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Habitat relationships of grassland birds in the Chihuahuan Desert

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Location(s):

Mimms Ranch, Marfa, TX

Objective(s):

1. Map Chihuahuan Desert grasslands,
2. Monitor wintering grassland bird assemblages associated with the desert grasslands,
3. Assess habitat conditions of desert grasslands, and
4. Evaluate bird-habitat relationships relative to habitat conditions in the study area of west Texas and northern Mexico.

Significant Deviation(s):

No significant deviations during this reporting period.

Background

In December 2016, Borderlands Research Institute (BRI) started monitoring overwinter survival and habitat use of Baird's and Grasshopper sparrows in the Marfa grasslands. In March 2019 we completed our third winter investigating winter survival and habitat relationships of Baird's and Grasshopper sparrows. In this report we present the work conducted during three winter seasons and present the final results obtained. We also present results on the Transboundary Conservation Program.

Introduction

Populations of grassland birds that winter in northern Mexico and southern United States are declining more than any other bird group in North America (Rosenberg et al. 2019). Baird's Sparrow (*Ammodramus bairdii*) and Grasshopper Sparrow (*Ammodramus savannarum*) have lost between 70–80% of their total population since 1966 (Sauer et al. 2017) and are identified as birds of conservation concern by the U.S. Fish and Wildlife Service (2008), species of greatest conservation need by the Texas Parks and Wildlife Department's Texas Conservation Action Plan (2011), and Chihuahuan Desert priority birds by the Rio Grande Joint Venture (2015). Yet causes of these declines are poorly understood, although habitat loss and degradation are thought to be the main causes. Shrub encroachment is also reducing the availability of suitable habitat for open-grassland obligates (Panjabi et al. 2010). The

Chihuahuan Desert is the critically important winter range to the survival of Baird's and Grasshopper sparrow species (Macias-Duarte et al. 2012; 2018). Birds are good indicators of the biological integrity of ecological systems and are useful for monitoring change in these systems. Despite the importance of understanding the ecological benefits of grassland birds (e.g., feeding on vegetation, invertebrates, and vertebrates; spreading seeds; being an indicator of biological integrity with the ecosystem, etc.), the study of grassland birds in the southern United States is limited. Bird Conservancy of the Rockies (BCR) has conducted a project "Identifying limiting factors for wintering grassland birds in the Chihuahuan Desert" for the last 7 years in three sites across the Chihuahuan Desert (Strasser et al. 2018). The principal site has been monitored since the winter of 2012-13 in Janos Chihuahua. Later two other sites in Mexico were added in collaboration with Universidad Autónoma de Nuevo León (UANL) and Universidad Juárez del Estado de Durango (UJED); one in Cuchillas de la Zarca, Durango, and in Valle de Colombia, Coahuila. In 2016-2017 we started monitoring a fourth site in Marfa, TX, which is the only winter site in the U.S.

Methods

We followed the methodology developed by Bird Conservancy of the Rockies (BCR) for three sites in Mexico: Janos (Chihuahua), Cuchillas de la Zarca (Durango) and Valle Colombia (Coahuila), within the Chihuahuan Desert in Mexico (Strasser et al. 2018). This will allow us to compare results across the study sites.

Study site

Field work was conducted at the Mimms Ranch, located in the Marfa Grassland Priority Conservation Area (CEC and TNC 2005; Fig. 1). The ranch is owned and operated by the Dixon Water Foundation since 2008. It encompasses 4,390 ha divided in 30 rotationally grazed pastures of approximately 105 ha grazed by 180-190 cattle, and one 858.3 ha pasture that is continuously grazed by 30 cattle. The study area is dominated by grama grasses (*Bouteloua* spp.), three awn grasses (*Aristida* spp.), and curly mesquite (*Hilaria belangeri*), and receives an average annual precipitation of 390 mm.

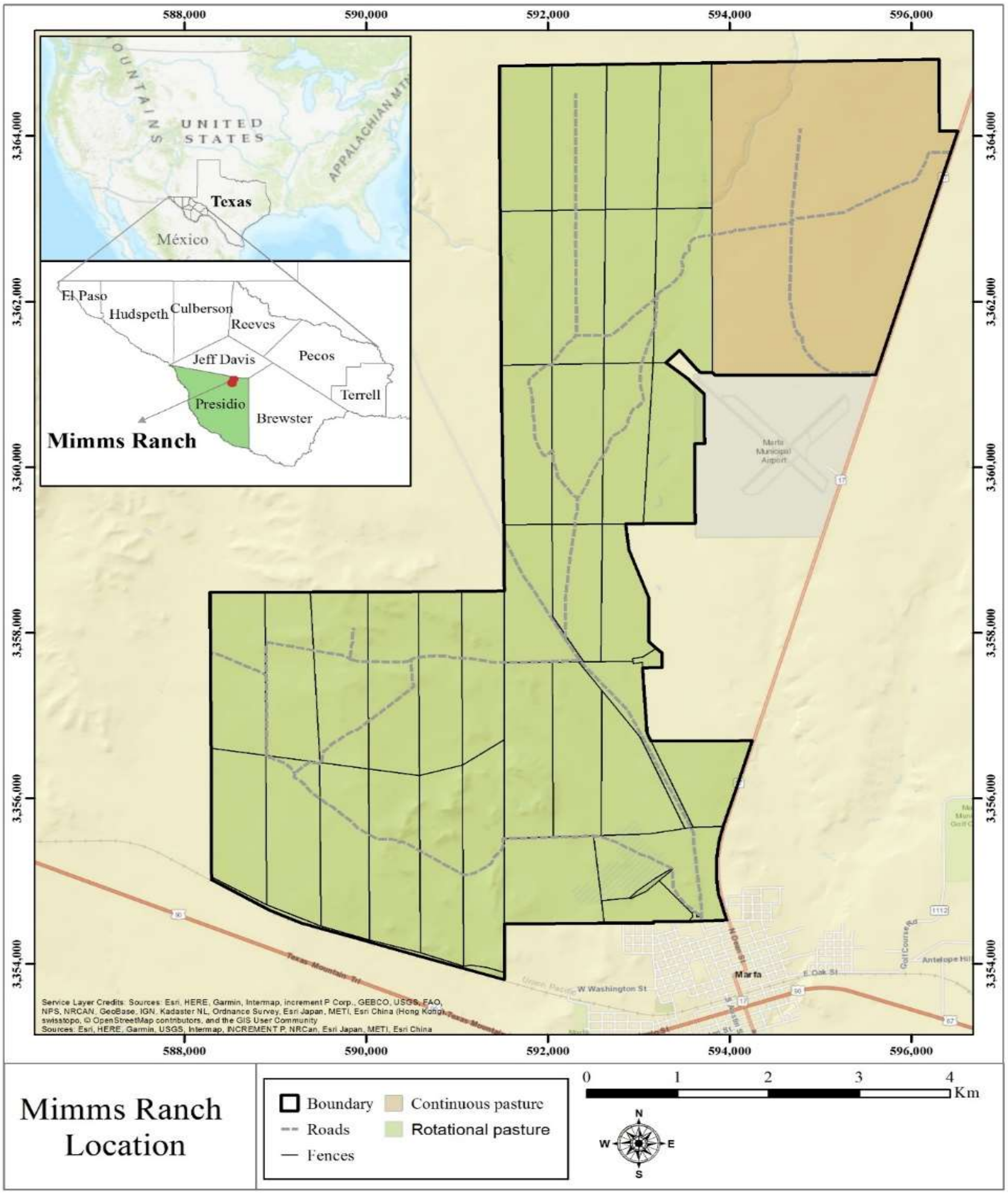

Figure 1. Study site.

Mist-netting

Grasshopper and Baird's sparrows were trapped using active mist-netting techniques as approved by SRSU Animal Care Committee, Texas Parks and Wildlife Department (permit number SPR-1117-238), and U.S. Fish and Wildlife Service (permit number 22415). We only captured in the rotationally grazed pasture in 2016-17 and 2018-19, and in both the rotationally and continuously grazed pastures in 2017-18. The first two winters, mist nets were placed in locations with appropriate habitat for the target species. In 2018-2019 we used a systematic mist-netting approach (Ruth et al. 2014). We randomly selected 20 grid points from the study polygon. In these points we placed a straight line of 4 mist nets of 12 m each. With the help of 15-20 volunteers, we then made a semicircle of exactly the same size around each side of the net for all 20 net points (Fig. 2), to flush birds inside the circle towards the net. We used sticks and Frisbees to try and keep birds inside the circle (Fig. 3). Trained observers made an attempt to identify all birds that escaped from the circle. In all seasons, captures took place mid-December, late January and early March.

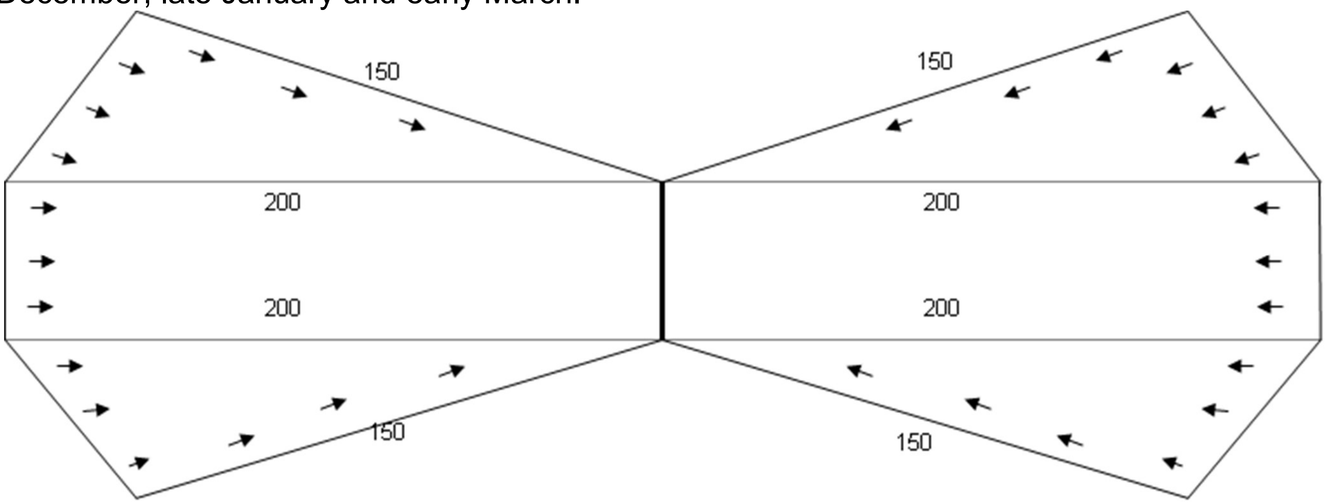

Figure 2. Representation of the systematic mist-net plots. Each plot consisted of 4 mist-nets of 12 m each.

Figure 3. In a semi-circle, staff and volunteers flush birds towards the mist-nets using sticks to keep birds inside the circle (photo by Paul Slocumb)

Once captured, we banded Baird's, Grasshopper, and Savannah sparrows with a unique band of the U.S. Geological Survey, collected standard morphometric measurements (wing cord, tail length, culmen and tarsus length), scored fat, assessed feather molt, determined age (when possible), and weighed the birds. Other species were recorded as being present in the mist-net plot and released. For Baird's and Grasshopper sparrows, we collected retrix 3 feathers for future analysis to genetically determine sex. We then deployed Very High Frequency (VHF) transmitters (PicoPip Ag379, Biotrack Ltd, Dorset, UK) on these two species to allow us to track them. Transmitters were placed on the bird's synsacrum using a harness that looped around the bird's legs. The transmitters weighed 0.49 g, and the combined weight of the transmitter and harness did not exceed 4% of the bird's mass. Birds that weighted <15.5g were released without a transmitter. We attempted to recapture tagged birds in January to replace their transmitter (battery life is 40-55 days) and in early March to remove transmitters before migration.

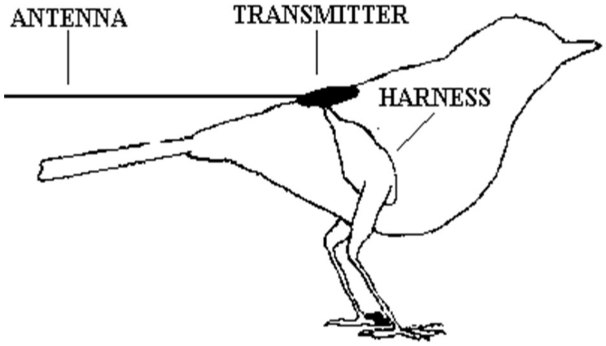

Figure 4 and 5. Position of the radio-transmitter and harness.

Monitoring

For three consecutive winters (2016-2019) Baird's and Grasshopper sparrows were monitored daily from mid-December to mid-March. Each radio-tagged bird was tracked and located once a day at different times of day between 0730 to 1800 h. We used triangulation to circle the birds and obtain their true location and not a location influenced by human disruption. Once located, we marked the location with a GPS unit. We recorded whether the bird was detected by sight or signal and noted the status of the bird (alive, dead, seen in good or bad condition). If a transmitter was found on a dead bird, we looked for signs of depredation such as blood, feathers, tracks, or a damaged or chewed transmitter. If any signs were found, we would attempt to identify the cause of predation. An extensive effort was made to locate birds that went missing (walking, driving, and searching by plane). Once a bird went missing, we scanned for its frequency every day for a week in different places throughout the ranch, and then once every week thereafter, until the expected life span of the transmitter had passed. At the end of the season, efforts were made to recapture all birds in order to take off the transmitters and assess the condition of the birds (conditions such as tattered feathers or skin irritation).

Figure 6. Denis Perez is looking for radio-tagged sparrows holding a 3 point Yagi antenna.

Habitat data

On the ground vegetation surveys were conducted using visual estimates of ground cover within a 5-m radius plot (Fig. 7), recording percent cover of grass, forbs, Russian thistle (*Salsola*), shrubs, bare ground, and other cover (litter, rocks, etc.). In addition, we recorded average height of grass, forbs, and shrubs as well as the relative percent cover of the three most dominant grass genera. Observers calibrated their measurements at the beginning of the season, and continued to calibrate throughout the season. Data from BCR comparing ocular and quantitative sampling indicates that both methods provide similar results when observers are trained and calibrate their measurements. Therefore, ocular sampling of vegetation cover parameters provides a reasonably accurate assessment of vegetation conditions without the associated time or expense of high-intensity sampling. We collected vegetation data across a grid of points spaced every 100 m throughout the study area. The study area was delineated based upon bird banding and tracking locations. During the first winter we only captured and tracked birds in the rotationally grazed sites. In December 2017 we added a second study site in the continuous grazed pasture. We also collected vegetation data for a minimum of 20 locations per bird.

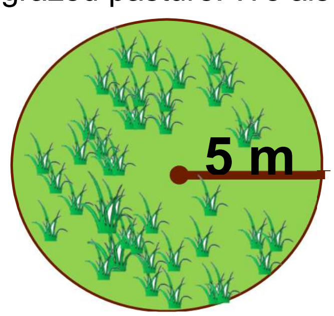

Figure 7. Schematic representation of the 5-m radius plot used to estimate vegetative cover.

Overwintering grassland birds depend on vegetation for thermal cover. In February 2018 and 2019 we placed 80 temperature loggers (iButton® DS1921) in the study site to explore the role of microclimates in movement patterns and habitat preferences. Forty loggers were placed in the exact location where a bird was observed while tracking it, and 40 loggers were placed in randomly selected grid points. We recorded cover type and height, took photos, and marked the point with a GPS. Loggers were staked into the ground with orange flags at 10 cm from the surface, facing down, to measure the temperature at the height of the birds. Temperatures were recorded every 10 min from early February to mid-March with an accuracy of 0.5 ºC. We calibrated the loggers against a mercury thermometer.

Figure 8. A temperature logger used to assess microclimates in the rotationally grazed site.

Results

Data collected

We tagged a total of 217 sparrows in three winters, for which we collected 6,486 bird locations (Table 1 and 2). In total, we collected vegetation data for 3,116 of these bird locations. In each year we also collected vegetation data in a grid of points spaced evenly throughout the study site, summing up to 1,548 vegetation surveys in total.

Table 1. Number of birds tagged, number of bird location, and number of vegetation plots surveyed in the three different winter seasons.

	2016-2017	2017-2018	2018-2019
# tagged	66	78	73
# bird locations	1,855	2,321	2,310
# veg points -birds	837	1,148	1,181
# veg points - grid	420	704 (424 Rot - 284 Cont)	424

Table 2 shows the number of birds that were banded and radio-tagged and their fate. In 2017-18 we recaptured one Grasshopper Sparrow that was banded and followed during the first winter. In that year we also recaptured one Grasshopper Sparrow that was banded in the summer of 2017 in a different project but at the same location. In 2018-19 we recaptured 2 Grasshopper Sparrows, one from 2016-17 and one from 2017-18. In that year we also banded, tagged, and tracked one Sprague's Pipit. The second Sprague's Pipit was captured and banded in March, and therefore not tagged.

Mid-season recapture success was improved in 2017-18 and 2018-19 compared to 2016-17; the first season we recaptured 4 tagged birds to replace their radio-transmitter and in the second season 14 and 18 birds were recaptured to replace (January) or remove (March) their transmitter (Table 2). The improved success is probably due to the change in recapture method; in 2016-17 we tracked a bird and then tried to flush it into the net using the same capture technique described above, whereas in 2017-18 we recaptured tagged birds by using mobile nets that were placed on top of a located bird (Fig. 9). We found this new method to work especially well with birds that allowed us to come close to them. The majority of the recaptured birds were in good condition, with a minor irritation on skin of legs and some back feathers on the back were missing.

Figure 9. In 2017-18 and 2018-19 we improved recaptures success of radio-tagged birds by using mobile mist-nets that were placed over a previously located bird.

Table 2. Number of birds by species that were banded, radio-tagged and recaptured, and number of mortalities, missing birds and confirmed survivals in three winter seasons.

	2016-2017			**2017-2018**			**2018-2019**			
	BAIS	**GRSP**	**Total**	**BAIS**	**GRSP**	**Total**	**BAIS**	**GRSP**	**SPPI**	**Total**
# Banded[a]	46	30	**76**	55	35	**90**	51	53	2	**106**
# Tagged[b]	40	26	**66**	48	30	**78**	35	37	1	**73**
# Recaptured[c]	2	2	**4**	4	12	**16**	6	14	0	**20**
# Dead[d]	2	1	**3**	11	10	**21**	7	6	0	**13**
# Radio fell off[e]	6	4	**10**	0	0	**0**	1	5	0	**6**
# Missing/unknown[f]	14	5	**18**	17	7	**24**	10	8	0	**18**
# Survived[g]	17	12	**29**	20	13	**33**	16	18	1	**35**

[a]**Banded:** Number of birds banded, including birds with and without transmitter. Recaptures not included.
[b]**Tagged:** Number birds with transmitter. Birds tagged more than one time count like one individual.
[c]**Recaptured:** Number of birds recaptured in January.
[d]**Dead:** Birds found dead by depredation or other cause.
[e]**Radio fell off:** Radio is found within the first week of capture.
[f]**Missing/unknown:** Birds not found after an extensive searching effort, or when it is not obvious if the bird is dead or the transmitter fell off.
[g]**Survived:** Birds that where observed during the transmitter life span (40-55 days), and birds that survived until the end of the season.

The total number of birds per species that was observed and captured in the 20 systematic mist-nets at the three different capture periods in 2018-19 is shown in Table 3. We intended to see if we could use the recaptures in January and March to estimate winter survival. However, we almost did not recapture birds that we had banded earlier in the season. This could either be due to mortality but it is unlikely that all those birds died, especially because most Baird´s and Grasshopper sparrows were radio-tagged and therefore we knew they were still alive. A more likely explanation is within-season dispersal; birds keep moving up to large distances throughout the season (see section on home ranges). High within-season dispersal rates were found in the summer season for Grasshopper Sparrows (Williams and Boyle 2019), and at least in part of the winter population of Baird´s and Grasshopper sparrows in Mexico (Strasser et al. 2018). High dispersal rates within the winter season could also account for the number of radio-tagged birds that go missing from the study site.

Table 3. Total number of birds captured and observed in 20 systematic mist-nets in three capture periods.

	December 2018		January 2019		March 2019		Total	
	# captured	# observed	# captured	# observed	# captured	# observed	# captured	# observed
Baird's sparrow	21	33	14	48	8	21	43	102
Grasshopper sparrow	25	29	10	14	13	23	48	66
Savannah sparrow	39	100	26	113	16	80	81	293
Ammodramus spp.[a]	0	0	0	0	0	84	0	84
Ammodramus-like[*]	0	0	0	101	0	105	0	206
Vesper sparrow	2	21	6	49	2	14	10	84
Brewer's sparrow	0	0	0	0	1	4	1	4
Cassin's sparrow	1	1	0	0	0	0	1	1
Black-throated sparrow	0	1	0	1	0	9	0	11
Lark bunting	0	0	0	2	0	25	0	27
Unknown sparrow	0	179	0	59	0	25	0	263
Sprague's pipit	0	12	1	6	1	12	2	30
Chestnut-collared longspur	0	332	0	271	0	199	0	802
Horned lark	0	58	0	96	0	32	0	186
Eastern meadowlark	1	1	1	11	0	26	2	38
Unknown meadowlark	0	59	0	24	0	3	0	86
Loggerhead shrike	0	0	0	1	0	1	0	2
Scaled quail	0	5	0	9	0	4	0	18

Common raven	0	0	0	2	0	0	0	2
Unknown raven	0	0	0	0	0	2	0	2
Northern harrier	0	2	0	2	0	0	0	4
Burrowing owl	0	1	0	0	0	2	0	3
American kestrel	0	0	0	1	0	0	0	1
Red-tailed hawk	0	0	0	1	0	0	0	1
Unknown falcon	0	0	0	1	0	0	0	1
Unknown raptor	0	0	0	2	0	0	0	2

[a]Ammodramus spp. = Baird's or grasshopper sparrow
[b]Ammodramus-like = Baird's or grasshopper or savannah sparrow

Winter Survival

In 2016-17, we had three confirmed mortalities (2 Baird's and 1 Grasshopper sparrow), in 2017-18 there were 21 confirmed mortalities (11 Baird's and 10 Grasshopper sparrows), and in 2018-19 we had 13 mortalities (7 Baird's and 6 Grasshopper sparrows; Table 2). Survival through the end of the season (mid-March) or to the end of the transmitter life-span (40-55 days) was confirmed for 29 birds (17 Baird's and 12 Grasshopper Sparrows) in 2016-17, 33 birds (20 Baird's and 13 Grasshopper Sparrows) in 2017-18, and 35 birds (16 Baird's and 18 Grasshopper sparrows, and 1 Sprague's Pipit) in 2018-19 (Table 2). The number of missing birds (radio signal was lost and the bird was not found after extensive searching) or of an unknown fate (not clear if radio fell of or bird was depredated) was 18 in 2016-17, 24 in 2017-18, and 18 in 2018-19. In 2016-17 and 2018-19, 10 and 6 radios fell off within one week of tagging, respectively.

We analyzed winter survival data using a generalized linear mixed model with the logistic exposure link function (Schaffer 2004). We used this method because logistic exposure allows for the inclusion of the days that an individual was tracked even if those individuals were lost, and accounts for birds that we started tracking at different days throughout the season. We built 22 hypothesis driven models to explore which environmental variables (temperature and vegetation characteristics) influenced winter survival of Baird's and Grasshopper sparrows. Of our confirmed mortalities we found several birds that presumably died from cold, their bodies were intact without signs of predation and they were generally found after cold nights (temperatures around or below 0 °C). To test the hypothesis that low temperatures negatively affect survival, we included the variable average weekly minimum temperature in some of our hypothesis-driven models. We decided to use the weekly average of the minimum temperature and not the daily minimum temperature because especially prolonged low temperatures could be negatively affecting the birds. All explanatory variables were scaled to allow for the direct comparison of the regression coefficients. We used an information-theoretic approach and AICc (Burnham and Anderson 2002) to select the most informative models and calculated model-averaged 95% confidence intervals for parameters in the top models (with ΔAICc < 2).

Estimated winter survival was lower in 2017-18 compared to 2016-17 and 2018-19, and generally lower for Grasshopper compared to Baird's Sparrow (Fig. 10). For Baird's Sparrow, estimated winter survival was 100%, 77%, and 80% for 2016-17, 2017-18, and 2018-19, respectively, with an overall average of 85.5% in three years (Fig. 9). Estimated winter survival of Grasshopper sparrow in 2016-17, 2017-18, and 2018-19 was 79%, 47%, and 75%, respectively, with a three-year average of 65.9% (Fig. 10). At the three study sites in Mexico, winter survival of Baird's and Grasshopper sparrows varied from 2-100%, depending on the year and location (Strasser et al. 2018). For the winter of 2016-17, survival probability in Marfa was comparable to the sites in Durango and Coahuila, but lower in Janos (Strasser et al. 2018). In 2017-18, survival of Baird's Sparrow was lower in Marfa compared to Janos and Coahuila, where 100% of the Baird's Sparrows survived. Grasshopper Sparrow survival was similar at those sites, but higher in Durango (Strasser et al. 2018). The data across the four sites has not been analyzed yet, but within sites temperature seems to be the most influential for survival rates (Janos: Macias-Duarte et al. 2017, Marfa: this report, see below).

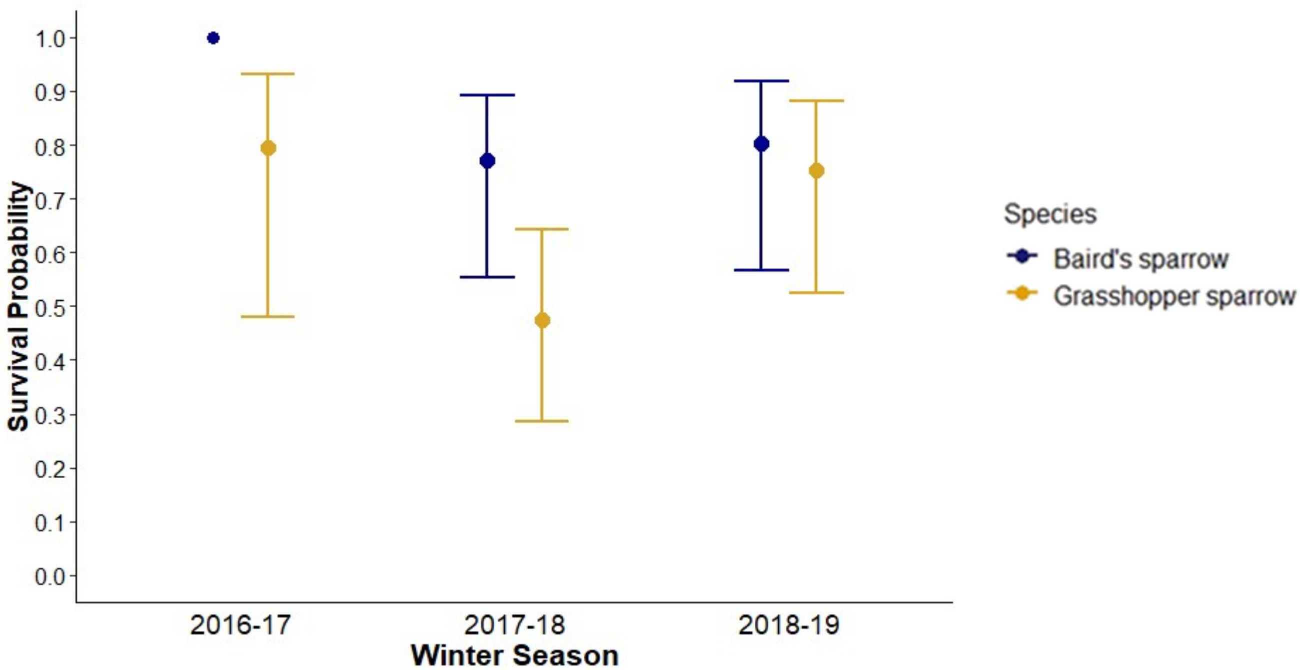

Figure 10. Estimated winter survival (± 90% CI) for Baird's Sparrow and Grasshopper Sparrow in 2016-17, 2017-18, and 2018-19.

We found three top models (ΔAICc < 2) that best explained winter survival of Baird's Sparrow (Table 4). These models included combinations of the following variables: average minimum weekly temperature, grass cover, and grass height. However, minimum temperature was the only variable for which the 95% confidence interval did not include zero (Fig. 11). For Grasshopper Sparrow there were two models that best explained winter survival (Table 4), including the variables average minimum weekly temperature and grass cover. The 95% CI of temperature did not include zero (Fig. 11).

Table 4. Top models explaining winter survival of Baird's and Grasshopper sparrow.

Model	**loglik**	**ΔAICc**	**df(K)**	**AICc weight**
Baird's Sparrow				
Model 2: Temperature	-44.380	0.00	2	0.213
Model 8: Temperature + Grass cover	-43.661	0.57	3	0.161
Model 13: Temperature + Grass cover + Grass height	-43.090	1.43	4	0.104
Grasshopper Sparrow				
Model 2: Temperature	-94.769	0.00	2	0.338
Model 8: Temperature + Grass cover	-94.687	1.84	3	0.135

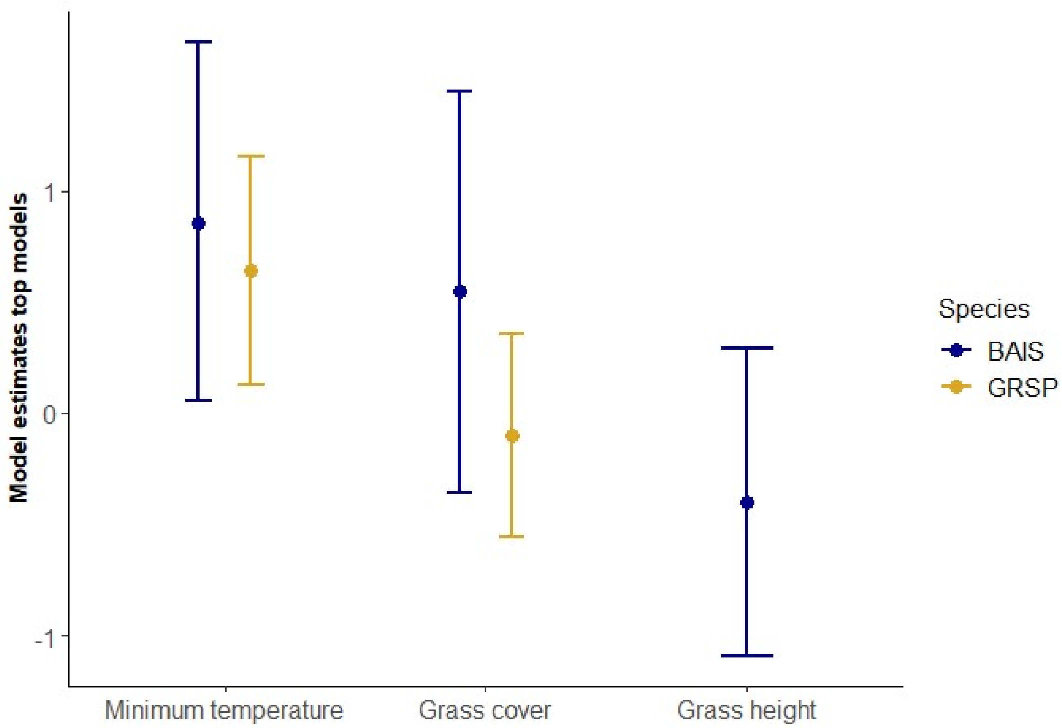

Figure 11. Model-averaged beta-coefficients (± 95% CI) for the variables in the top models (ΔAICc < 2) explaining winter survival probability of Baird's Sparrow (BAIS) and Grasshopper Sparrow (GRSP).

Based on these results, we can conclude that lower minimum temperatures have a negative impact on winter survival. This is in agreement with Macias-Duarte et al. (2017) who also found that winter survival of Baird's and Grasshopper sparrows in Janos, Mexico, is negatively affected by minimum temperature. We found that winter survival was lower in the second winter of the study, which was the coldest winter of the three (Fig. 12).

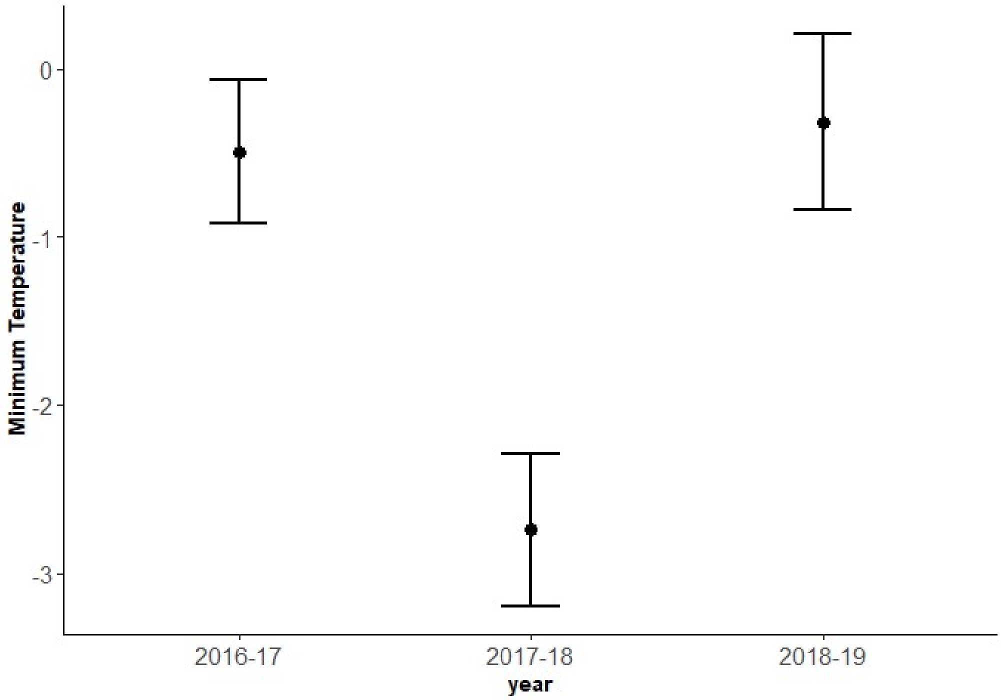

Figure 12. Average minimum temperature (± SE) from mid-December to early March (the study season) by year.

The support for the effect of grass cover and grass height on winter survival is inconclusive. The Mimms ranch is considered a healthy grassland in good condition, grass cover and height are generally optimal. Therefore, it is possible that we did not find a clear effect of these variables on winter survival because at our study site they are not a limiting factor. However, at the Janos site there was also a lack of a clear relationship between grass cover or height and winter survival (Macias-Duarte et al. 2017). The analysis of the four study sites combined can possibly provide an answer to the question whether grass cover will become a limiting factor when conditions are less optimal. In Marfa we did not find a negative relationship of shrub cover on winter survival. Earlier, when we analyzed the data for the first two winters only, we did find this relationship for Baird's Sparrows (3^{rd} progress report). Macias-Duarte et al. (2017) also found a negative relationship between shrubs and winter survival, which they attributed to the fact that the Loggerhead Shrike (*Lanius ludovicianus*), the main predator for Baird's and Grasshopper sparrow, uses shrubs as perches to search for prey. Therefore, shrub cover likely increases mortality of Baird's and Grasshopper sparrows due to predation. Possibly, we did not find this relationship because shrub cover is low at the Mimms ranch (mean shrub cover = 0.28 ± 1.25% based on grids cells in 3 years of monitoring), and therefore can be avoided. To determine the effects of shrub cover on survival, more study sites with a larger variation in shrub cover could be included in future research.

Microclimate

We analyzed iButton® data from February 10 – March 3, 2018, and February 7 – March 11, 2019 which are the periods for which we obtained 24-hour measurements for all 80 loggers. In 2018 and 2019 the average daily temperatures for the observed periods were 11.88 (± 3.58) ºC and 9.63 (± 4.06) ºC for bird points, and 12.08 (± 3.45) ºC and 9.50 (± 3.98) ºC for random points, respectively. The average minimum temperatures were -3.48 (± 4.86) ºC and -3.97 (± 4.55) ºC in bird points, and -2.88 (± 4.79) ºC and -4.19 (± 4.40) ºC in random points, in 2018 and 2019, respectively. The average maximum temperatures were 34.00 (± 5.58) ºC and 28.09 (± 7.12) ºC in bird points, and 32.91 (± 5.66) ºC and 27.07 (± 6.70) ºC in random points, in 2018 and 2019, respectively.

To determine if microclimate was different for bird compared to random locations, we pooled the 24-h temperature distribution for all bird locations in both years, and all random locations in both years (Fig. 13). We then compared these pooled distributions with a Kolmogorov-Smirnov test, that indicated that the distributions were not significantly different ($P = 0.109$). Therefore, we cannot conclude that microclimate was different in bird than random locations. It should be noted that we placed the iButtons® in a bird location that was observed during telemetry, which was only done during daytime. Therefore, we do not know if birds choose different locations at night, when minimum temperatures are lowest. Furthermore, habitat conditions at the Mimms ranch are considered to be relatively good. Possibly, there are not enough areas lacking thermal cover to detect a difference between bird and random locations.

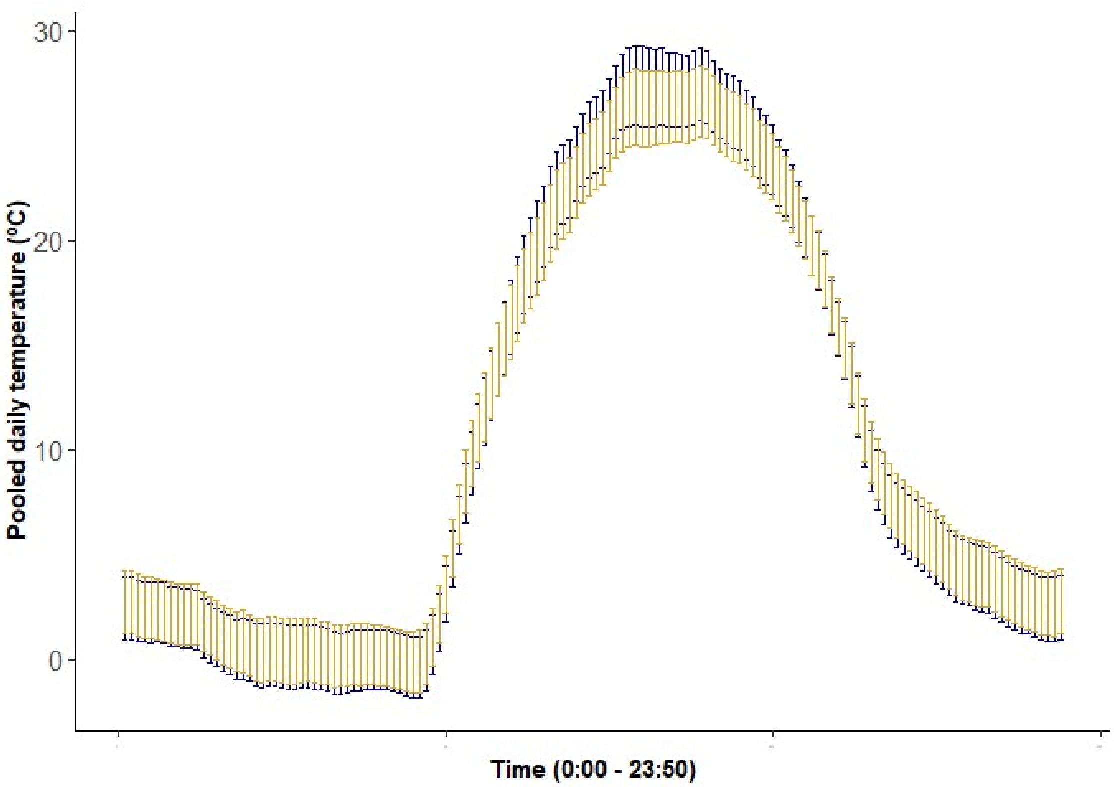

Figure 13. Pooled 24-h temperature distributions for bird (blue) and random (yellow) locations over a 2-year period. Bars represent 95% confidence intervals at 10 min. measurement intervals from midnight to 23:50 h.

We ran linear mixed models to determine the effect of vegetation and location (bird/random) on average mean, minimum, and maximum daily temperatures. For the vegetation classes we divided grass cover in short and medium to tall grass, resulting in the following categories: bare ground, short grass (< 13 cm, clearly grazed), tall grass (> 13 cm, clearly not grazed), shrub, and litter. Date was included as a fixed effect and logger ID as a random effect in the model. The results show that, when controlling for vegetation type, logger location (bird/random) did not affect mean ($P = 0.664$) or minimum daily temperatures ($P = 0.274$), but it did affect maximum daily temperature ($P = 0.013$). Maximum daily temperatures were higher at bird location compared to random locations (Fig. 13). Vegetation type did have an effect on mean, minimum, and maximum daily temperature (all $P < 0.001$).

The results from a post-hoc test (Tukey LSD) indicate that the average daily temperature was not different among vegetation types (Fig 14.A). Minimum daily temperature was significantly lower in short grass and litter compared to tall grass and bare ground (Fig. 14.B). The minimum temperature in shrub was significantly higher compared to the other vegetation types (Fig. 14.B). This is in agreement with other studies finding warmer nighttime temperatures under shrub canopy (D'Odorico et al. 2010, He et al. 2010, Shelef and Groner 2011). In contrast, the maximum daily temperature was significantly lower in shrubs compared to tall grass (Fig. 14.C), which is also in agreement with previous studies (Shelef and Groner 2011, Tracol et al. 2011). Heat fluxes are higher in bare ground compared to grass or forb cover (He et al. 2010). Possibly, higher nighttime temperatures under shrub canopy are related to the higher fraction of bare soil in shrub dominated areas; bare soil is heated during the day and this energy is released during the night (D'Odorico et al. 2010, He et al. 2010). This heat could then be trapped under the shrub by its canopy. Thus, ours and previous results indicate that shrub canopy can buffer microclimatic variability.

The difference in maximum temperature between shrub and tall grass likely explains why the maximum temperature was higher in bird points; Baird's and Grasshopper sparrows tend to avoid shrub cover and select for taller grasses (see habitat selection). Although the difference between short and tall grass was small it was statistically significant, and considering the fact that minimum temperature was the most influential variable for winter survival, short grass may not provide sufficient protection against low temperatures on cold days. More research is needed to test this hypothesis and evaluate the relation between vegetation, microclimate, and winter survival.

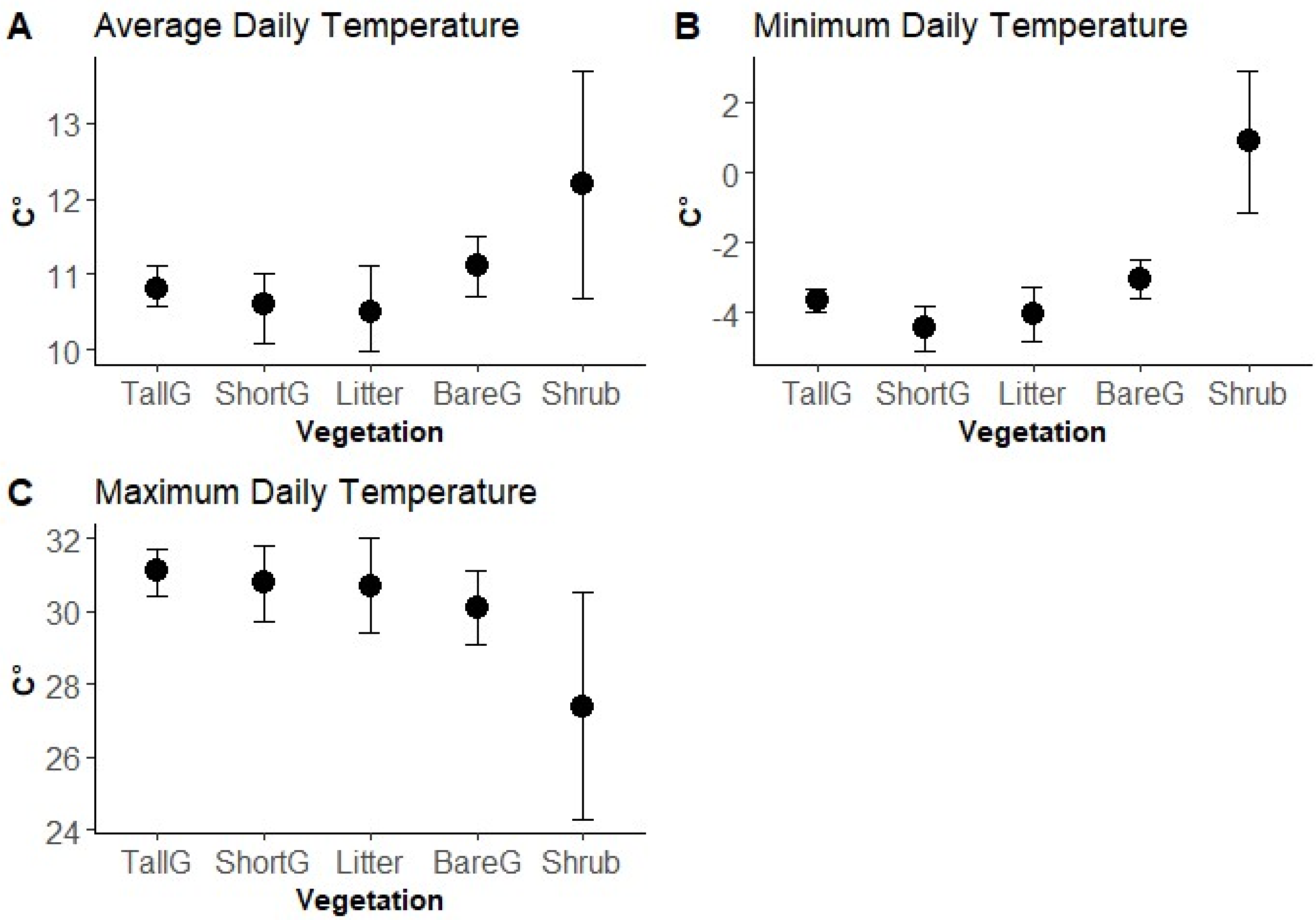

Figure 14. Average, minimum, and maximum daily temperature (least-square means ± 95% CI) in different vegetation types, measured 10 cm from the ground.

Home range

We calculated the size of home range and core area for birds with more than 30 locations, following recommendations of Seaman et al. (1999). In 2016-17 this gave us home ranges for 24 Baird's and 14 Grasshopper Sparrows, in 2017-18 for 24 Baird's and 17 Grasshopper Sparrows, and in 2018-19 for 19 Baird's and 21 Grasshopper Sparrows. We used fixed kernel density estimators with the least squares cross validation (LSCV) smoothing parameter to calculate the utilization distribution. Home range and core area size were estimated at 95% and 50% of the utilization distribution, respectively. The analysis was performed with package adehabitatHR (Calenge 2006) in R 3.4.2 (R Core Team 2019). Home range and core area size varied among birds and seasons, with a mean of 7.58 (± 10.16) ha, 4.38 (± 4.87) ha, and 6.33 (± 8.04) ha in 2016-17, 2017-18, and 2018-19, respectively, for both species combined (Table 5). Combining the three years, Baird's Sparrows had an average home range size of 6.87 (± 9.42) ha and Grasshopper Sparrows of 4.92 (± 5.65) ha.

Table 5. Size of home range and core area of both species combined in 3 winter seasons.

	Home Range (95%) ha			**Core Area (50%) ha**		
	2016-17	2017-18	2018-19	2016-17	2017-18	2018-19
Mean	7.59	4.17	6.33	1.52	0.80	1.42
Minimum	0.89	0.80	0.59	0.15	0.18	0.13
Maximum	54.91	25.94	48.76	11.46	3.29	12.49
SD	10.16	4.86	8.04	2.05	0.77	2.03

We used additive linear regression models to determine which environmental variables could affect the variation observed in home range size. We built 7 hypothesis-driven models including combinations of the variables year, and the different vegetation measures as predictors. The variables were scaled to facilitate comparison of the parameter estimates. We then used an information theoretic approach and Akaike Information Criterion corrected for small sample size (AICc) to evaluate the goodness-of-fit and select the best models containing the most informative variables (Burnham and Anderson 2002). For the variables in the top models, we calculated the model averaged 90% confidence intervals for inference.

For Baird's Sparrow we found two top models including the variables grass height, grass cover, and year (Table 6). For Grasshopper Sparrow we found four top models including the variables year, shrub cover, grass cover, and grass height. The model-averaged confidence intervals for the variables in the top models for Baird's Sparrow all included zero (Fig. 15). For Grasshopper Sparrow, the 90% confidence intervals for grass height, and shrub cover did not include zero, these two variables presented a negative relationship with home range size (Fig. 15). The confidence interval for the year 2017-18 compared to 2016-17 was also negative (90% CI= [-1.32; -0.2]), indicating that Grasshopper Sparrows had smaller home ranges in the second season. 2018-19 was not different from the first year.

Average home range size between 2014 and 2017 at the three Mexican sites was 5.52 ha for Baird's Sparrow and 3.59 ha for Grasshopper Sparrow (Strasser et al. 2018), which is slightly smaller than the average home ranges we found in Marfa (6.9 ha for Baird's and 4.9 ha for Grasshopper Sparrow), but in agreement with Baird's Sparrows having larger home ranges. At the Mexican sites they also observed a large variation across individual birds, with home ranges varying between 0.22 ha and 48.93 ha (Strasser et al. 2018). Based on the data from the Mexican sites, Strasser et al. (2018) identified different space-use strategies that could explain the large variation in home range size across individuals; some birds remain sedentary within a small home range, some individuals have two discrete home ranges, usually reflecting a shift somewhere during the winter, and some individuals, referred to as floaters, roam within larger areas throughout the winter. Our observations at the Marfa site seem to be in agreement with this.

Table 6. Top models (ΔAICc < 2) explaining home range size of Baird's and Grasshopper Sparrow.

Model	ΔAICc	df(K)	AICc weight
Baird's Sparrow			
Model 5: Grass height + Grass cover	0.0	4	0.373
Model 6: Year	0.7	4	0.266
Grasshopper Sparrow			
Model 7: Year + Shrub cover	0.0	5	0.326
Model 6: Year	0.8	4	0.215
Model 5: Grass height + Grass cover	1.5	4	0.157
Model 3: Year + Grass cover	1.8	5	0.134

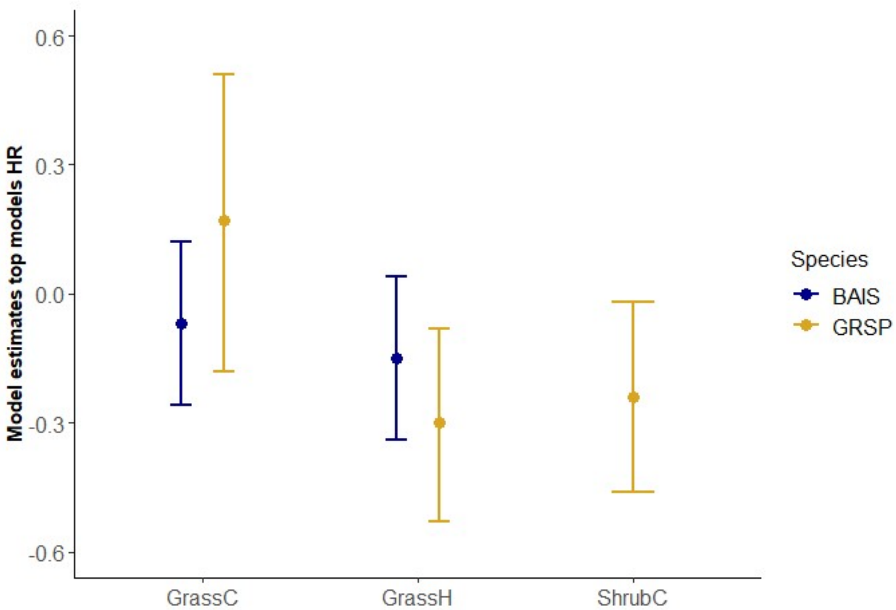

Figure 15. Model-averaged estimates (± 90% CI) of the vegetation variables (grass cover, grass height, shrub cover) in the top models explaining home range size of Baird's (BAIS) and Grasshopper Sparrow (GRSP).

Habitat selection

Over the three winters, the average cover in Baird's Sparrow locations was 38.2 (± 19.7) % grass cover, 0.5 (± 1.7) % forb cover, 0.2 (± 0.6) % shrub cover, 51.4 (± 24.5) % bare ground, 0.3 (± 1.1) % *Salsola*, and 9.5 (± 11.9) % other cover. Average height was 18.7 (± 5.3) cm for grass, 5.1 (± 10.2) cm for forb, and 6.2 ± (17.5) cm for shrubs. Grasshopper Sparrow locations had an average of 41.8 (± 18.9) % grass cover, 1.0 (± 3.5) % forb cover, 0.2 (± 0.8) % shrub cover, 42.9 (± 20.9) % bare ground, 1.16 (± 2.9) % *Salsola*, and 12.9 (± 12.0) % other cover. Average height was 21.5 (± 6.7) cm for grass, 8.6 (± 13.5) cm for forb, and 8.9 (± 24.8) cm for shrubs.

To determine which habitat variables are selected for by Baird's and Grasshopper sparrows, we used a resource selection function with a logistic regression to model habitat use vs. availability (i.e. bird vs. grid locations; Boyce et al. 2002) based on the vegetation parameters that we estimated in the vegetation plots. We built 10 hypothesis-driven models with different combinations of these variables. Bird ID and winter season were added as random effects to all models. Because grass cover and bare ground were correlated (r = -0.84 for Baird's Sparrow and -0.81 for Grasshopper Sparrow), we first ran the model once with each of these variables and compared the models with AICc to determine which variable was more explicative (Burnham and Anderson 2002). For Baird's Sparrow this was grass cover, and for Grasshopper Sparrow bare ground. We therefore used grass cover in subsequent models for Baird's Sparrow and bare ground in the models for Grasshopper Sparrow. We used an information theoretic approach and AICc to select the most influential models (Burnham and Anderson 2002). We then calculated the model averaged 95% confidence intervals for the variables in those models. All variables were scaled to allow for the direct comparison of the regression coefficients.

The full model was the only top model (ΔAICc < 2) for Baird's sparrow, and included the variables; grass cover, grass height, shrub cover, shrub height, forb cover, forb height, *Salsola*, and other cover. For these variables, the confidence intervals of grass cover, grass height, shrub height, forb cover, Salsola, and other cover did not include zero (Fig. 16A). There was only one top model for Grasshopper Sparrow (ΔAICc < 2) including the variables; bare ground and grass height. For both variables the 95% confidence interval did not include zero (Fig. 16B).

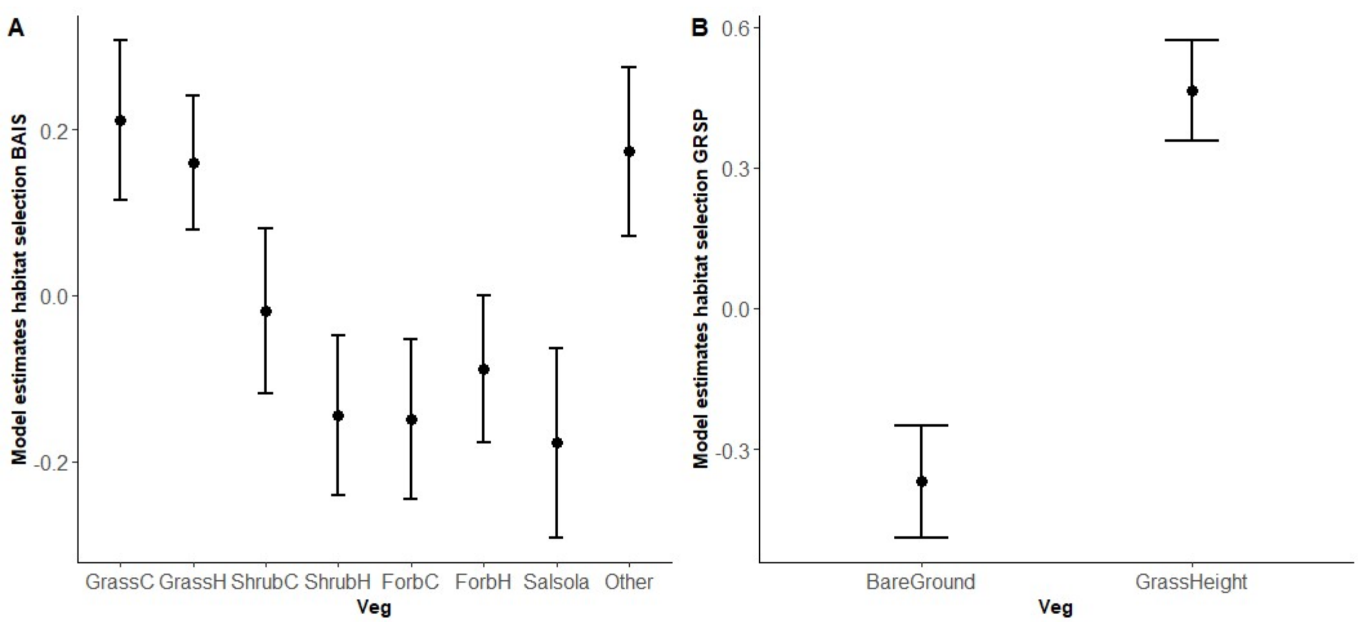

Fig. 16. Model estimates (± 95% CI) of the top models (ΔAICc < 2) explaining habitat selection of (A) Baird's Sparrow (BAIS), and (B) Grasshopper Sparrow (GRSP).

These results show that Baird's Sparrows select for more grass cover, taller grass, and other cover, and avoid tall shrubs, forb cover, and *Salsola* (Fig. 16A). Grasshopper Sparrows select for less bare ground and tall grass (Fig. 16B).

Soil seed bank

To determine if birds were selecting for seed resources, we compared the seed biomass in the soil seed bank between bird and random points with an analysis of variance. The full model included point type (bird vs. random), grazing system (rotational vs. continuous), and their interaction. We log-transformed seed biomass to fulfill model assumptions. We compared the full model to simpler models with no interaction, only one of the explanatory variables, and the null model using AICc (Burnham and Anderson 2002). The results indicated that the model with the interaction term was the only top model (ΔAICc = 2.9). Figure 17 shows the back-transformed results, indicating that seed biomass was higher in bird points compared to random points, but only in the rotational grazing system. This could mean that overall seed biomass is lower in the continuous grazing regime and birds select for seed resources when possible. Alternatively, birds could be selecting for some other habitat feature in the continuous grazing system. However, we determined the most dominant genera in the soil samples and found that seed resources are more variable in the rotational grazing system. Furthermore, the genus Panicum is the most dominant in the majority of the samples in the rotational grazing system, but absent in the continuous grazing system (Fig. 18). Panicum was the most dominant seed in the diets of wintering Baird's and Grasshopper sparrows in northern Mexico (Titulaer et al. 2017). Therefore, this seems to suggest that Baird's and Grasshopper sparrows are selecting for Panicum seeds in the rotational grazing system, whereas they do not have this option in the continuous grazing system. This does not mean that the grazing regime is promoting or impeding the growth of Panicum. The continuously grazed site differs from the rotationally grazed site in a number of ways, including soil type, rainfall, aspect, and slope. All these differences are probably the reason for the variation in plant species across the two sites. What is notable is that there appears to be more variation in seed species in samples from the rotational compared to the continuous sites (Fig. 18). Further research is needed to determine if this variability can be attributed to grazing practices and how that influences the soil seed bank and food availability for overwintering grassland birds.

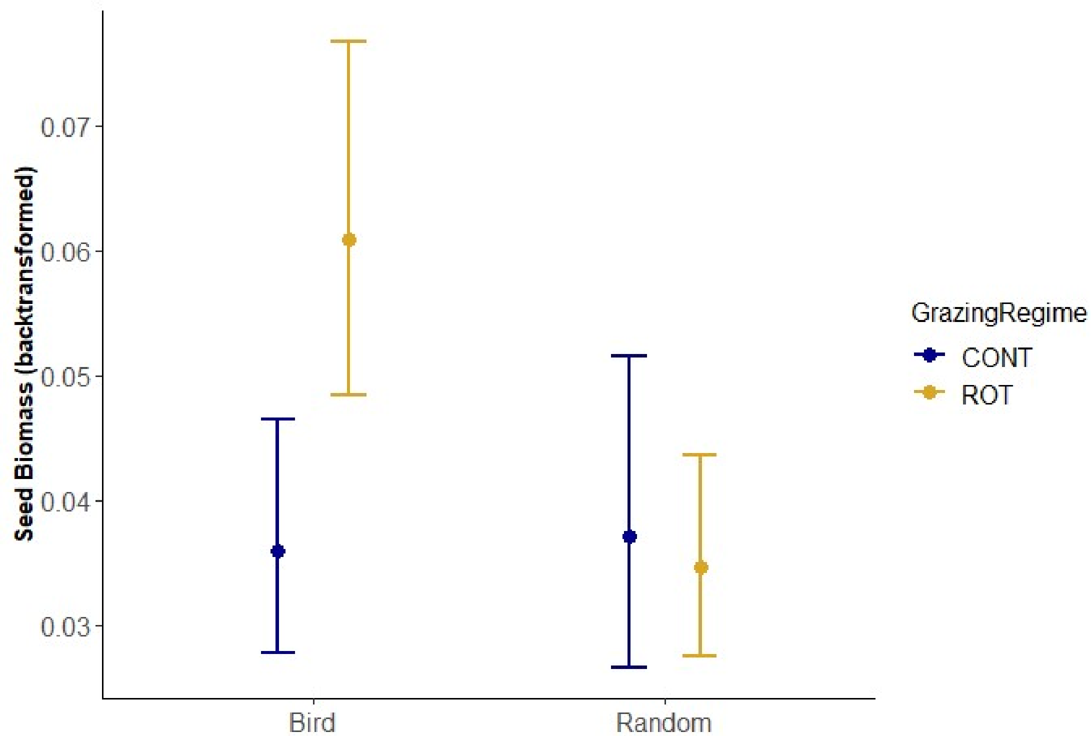

Figure 17. Back-transformed seed biomass (g, ± 95% CI) in bird and random points in the continuous (CONT) and rotational (ROT) grazing system.

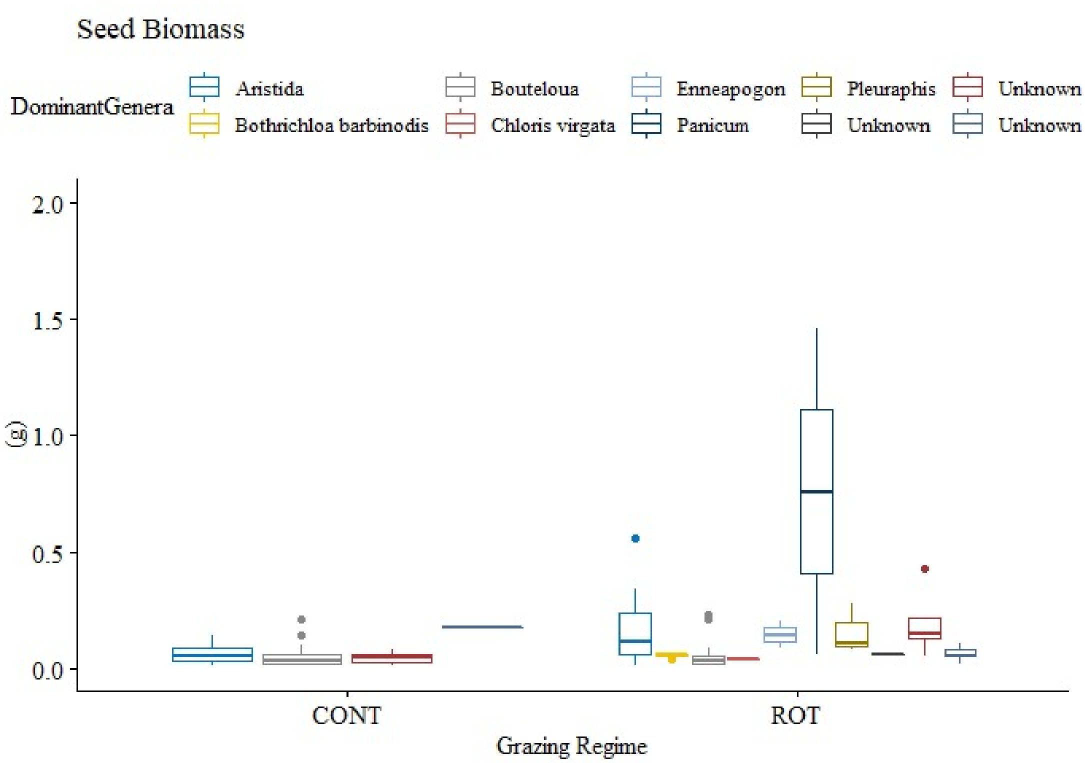

Figure 18. Most dominant seed genera in the soil samples taken in the continuous (CONT) and rotational (ROT) grazing regime.

Conclusion

Winter survival of Baird's and Grasshopper sparrows is most affected by low minimum temperatures. The second year was the coldest winter of the study, with smaller home ranges for Grasshopper Sparrow, and the lowest survival rates, especially for Grasshopper Sparrow. This suggests that temperature influences movement patterns and home range size as well as survival rates. Possibly, cold temperatures restrict movements because birds need to stay in places that protect them from harsh weather conditions. This could then limit the ability to search for food and better habitat conditions. More research is needed to test this hypothesis. Microclimate results show a small but significant difference in minimum temperature between short and tall grass, indicating that short grass may not provide sufficient protection against harsh weather conditions. Both birds select for taller grasses which seems to support this, although there may be other reasons to select for tall grass, such as cover from predators. Habitat selection results also show that Baird's Sparrow is more sensitive to a variety of vegetation characteristics than Grasshopper Sparrow, which seems in agreement with the more restricted range of Baird's Sparrows. Finally, both species seem to select for sites with preferred seed resources (e.g. Panicum) when possible. More research is needed to determine how grazing influences seed availability in the soil seed bank, as well as vegetation composition, and how this affects wintering Baird's and Grasshopper sparrows.

Identifying Priority Areas for Grassland Restoration

A side project to this study on overwinter survival and habitat use of Baird's and Grasshopper sparrows was identified in the final amendment to this project. We determined the need to identify priority areas for grassland restoration in the Trans-Pecos. To start, we determined the need to evaluate feasibility of delineating the grasslands in the Trans-Pecos. We met with several partners and through the sharing of data we were able to produce a map that provides the most accurate and up to date information on the delineation of the grasslands of the Trans-Pecos (Fig. 19). Based on this data, we are now planning the next steps, which include to make this data layer available to all interested partners, provide a short methods paper that can be referenced, and then use this data layer together with other criteria (to be determined in stakeholder meetings) to produce a map of priority areas for grassland restoration. Because this process was slower than expected and involves many different parties, we were not able to complete the final product before the end-date of the present project.

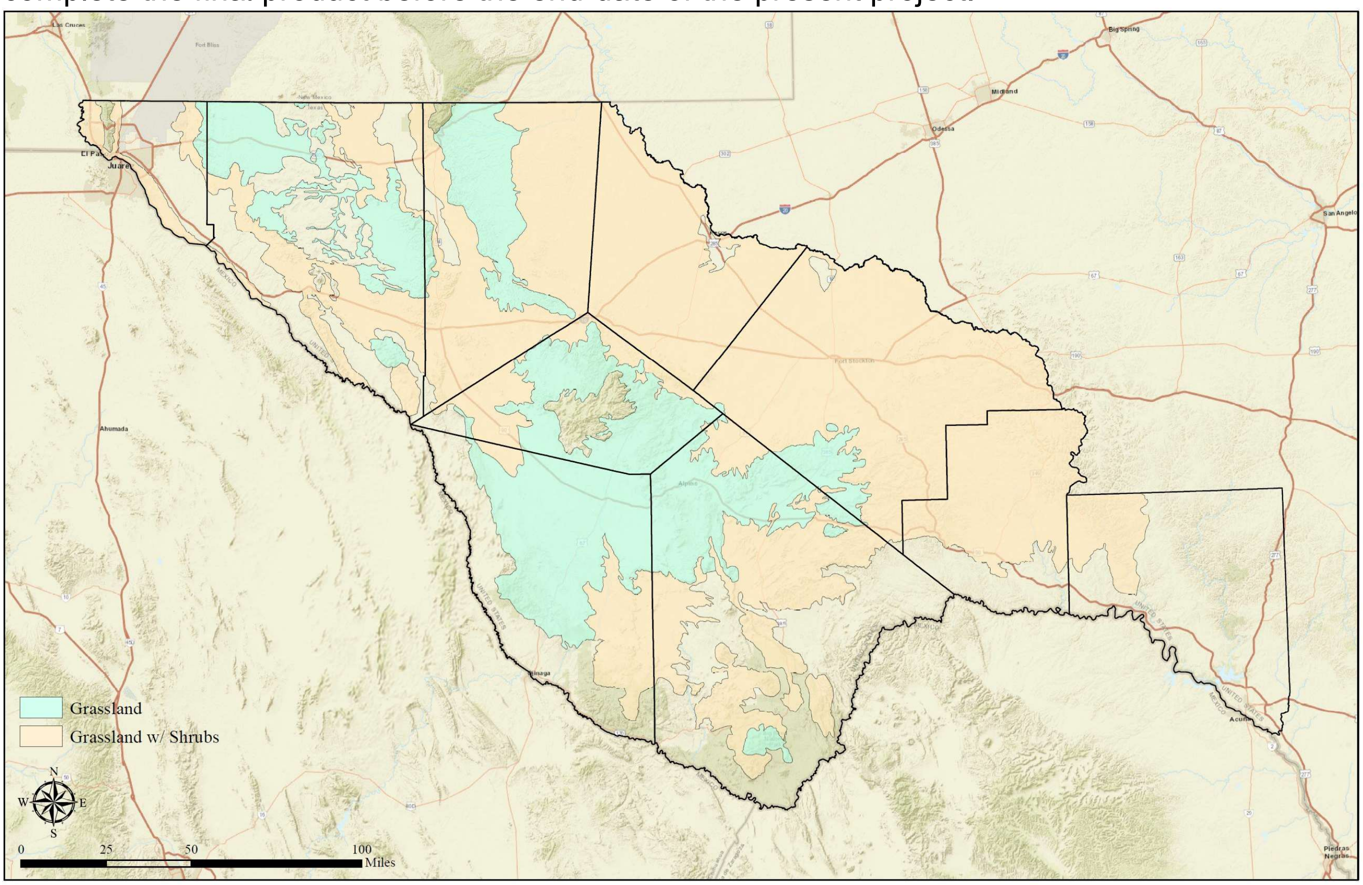

Figure 19. Delineation of the grasslands in the Trans-Pecos.

Research Priorities

Based on our final results, as well as partner meetings (specifically the RGJV/BCR Grassland Bird Conservation Planning & Monitoring Workshop held in Alpine on September 11-12, 2019), we defined the following topics as research priorities for grassland bird conservation:

- Population viability of target species and its relation to climate, habitat conditions and management.

- How do management practices affect vegetation and bird populations?
    - How does shrub removal affect target and non-target (eg. shrub dependent) bird species?
    - What are the effects of different shrub removal practices on vegetation (eg. forb shock, Lehmann lovegrass invasion) and how do these results affect grassland birds?
    - Effects of grazing practices on vegetation and grassland birds.

- Climate change effects on bird populations
    - Effects of increasing temperatures and changes in timing and amount of rainfall on range shifts, phenology, migratory behavior and consequences for declining bird species populations.
    - Interaction between management practices and changing climate on vegetation and bird populations.

- Space requirements of target species relative to habitat conditions (The tool that was presented at the RGJV/BCR workshop by Macias and Panjabi answers these questions to a certain degree, but predictions need to be tested)
    - How many birds can a specified area in a certain condition support?
    - What parameters (vegetation, climate, abundance, food availability, etc.) influence space requirements and movement patterns?
    - Flexibility of target species to adapt to variable conditions

Transboundary Conservation Program

Research Team

The research team consisted of three Mexican graduate students and the PI who is working part-time at BRI and part-time at the University of Chihuahua in Mexico, thereby facilitating the collaboration between the two institutions as proposed in the transboundary conservation program.

Research scientist: Mieke Titulaer

Dr. Mieke Titulaer is from the Netherlands. She has a BS in Animal Management from the University of Applied Sciences Van Hall-Larenstein in the Netherlands and a MS in Animal Sciences from Wageningen University, the Netherlands, which she received in 2010. In December 2011, she moved to Chihuahua, Mexico, where she received her Ph.D. in Natural Resource Management from Universidad Autónoma de Chihuahua in 2015. For her dissertation, she studied the winter diet of grassland sparrows in the Chihuahuan Desert of northern Mexico. She investigated seed selection in the field, and looked at possible effects of invasive exotic grasses on wintering grassland sparrows in captive bird experiments. Before moving to Mexico, she performed research on the effects of artificial light on reproduction and survival of songbirds with the Netherlands Institute of Ecology (NIOO-KNAW).

Graduate student: Denis J. Perez Ordoñez

Denis Perez is from Chihuahua, Chihuahua, Mexico. She earned her bachelor's degree in Ecology from the Universidad Autonoma de Chihuahua. During college, she volunteered on different projects related to wildlife such as marine turtle conservation, mule deer captures, pronghorn, burrowing owls and prairie dog surveys. After graduating, she focused on field work related to wildlife conservation and environmental education. She worked as a wildlife technician on several projects related to grassland birds including survival and habitat use of Baird's and Grasshopper Sparrows in Chihuahua and North Dakota, and wintering and breeding grassland bird surveys in Chihuahua and Colorado.

Graduate student: Fabiola Baeza Tarin

Fabiola Baeza is from Ojinaga, Chihuahua, Mexico. During her elementary years, she attended a public school 50% of the time and the other 50% she was homeschooled by her mother on her father's ranch in a remote place in Mexico. Before she finished elementary school, she moved with her family to Presidio, Texas, with the intention of providing Fabiola and her siblings with a better education. She then graduated from Presidio High School on May 2012 on the top 25% of her graduating class. In 2016 she received her BS in Biology from Sul Ross State University. While doing her undergrad she participated in the The McNair Scholars Program studying Common Black-Hawks and Gray Hawks in the Big Bend National Park, and in BRI's Undergraduate Research Mentorship Program studying Mule Deer demographics. After graduation she worked for the TTU's Quail Tech Alliance as a research technician studying Bobwhite Quail in the rolling plains of Texas.

Graduate student: Alejandro Chavez

Alejandro Chávez Treviño is from Monterrey, Nuevo León, Mexico. He earned his bachelor´s degree in Biotechnology and Genomics at the Universidad Autónoma de Nuevo León. During college he volunteered is several projects in the laboratory and the field. As an undergrad he was in charge of determining sex of sparrows using molecular techniques, he was an active participant of the Scientific Ornithology Collection, and volunteered in a Marine Turtles Breeding Monitoring project with Pronatura Penínusla de Yucatán. He developed an undergraduate thesis determining genetic diversity of grassland sparrows. After college he worked as a field technician collecting data of grassland birds in Chihuahua and Montana, and volunteered in Thunder Bay, Canada, at a banding station. Currently, Alejandro is a Graduate Student with the Borderland Research Institute at Sul Ross State University conducting research on grassland restoration and its impact on birds.

Technicians and undergraduate students

We recruited technicians with a variety of backgrounds. In 2016-17 we had two technicians, one from Mexico and one from the US. In 2017-18 and 2018-19 we hired one technician from Peru and two from the US. In 2016-17 one undergraduate student was hired through BRI's mentorship program to participate in bird captures, and in 2017-18 an undergraduate student worked with the soil seed bank samples.

Outreach

The project had a high participation of volunteers, from birding community to home schooled children, and two volunteers from Chihuahua (apart from the UACH students). In 2016-17, we had 63 different volunteers that worked for a total of 706 hours participating in bird captures. In 2017-2018, 70 different volunteers contributed 804 volunteer hours to the project (excluding children). For the 2018-19 captures we the highest participation of volunteers, contributing a total of 1,446 hours to the project. We hosted students from 6 different universities (Texas Tech University, Tarleton State University, UT-Austin, Abilene Christian University, Autonomous University of Chihuahua, and of course Sul Ross State University). Other volunteers were birders from all over Texas, naturalists for the Texas Master Naturalists Program, current and retired wildlife biologists, herpetologists, ornithologists, and people from the local community. We also hosted representatives from OXY who are funding grassland restoration projects from BRI and TPWD through NFWF, and a film crew from TPWD tv.

Research scientist Mieke Titulaer explains the difference between a Baird's and a Grasshopper Sparrow to a group of home schooled children.


A volunteer releases a radio-tagged Baird’s Sparrow.


Graduate student Fabiola Baeza and field technician Sebastian Orue show two captured sparrows to the volunteers.

In 2017-18 we invited students from the Autonomous University of Chihuahua (UACH) to participate in our bird captures. We received 4 students for the January captures in 2017-18. In December 2018-19 we again received 4 UACH students. They did not only help us with captures but we provided training on grassland bird identification and monitoring, mist-netting and bird banding, and telemetry. One of them (Ivan Gonzalez) was then hired by BCR as a field technician to perform bird transects on the NFWF grassland restoration sites.

Students from the University of Chihuahua help to set up the mist nets in the morning.


UACH student Ivan Gonzalez releases a radio-tagged Grasshopper Sparrow.

Presentations and workshops

- Binational Conservation Workshop hosted by BRI and TPWD International affairs (April 29-30, 2017)
- RGJV Bird Science Team Meeting in Chihuahua, MX, attended by Mieke Titulaer (April 24, 2017)
- RGJV Bird Science Team Meeting in Alpine, TX, attended by Denis Perez (May 9, 2017)
- Article in Desert Tracks titled Wintering Grassland Birds in West Texas, Fall 2017, Vol10(3).
- Oral presentation at America's Grasslands Conference in Fort Worth, TX (November 14-17, 2017)
- Project presentation for PLJV and Audubon at Mimms Ranch, Marfa, TX (January 18, 2018)
- Poster presentation at Texas Chapter of The Wildlife Society Meeting in Dallas, TX (February 9-11, 2018)
- Episode on wintering grassland birds on Marfa Public Radio's Nature Notes (February 15, 2018) http://marfapublicradio.org/blog/nature-notes/pulse-of-the-desert-plains-tracking-grassland-birds-on-the-marfa-plateau/
- Article in Texas Wildlife Borderlands News titled Wintering Grassland Birds in West Texas, March 2018.
- Oral and poster presentation at the American Ornithology Meeting in Tucson, AZ (April 10-14, 2018)
- Presentation at RGJV workshop for conservation partners at Mimms Ranch, Marfa, TX (April 24, 2018)
- Presentation at Texas Ornithological Society Meeting in Alpine, TX (April 5, 2018),

- Grassland bird workshop hosted by Ballroom Marfa at the Mimms ranch, Marfa, TX (August 5, 2018),
- Grassland bird workshop workshop for the Tierra Grande Chapter of the Texas Master Naturalists at the Mimms ranch, Marfa, TX (November 10, 2018),
- Grassland bird workshop hosted by the Chinati Foundation on their property in Marfa, TX (December 1, 2018),
- Graduate student Denis Perez gave a presentation for “nerd nite” at Hotel Ritchie in Alpine, where the local community can go to hear presentations on a variety of topics (December 20, 2019),
- Graduate student Deniz Perez presented BRI’s grassland bird research at the Rio Grande Joint Venture Board Meeting (January 6-7, 2019)
- Graduate student Fabiola Baeza presented a poster on her thesis project at the Texas Chapter of the Wildlife Society meeting (February 20-23, 2019),
- Sul Ross news featured an article on our grassland bird project, “Field Guide: BRI Grassland Bird Research at Mimms Ranch https://news.sulross.edu/field-guide-bri-grassland-bird-research-at-mimms-ranch/?fbclid=IwAR1mOwRcx-TIAq6hCJ6HWMKpqV4Luww5WCyKcBBsOu5zcWtzHsS8yCyml2g (Published on February 6, 2019),
- Graduate student Fabiola Baeza presented a poster on her project at the 2nd Annual Women in STEM meeting at Sul Ross State University, Alpine, TX (March 29, 2019),
- Research Scientist Mieke Titulaer gave an oral presentation at the Ornithology Conference (XVII Congreso para el estudio y la conservacion de las aves) in Merida, Mexico (September 2-6, 2019),
- RGJV/BCR Chihuahuan Desert Grassland Bird Conservation & Monitoring Workshop, Alpine TX, attended by Mieke Titulaer, Fabiola Baeza, and Alejandro Chavez (September 11-12, 2019),
- Graduate students Fabiola Baeza and Alejandro Chavez presented at the Trans-Pecos Grazing Lands Coalition in Alpine, TX (September 16, 2019),
- Research Scientist Mieke Titulaer gave a poster presentation at the grassland conference (IX congreso internacional de manejo de pastizales) in Chihuahua, Mexico (October 17-18, 2019).

Timeline

The project timeline was delayed after conducting two rounds of interviews for the PI position during Fall 2016 and both respective selectees, tenured professors at Mexican universities, declined the position offer. However, the PI position was accepted by Dr. Mieke Titulaer with a start date of September 1st, 2017. The second graduate student, Fabiola Baeza, also started on September 1st, 2017. Despite the challenges with filling the PI position, we did hire the first graduate student, Denis Josefina Perez in 2016, who was able to initiate field work in the winter of 2016-2017. The project was then extended with a no-cost extension with a new end date of August 31, 2019. The PI position was reduced to half time to leave sufficient funds for research activities and we received a donation of $6000 from the Texas Ornithological Society to complete the funds needed for another field season.

Time	Action	Status	Comments
Spring 2016	Advertise and hire staff and student position	Completed	Hired M.S. student August 2016
Fall 2016	Order equipment; coordinate with TPWD regarding study sites	Completed	Selected Mimm's Ranch as study site
Winter 2017	Monitor bird and habitat conditions	Completed	Hired PI position
Summer 2017	Analyze data and write end of year reports and hire second graduate student	Completed	First report was submitted on 5/19/17
Fall 2017	Assemble GIS coverages; field reconnaissance of study sites	Completed in Winter	PI and 2nd M.S. student position started 9/1/18
Winter 2018	Monitor bird and habitat conditions	Completed	Drone imagery of field site collected
Summer 2018	Analyze data and write end of year reports	Completed	Report submitted on 5/18/18
Fall 2018	Continue data analysis, hire technicians, prepare for field season	Completed	Results from new analysis presented in this report
Winter 2019	Monitor bird and habitat conditions	Completed	Hired third M.S. student (with NFWF funds) with start date 1/1/19
Summer 2019	Analyze data and write end of year reports	Completed	Denis Perez defended her thesis on 4/2/19
Fall 2019	Write Final report	Completed	This report submitted on 10/22/19

Deliverables

Deliverable	Status	Comments
Quarterly and annual research reports for the grasslands birds projects described above (i.e., GIS coverages, habitat maps, and demographic data).	Completed	Annual Performance Reports submitted on 5/19/17, 5/18/18, 3/27/19, and this report submitted on 10/22/19.
Posters and presentations at regional, state, and international conferences (TSSRM, TCTWS, TWS, SWN, etc…) as well as, partner meetings (RGJV, CEC,	Completed	See Tranboundary Conservation Program

Desert LCC, etc…) that promote the BRI-TPWD Transboundary Program.		
BRI will coordinate with TPWD International Affairs Program to host a Binational Conservation Workshop (in conjunction with the Trans-Pecos Wildlife Conference 2016 (scheduled for August 2016).	Completed	Hosted 4/29-30/17
BRI will coordinate with TPWD District and WMA staff and formulate a research priority list for the district, WMAs, and borderlands region.	Completed	Page 27 of this report.
BRI will provide quarterly reports outlining activities of Transboundary Conservation Program (contacts, partnerships, accomplishments, etc…).	Completed	See Tranboundary Conservation Program and previous reports
BRI will help develop a cooperative agreement with University of Chihuahua and establishing an internship program for undergraduates (which will include opportunities within TPWD).	Completed	BRI received students from UACH in January 2018 and December 2019.
BRI will coordinate with and report implementation activities and results to TPWD's International Affairs Program for coordination with the Border Governors' Wildlife Table, the Trilateral Committee for Wildlife and Ecosystem Conservation and other forums that TPWD participates in.	Completed	Working with TPWD International Affairs Program, BRI and TPWD co-hosted a binational workshop: "Wildlife Management in the Trans-Pecos" on April 29-30, 2017 at Sul Ross University & Elephant Mountain WMA
BRI will produce a map that identifies priority grasslands in the Trans-Pecos for potential restoration	Delayed, first map completed.	Fig. 19 on page 26 of this report contains the first map and justification.

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