (Ammodyramus savannarum) have lost between 70–80% of their total population since 1966 (Sauer et al. 2017), and are currently identified as species of conservation concern by the U.S. Fish and Wildlife Service (USFWS), species of greatest conservation need by the Texas Parks and Wildlife Department’s (TPWD) Texas Conservation Action Plan, and priority birds of the Chihuahuan Desert by the Rio Grande Joint Venture.

In order to better understand and truly explain the reasons for their declines, it is important to study the species throughout their full annual cycle (Hostetler et al. 2015). Baird’s and grasshopper sparrow are long-distance migrants that inhabit the Chihuahuan Desert during the nonbreeding season, and this area is vital to the overwinter survival of these species (Máicas-Duarte and Panjabi 2013). However, most of the research studies conducted on these species are on their breeding grounds and only a few studies have been conducted at their wintering sites. Limiting factors during winter may indirectly reduce breeding success (Winder et al. 2012); therefore, it is important to obtain more information on winter survival estimates of grassland bird populations, and the factors affecting these winter survival rates.

Although little is known about their winter survival, one study estimated a weekly survival of 92.73% for Baird’s sparrow, and 93.48% for grasshopper sparrow in the winter of 2012-2013, and 98.78% during the winter of 2013-2014 for grasshopper sparrows (Máicas-
Duarte et al. 2017). Furthermore, the same study found winter survival was lower on colder days for both species and showed a negative association between grasshopper sparrow survival and shrub height. A similar study on vesper sparrows (Pooecetes gramineus) in the Chihuahuan Desert found a positive association of winter survival with vegetation structure, specifically grass height and shrub height, and reported a daily winter survival of 99.1% (Macías-Duarte and Panjabi 2013).

Thus, factors such as low temperatures and habitat structure may affect survival during winter (Macías-Duarte et al. 2017), and these effects may be exacerbated by habitat fragmentation and deterioration. In this regard, Baird’s and grasshopper sparrows are grassland obligate (Vickery et al. 1999) and therefore strongly depend on intact grasslands, making these birds very vulnerable to habitat changes (Pool et al. 2014). Both species prefer areas with dense grass cover and tall grass, and avoid areas with shrubs (Macías-Duarte et al. 2009, Martínez-Guerrero et al. 2011; Chapter 2). These habitat characteristics could be important for their winter survival.

Because winter survival for both Baird’s and grasshopper sparrows is lower on cold days (Macías-Duarte et al. 2017), microclimates may play a vital role in the winter survival of grassland birds. The thermal heterogeneity of microclimates near the ground can vary depending on vegetation structure (Suggitt et al. 2010), which may be one mechanism through which vegetation structure could be affecting survival. There are no studies regarding the effects of microclimate on grassland birds’ wintering grounds. Nevertheless, Tomecek et al. (2017) found that cover is an important thermal refuge in extreme weather for breeding northern bobwhite (Colinus virginianus), and a study of breeding sharp-tailed grouse (Tympanuchus phasianellus) found that grassland characteristics such as dense vegetation cover can be a protection from
unfavorable climate conditions (Raynor et al. 2018). The variation of temperatures in desert climates can be particularly extreme; in the Chihuahuan Desert grasslands, temperatures can vary almost 30˚ C within a single day (Weather Underground 2018), making the study of microclimates in relation to habitat structure and survival of particular relevance.

I used telemetry to study winter survival of these species to obtain a better information on their fate. I also studied habitat structure and used temperature data loggers to better understand the microhabitat selected by birds, and how this may affect their survival. This pilot study of microclimate can be used as a baseline for future studies on microclimates of grassland birds in their wintering grounds. I hypothesized that vegetation structure and temperature would have an effect on winter survival of Baird’s and grasshopper sparrows. In addition, I hypothesized that temperature in bird points would be less extreme than in random points, and that vegetative cover would have less extreme temperatures compared to bare ground.

**Study area**

The study area was located in the Marfa Grasslands within the Chihuahuan Desert. This area was identified as a Grassland Priority Conservation Area (GPCA) by the Commission of Environmental Cooperation in 2004 due to its ecological significance as wintering areas for migratory birds, rich in wildlife and intact grasslands (Pool and Panjabi 2011). The Marfa Grasslands are privately owned rangelands used mostly for cattle ranching and hunting (Pool and Panjabi 2011). I conducted field work on the Mimms Ranch, located within the Marfa grasslands GPCA just north of Marfa in Presidio County, Texas. The ranch measures 4,390 ha and is owned and operated by the Dixon Water Foundation. The Mimms Ranch has been actively grazed by cattle since 2008 and managed with a holistic grazing management plan. This grazing management is also known as a Savory grazing method that involves frequent movement of
animals and incorporates the growth cycle of the plants with their movements (Savory and Parsons 1980). The Ranch is divided into 2 different grazing regimes: one 858.3-ha pasture is continuously grazed by 30 cattle year-round, and the other consists of 30 pastures of roughly 100 ha each that are rotationally grazed by 80–100 cattle. Each of these pastures is subdivided in smaller pastures by movable electric fence and cattle are rotated every day. The study area is dominated by gramma grasses (*Bouteloua* spp.), threeawn grasses (*Aristida* spp.), Swallen’s curly mesquite (*Hilaria swallenii*), and a low density of mixed shrubs dominated by yucca (*Yucca* spp.) and mesquite (*Prosopis* spp.). The study area has an elevation of 1,450 m to 1,480 m, and a semi-arid climate with an average annual precipitation of 390 mm.

**Methods**

The methodology for this project follows the protocol developed by Bird Conservancy of the Rockies that is used at the other research sites: Janos (Chihuahua, MX), Cuchillas de la Zarca (Durango, MX) and Valle Colombia (Coahuila, MX), all within the Chihuahuan Desert in Mexico (Strasser et al. 2018).

**Capture**

I captured Grasshopper and Baird’s sparrows using active mist-netting techniques as approved by Sul Ross State University (SRSU) Animal Care and Use Committee, TPWD (permit number SPR-1216-286), and U.S. Fish and Wildlife Service (permit number 22415). I placed between 2-4 mist nets in a straight line through patches of dense, tall grass. With the help of 7-15 volunteers, we made a semicircle up to 200 m around each side of the nets to flush the birds toward the nets. To deter any birds from escaping, I used sticks with bright flagging attached as well as fabric frisbees to drive the birds toward the nets. I made an effort to capture the same ratio of both species, as much as possible, given local abundance each year.
Once captured, I banded all birds with a unique band from the U.S. Geological Survey and collect standard morphometric measurements including wing chord, tail, culmen, and tarsus length. I also scored fat, evaluated feather molt, determined age (when possible), and weight of the birds. One retrix feather (r4) was taken for future analysis to genetically determine sex for further analysis. I deployed Very High Frequency (VHF) transmitters PicoPip Ag379 (Biotrack Ltd, Dorset, UK) on the birds for future tracking. I placed a transmitter on the birds’ synsacrum using a harness of 1 mm nylon coated elastic that loops around the bird’s legs (Rappole and Tipton 1991). This method is more desirable than gluing the transmitter on the back of the bird because glue increases the mortality due to a lack of feathers during winter. The transmitters weighed 0.49 g, and the combined weight of the transmitter and harness did not exceed 5% of the bird’s mass. Individuals that weighed <15.5 g were released without a transmitter. In order to reduce stress, birds did not stay more than 30 min at the banding area before being released.

**Monitoring**

I radio-tagged and monitored birds from mid-December to mid-March 2016–2018 using a 3-element folding Yagi antenna and a Biotracker (LOTEK, Dorset, UK) receiver. I tracked and located individual birds once a day at different times between 0730 to 1800 hrs to avoid biasing results on habitat selection by time of day. I avoided taking locations before sunrise and after sunset because these species are not nocturnal and lack night vision. To obtain the most accurate location and to visually confirm bird location, I performed triangulation to obtain the true location of the birds. To avoid predation due to human disturbance, I did not flush birds while tracking if a known predator was in the area. Once located, I marked the location with a Global Positioning System unit (GPS) Garmin Oregon 650t (Garmin Ltd., Olathe, KS), recorded how the bird was detected (sight or signal), and noted the status of the bird (alive, dead, and seen in
good or bad condition). If a transmitter was found on a dead bird, I looked for signs of
depredation such as blood, feathers, tracks, or a damaged or chewed transmitter. If any signs
were found, I attempted to identify the cause of mortality.

I also tried to locate birds that went missing. I scanned for its frequency every day for a
week at different places, walking and driving throughout the ranch, and then once every week
thereafter until the expected life span of the transmitter had passed. Additionally, I flew in a
high wing monoplane once every winter to locate birds that might be more than 5 km away from
the study site. Because the transmitter batteries only last 40-55 days, I recaptured birds in the
middle of the season (early-mid January) to replace transmitters. At the end of the season (early
March), I attempted to recapture all birds in order to recover the transmitters and assess the
condition of the birds (i.e., tattered feathers or skin irritation).

**Vegetation Sampling**

I obtained visual estimates of ground cover within 5-m radius plots, for ≥20
radiotelemetry locations per bird. I also collected vegetation data across a grid of points spaced
every 100 m within the study area. I used Geographic Information System (GIS) and ArcMap
(Environmental Systems Research Institute, Inc., Redlands, CA) to delineate the grid of sampling
points based on the first month of bird tracking locations, ranch boundaries, and site
characteristics (avoiding places with >25% of shrub density and roads). To estimate vegetation
in each plot, I recorded percent cover of grass, forbs, Russian thistle (*Salsola* spp.), shrubs, bare
ground, and other cover (litter, rocks, etc.), with the total of each type of cover on each plot
equalling 100%. In addition, I recorded average height of grass, forbs, and shrubs as well as the
relative percent cover of the 3 most dominant grass genera. This is a quantitative sampling
method that is less time-consuming than other sampling methods, and used on the other 3 project
sites in Mexico. To reduce variability in data collection, all technicians were trained, and the cover estimates calibrated with one another at the beginning of the season. The technicians and I, continuously calibrated cover estimates throughout the rest of the season.

**Microclimate data**

To assess microclimate conditions, I placed 80 temperature loggers, iButton® DS1921 (Dallas Semiconductor, Sunnyvale, CA) accurate to 0.5 °C, in the rotationally grazed pasture from 10 February 2018 to 3 March 2018. During tracking of birds, I set a temperature logger at the location where I detected the bird immediately after observing it (loggers were only placed when the bird was detected before it moved from its original location, \( n = 40 \)), and I placed an additional 40 loggers at randomly selected vegetation grid points. Loggers were positioned 10 cm from the ground facing down where they measured temperature at the height of the bird. Each logger recorded temperature every 10 minutes. I calibrated loggers against a mercury thermometer, and recorded vegetation cover type and height of the vegetation at every logger location.

**Analysis**

**Survival**

To estimate winter survival of Baird’s and grasshopper sparrows, I used location data gathered throughout the 2016-2017 and 2017-2018 seasons. I excluded data of the first 7 days, after the birds were tagged to reduce potential bias, because the birds are more vulnerable to depredation within a few days after the transmitters are deployed. I used temperature and vegetation structure as explanatory variables that could be influencing survival of both species. As temperature explanatory variables, I considered minimum daily temperature, and average of minimum temperature of the current and previous 6 days (that I called “average weekly
minimum temperature” for practical purposes). I obtained daily minimum temperature records for both seasons from the Marfa airport weather station, which shares a border with the study site. For habitat structure variables, I used % of grass cover, grass height, % of shrub cover, shrub height, % of forb cover, forb height, % of Russian thistle, and % of bare ground. To avoid multicollinearity, I tested correlation within the variables (|r| > 0.6) to identify variables that were highly correlated with each other. Both species obtained the same correlations within variables. I found a strong correlation of minimum daily temperature with average minimum temperature (mean of the 6 previous days and day of detection). I ran the model once (with both species combined) for each of the temperature variables and compared these two models with AICc. Delta AICc for the comparison of the two models was smaller than 2 (ΔAIC = 0.43) but the model with average temperature had the highest Akaike weight (0.55), therefore I decided to keep average minimum temperature and delete daily minimum temperature from further analysis. Bare ground was strongly correlated with grass cover. I ran the model once with bare ground and once with grass cover for both bird species combined and compared the two models with AICc (Burnham and Anderson 2002). Delta AICc for the comparison of the two models was smaller than 2 (ΔAIC = 0.78) but bare ground had the highest Akaike weight (0.59), therefore I decided to keep bare ground and remove grass cover from my models. Shrub cover and shrub height also showed a correlation of r > 0.6; I therefore removed shrub cover because I previously found shrub height was an important variable for habitat selection (see Chapter 2), and Macias-Duarte et al. (2017) also found an association of grassland bird survival with shrub height.

I then used logistic exposure to explicitly model winter survival (Shaffer and Burger 2004). This method provides similar results to the “nest survival” model in program MARK.
(White and Burnham 1999) and allows the user to account for the exposure period of the individual (i.e., time that an individual is tracked) and accounts for birds that I started tracking at different times throughout the winter season (Shaffer and Burger 2004). The models were run for Baird’s and grasshopper sparrow separately. I constructed 22 models to explore which environmental variables influenced survival (Table 3.1). The models were constructed based on literature and personal experience, and included different combinations of the following variables: average minimum temperature, forb presence, forb height, shrub height, bare ground, grass height, Russian thistle, and other cover. To be able to directly compare the estimates of the regression coefficients of every variable, I scaled all variables using the “scale” function in base R. The variable “forb cover” contained outliers that disallowed me to proceed with the analysis, therefore, I developed and included a binary metric of “forb presence” that indicated whether or not any forbs were present at the survey point. I then fitted the models with the glmm function and the logistic-exposure link function (Shaffer and Burger 2004) using package lme4 (Bates et al. 2015) in program R (R Core Team 2016). I used Akaike Information Criterion for small sample size (AICc), to compare and identify the best-performing models. All models with ΔAIC < 2 where included in further analysis to determine which variables influenced winter survival (Burnham and Anderson 2002).

Microclimate Analysis

I compared daily temperature fluctuations between bird and random locations by comparing the pooled temperature distributions for bird and random points, respectively, with a Kolmogorov-Smirnov two-sample t-test using the ks.test function in base R (R Core Team 2016), with the null hypothesis being that the distributions were similar. I then compared the average mean, minimum, and maximum temperatures between bird and random locations and
Table 3.1 Candidate models used for Baird’s sparrows and grasshopper sparrows, separately, to explain survival during the winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas.

<table>
<thead>
<tr>
<th>Model</th>
<th>Model Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Null) 1</td>
<td>Survive/trials ~ 1</td>
</tr>
<tr>
<td>2</td>
<td>Survive/trials ~ Temperature</td>
</tr>
<tr>
<td>3</td>
<td>Survive/trials ~ Bare ground</td>
</tr>
<tr>
<td>4</td>
<td>Survive/trials ~ Grass height</td>
</tr>
<tr>
<td>5</td>
<td>Survive/trials ~ Shrub height</td>
</tr>
<tr>
<td>6</td>
<td>Survive/trials ~ Forb presence</td>
</tr>
<tr>
<td>7</td>
<td>Survive/trials ~ Russian thistle</td>
</tr>
<tr>
<td>8</td>
<td>Survive/trials ~ Temperature + Bare ground</td>
</tr>
<tr>
<td>9</td>
<td>Survive/trials ~ Bare ground + Grass height</td>
</tr>
<tr>
<td>10</td>
<td>Survive/trials ~ Bare ground + Shrub height</td>
</tr>
<tr>
<td>11</td>
<td>Survive/trials ~ Bare ground + Forb presence</td>
</tr>
<tr>
<td>12</td>
<td>Survive/trials ~ Bare ground + Russian thistle</td>
</tr>
<tr>
<td>13</td>
<td>Survive/trials ~ Temperature + Grass height + Bare ground</td>
</tr>
<tr>
<td>14</td>
<td>Survive/trials ~ Temperature + Bare ground + Shrub height</td>
</tr>
<tr>
<td>15</td>
<td>Survive/trials ~ Temperature + Bare ground + Forb presence</td>
</tr>
<tr>
<td>16</td>
<td>Survive/trials ~ Temperature + Bare ground + Russian thistle</td>
</tr>
<tr>
<td>17</td>
<td>Survive/trials ~ Bare ground + Shrub height + Russian thistle</td>
</tr>
<tr>
<td>18</td>
<td>Survive/trials ~ Temperature + Bare ground + Grass height + Shrub height</td>
</tr>
<tr>
<td>19</td>
<td>Survive/trials ~ Temperature + Bare ground + Shrub height + Forb presence</td>
</tr>
<tr>
<td>20</td>
<td>Survive/trials ~ Bare ground + Shrub height + Forb presence + Russian thistle</td>
</tr>
<tr>
<td>21</td>
<td>Survive/trials ~ Temperature + Bare ground + Shrub height + Forb presence + Russian thistle + Grass height</td>
</tr>
<tr>
<td>(Global) 22</td>
<td>Survive/trials ~ Temperature + Forb presence + Forb height + Shrub height + Bare ground + Grass height + Russian thistle + Other</td>
</tr>
</tbody>
</table>
vegetation types with linear mixed models (for each average) with vegetation (bare ground, short grass, medium to tall grass), sampling location (bird, random), date as fixed effects, and logger ID as a random effect to control for logger-specific variation. I used lmer function from the packages lme4 (Bates et al. 2015) in program R (R Core Team 2016). Medium and tall grass were grouped because preliminary analysis indicated they were not different, and to make the distinction between grazed patches (short grass) and non-grazed patches (medium to tall grass). Rocks, litter, and bare ground were all grouped under bare ground, because the individual categories were too small to be meaningful in the analysis.

Results

Survival

Throughout all my research, I tagged a total of 144 sparrows (88 BAIS, 56 GRSP): 66 individuals (40 BAIS, 26 GRSP) the winter of 2016-2017, and 78 individuals (48 BAIS, 30 GRSP) in the winter of 2017-2018. One grasshopper sparrow was captured and tracked both winters. I captured another grasshopper sparrow during winter 2017-2018, that had been previously captured during summer 2017. It is possible that this individual was a resident because I captured the individual in nearly the same location. I collected a total of 4,176 bird locations: 1,855 first winter and 2,321 second winter. I did not include the first week of monitoring in the survival analysis because mortality or disappearance could possibly have been caused by manipulating the birds. Therefore, out of the 144 sparrows tagged, I used only 113 for survival analysis.

Throughout the 2 winters, I recorded 17 mortalities and 2 birds with unknown fate in which I was unable to determine if the transmitter fell off or the bird died. I determined 5 cases of depredation by raptors and 5 by loggerhead shrike (*Lanius ludovicianus*). Also, 3 appeared to
die from extreme low temperature and 4 died from unconfirmed causes. Diurnal raptors and loggerhead shrikes appeared to be the main cause of depredation. The first winter had notably less mortalities (0 Baird’s sparrows and 2 grasshopper sparrows) compared to second winter (5 Baird’s sparrows and 10 grasshopper sparrows). Around 20% of the birds went missing and I was not able to acquire information on their whereabouts; there were 13 missing individuals in winter 2016-2017 and 10 individuals in winter 2017-2018.

Estimation of daily survival extrapolated by 85 days (total days of the winter season) for Baird’s sparrow was $\hat{s} = 100\%$ for winter 2016-2017, and $\hat{s} = 70.24\%$ (95 % confidence interval: 47.90 % - 84.42 %) for winter 2017-2018. Estimation of daily survival extrapolated by 85 days for grasshopper sparrow was $\hat{s} = 77.67\%$ (95 % confidence interval: 44.59 % - 92.41 %) for winter 2016-2017, and $\hat{s} = 44.22\%$ (95 % confidence interval: 25.55 % - 61.73 %) for winter 2017-2018 (Figure 3.1).

For Baird’s sparrow, I identified 6 top models out of the 22 candidate models with $\Delta\text{AICc} < 2$ (Table 3.2). The top model predicting survival, contained bare ground and shrub height (Model 10; Akaike weight = 0.135). Model 5 (Akaike weight = 0.131), included only shrub height, and received almost the same support as the top model ($\Delta\text{AICc} = 0.06$). The other 4 models included one or more of the variables bare ground, grass height, shrub height, and “average minimum temperature” (Table 3.2). I identified 3 top models with $\Delta\text{AICc} < 2$ (Table 3.2) for grasshopper sparrow. The top model predicting survival of grasshopper sparrow included only “average minimum temperature” (Model 2; Akaike weight = 0.230). This model was 1.04 times better than the null model (Akaike weight = 0.137). The third model with $\Delta\text{AICc} < 2$ included “average minimum temperature” and bare ground (Model 8; Akaike weight = 0.087).
Figure 3.1 Winter survival and confidence intervals of winters 2016-2017 and 2017-2018 for Baird’s and grasshopper sparrows in the Marfa grasslands, Texas.
Table 3.2 Rank of models explaining survival of both species with ΔAICc value lower than 2, during winters 2016-2017 and 2017-2018 in the Marfa Grasslands, Texas.

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>loglik</th>
<th>ΔAICc</th>
<th>df(K)</th>
<th>AICc weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baird's sparrow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 10: Bare ground + Shrub height</td>
<td>-30.623</td>
<td>0.00</td>
<td>3</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td>Model 5: Shrub height</td>
<td>-31.656</td>
<td>0.06</td>
<td>2</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>Model 14: Temperature + Bare ground + Shrub height</td>
<td>-30.052</td>
<td>0.87</td>
<td>4</td>
<td>0.088</td>
</tr>
<tr>
<td></td>
<td>Model 18: Temperature + Bare ground + Grass height + Shrub height</td>
<td>-29.260</td>
<td>1.29</td>
<td>5</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td>Model 2: Temperature</td>
<td>-32.527</td>
<td>1.80</td>
<td>2</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>Model 3: Bare ground</td>
<td>-32.597</td>
<td>1.94</td>
<td>2</td>
<td>0.051</td>
</tr>
<tr>
<td><strong>Grasshopper sparrow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 2: Temperature</td>
<td>-69.371</td>
<td>0.00</td>
<td>2</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Model 1: Null</td>
<td>-70.892</td>
<td>1.04</td>
<td>1</td>
<td>0.137</td>
</tr>
<tr>
<td></td>
<td>Model 8: Temperature + Bare ground</td>
<td>69.341</td>
<td>1.95</td>
<td>3</td>
<td>0.087</td>
</tr>
</tbody>
</table>
I averaged the regression coefficients and 95% confidence intervals of the predictors in the top models for each species. Among all variables, the only variable that predicted Baird’s sparrow survival was shrub height, which was the only variable for which the 95% CI did not include zero (Table 3.3). All variables included zero in 95% CI for Grasshopper sparrow.

**Microclimate data**

Average daily temperature from 10 February to 3 March 2018 was 11.88 °C (± 3.58 °C) at bird points and 12.07°C (± 3.45 ºC) at random points. The average minimum daily temperatures at bird points and random points were -3.48 °C (± 4.86 ºC) and -2.84 °C (± 4.78 ºC) respectively. Maximum daily temperatures at bird points and random points were 34.00 °C (± 5.58 ºC) and 32.84 °C (± 5.70 ºC), respectively.

I found that the distribution of the daily temperatures was different for bird locations and random locations (D = 0.039, P = 0.015) (Figure 3.2). Average maximum temperatures were higher at bird locations whereas the average minimum temperatures were lower at bird locations.

The results show that, when controlling for vegetation type, logger location (bird/random) did not affect mean, minimum, or maximum daily temperatures (all p > 0.05). Mean daily temperature was not affected by vegetation type (p =0.125) (Figure 3.3). However, vegetation type had an effect on minimum (p < 0.001) and maximum daily temperatures (p = 0.011). After running a post-hoc test (Tukey LSD), I found that minimum daily temperature was lower in short grass compared to bare ground or medium-tall grass (Figure 3.2), and maximum daily temperature was lower for bare ground compared to medium-tall grass.

Vegetation type and logger location were related (Chi-square test: χ²=469.99, P < 0.001); there was more short grass in bird locations, and bare ground was only found in random
Table 3.3 Model averaged regression coefficients (beta estimates) and 95% confidence intervals for the variables in the top models (ΔAICc < 2) for Baird’s sparrow and grasshopper sparrow during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Asterisks indicate variables for which the 95% CI of the estimates did not include zero.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Estimate (β)</th>
<th>Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2.5%</td>
</tr>
<tr>
<td><strong>Baird’s sparrow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bare ground</td>
<td>-0.652</td>
<td>-1.60</td>
</tr>
<tr>
<td>Shrub height*</td>
<td>-0.480</td>
<td>-0.87</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.600</td>
<td>-0.45</td>
</tr>
<tr>
<td>Grass height</td>
<td>-0.076</td>
<td>-1.40</td>
</tr>
<tr>
<td><strong>Grasshopper sparrow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>0.531</td>
<td>-0.09</td>
</tr>
<tr>
<td>Bare Ground</td>
<td>0.071</td>
<td>-0.50</td>
</tr>
</tbody>
</table>
Figure 3.2 Pooled temperature distributions from 10 February 2018 to 3 March 2018 for bird (Baird’s and grasshopper sparrows) and random locations at the Marfa Grasslands, from 0000 to 2350 hours. Bars represent measurements that are 10 min. apart and indicate the mean temperature (°C) ± 95% CI.
Figure 3.3 Average mean, minimum, and maximum daily temperatures (°C) from 10 February 2018 to 3 March 2018 for the three different vegetation classes. Bars are means ± 95% CI.
locations (Table 3.4). Consequently, this explains why temperatures appear more extreme (lower minimum and higher maximum) at bird locations compared to random locations looking at the two distributions.

Discussion

This study shows the first estimates for winter survival of any grassland bird in the Marfa grasslands. Winter survival estimates for Baird’s and grasshopper sparrows were higher for the winter of 2016-2017 (100% and 77.67% respectively) than for the winter of 2017-2018 (70.24% and 44.22% respectively), and higher for Baird’s than grasshopper sparrow. I found a negative association of shrub height with winter survival of Baird’s sparrows. This study is also the first attempt to determine the association of vegetative cover with microclimates during winter that may be affecting sparrows. Results showed that microclimates are affected by vegetation structure, and that survival may be influenced by low temperatures, indicating a potential relation between microclimates, vegetation structure, and winter survival.

According to Strasser et al. (2018), estimation of daily winter survival for both Baird’s and grasshopper sparrows throughout the Chihuahuan Desert can fluctuate from 2-100% depending on year and site. I converted our winter survival metrics to daily survival estimates to directly compare to other sites in the Chihuahuan Desert. I found probabilities of daily survival for Baird’s and grasshopper sparrows of 100% and 99.70%, respectively, in the winter of 2016-2017, and 99.58% and 99.04%, respectively, in the winter of 2017-2018. I also found a negative association of shrub height with winter survival of Baird’s sparrows. Macias-Duarte et al. (2017) found similar daily survival probabilities for grasshopper sparrows of 99.04% and 99.82% during the winters of 2012-2013 and 2013-2014 respectively, and a lower daily survival probability of 98.93% for Baird’s sparrows during winter 2012-2013. A study on Vesper sparrows in the
Table 3.4 Number of loggers in the three different vegetation categories in bird and random locations during winters 2016-2017 and 2017-2018 in the Marfa grasslands, Texas. Parentheses indicate the expected cell counts under the null hypothesis of independence.

<table>
<thead>
<tr>
<th></th>
<th>Bare ground</th>
<th>Short grass</th>
<th>Tall grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird locations</td>
<td>0 (178.23)</td>
<td>198 (133.69)</td>
<td>682 (568.1)</td>
</tr>
<tr>
<td>Random locations</td>
<td>352 (173.77)</td>
<td>66 (130.33)</td>
<td>440 (553.9)</td>
</tr>
</tbody>
</table>
Chihuahuan Desert found a daily survival probability of 99.1% in winters 2009 and 2010 (Macías-Duarte and Panjabi 2013), showing similarity in survival estimates of sparrows in the Chihuahuan Desert.

Winter survival of Baird’s sparrows was negatively related to shrub height. Macías-Duarte et al. (2017) found a similar negative association between shrub height and survival for grasshopper sparrows in Janos, Chihuahua. Furthermore, my results provide some support for an influence of temperature and grass cover on winter survival. Although the 95% CIs for these variables included zero, both variables were included in the best AICc models of both species. It is possible that I did not find enough evidence because more data is necessary, or because of the good condition and little variability of cover throughout the study site. Especially “Average minimum temperature” seems to be an important factor. Five of the 9 best AICc models predicting survival of both species included temperature. Also, using the 90% confidence interval of the estimate of “average minimum temperature” in grasshopper sparrow is all above zero (CI: 0.01 to 1.05), indicating that the increment of temperature might be associated with survival of this species. In this regard, Macias-Duarte et al. (2017) found that lower temperatures during winter affected survival of both species in the Chihuahuan Desert.

Consecutive days of low temperatures in the Marfa Grasslands were more frequent in winter 2017-2018 than in winter 2016-2017 (Figure 3.4). Also, average minimum daily temperature was lower in winter 2017-2018 compared to winter 2016-2017. These low temperatures may affect the survival of the species and may be the reason survival was considerably different between years and had lower survival rates in winter 2017-2018 compared to winter 2016-2017 for both species. Other factors not considered here could also explain the variability of survival
Figure 3.4 Minimum daily temperature at the Marfa grasslands from December 14 to March 10 of the winters 2016-2017 and 2017-2018.
between winters, like density of predators in the study area, or summer rainfall to produce food or shelter for these sparrows.

My results on microclimate showed more extreme temperatures in bird points compared to random points, probably caused by the difference in vegetation cover between bird and random points. However, loggers were only placed at bird points observed during daytime hours. Therefore, these points may not be a representative sample for daily minimum temperature, considering that birds may be in different areas during the night. Baird’s and grasshopper sparrows depend on vegetation for cover from predators and harsh weather. The results show that short grass may not provide protection from cold temperatures. Based on this result, more detailed research must be conducted to determine the relation between vegetation structure, minimum daily temperatures, and survival.

**Management implications**

Two winters of survival studies showed that shrub height negatively affected winter survival of Baird’s sparrow, and indicated that cold temperatures may also negatively affect winter survival of Baird’s and grasshopper sparrows. The conservation of the remaining grasslands and restoration of the grassland ecosystem is vital for the survival of these species. Therefore, these results indicate that management for these species should focus on reducing shrub cover and promoting tall, dense grass cover. Better grazing management can be a tool to get dense and tall grass cover to provide thermal coverage and protection from predators. I recommend the continued study of winter survival of Baird’s and grasshopper sparrows in the Marfa grasslands over more years to measure more annual variation, obtain more conclusive evidence on the variables affecting their winter survival, and include to the study the relationship of survival with density of predators and summer rainfall.
LITERATURE CITED


VITA

Name: Denis Josefina Perez-Ordonez

Address: Department of Natural Resource Management
College of Agricultural and Natural Resource Sciences
Sul Ross State University
Box C-21 Alpine, TX 79832

E-mail Address: denisjperezo@gmail.com

Education: B. S., Ecology Engineering, Universidad Autonoma de Chihuahua,
Chihuahua, Mexico, 2009

M. S., Range and Wildlife Management, Sul Ross State University,
Alpine, 2019