Identifying limiting factors for wintering grassland birds in the Chihuahuan Desert: 2012-2015

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BIRD CONSERVANCY OF THE ROCKIES

(FORMERLY ROCKY MOUNTAIN BIRD OBSERVATORY)

Connecting people, birds and land

Mission: Conserving birds and their habitats through science, education and land stewardship

Vision: Native bird populations are sustained in healthy ecosystems

Bird Conservancy of the Rockies conserves birds and their habitats through an integrated approach of science, education and land stewardship. Our work radiates from the Rockies to the Great Plains, Mexico and beyond. Our mission is advanced through sound science, achieved through empowering people, realized through stewardship and sustained through partnerships. Together, we are improving native bird populations, the land and the lives of people.

Core Values:
1. Science provides the foundation for effective bird conservation.
2. Education is critical to the success of bird conservation.
3. Stewardship of birds and their habitats is a shared responsibility.

Goals
1. Guide conservation action where it is needed most by conducting scientifically rigorous monitoring and research on birds and their habitats within the context of their full annual cycle.

2. Inspire conservation action in people by developing relationships through community outreach and science-based, experiential education programs.

3. Contribute to bird population viability and help sustain working lands by partnering with landowners and managers to enhance wildlife habitat.

4. Promote conservation and inform land management decisions by disseminating scientific knowledge and developing tools and recommendations.

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Cover Photo: A Baird's Sparrow is released after being outfitted with a radio-transmitter. Photo by José Hugo Martinez Guerrero.

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ABSTRACT

Many grassland birds have lost 70-95% of their global population since 1966 yet causes of these declines are poorly understood. Increasing evidence suggests non-breeding survival in migratory species may have a strong influence on population trends. Our aim was to advance our understanding factors that limit survival by implementing a long-term research project on overwintering survival of declining grassland birds in the Chihuahuan Desert. This final report summarizes our observations, data collected, and analyses from the first three seasons of this research. We radio-tracked 485 Baird's and Grasshopper Sparrows over three winters at three sites across the Chihuahuan Desert. We monitored birds daily to identify causes of mortality and calculate survival probabilities, determine home range sizes through fixed-kernel density estimates and classify movement patterns. We also collected data on habitat conditions to identify habitat preferences and availability and grassland bird densities. We found that survival varied considerably between seasons and sites and that the proportion of birds surviving a winter can range from as low as 14% to upwards of 91%. Survival was lower for Grasshopper Sparrows than Baird's Sparrows. Grasshopper Sparrows generally used smaller territories that were characterized by sparser grass cover and more shrubs, two factors which may contribute to their reduced survival.

TABLE OF CONTENTS

INTRODUCTION

Grassland birds have declined more than any other North American bird guild over the last 4 decades (Samson and Knopf 1994, Sauer et al. 2011). Factors driving these population declines are poorly understood, but are likely related to the conversion of native grasslands to farmland, pesticide use, and habitat alteration by grazing throughout the breeding grounds of the Great Plains of Canada and the United States (Peterjohn and Sauer 1999). Knowledge of the winter ecology of migratory birds is lacking for most species (Faaborg et al. 2010) and the importance of the role of winter habitat degradation in driving populations declines in migratory grassland birds remains to be explored (Rappole and McDonald 1994).

Large numbers of North American grassland birds winter in the Chihuahuan Desert and Sierra Madre foothills of northern Mexico (Peterson and Robbins 1999) where grassland habitat is disappearing at an alarming rate. Grasslands in northern Mexico (BCRs 34 and 35) cover roughly 1/5 the area of grasslands in the breeding grounds of the Northern Great Plains (BCRs 17 and 11; Commission for Environmental Cooperation 2010). Therefore, continuing habitat loss and degradation on the wintering grounds in Mexico will probably play a major role in exacerbating the ongoing population declines in grassland birds. Extensive conversion of grasslands to farmland (Macias-Duarte et al. 2009, Pool et al, 2014), incompatible grazing regimes, woody plant encroachment, invasive species, and increasing aridity (Seager et al. 2007) threaten the persistence of desert grasslands in northern Mexico.

Recent work has advanced our knowledge of the influence of habitat structure on both presence and abundance of grassland birds in Mexico (Desmond et al. 2005, Macias-Duarte et al. 2009, Panjabi et al. 2010). However, until recently no study has directly evaluated how patterns of habitat use by grassland birds directly relate to demographic parameters of interest, such as winter survival (Macias-Duarte and Panjabi, 2013(a)).

In winter 2012-2013, Bird Conservancy of the Rockies (BCR) initiated a pilot project to investigate overwinter survival, habitat use and movement patterns of two high-priority grassland bird species, Baird's Sparrow (*Ammodramus bairdii*) and Grasshopper Sparrow (*Ammodramus savannarum*). These species have lost between 70-80% of their population since 1966 and causes of these declines are not well understood. Like most migratory birds that breed in the Northern Great Plains, both overwinter in the Chihuahuan Desert grasslands where environmental factors may limit survival and could have a disproportionate impact on populations. This project was initially conceived with the goal of focusing on Sprague's Pipit (*Anthus spragueii),* another steeply declining grassland bird, and candidate species for protection under the Endangered Species Act. However attempts to capture this species have proven difficult due to its evasive escape behavior. Baird's and Grasshopper Sparrows share similar for habitat requirement with Sprague's Pipit, particularly their preference for healthy, relatively shrub-free grasslands, on both the breeding and wintering grounds. Therefor all three species stand to benefit from the outcomes of this research.

This ongoing research aims to fill critical information gaps needed to understand causes of grassland bird declines and effectively inform grassland restoration and management efforts on the wintering grounds. Results will provide the tools to model survival and movement patterns of grassland birds in relation to habitat and climactic conditions and devise best management practices to enhance grassland conditions and promote overwinter survival. Long-term data will be used to construct full-annual cycle demographic models for Baird's and Grasshopper Sparrows which will help us identify drivers of population trends and factors limiting population growth.

Specific project objectives were to 1) monitor winter survival rates of Baird's and Grasshopper Sparrows at multiple sites within the Chihuahuan Desert using radio-telemetry 2) identify causes of mortality, 2) develop models to assess the influence of factors such as habitat characteristics, bird density, and climate on winter survival rates 3) evaluate how spatial and temporal movement patterns are related to habitat, survival and individual characteristics (sex, age, condition) and 4) collect data on annual return rates to assess winter site fidelity and annual survival.

To address these objectives, we used radio-telemetry to track sparrows wintering in the Chihuahuan Desert grasslands of northern Mexico. We radio-tagged and banded hundreds of *Ammodramus* sparrows, determined causes of mortality, collected data on grassland bird densities, recorded sparrow movement patterns and home range characteristics, and collected data on habitat conditions (vegetation cover and structure and species composition) for three winters.

STUDY AREA

Field activities were conducted at three sites across the Chihuahuan Desert grasslands of northern Mexico with the aid of collaborators from Universidad Juárez del Estado de Durango (UJED) and Universidad Autónoma de Nuevo León (UANL) (Figure 1). The principal site, monitored since winter 2012-13 is within the Nature Conservancy owned Reserva Ecológica El Uno near Janos, Chihuahua. In winter 2013-14 we added a field site within the Cuchillas de la Zarca Grassland Priority Conservation Area (GPCA) in northern Durango and winter 2014-15 we began monitoring in the Valle Colombia GPCA, Coahuila.

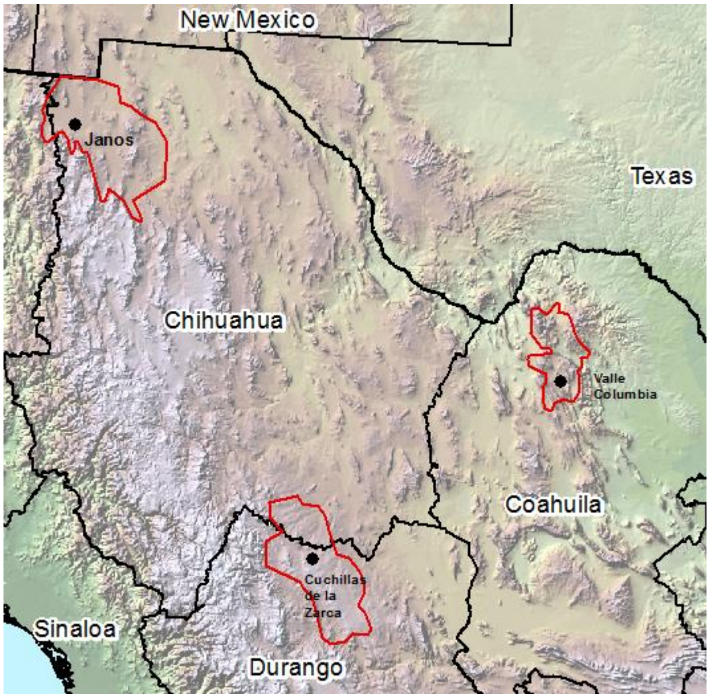

Figure 1. Study areas within the Janos GPCA, Chihuahua, within the Cuchillas de la Zarca GPCA, Durango, and within the Valle Colombia GPCA, Coahuila.

METHODS

Training

BCR conducted training sessions in Janos, Chihuahua, Mexico prior to the 2013-14 and 2014-15 field seasons. Field team members from each of the three field sites attended and were instructed in bird capture, banding, transmitter attachment, as well as data collection and management protocols. BCR has developed a detailed field and data management protocol (in Spanish) for use at the three field sites. This protocol has been maintained and modified with suggestions from each site and is a work in progress.

Bird Capture and Monitoring

We monitored radio-tagged Grasshopper and Baird's Sparrows (as well as two Sprague's Pipits) from early December to mid-March at the three study sites. We began trapping birds in mid-November 2012 for the 2012-13 pilot field season. However after a several birds disappeared, it became clear that many birds were still migrating this early in the winter and thereafter we initiated bird captures in early December. We aimed to radio-tag between 30-45 birds per site during initial captures and maintain this sample size throughout the winter. Therefore, as marked birds disappeared or were depredated, new birds were captured and radio-tagged as needed. Although Baird's and Grasshopper Sparrow abundance can fluctuate from winter to winter, we aimed to split transmitters equally between the two species.

Birds were captured or recaptured using a flush netting technique. Briefly, an array of 3-5 nets were placed in suitable habitat (dense patches of grass, low shrub density) within study area boundaries. Using crews of 5-20 people we formed semi-circles up to 200 m away from the nets and walked slowly toward the nets to flush birds from the grass. Trapping methods have been improved to increase capture success while reducing the number of people in the field. Fabric Frisbees and bamboo poles strung with bright flagging to maintain birds with the flush-net circle are very effective trapping methods.

After capture, we collected standard morphometric measurements (wing cord, tail length, culmen and tarsus length), scored fat, assessed feather molt, determined age (when possible), and weighed birds to the nearest tenth of a gram. We collected one retrix (r3) to genetically determine sex for radio-tagged birds and collected the regrown feather when birds were recaptured for analyses of stress and genetic diversity. Beginning in winter 2015, we collected feather samples from un-tagged birds for stable isotope analyses.

A portion of the birds were outfitted with 0.5-0.6 g radio-transmitters of unique frequencies (PicoPip Ag379, Biotrack Ltd, Dorset, UK). Transmitters were attached using a figure-eight leg loop harness of 1mm nylon coated elastic (Rappole and Tipton, 1991). Total transmitter and harness weight did not exceed 4% of bird mass (Figure 2).

Figure 2: A Baird's Sparrow outfitted with a radio transmitter. The antenna is barely visible, extending beyond the tail.

Birds were located once daily between 07:30-18:00 and tracked with an effort to reduce potential time of day effects. We tracked birds using 3-element folding Yagi antennas and Biotracker receivers (Lotek Wireless). After the bird left the area we marked the location with a GPS and recorded whether the bird was detected visually or by signal only. If a predator was in the vicinity, we projected points with the GPS units to avoid flushing the bird.

If a transmitter or carcass was discovered we looked for signs of depredation such as blood, feathers or bite marks on carcasses or transmitters. We attempted to identify whether the predator was mammalian (carcass cached underground), owl (transmitter in pellet), Loggerhead Shrike (body or transmitter impaled on a branch, or cached in dense vegetation), or raptor (plucked feathers and transmitter).

Extensive efforts were made to locate "missing" individuals that may have moved (or were carried) out of receiver range. We scanned for missing birds by walking transects, climbing to high points and driving roads within 10 km of the study area, using either a handheld Yagi or a truck-mounted omnidirectional antenna (Figure 3). In 2015 we purchased a 5-element antenna and 30ft telescoping pole and developed a prototype roof-top mount for our field vehicle to increase our scanning range. Because transmitter battery life ranged from 40-55 days, we recaptured tagged individuals to replace transmitters as well as mark new birds in late January to early February each winter. Radio-tagged birds were recaptured at the end of the study period in early to mid-March to remove transmitters and assess bird condition.

Figure 3: A technician scans for a lost radio-tagged sparrow from a high point.

Survival Estimates

Daily survival probabilities for each species and site and were generated in Program MARK using nest survival models. Nest survival models were more appropriate than known-fate analyses as there were many occasions when the exact date of bird death was unknown and sampling occasions varied (e.g. some birds were not tracked daily as they may have gone missing). We suspected that birds were more vulnerable to depredation within the first few days of transmitter deployment while adjusting to the presence of the transmitter on their backs. Thus, in estimating daily and weekly survival probabilities we included a conditioning period of 7 days to reduce this potential bias.

Home Range Estimation

We determined home range size for individuals at the Chihuahuan site with more than 30 location points (Baird's n=50, Grasshopper n=96) as recommended by Seaman et al. 1999. We estimated home ranges using the fixed kernel density estimators of the utilization distribution with smoothing determined by least squares cross validation. Home range size was calculated with Program R package adehabitatHR (R Core Team 2015).

We also examined strategies of space use which could vary between individuals or winters based on endogenous (sex, age, behavioral phenotype) or exogenous factors (e.g. climate, predation pressure, habitat conditions). Birds were categorized as "sedentary" or "floaters" based on their movement patterns. Sedentary individuals used a contiguous area and did not make a long distance shift (greater than 200m) to a new territory. Floaters were those that did not maintain a singular fixed area over the course of the winter.

Vegetation Sampling and Habitat Preferences

Prior to the winter 2014-15 field season we implemented a new study design to better estimate habitat and effects of vegetation structure and composition on survival. Our pilot season protocol required collecting vegetation data at each bird location, however we discovered that this sampling design could not capture the full scale of habitat variation within and between winters or provide unbiased estimates of available vs. used habitat. With the modified protocol, we collected habitat data across a grid of points spaced every 50m within the delineated study areas. Study areas were delineated based upon prior bird banding and tracking locations, site characteristics (shrub density < 25%, major roads) and ranch boundaries. Study area size varied between the sites: 999 ha in Chihuahua, 324 ha in Durango and 1238 ha in Coahuila. With the 2014-15 data we determined that vegetation sampling intensity could be reduced, spacing points every 100m instead of 50m (Figure 4).

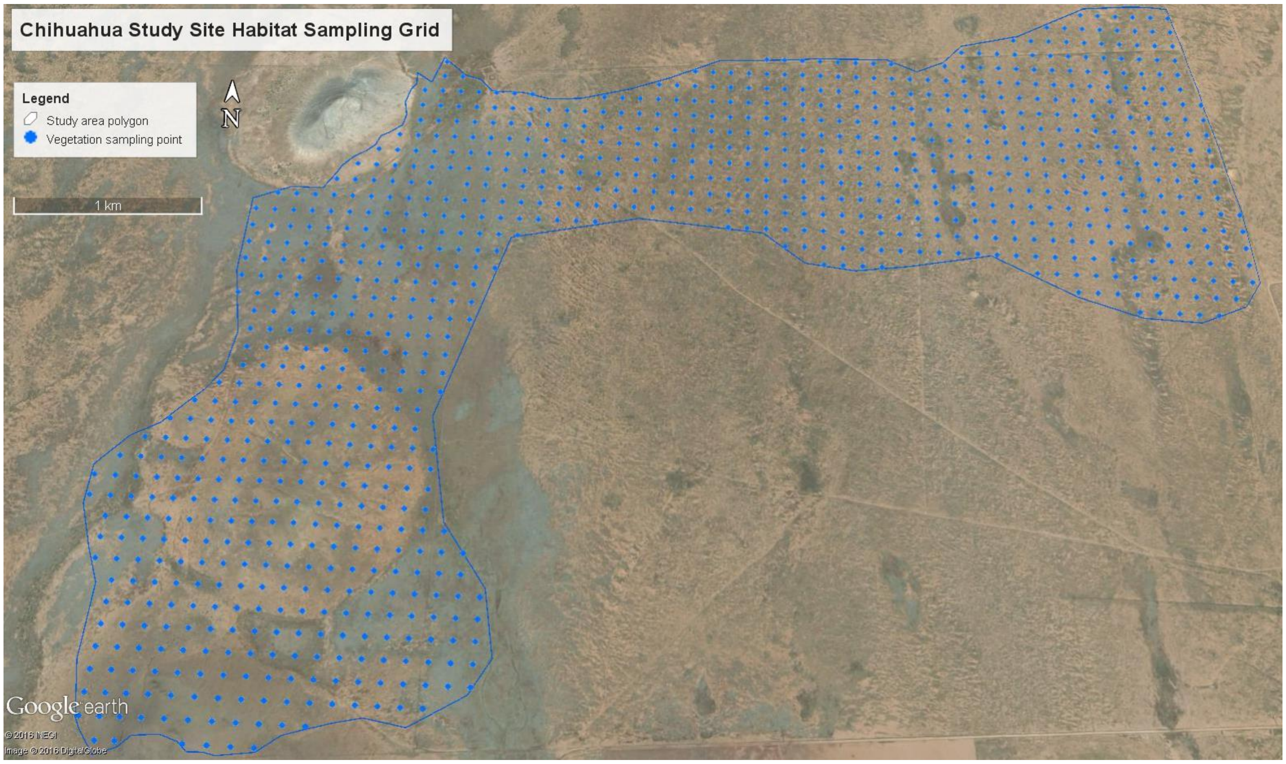

Figure 4. Chihuahua study site habitat sampling scheme. The blue outline signifies the study area boundaries. Blue dots are points at which vegetation cover and structure data were collected (n=982).

Within a 5m radius plot centred around each point, one or two trained and calibrated observers visually estimated percent cover of grass, forbs, tumbleweed, shrubs >30 cm in height, bare ground, and other cover (litter, duff, animal excrement, rocks). At each point we recorded the relative percent cover of the three dominant grass genera and average height of grass, forbs, and shrubs was estimated to the nearest cm.

Raw vegetation data were used to create predictive habitat surfaces that interpolated vegetation characteristics at unsampled areas across the Chihuahua study area for winter 2014-2015. This was accomplished through kriging in ArcMap (Geostatistical Wizard in ArcGIS version 10.2) which yielded raster files containing vegetation information within each pixel. The surface maps were then used to associate vegetation data with each bird location and grid point to determine habitat preferences. We used the Extract Multi Values to Points tool in ArcGIS to extract estimated vegetation variables from the raster files at bird location points.

Bird Density

Beginning in winter 2013-14, we conducted mid-season line transects to determine densities of focal species within study areas. Within the study area polygons we sampled 500m long pseudo-randomly placed transects spaced at least 200m and oriented East-West. We sampled 49-500 m transects in Chihuahua, 12 in Durango, and 44 in Coahuila. Surveys were conducted by a singular observer at each site within a one week period between the hours of 0700-1200. We recorded all avian species observed, lateral distance from transect, flock size, detection type, and weather data (wind, cloud cover, temperature). Density analyses were performed using program Distance (Laake et al. 1994). This sampling method also provided density estimates for avian predators such as Loggerhead Shrikes and Northern Harriers.

PRELIMINARY RESULTS

Bird Captures, Band Recoveries and Monitoring

Between November 2012 and March 2015 we radio-tagged a total of 485 individual sparrows (204 Baird's and 281 Grasshopper Sparrows) and two Sprague's Pipits across the three study sites (Table 1). We monitored individuals for 1-96 days. We had high success rates with mid-season recaptures to replace failing transmitters and continue monitoring the same individuals throughout the winter. In general we did not observe any negative effects of transmitters on birds such as chaffing or feather loss, however a few birds displayed increased dried skin around the base of their legs from the harness and others had worn back feathers from the body of the transmitter.

Although the Sprague's Pipit captured in Coahuila was depredated by a shrike after a few days of monitoring, the pipit at the Chihuahua site was tracked for over 50 days and recaptured prior to migration in March. These data are extremely novel and valuable as these are the first radio-tagged Sprague's Pipits on the wintering grounds.

Since December 2012 we have banded a total of 518 individual sparrows at the Chihuahua site (388 Grasshopper, 130 Baird's, and 1 Pipit), 197 in Durango (103 Baird's, 94 Grasshopper), and 41 in Coahuila (32 Baird's, 9 Grasshopper and 1 Pipit). At the Chihuahua site we have recaptured 16 birds that were banded in previous seasons (15 Grasshopper and one Baird's). All ten birds were recaptured near their original capture site and three of these birds wore different transmitters in two seasons. We overlaid locations from both seasons for these individuals and found that territories overlapped between winters (Figure 5). These numbers are interesting as they illustrate that a proportion of these species display winter site fidelity, which may have implications for survival and provide insight into these species' flexibility in habitat use with climate change and habitat loss. It also highlights the potential for utilizing other tracking technologies which require recapturing an individual the following year (e.g. geolocators or miniature gps tags) in the future

Table 1. Number of radio-marked, depredated, and lost Baird's and Grasshopper Sparrows, and Sprague's Pipits over winters 2012-13, 2013-14 and 2014-15 at three study sites within the Chihuahuan Desert: Janos = Janos, Chihuahua, Vaco =Valle Colombia, Coahuila and Cuza =Cuchillas de la Zarca, Durango. Bird of Lost/Unknown fate are individuals that could not be located after extensive searching, birds that had radios that failed prematurely, or radios that fell off after deployment. Known survived include recaptured birds and those that were observed alive through expected transmitter life.

	Radio-tagged			Total	**Depredated**			Total	**Lost/Unknown Fate**			Total	**Known Survived**			Total
	Janos	**Cuza**	**Vaco**		**Janos**	**Cuza**	**Vaco**		**Janos**	**Cuza**	**Vaco**		**Janos**	**Cuza**	**Vaco**	
Species																
Baird's	89	85	30	204	28	26	5	59	26	41	7	74	35	18	17	70
Grasshopper	179	94	8	281	38	48	1	87	73	37	5	115	68	9	2	79
Sprague's Pipit	1	0	1	2	0	0	1	1	0	0	0	0	1	0	0	1
Total	269	179	39	**487**	66	74	7	**147**	99	78	12	**189**	104	27	19	**150**

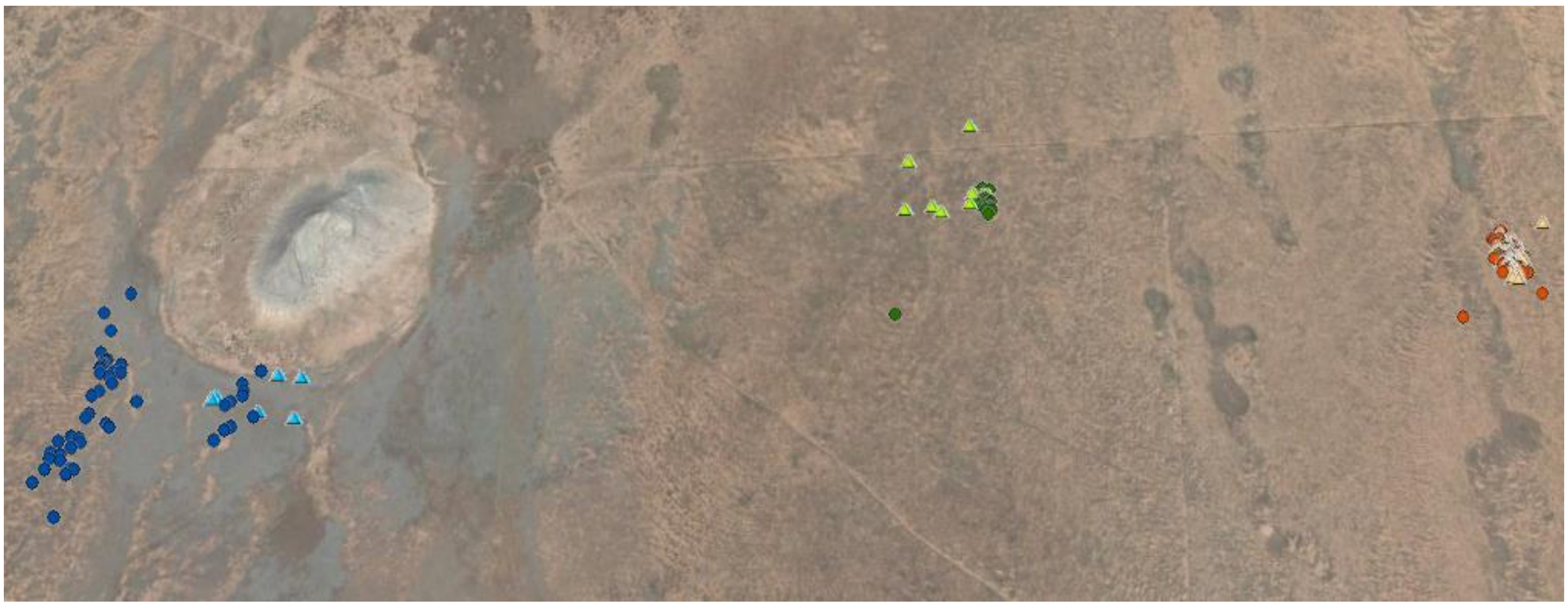

Figure 5. Map showing overlap in wintering locations of three individual birds that wore transmitters in more than one winter. Triangles are points taken in winter 2012-13 or 2013-14 and circles are from 2014-15. Blue, green and orange represent different individuals.

Bird Fate and Survival Probability

Across the three sites we documented 147 mortalities out of 487 radio-marked birds, or 30% of individuals (Table 1). Most documented mortalities were the result of depredation, mainly by Loggerhead Shrikes and diurnal raptors (Figure 6). Several birds were depredated within seven days following deployment. 189 individuals (38%) went missing or their fate was unknown (radio failure, radio fell off).

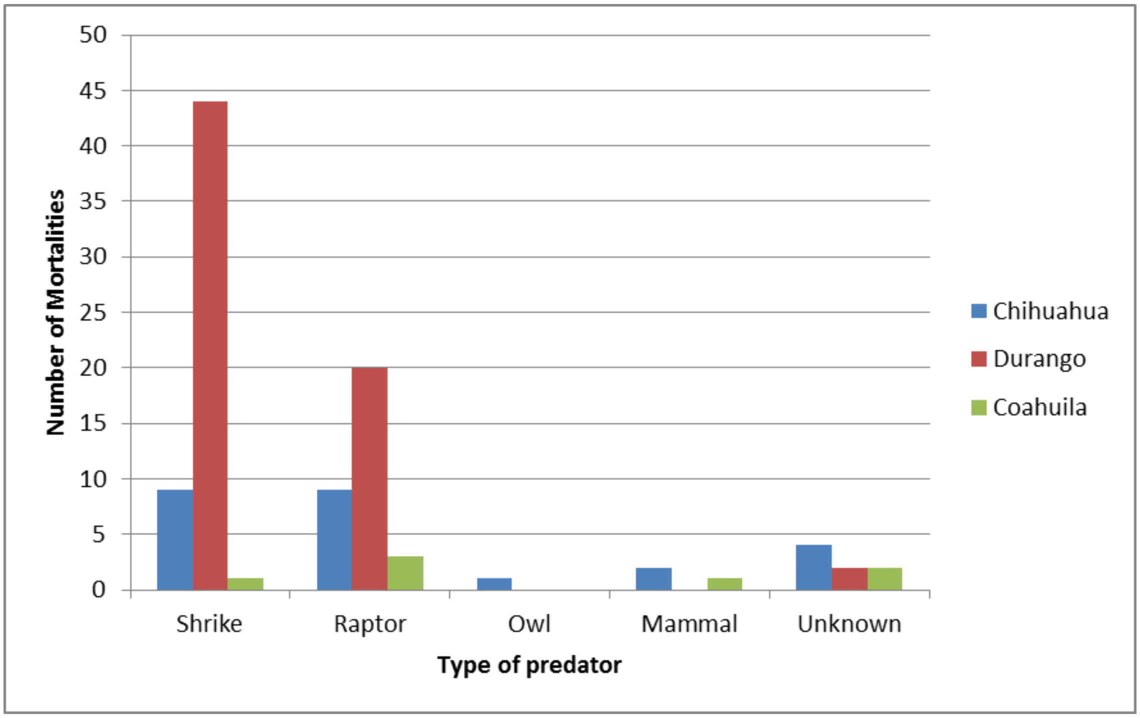

Figure 6. Frequency of Baird's and Grasshopper Sparrow and Sprague's Pipit mortalities by predator type and study site for winter 2014-15. Raptors include American Kestrel, Northern Harrier, Sharp-shinned Hawk, and Merlin. Unknown are those mortalities that could not be definitively attributed to a predator type.

We observed an average apparent survival rate across years and sites of 31% based on raw data (Table 1). Daily survival probabilities estimated in Program Mark extrapolated to the four month wintering period, suggest that between 13.71-90.56% (mean = 53.81%) of Baird's and Grasshopper Sparrows survived the winter (Table 2). Survival probability varied with study area and year as well as species. Grasshopper Sparrows exhibited lower mean survival across sites and years (44.74%) when compared with Baird's (62.88%). Baird's Sparrows were not present at the Chihuahua site in 2013-14 thus we could not calculate survival estimates.

We observed that survival varied over the course of a winter and is lowest following bouts of cold weather and precipitation (Figure 7).

Table 2: Daily survival probabilities (DSP), estimated proportion of number of birds surviving (% Surv.) during the study period (days) including standard error (SE) and 95% confidence intervals (LCI and UCI) by site. JANOS = Janos, Chihuahua, VACO =Valle Colombia, Coahuila and CUZA =Cuchillas de la Zarca, Durango. BAIS = Baird's Sparrow, GRSP = Grasshopper Sparrow.

Site	Year	Species	DSP	SE	LCI	UCI	Days	% Surv.	LCI	UCI
JANOS	2015	GRSP	0.993	0.002	0.987	0.996	97	**50.60**	0.270	0.702
JANOS	2015	BAIS	0.996	0.002	0.991	0.998	97	**66.57**	0.405	0.833
VACO	2015	BAIS	0.998	0.001	0.994	0.999	90	**83.01**	0.562	0.942
CUZA	2015	BAIS	0.996	0.004	0.969	0.999	76	**71.07**	0.090	0.953
CUZA	2015	GRSP	0.974	0.009	0.949	0.987	76	**13.71**	0.019	0.371
JANOS	2014	GRSP	0.999	0.001	0.997	1.000	97	**90.56**	0.735	0.969
JANOS	2013	GRSP	0.988	0.004	0.979	0.993	120	**24.10**	0.077	0.455
JANOS	2013	BAIS	0.990	0.003	0.982	0.995	120	**30.87**	0.111	0.532

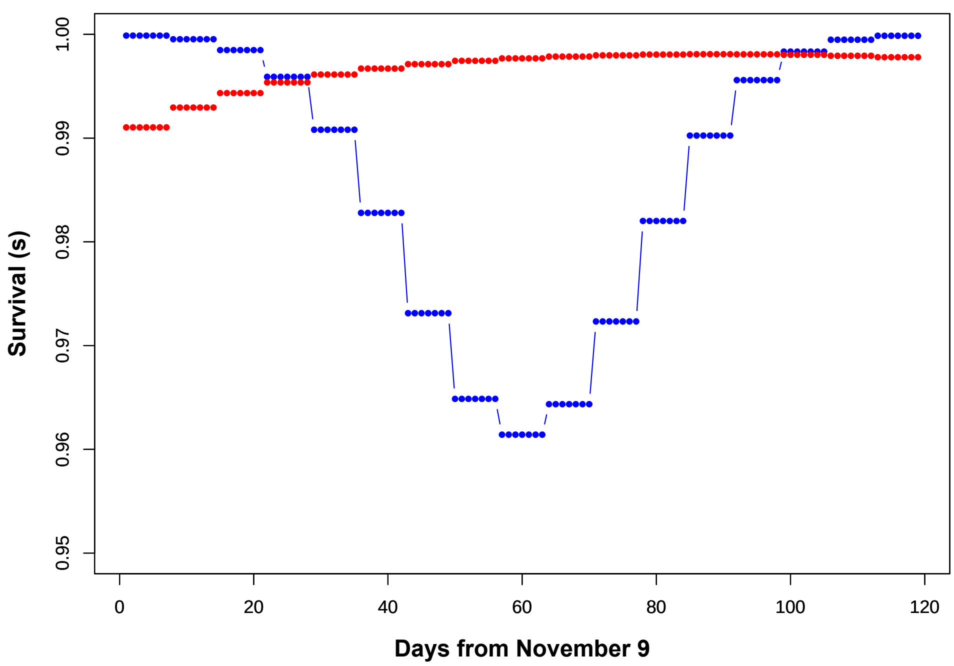

Figure 7: Probability of survival and number of days since the start of the winter field season (November 9) at the Chihuahua site for winters 2012-13 (blue line) and 2013-14 (red line). Survival dropped mid-season in 2012-13 possibly because of cold wet weather.

Home Ranges and Movement Patterns

We calculated home ranges for 146 individuals at the Chihuahua site (50 Baird's and 96 Grasshopper). Sparrow home range size averaged 5.09 ha (min= 0.22, max= 48.90 ha, Figure 8). Baird's Sparrows had larger home ranges (mean =7.18 ha, min= 0.71, max = 37.27) than Grasshopper Sparrows (mean = 4.01 ha, min= 0.22, max = 48.89).

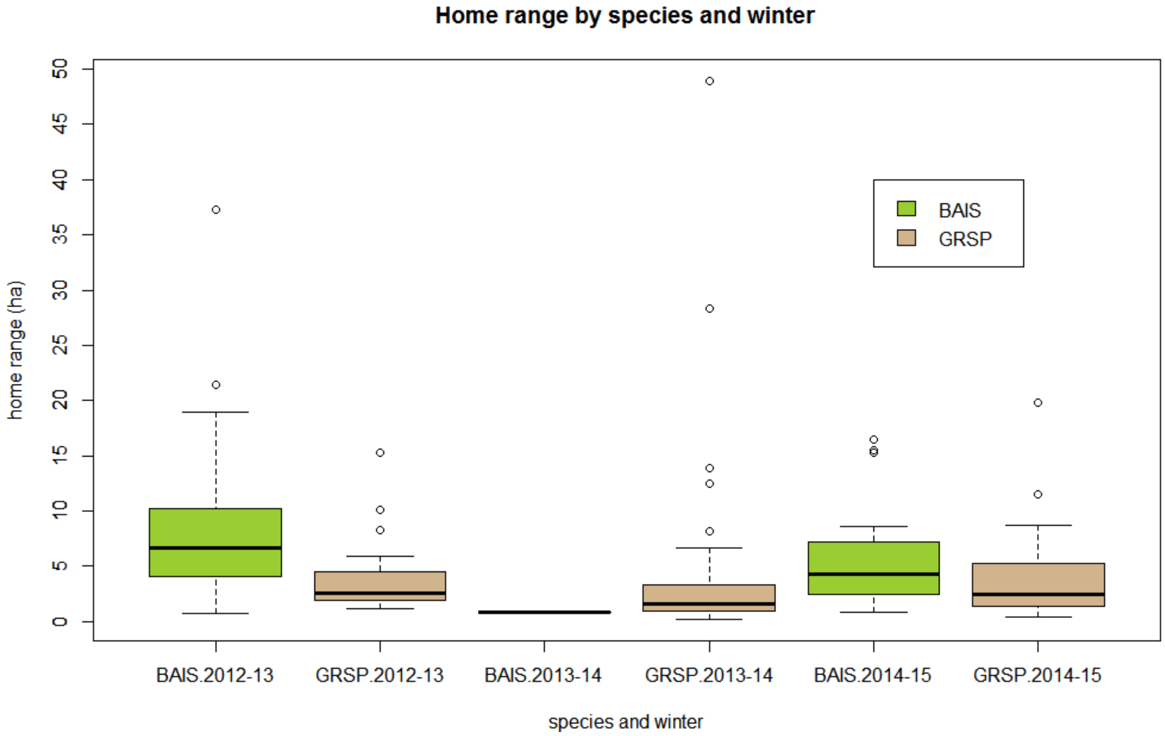

Figure 8: Home range size (in hectares) for wintering Baird's Sparrows (BAIS) and Grasshopper Sparrows (GRSP) by winter (2012-13, 2013-14, and 2014-15) in Chihuahua.

We observed two different space-use patterns in sparrows: territorial or sedentary individuals and floaters (Figure 9). There was no difference between species and movement patterns. The majority of birds maintained territories and remained in those territories throughout the winter (56-70% individuals). Fewer birds made mid-season home-range shifts or wandered over large areas (up to 3 km away from initial banding location). Less birds were floaters in 2012-13 (30%) than 2013-14 (44%) and 2014-15 (33%) fell in the middle. Floaters followed two general patterns: most made home range shifts from one discrete location to another (i.e. multiple territories) and a few individuals moved over large areas throughout the season. Preliminary DNA results indicated that sex did not influence movement strategy.

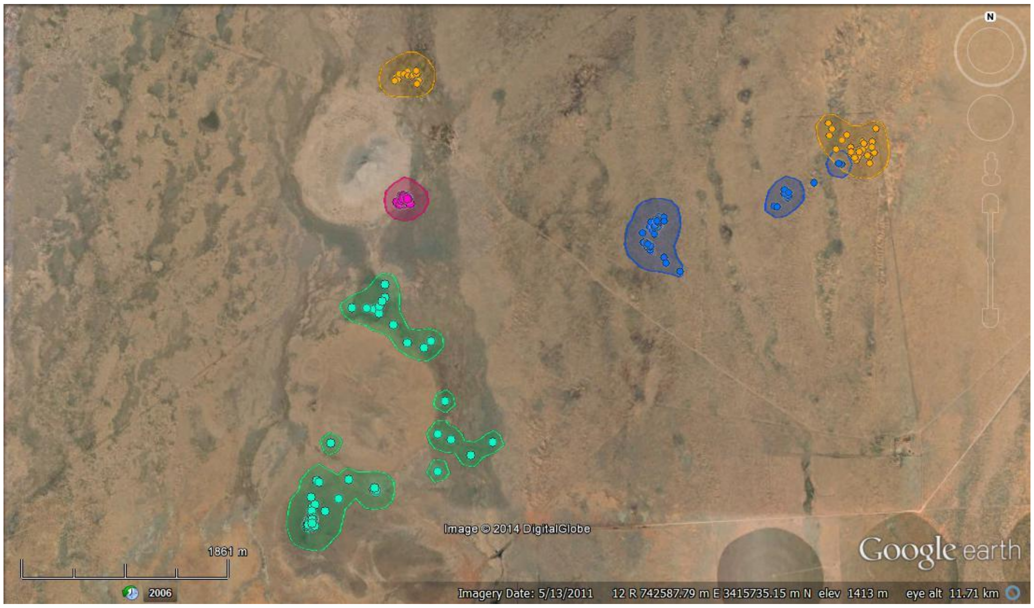

Figure 9. Examples of different space-use patterns in wintering Grasshopper Sparrows at the Chihuahua study area. Each color represents an individual bird. Dots are locations and outlines are 95% KDEs. The pink bird has a typical fixed territory, the green bird wandered extensively and the blue and orange bird made territory shifts.

Vegetation data

We collected vegetation data at 3,809 points in Chihuahua, 1068 in Durango, and 1324 points in Coahuila in order to characterize habitat conditions at each site. Individual surface maps were generated to classify land cover based upon our habitat variables (cover and height classes) at the Chihuahua site (Figure 10).

Locations where Baird's Sparrows were located tended to have higher percent grass cover and taller grass compared to the study area as a whole and when compared with Grasshopper Sparrow and Sprague's Pipit locations (Table 3). Grasshopper Sparrows utilized sites with greater shrub cover and slightly taller shrubs. The Pipit was located in areas with more bare soil and less grass cover, characteristics that more closely resembled Grasshopper Sparrow habitat use (Table 3).

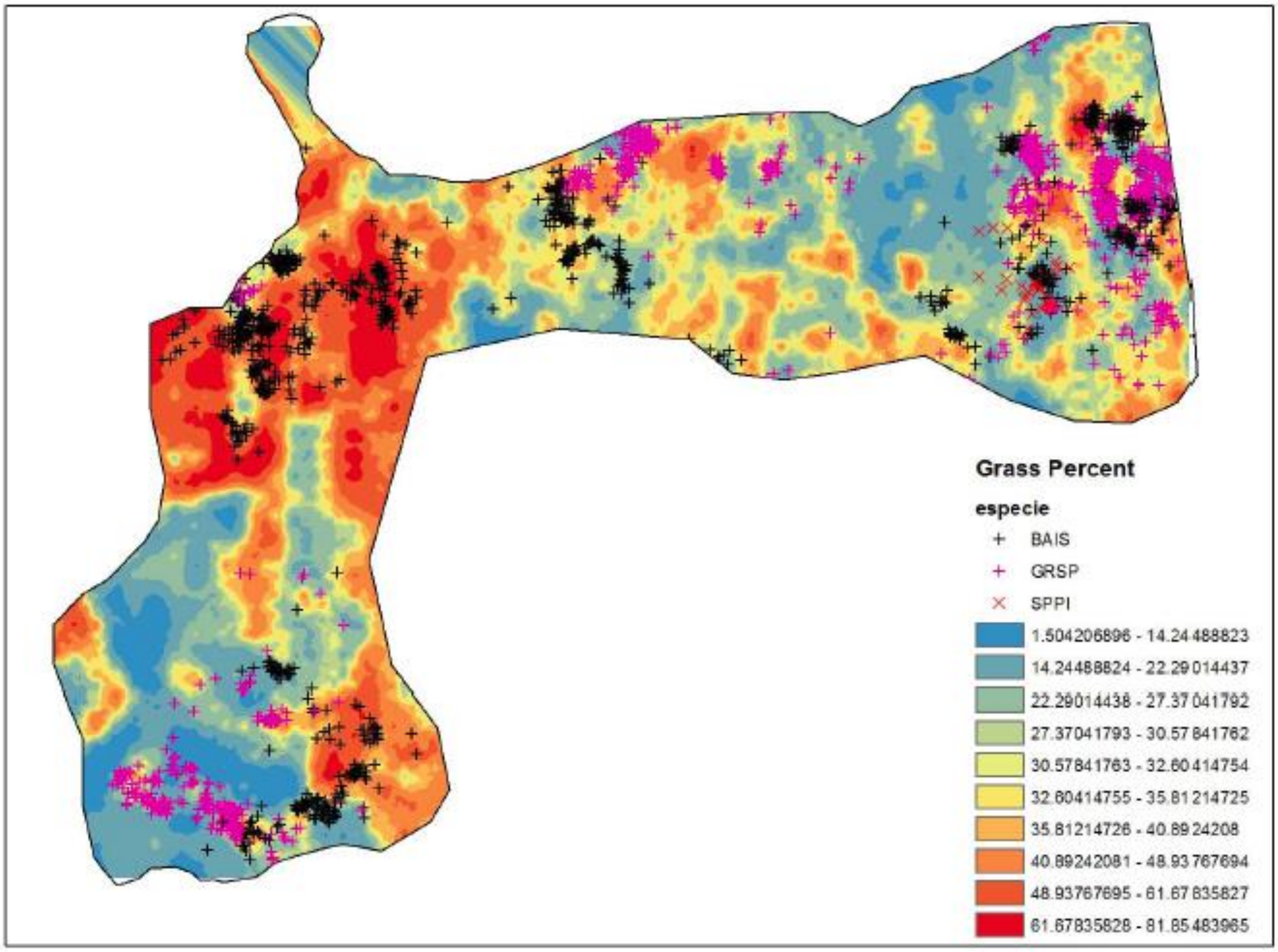

Figure 10: Surface map of percent grass cover generated from the vegetation sampling grid within the Chihuahua study area. Warmer colors indicate higher percent grass cover. Bird location points are identified by species: BAIS= Baird's Sparrow, GRSP=Grasshopper Sparrow, and SPPI=Sprague's Pipit.

Table 3: Vegetation cover and height characteristics for vegetation grid points and by species at the Chihuahua study site for winter 2014-15. **A.** Vegetation characteristics associated with 50m grid points across the Chihuahua Study area. **B.** Vegetation characteristics associated with Baird's Sparrow locations **C.** Vegetation characteristics associated with Grasshopper Sparrow locations. **D.** Vegetation characteristics associated with Sprague's Pipit locations.

A.

Grid Points	*Forb Cover*	*Forb Height*	*Shrub Cover*	*Shrub Height*	*Grass Cover*	*Grass Height*	*Other Cover*	*Salsola*	*Bare Soil*
Mean	**0.91**	**6.37**	**0.72**	**47.98**	**34.17**	**18.61**	**12.35**	**0.02**	**52.01**
Standard Error	0.03	0.16	0.04	0.47	0.35	0.09	0.21	0.01	0.40
Minimum	0	1	0	4	0	1	0	0	0

Maximum	20	48	39	201	96.5	63	84	18.5	99
n	3783	2288	3783	1259	3783	3771	3783	3783	3783

B.

BAIS	*Forb Cover*	*Forb Height*	*Shrub Cover*	*Shrub Height*	*Grass Cover*	*Grass Height*	*Other Cover*	*Salsola*	*Bare Soil*
Mean	**0.91**	**8.19**	**0.43**	**46.22**	**39.20**	**19.83**	**10.72**	**0.01**	**48.98**
Standard Error	0.01	0.13	0.01	0.16	0.36	0.07	0.16	0	0.42
Minimum	0	1.00	0	30.21	13.92	12.30	2.55	0	15.08
Maximum	3.72	23.33	3.85	70.61	71.38	27.69	54.51	0.30	86.22
n	1541	1512	1541	1054	1541	1541	1541	1541	1541

C.

GRSP	*Herb Cover*	*Herb Height*	*Shrub Cover*	*Shrub Height*	*Grass Cover*	*Grass Height*	*Other Cover*	*Salsola*	*Bare Soil*
Mean	**0.99**	**3.62**	**0.85**	**48.30**	**27.80**	**18.69**	**9.96**	**0.04**	**60.16**
Standard Error	0.01	0.05	0.02	0.13	0.17	0.06	0.23	0	0.32
Minimum	0.10	1.00	0	32.57	11.57	11.17	2.03	0	25.03
Maximum	2.42	12.00	6.09	68.04	50.61	26.21	49.88	1.31	82.66
n	1497	1497	1497	1477	1497	1497	1497	1497	1497

D.

SPPI	*Herb Cover*	*Herb Height*	*Shrub Cover*	*Shrub Height*	*Grass Cover*	*Grass Height*	*Other Cover*	*Salsola*	*Bare Soil*
Mean	**1.00**	**3.05**	**0.64**	**47.23**	**23.24**	**18.11**	**5.15**	**0**	**71.43**
Standard Error	0.03	0.11	0.07	0.56	0.78	0.26	0.14	0	0.90
Minimum	0.44	1.67	0.06	42.86	14.63	14.19	3.99	0	49.91
Maximum	1.48	5.16	2.78	60.74	34.67	22.23	8.62	0	80.91
n	46	46	46	46	46	46	46	46	46

Bird Densities

We conducted mid-winter bird surveys across the study areas. We completed 49-500m transects in Chihuahua, 12 in Durango, and 44 in Coahuila. In general, grassland bird densities were lower winter 2014-15 than 2013-14 (Figure 6). However, Baird's Sparrows densities, which were extremely low at the Chihuahua site in winter 2013-14 (few detected and only two radio-marked), rebounded this winter; Almost half of the radio marked birds in Chihuahua in 2014-2015 were Baird's Sparrows and Baird's Sparrows have not been abundant at the Coahuila site in previous years of but they comprised the majority of radio-tagged birds in 2014-2015. Densities for Grasshopper Sparrows and Baird's Sparrows varied between sites (Table 2). Chihuahua had the lowest densities for both species.

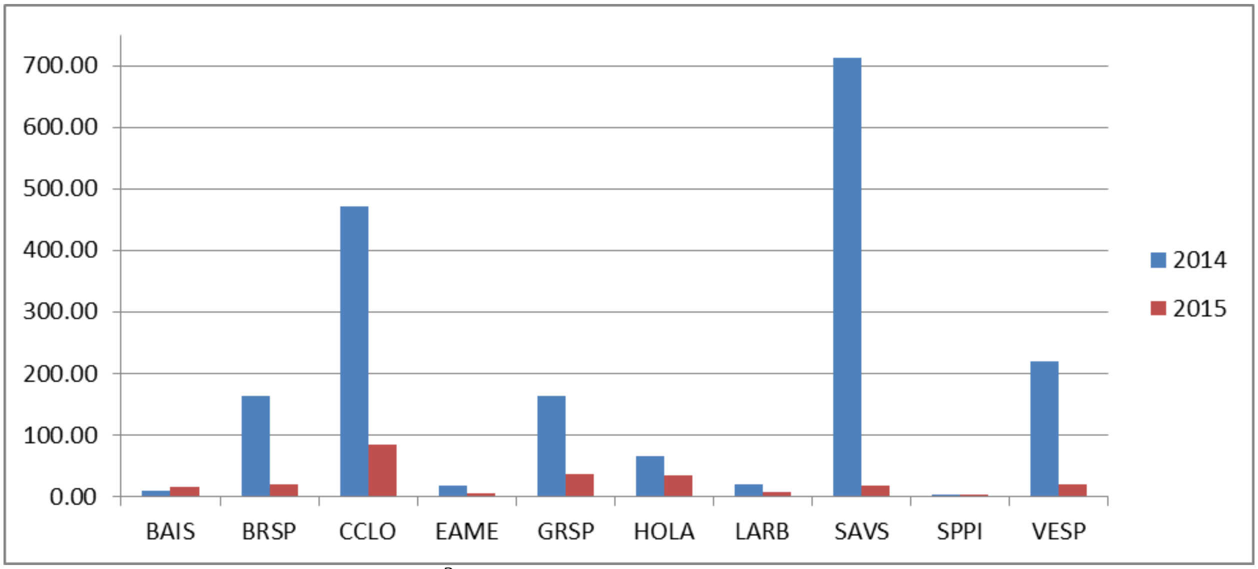

Figure 6. Bird densities (birds/km^2) at the Chihuahua site in winter 2013-14 (2014) and 2014-15 (2015).

Table 2. Mid-winter density estimates (birds/km^2) and corresponding coefficients of variation (CV) and 90% lower and upper confidence intervals (L and U CL) generated by program DISTANCE for Grasshopper and Baird's Sparrows at the three study sites in 2014-15.

Grasshopper Sparrow

Site	Estimate	CV	df	LCI	UCI
Chihuahua	36.88	27.55	53.41	23.45	58.01
Durango	150.61	11.06	23.94	124.72	181.87
Coahuila	43.031	26.96	45.84	27.583	67.13

Baird's Sparrow

Site	Estimate	CV	df	LCI	UCI
Chihuahua	14.93	49.08	50.69	6.86	32.52
Durango	91.45	31.21	12.63	53.23	157.12
Coahuila	69.679	21.48	55.15	48.842	99.405

DISCUSSION

Monitoring of overwinter survival in Baird's and Grasshopper Sparrows for three winters has provided novel insight into grassland bird winter ecology and survival. Preliminary results indicate generally low survival that varies substantially among years and sites, and that predation is the leading cause of direct mortality in grasslands.

Grasshopper Sparrow survival probabilities were lower than Baird's Sparrows. Predation rates may have been higher for this species because of their smaller body size which may make them more vulnerable to colder temperatures. Across our sites, average mass of wintering Grasshopper Sparrows was 16.97g compared with Baird's Sparrows which averaged 18.13g.

Smaller birds have a proportionally larger surface area from which to lose heat putting them at a disadvantage in colder temperatures. It would be expected that Grasshopper Sparrows would prefer sites with denser grass which may provide better protection from colder temperatures. However, they tended to use sites with lower percent grass cover compared to what was available in the study area. Birds under cold stress may be more likely to be depredated as they must spend more time foraging at the cost of remaining vigilant for predators. In fact, in 2012-13 we observed drops in survival rates during late December and mid-January following cold weather, particularly after snowfall which may make sparrows more visible to predators. Elevated Grasshopper Sparrow survival rates observed in winter 2014 may have been related to warmer and drier conditions that winter.

Pre-winter precipitation likely played a role in winter habitat suitability which could affect survival rates. For example, a wet summer in 2013 may have promoted relatively high survival rates (90.56% of birds surviving) in Chihuahua for winter 2013-14 by increasing grass cover and food availability. In addition, bird densities were higher winter 2013-14, potentially reducing predation pressure.

Shrub density may also be related to survival rates. Predators, particularly Loggerhead Shrikes, utilize taller shrubs to scan their surroundings for prey. The Durango study site which exhibited very low survival in 2014-15 had high shrub density, with much of the open grasslands surrounded by a wall of Juniper trees. Also, Grasshopper Sparrows were more likely to use habitat with greater shrub cover and taller shrubs, another possible explanation for their lower survival overall.

Preliminary results from molecular sexing of tagged birds indicate that the sex ratio of birds in Valle Colombia was male-biased compared with the Durango site which was female biased. Valle Colombia birds also had higher survival in 2014-15 (83.01% survived) compared with Durango's 13-71% survival. Higher survival in this population may indicate that males of higher quality are migrating to the shorter distance to the more northerly site in Coahuila. The population-level implications of male-biased survival are something we hope to study further in conjunction with our research on the breeding grounds.

Many radio-tagged birds' fates were unknown. Home range analyses demonstrated that a proportion of the wintering population made forays outside of their territories, established new territories, or wandered widely across the study area. Thus some "missing" individuals may have moved out of our range of detection. Similarly, predators may have moved carcasses outside of the study area, as has been observed with recovered carcasses. It is also possible that transmitter batteries failed prematurely or were damaged by predators.

Less birds were floaters in 2012-13 (30%) than 2013-14 (44%) and 2014-15 (33%) fell in the middle. The variation in proportion of territorial and floater birds could be attributed to bird densities in the study area. In 2013-14, the winter with the highest proportion of floaters, bird densities were much higher that what was observed in 2012-13 and calculated in 2014-15. More birds in an area may reduce predation pressure contributing to movements, or could lead to more territorial disputes, driving birds from one area to another. Future analyses will examine how density affects movements, whether movement patterns are related to age, or if birds move in search of higher quality habitat conditions. Additionally we hope to examine the implications that space-use strategies have on survival as we have observed a number of birds depredated after switching territories.

Our experience with capturing and recapturing the Sprague's Pipit in Chihuahua provided insight into pipit behavior which will advance our study of this species in subsequent seasons.

For example, we noted that the marked individual as well as pipits observed in the vicinity of the marked pipit were hesitant to flush and would walk slowly across patches of bare dirt until we were within 10-15m. Although we have no information on site fidelity, we expect that we can return to areas where we observed pipits in previous winters, locate a bird and set up a net array, slowly approach the bird and flush them towards the net. Unfortunately, when we returned to this area in December 2015, we did not observe any pipits. One pipit was radio-tagged at the Durango site in December 2015.

Our initial observations in December 2015 indicated that grassland bird densities can vary noticeably between winters. The Coahuila site, the site with the highest survival rates in 2014-15, had very low wintering bird densities and Baird's and Grasshopper Sparrows were few and far between. The Durango site was heavily overgrazed, supported few grassland birds and was considered not viable. Therefore, bird were monitored at a second site located 10km south of the original Durango study area. This site harbored high densities of sparrows despite relatively low grass cover. The Chihuahua site contained sufficient sparrow numbers although a portion of the site, an area with higher shrub (*Ephedra spp*.) densities, which in the past contained many radio-tagged sparrows, was sparsely populated. 30-40 sparrows were radio-tagged at the Durango and Chihuahua sites in December 2015. The Coahuila team radio-tagged a variety of grassland sparrow species including Cassin's, Savannah, and few *Ammodramus* sparrows. Mortality at the three sites was noticeably higher in December, possibly because of wetter and colder conditions created by "El Niño".

FUTURE DIRECTIONS

With the information we have gathered it is clear that overwinter survival and movement patterns are variable within and across seasons and space, so a long-term and spatially broad perspective, with data from across the winter period and range, is needed to fully understand the impact and scope of potential limiting factors. We will continue to monitor survival rates, vegetation parameters, climate, bird and predator densities, and space use patterns across the three sites. With our existing data we will model survival probabilities incorporating covariates related to climate, vegetation and bird density to determine their relative contribution to survival probabilities. With this information we hope to populate integrated population models that can help identify bottlenecks across the full annual cycle and guide conservation efforts at both continental and local scales.

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The 2014-15 Chihuahua field crew.

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