Wintering Bird Inventory and Monitoring in Priority Conservation Areas in Chihuahuan desert Grasslands in Mexico: 2007 pilot results

Final technical report
Dec. 12, 2007

The mission of the Rocky Mountain Bird Observatory (RMBO) is the conservation of Rocky Mountain and Great Plains Birds and their habitats. *RMBO promotes a broad, balanced approach to bird conservation and accomplishes its work through daily cooperation with other nonprofit organizations, schools, private landowners, and state and federal natural resource agencies. RMBO accomplishes its mission by working in four arenas:*

Research*:* *RMBO conducts scientific research on bird distribution and abundance in relation to habitat, habitat changes, and other ecological patterns and processes important to bird conservation.*

Monitoring*:* *RMBO conducts long-term, broad-scale monitoring of bird populations to track population trends in the western Great Plains and southern Rocky Mountains.*

Education*:* *RMBO provides active, experiential education programs for K-12 students and adults in order to create an awareness and appreciation for birds, and promote an understanding of the need for bird conservation.*

Outreach*:* *RMBO shares the latest information in land management and bird conservation practices with private landowners, land managers, and other resource professionals. RMBO develops voluntary, working partnerships with these individuals and to conserve bird habitat throughout the Great Plains and Rocky Mountains.*

On behalf of RMBO, I am pleased to submit the following technical report.

Arvind Panjabi
Director, International Program

Suggested Citation:
Panjabi, Arvind, Gregory Levandoski, and Robert Sparks. 2007. Wintering Bird Inventory and Monitoring in Priority Conservation Areas in Chihuahuan desert Grasslands in Mexico: 2007 pilot results. Rocky Mountain Bird Observatory, Brighton, CO, Final technical report I-MXPLAT-TNC07-01. 72 pp.

Cover Photo: Black-tailed Prairie Dog on Ejido Pancho Villa, Janos, Chihuahua, by Arvind Panjabi

Contact Information:
Arvind Panjabi arvind.panjabi@rmbo.org
RMBO Fort Collins Office
230 Cherry Street
Fort Collins, CO 80521
970.482.1707

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Acknowledgements

This project was made possible through support provided by the USDA Forest Service, the US Fish and Wildlife Service and The Nature Conservancy, under the terms of Grant Agreements 02-CA-11132762-077, VA-N121, VA-N291. The content and opinions expressed herein are those of the author(s) and do not necessarily reflect the position or the policy of the USDA Forest Service, the US Fish and Wildlife Service or The Nature Conservancy, and no official endorsement should be inferred.

Implementation of field surveys in Mexico was coordinated by the Universidad Autónoma de Nuevo León, which assembled field crews, conducted many of the surveys, and handled logistics in Mexico. Without their assistance this project would not have been possible. We are also thankful for the support and participation of other partner organizations, including Pronatura Noreste for providing facilities for training and field operations near Janos, as well as Profauna Chihuahua, Profauna Coahuila, and the Universidad Juárez de Durango for implementing field surveys.

The authors are especially grateful to Jose Ignacio González Rojas and Irene Ruvalcaba Ortega for their invaluable assistance in coordinating and implementing this effort. We also thank Jennifer Blakesley, Aixa Bujduj Leon, Pedro Angel Calderon Domínguez, Eglantina Canales, Rafael Humberto Cárdenas Olivier, Enrique Carreón Hernández, Silvia Alejandra Chavarria Rocha, Jim Chu, Javier Cruz Nieto, Miguel Ángel Cruz Nieto, Nereyda Cruz Maldonado, Teresita De Jesús Lasso López, Martha Desmond, Lucas Foerster, Javier Saúl García, Miguel Ángel Grageda, Armando Jiménez Camacho, David Hanni, Nancy Hernández Rodríguez, Jurgen Hoth, Alberto Lafón Terrazas, Juan Francisco Maciel Najera, José Hugo Martínez Guerrero, Robert McCready, David Mehlman, Adriana Núñez Gonzalí, Martín Emilio Pereda Solís, José Roberto Rodríguez Salazar, Daniel Sierra Franco, Fernando Solís Carlos, and Alicia Zarate Martínez. We also thank the many landowners in Mexico who allowed access to their lands for field surveys.

Summary

Many grassland bird species are of high continental conservation concern due to large-scale, continuing habitat loss and degradation over much of their range. Chihuahuan desert grasslands are globally important to many grassland birds of western North America, especially in winter, but they are increasingly being lost to agriculture, desertification, and shrub encroachment. There is very little information on wintering grassland bird distribution, abundance, habitat use, and seasonal movements to guide conservation in this region.

In January 2007, we initiated a first-ever, region-wide survey to inventory, research and monitor wintering birds in Chihuahuan desert Grassland Priority Conservation Areas (GPCAs) in Mexico to provide information to facilitate their conservation in this region. We used GIS to identify grasslands in the region and we conducted 468 1-km line transects and 78 variable-length driving transects at randomly-selected grassland

sites across the GPCAs. These surveys generated information on 40 grassland-associated species, including 25 priority species of high regional or continental conservation interest to Partners in Flight, the U.S. Fish and Wildlife Service, SEMARNAT, and/or The Nature Conservancy. We obtained reasonably precise density estimates for 23 species, including 12 priority species, across GPCAs, and post-stratified estimates by each GPCA. We assessed key vegetation and habitat parameters at each site that we believed could be important in determining grassland bird use. We determined habitat preferences relative to shrub and grass cover for 22 species. We also examined preference of prairie dog towns by selected species.

Densities and richness of wintering grassland birds varied across GPCAs. Some species showed strong gradients of abundance across the region, particularly from north to south, suggesting limited distributions. Eleven species showed strong preference toward grasslands with a high proportion of grass cover and avoidance of those with little cover. Five species preferred sites with only moderate levels of grass cover. At least 16 species strongly preferred sites with less than 1% shrub cover and avoided sites with moderate to high levels of shrub cover. Three species preferred sites with moderate levels of shrub cover. At least four species showed strong preferences towards sites with active prairie dog colonies.

Unfortunately, the habitat features preferred by many grassland birds were rare or uncommon in many of the GPCAs. Nearly 2/3 of our grassland sites had more than 3% shrub cover, a threshold above which habitat use began to decline for many grassland species. Given the widespread degradation of grasslands in the region, and the preference of many species for relatively rare grassland conditions (e.g., little or no shrub cover), the restoration of grasslands in Chihuahuan desert could significantly improve the region's carrying capacity for many wintering grassland bird species.

Based on our results and experience from 2007, we will adjust various aspects of the project in 2008 that should enhance the quality of data collected in the future. Some challenges still remain, particularly in regards to the GIS, but with the improvements identified, we are optimistic that these can be overcome.

Introduction

Populations of many grassland bird species, including 27 species of continental importance for Partners in Flight (PIF) and/or the U.S. Fish and Wildlife Service (USFWS), are undergoing massive population declines due to large-scale, on-going habitat loss and degradation over much of their range. Threats to native grasslands are accelerating in many regions due to expanding agriculture, urbanization, desertification, and invasive species.

The western Great Plains, from southern Alberta and Saskatchewan to southern New Mexico and west Texas, have the most extensive and intact native grasslands remaining in North America, and support the most important breeding areas for the greatest number of grassland bird species (Figure 1A). Over 90% of grassland-breeding bird species in the area are migratory; only the Galliforms (i.e., prairie chickens, grouse) are truly resident. The greatest number of migratory grassland species in the western Great Plains over-winter in the Chihuahuan desert of northern Mexico and the southwestern United States (Figure 1B). Native grasslands are limited in this region, occupying less than 12% of the Chihuahuan desert (Bird Conservation Region 35) in Mexico, yet they are globally important for the over-winter survival of many millions of North American grassland birds. However, little information exists on their distribution, abundance, habitat use, and movements in the region. Also no baseline data exists to monitor regional population trends, impacts of continuing habitat loss, or restoration. The goal of this project is to provide this information through a standardized random-sampling scheme that allows for local and regional population monitoring, rapid inventories of priority sites, and insight into important habitat requirements for grassland birds in the region. This information is urgently needed to facilitate conservation actions for wintering and resident grassland birds in the Chihuahuan desert.

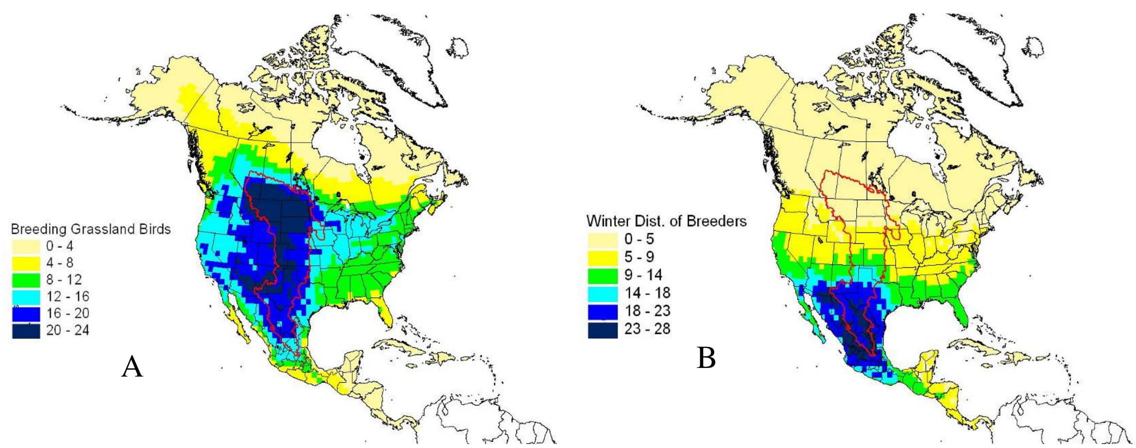


Figure 1. Areas important to breeding (A) and wintering (B) grasslands birds of the western Great Plains (courtesy P. Blancher, Canadian Wildlife Service).

In cooperation with The Nature Conservancy (TNC), the Universidad Autónoma de Nuevo León (UANL), and other U.S. and Mexican partners, we implemented bird surveys across eight Grassland Priority Conservation Areas (GPCAs) in the Chihuahuan desert of Mexico in January and February of 2007. These eight GPCAs (Sonorita, Janos, Valles Centrales, Valle Colombia, Cuchillas de la Zarca, Mapimí, Cuatro Ciénegas, and El Tokio) encompassed 97,937 km^2 of grasslands in seven states, including Sonora, Chihuahua, Coahuila, Durango, Zacatecas, Nuevo León, and San Luís Potosí. Our primary objective was to estimate abundance of all grassland birds, while emphasizing priority species as identified by major bird conservation initiatives including PIF, TNC, USFWS, and the U.S. and Canadian Shorebird Conservation Plans.

The goals and objectives of this project were designed with participation from over 20 partners from universities, NGO's, and federal and state agencies in the U.S. and Mexico at the Third International Symposium on Grasslands, in Chihuahua, Chihuahua, Mexico, in August 2006. A detailed account of the program goals, study design, and methodology are given in Panjabi et al. (2006). UANL coordinated implementation of the field surveys through a network of regional partners, including Profauna Chihuahua, Profauna Coahuila, Universidad Juárez de Durango, UANL, and RMBO.

Methods

Survey design -- We used GIS data available from CONABIO (Inventario Forestal 2002) and TNC (Karl and Hoth 2005) to identify existing target vegetation types (native grasslands and halophytic vegetation) and GPCAs within Bird Conservation Regions 34 (Sierra Madre Occidental) and 35 (Chihuahuan desert) in Mexico. Although this project is focused on the Chihuahuan desert, it was necessary to include BCR 34, as BCR35 did not include the extensive grasslands of the lower Sierra Madre Occidental, in northwest Chihuahua and in northeast Sonora. We placed a grid of roughly 18 x 18 km blocks over this area to identify potential random survey sites and ensure adequate dispersion among samples. We eliminated blocks with less than 5 km of road running through targeted vegetation types, to exclude blocks with few or inaccessible grasslands. We split these blocks into two groups, those that intersected with GPCAs and those that did not. One hundred and forty-two blocks intersected with the GPCAs that also met the other aforementioned criteria (Figure 2). From these, we randomly selected 80 blocks (in proportion to their availability in each GPCA) for our random sample. Using GIS, we placed randomly-numbered points 500 m apart along all roads in each survey block to mark potential start locations for transect surveys.

Observers were instructed to scout out transect surveys routes prior to conducting surveys to locate the first three random points that fell in grassland habitat, and obtain landowner permission for access. Transect starting points that fell in unsuitable habitat (i.e. desert shrubland, agricultural fields), or were inaccessible (i.e., access not granted, road no longer existed, etc.) were dropped and replaced with the next successively numbered random point. If the entire block was unsuitable, the block was discarded and replaced with the nearest available block.

It was necessary to adapt our survey design in the field to account for problems with the GIS used to identify sites. Frequently, roads shown on the GIS that were used to identify random starting locations for transects had either been obliterated, closed, or relocated.

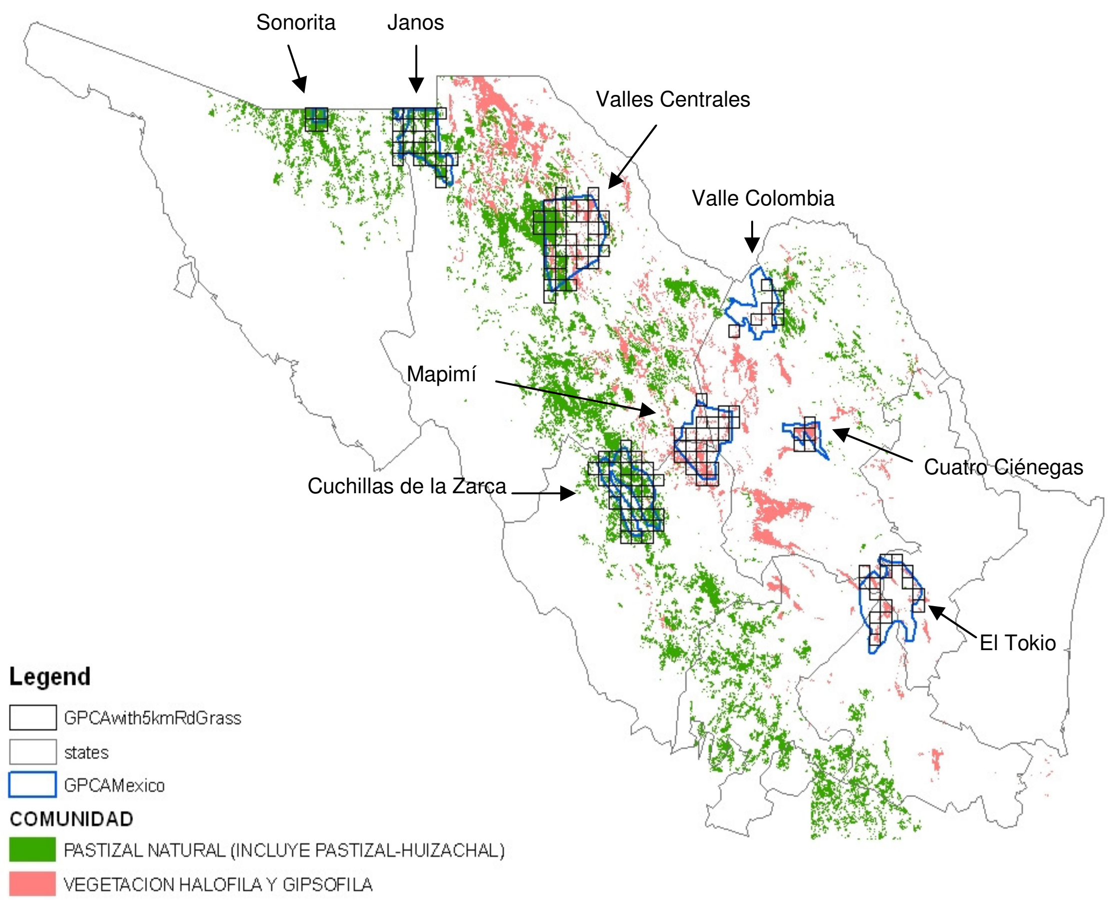


Figure 2. Grassland Priority Conservation Areas (GPCAs) in northern Mexico and potential survey blocks identified.

Also, additional roads frequently existed that were not shown in the GIS. In situations where pre-identified points were not accessible, observers dropped these points and replaced them with the next lowest-numbered random point, or if other roads were available near the originally-selected point, they used GPS to navigate to a point nearest to the original start location on the "new" road. The new point served as surrogate for the randomly located transect start point, all other conditions (i.e., habitat) being equal.

Survey protocol -- The bird survey methodology employed followed that described by Panjabi et al. (2006), with minor modifications as described below. We used two complimentary survey techniques to maximize detections in each survey block: six 1-km line transects (Buckland et al. 2003), and a variable-length driving transect (Figure 3). Line transects were paired, with each pair starting from one of three random points along roads in grasslands and heading perpendicularly away from each other and the road. Although we had originally intended to do 10 1-km line transects in each block (as described in Panjabi et al. 2006), this was not possible due to long on-the-ground travel times between points. Observers estimated lateral distances from the transect line to each bird or bird cluster detected, using laser rangefinders to measure distances and gauge estimates whenever possible.

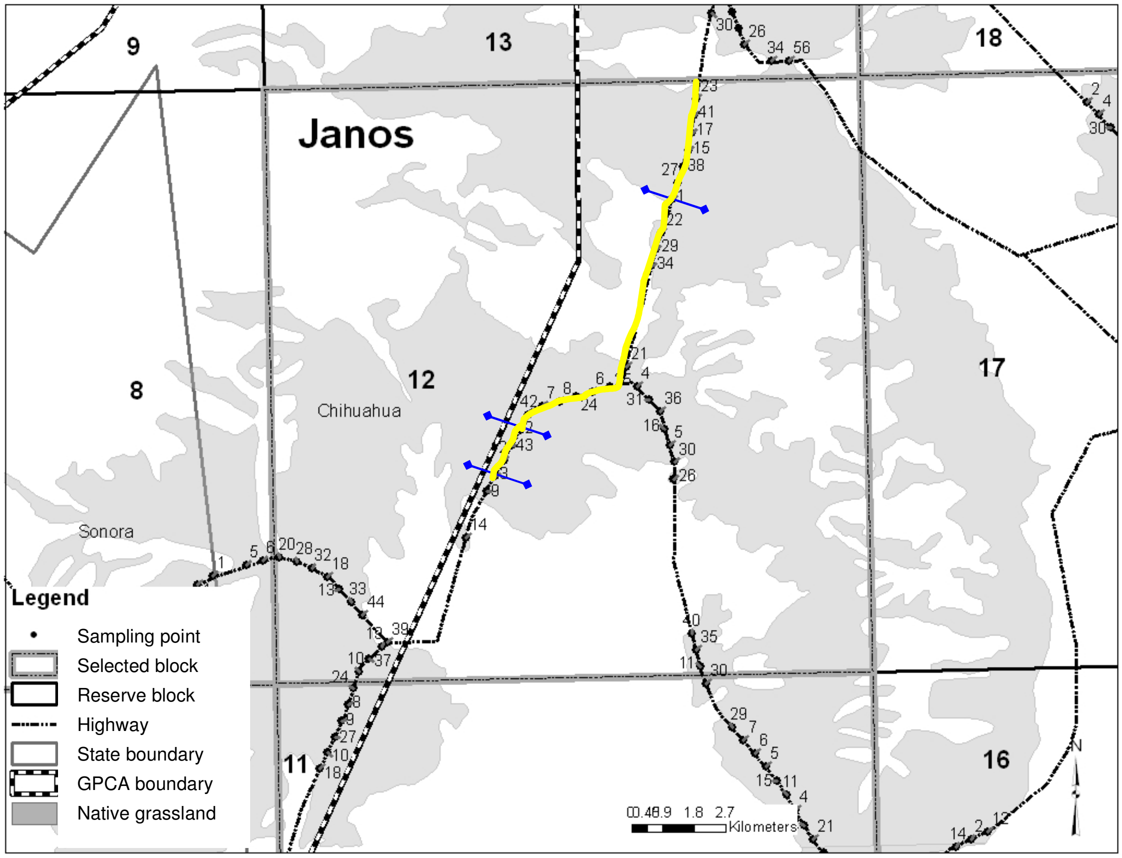


Figure 3. Example of a survey block, with driving line transect shown in yellow, and paired 1-km line transects shown in blue.

Variable-length driving transects were conducted along roads from moving vehicles (<30 kph, safety permitting) by one or more observers while traveling in the block between the random start locations of the line transects. Driving transects focused only on a subset of larger, more detectable grassland birds, including several priority species (see Appendix D). Observers recorded the mileage driven during each leg of this transect, and recorded UTM locations for priority species detected. Lateral distances to birds from the road were not recorded consistently among observers, rendering the data largely unusable for estimating density from these surveys.

Vegetation Surveys -- After completing line transects, observers made visual estimates of vegetation parameters while returning to the transect start point. Observers used GPS to identify three 100 m segments along each transect (starting from the transect end, at 800-700 m, 550-450 m, and 300-200 m) where vegetation parameters were surveyed out to 50 meters on either side of the transect (Figure 4). Along each segment, observers estimated percent cover shrubs, trees, and tall cactus and yuccas (>.33 m) within categories of <1%, 1-3%, 4-10%, 11-25%, 26-50%, 51-75%, and 76-100%. Using these same categories, observers also estimated percent ground cover of grasses, forbs, bare ground, low (<.33 m) woody cover, low cactus, low yuccas and rock. When estimating ground cover, observers focused primarily along and near the transect line as they walked each segment,

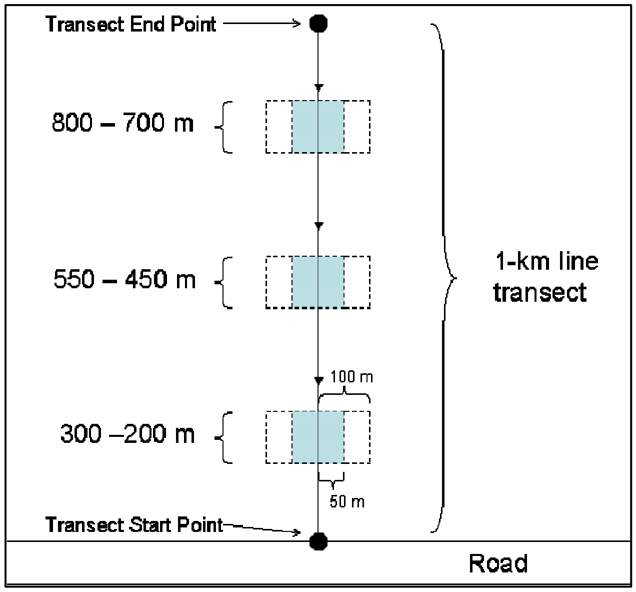


Figure 4. Vegetation survey plots along line transects.

and then extrapolated estimates out to 50 m, modifying them only if there were major changes apparent within 50 m. For grass cover, observers estimated the percent of available grass above and below 15 cm, generally to the nearest 10%.

Out to 100 m on either side of the same line transect segments, observers also recorded the presence/absence of prairie dogs, artificial perches, and surface water. They also visually evaluated grazing intensity in each segment, relative to what the land appeared able to support, and ranked it as either high, medium, or low, based on visual characteristics reflective of range health, such as extent and height of cropped grass, extent of bare ground, extent of shrub-invasion, extent of browsing on shrubs and other woody or succulent vegetation, and visual evidence of soil erosion and other environmental conditions.

Other field procedures -- Observers were to begin surveys at dawn and continue until the six line transects and the variable-length driving transect in each survey block were completed, usually within six hours. However, there was confusion over this, as some observers conducted surveys in the afternoon. We used Beaufort scales to estimate atmospheric conditions at the start and end of the variable length driving transect. We did not conduct surveys during winds higher than 4 (20-29 kph) or during any precipitation greater than drizzle.

Training -- One Canadian, one U.S., and 13 Mexican field biologists completed a five-day training session led by RMBO at Rancho El Uno, near Janos, Chihuahua, from January 22-27, 2007. Three other Mexican biologists, who did not conduct surveys for this project, also participated in the training.

The training curriculum included presentations and lectures on the project background, survey design, Distance sampling theory and practice, and grassland bird identification.

The five-day course emphasized in-field practice of bird identification, distance estimation, and survey procedure, but also used audio-visual aids such as Thayer's birding software, slides, and other digital images to practice and discuss grassland bird identification in a classroom setting. Daily testing was an integral part of the training that helped engage participants in learning and improving their skills, and provided quantitative measures of observer's skill level and progress over the course of the training.

Unfortunately, the training session was affected by inclement weather on four out of five field days. Wet, heavy snow fell nearly continuously, leading to the closure of all highways in northern Chihuahua and severe deterioration of secondary roads. Needless to say, this complicated field activities. Vehicle travel on and off the ranch was difficult, limiting opportunities for practice. Studying birds in the field was also more difficult, as the cold wet weather rendered many participants' binoculars unusable. Aside from optics malfunctioning, the deep snow actually made it easier to see some otherwise cryptic species, such as *Ammodramus* sparrows and Sprague's Pipit (*Anthus spragueii)*, albeit under unusual conditions that caused atypical behaviors.

Despite the weather, the 15 observers persevered and improved their bird identification skills over the course of the training. By the end of the session, most could readily identify 80-90% of the species encountered. Observers were provided with hard copies of survey protocols, data forms and instructions, data codes, and grassland bird identification materials, and were instructed to continue practicing bird identification in their respective survey areas before initiating counts.

Analyses -- All density estimates were generated using program Distance 5.0 (Thomas et al. 2006). Line transects were the primary sampling unit. In most cases, we right-truncated species datasets between 5-15% to eliminate outliers and improve model performance. In a few cases, specific truncation points were chosen to correspond to where detectability dropped below 10-20%. We used global detection functions for each species and post-stratified density estimates by GPCA. We used the following functions to model bird density, Half-normal/Cosine, Half-normal/Hermite Polynomial, Uniform/Cosine, and Hazard Rate/Simple Polynomial, and used AIC, or where sample size was small AICc (n<60), to select among them. A secondary consideration in model selection was the number of parameter adjustments required to fit each model. In a few instances, heaping of recorded distances around commonly used numbers (e.g., 25 m, 50 m, etc) caused poor model fit. In these cases, we grouped observations into equal distance bins to improve performance of models. We ran analyses for all grassland-associated species or species groups with at least 20 independent observations across all transects, although only five of 23 species analyzed had fewer than 60 observations. Although this minimum threshold of n=20 is below that recommended by the authors of program Distance (n>60), some species for which relatively small sample sizes were obtained are of conservation interest. Thus, we felt it was better to present information on these species in a manner consistent with other analyses, that consider detection probability and provided comparable measures of error, rather than present unadjusted indices of abundance for these species.

We calculated average richness of grassland-associated bird species in each GPCA by tallying the number of grassland-associated species recorded on each transect in each GPCA (excluding unknowns) and averaging these across all transects in the GPCA. For this report, grassland associate bird species includes all species that depend on (entirely or in part), or prefer, native grasslands in the Chihuahuan desert in winter. We calculated total species richness in each GPCA by including all species detected in each GPCA during both line and driving transects.

We used Chi-square Goodness-of-Fit tests and Bonferroni-adjusted confidence intervals (Neu et al. 1974, Byers et al. 1984) to determine significant differences in observed vs. expected bird use among vegetation types. We performed these Chi-square analyses for all grassland bird species for which we had at least 30 independent detections to determine preference among classes of shrub and grass cover, as well as sites with prairie dogs vs. sites without.

To analyze use vs. availability of these classes, we used only independent detections (i.e. clusters) of each species per transect to determine use, rather than the total number of individuals observed, in order to increase independence among samples. Availability of vegetation types was based on the proportion of times each category was assigned along the three 100-m vegetation samples along each transect. Because of the unequal nature of the cover estimation categories, it was not possible to determine average coverage of grasses, shrubs, and other categories along each transect. However, since we did not record specific locations of birds along each transect, it was also not possible to associate individual birds with a specific vegetation assessment on a transect. Therefore, we related each species' abundance on a transect to all three vegetation assessments made along that transect. This did not affect the analyses related to use of prairie dog towns.

Results

Twenty-one observers conducted 468 off-road 1-km line transects and 78 variable-length driving transects, in 78 survey blocks in seven GPCAs between January 30 and March 3, 2007. We conducted 18 transects in 3 blocks in Cuatro Ciénegas, 96 transects in 16 blocks in Cuchillas de la Zarca, 78 transects in 13 blocks in Janos, 72 transects in 12 blocks in Mapimí, 54 transects in 9 blocks in El Tokio, 126 transects in 21 blocks in Valles Centrales, and 24 transects in 4 blocks in Valle Colombia. Twelve transects in the only two survey blocks in Sonorita were not completed due to time constraints, logistics, and potential safety concerns.

It is important to note that the boundary for Valle Colombia, a GPCA in northern Coahuila, seems to be somewhat misplaced in respect to the important grasslands in this area. Observers to this GPCA discovered that the boundaries mainly encompassed the Sierra del Carmen and some lowland desert areas to the west, but did not include the extensive grasslands around the small community of Valle Colombia, which lies east of this range. Hence, the results from this GPCA reflect densities of grassland birds in the more limited grasslands of the mountains and desert, rather than in the extensive grasslands around Valle Colombia.

Density

Off-road 1-km line transects -- In total, observers recorded 6,848 bird detections totaling 25,409 birds of 125 species (Appendix A), including 34 grassland-associated bird species, 28 of which are of high continental, national, or regional conservation importance to PIF, USFWS, TNC, or Instituto Nacional de Ecologia (INE) ("*priority species*"; Table 1). An additional 2,550 birds recorded by observers were not identified to species. Most important of these were 469 unidentified *Spizella* sparrows, 114 unidentified *Ammodramus* sparrows, 954 additional unidentified sparrows (Emberizidae), 673 unidentified longspurs (*Calcarius* sp.), and 229 unidentified meadowlarks (*Sturnella* sp.).

Table 1. Grassland-associated conservation priority species detected on line-transects in Chihuahuan desert Grassland Priority Conservation Areas (GPCAs) in Mexico.

Common Name	Scientific Name	Partners in Flight[1]			USFWS BCC 2002[2]			TNC "Unlucky 13"[3]	INE[4]
		U.S.-Canada	BCR34	BCR35	National	BCR34	BCR35		
Scaled Quail	Callipepla squamata	Y	Y	Y				Y	
Northern Harrier	Circus cyaneus		Y	Y	Y		Y		
Bald Eagle	Haliaeetus leucocephalus								Y
Harris's Hawk	Parabuteo unicinctus		Y						Y
White-tailed Hawk	Buteo albicaudatus								Y
Ferruginous Hawk	Buteo regalis		Y	Y	Y	Y	Y	Y	Y
Golden Eagle	Aquila chrysaetos								Y
Prairie Falcon	Falco mexicanus		Y	Y	Y				Y
Sandhill Crane	Grus canadensis								Y
Mountain Plover	Charadrius montanus		Y	Y	Y	Y	Y	Y	Y
Long-billed Curlew	Numenius americanus			Y	Y		Y	Y	
Burrowing Owl	Athene cunicularia		Y	Y	Y		Y	Y	
Long-eared Owl	Asio otus			Y					
Short-eared Owl	Asio flammeus	Y	Y	Y	Y				Y
Loggerhead Shrike	Lanius ludovicianus		Y	Y	Y		Y		
Sprague's Pipit	Anthus spragueii	Y		Y	Y	Y	Y	Y	
Cassin's Sparrow	Aimophila cassinii		Y	Y	Y		Y	Y	
Botteri's Sparrow	Aimophila botterii					Y			
Brewer's Sparrow	Spizella breweri	Y	Y	Y	Y				
Clay-colored Sparrow	Spizella pallida			Y					
Vesper Sparrow	Pooecetes gramineus			Y					
Lark Sparrow	Chondestes grammacus			Y					
Lark Bunting	Calamospiza melanocorys		Y	Y	Y	Y	Y	Y	
Grasshopper Sparrow	Ammodramus savannarum				Y	Y			

Common Name	Scientific Name	Partners in Flight[1]			USFWS BCC 2002[2]			TNC "Unlucky 13"[3]	INE[4]
		U.S.-Canada	BCR34	BCR35	National	BCR34	BCR35		
Baird's Sparrow	Ammodramus bairdii	Y			Y	Y	Y	Y	
McCown's Longspur	Calcarius mccownii	Y		Y	Y		Y	Y	
Chestnut-collared Longspur	Calcarius ornatus		Y	Y	Y	Y	Y	Y	
Eastern Meadowlark	Sturnella magna		Y	Y					

[1] Partners in Flight Species Assessment Database. 2005. Rocky Mountain Bird Observatory Website (www.rmbo.org/pif/pifdb.html). Regional priority status reflects both breeding and wintering regional conservation assessments for BCRs 34 and 35.
[2] U.S. Fish and Wildlife Service. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia. 99 pp. http://migratorybirds.fws.gov/reports/bcc2002.pdf
[3]The Nature Conservancy, Prairie Wings project. http://www.nature.org/initiatives/programs/birds/explore/
[4]Instituto Nacional de Ecologia. NORMA Oficial Mexicana NOM-059-ECOL-2001. http://www.ine.gob.mx/ueajei/norma59a.html

We obtained sufficient sample sizes (n>20) for analyses for 23 grassland-associated species, including 13 priority species, and 4 generic groups (Table 2). No single grassland species was found on more than 47% of transects. Vesper Sparrow, a regional wintering priority species for PIF in the Chihuahuan desert Bird Conservation Region (BCR35), was the most widespread species and it also occurred in highest average density across the region relative to other species, although it was by far more abundant in the North. In descending order, the next most abundant species, region-wide, were Clay-colored Sparrow, Savannah Sparrow, *Ammodramus* sparrows, and Mourning Dove. In descending order, the most widespread grassland species (or groups), as measured by the proportion of transects on which they were detected (*prp. trans*.), were Vesper Sparrow, Mourning Dove, *Spizella* sparrows, Savannah Sparrow, and *Ammodramus* sparrows.

Of the five highest density species mentioned above, only three are also among the five most numerous species recorded on transects (total number individuals detected, pre-truncation): Lark Bunting (N=3,014), Mourning Dove (N=2,723), Chestnut-collared Longspur (N=2,586), Vesper Sparrow (N=2,152), and Clay-colored Sparrow (N=1,861). The species that are in both groups occur in different order in these lists, suggesting that detectability of species is important in measuring populations of wintering grassland birds and interpreting results.

Table 2. Average densities of wintering grassland bird species detected on line transects in Chihuahuan desert Grassland Priority Conservation Areas (GPCAs) in Mexico.

Common Name	***Scientific Name***	***D***	***LCL***	***UCL***	***CV***	***n***	***prp. trans.***
Scaled Quail	*Callipepla squamata*	9.61	3.91	23.62	46%	38	0.07
Northern Harrier	*Circus cyaneus*	0.70	0.51	0.95	16%	76	0.20
Red-tailed Hawk	*Buteo jamaicensis*	0.33	0.22	0.48	19%	68	0.15
American Kestrel	*Falco sparverius*	0.52	0.38	0.70	16%	64	0.13
Sandhill Crane	*Grus canadensis*	0.57	0.20	1.63	55%	20	0.02
Mourning Dove	*Zenaida macroura*	38.90	29.88	50.63	13%	476	0.41
Burrowing Owl	*Athene cunicularia*	1.44	0.54	3.87	52%	28	0.06
Say's Phoebe	*Sayornis saya*	1.35	1.06	1.73	12%	112	0.19

Common Name	*Scientific Name*	*D*	*LCL*	*UCL*	*CV*	*n*	*prp. trans.*
Loggerhead Shrike	*Lanius ludovicianus*	1.42	1.14	1.76	11%	140	0.24
Chihuahuan Raven	*Corvus cryptoleucus*	2.55	1.50	4.32	27%	76	0.18
Horned Lark	*Eremophila alpestris*	9.35	6.32	13.85	20%	193	0.15
Mountain Bluebird	*Sialia currucoides*	4.74	1.24	18.19	65%	61	0.08
Sprague's Pipit	*Anthus spragueii*	2.93	1.20	7.15	44%	40	0.07
Clay-colored Sparrow	*Spizella pallida*	53.01	37.71	74.51	17%	267	0.24
Brewer's Sparrow	*Spizella breweri*	8.65	5.08	14.74	27%	86	0.13
Spizella spp.	*Spizella* spp.	103.19	81.42	130.77	12%	552	0.39
Vesper Sparrow	*Pooecetes gramineus*	69.16	57.85	82.69	9%	838	0.47
Lark Sparrow	*Chondestes grammacus*	4.11	2.10	8.06	35%	48	0.06
Lark Bunting	*Calamospiza melanocorys*	31.69	12.98	77.35	47%	82	0.10
Savannah Sparrow	*Passerculus sandwichensis*	52.25	32.35	84.39	24%	401	0.28
Grasshopper Sparrow	*Ammodramus savannarum*	25.53	18.53	35.19	16%	191	0.18
Ammodramus sp.	*Ammodramus* spp.	40.58	30.37	54.22	15%	304	0.25
Chestnut-collared Longspur	*Calcarius ornatus*	33.59	21.74	51.90	22%	184	0.12
Calcarius spp.	*Cacarius* spp.	34.35	22.13	53.32	23%	209	0.12
Eastern Meadowlark	*Sturnella magna*	1.08	0.71	1.65	21%	68	0.10
Western Meadowlark	*Sturnella neglecta*	2.06	0.96	4.44	40%	44	0.07
Sturnella spp.	*Sturnella spp.*	5.27	3.69	7.50	18%	203	0.22

D=average density (birds/km^2); LCL=lower confidence limit on D; UCL=upper confidence limit on D; CV=Coefficient of variation on D; n=number of observations used to estimate D (*post-truncation*); prp. trans. = proportion of transects on which species was detected

Average densities of most species varied across GPCAs (Appendix B), but aside from cases where some species were completely absent from certain GPCAs, statistically significant differences were relatively few. However, based on non-overlapping 95% confidence limits around density estimates, a few differences are notable. Say's Phoebes were more abundant in Mapimí (*D*=4.2 birds/km^2) than in other GPCAs. Lark Buntings (*D*=196.8 birds/km^2) and Chestnut-collared Longspurs (*D*=178.0 birds/km^2) were significantly more abundant in Janos than in other GPCAS. Clay-colored Sparrows (*D*=239.1 birds/km^2) and Lark Sparrows (*D*=25.9 birds/km^2) were most abundant in Cuchillas de la Zarca, although the 95% confidence interval on the estimate for Clay-colored Sparrow overlaps slightly with the interval for this species in Mapimí. Vesper Sparrows were significantly more abundant in Janos (*D*=231.2 birds/km^2) and Valles Centrales (*D*=174.6 birds/km^2) than other GPCAs. Eastern Meadowlark was also more abundant in Janos (*D*=5.2 birds/km^2) and Valles Centrales (*D*=1.7 birds/km^2) than in other GPCAs.

Variable-length driving transects -- Observers recorded 1024 birds of 22 species during the variable-length driving transects conducted in each survey block (Appendix C). Although this survey did add several additional species to the GPCA inventories, including sometimes priority or other rare species, it does not appear that it provided substantially more detections than the off-road line transects for any species not already adequately sampled by the line transect survey. The survey did yield more observations of Ferruginous Hawk (N=22) and Harris's Hawk (N=26) than line transects.

Surprisingly, this survey didn't yield a single observation of Mountain Plover or Long-billed Curlew, and it provided significantly fewer observations of Burrowing Owl (N=7) than the line transects (N=33). The most numerous species recorded on driving transects were common raptors, including Red-tailed Hawk, Northern Harrier, American Kestrel, as well as Loggerhead Shrike. No densities were estimated from these data as distance estimates were not recorded consistently.

Species Richness

In total, 40 grassland-associated species were detected on both the line transect and driving transect surveys, although the numbers of such species found in each GPCA varied considerably (Table 3). Cuatro Cienégas had the fewest species on average while Janos and Cuchillas de la Zarca had the most. The relatively low value for Valle Colombia should be considered in light of the present boundary for this area, which includes mostly mountains and desert rather than grasslands. Based on combined results from both line transect and driving transect surveys, Valles Centrales supported the greatest number of grassland-associated species, followed by Janos, Mapimí, Cuchillas de la Zarca, El Tokio, Valle Colombia and Cuatro Ciénegas.

Table 3 Species richness of grassland-associated birds in each Grassland Priority Conservation Area (GPCA).

GPCA	Total # grassland species detected*	Average # grassland species per 1-km transect	Standard Error
Cuatro Ciénegas	11	1.94	0.36
Cuchillas de la Zarca	27	9.66	0.48
Janos	34	9.56	0.48
Mapimí	29	6.32	0.41
El Tokio	22	5.24	0.36
Valles Centrales	35	6.09	0.28
Valle Colombia	18	3.38	0.51
All GPCAs	40	7.04	0.20

Vegetation

Although we did not test for statistical differences, vegetation characteristics appear to vary substantially among GPCAs (Appendix E).

Shrub cover – Only 22% of grasslands across GPCAs had little to no shrub cover (<1% cover); nearly half (49%) had >10% cover. The Janos grasslands appeared to be in best shape, with 53% essentially free of shrub cover (<1% cover); well more than twice the proportion of any other GPCA (Table 4). Cuchillas de la Zarca and Mapimí had the fewest open grasslands (<1% shrub cover; 8% and 13%, respectively). Sixty-six percent of grasslands surveyed in Cuchillas de la Zarca GPCA had more than 10% shrub cover, whereas in Janos, only 18% of sites had more than 10% shrub cover. Grasslands in other GPCAs also had a high prevalence (39-58%) of shrubs (>10% cover), indicating that shrub invasion in grasslands is very widespread.

Table 4. Shrub cover estimates in grasslands in Grassland Priority Conservation Areas (GPCAs) in Mexico.

	Proportion of sites in each GPCA*							
Shrub Cover	CUAT	CUZA	JANO	MAPI	TOKI	VACE	VACO	All GPCAs

<1%	0.17	0.08	0.53	0.13	0.18	0.21	0.20	0.22
1-3%	0.09	0.12	0.17	0.09	0.10	0.15	0.10	0.13
3-10%	0.35	0.14	0.12	0.27	0.13	0.14	0.23	0.17
10-25%	0.35	0.15	0.08	0.28	0.27	0.13	0.28	0.18
25-50%	0.04	0.24	0.06	0.19	0.19	0.16	0.13	0.16
50-75%	0.00	0.18	0.03	0.03	0.10	0.14	0.06	0.10
75%-100%	0.00	0.09	0.01	0.00	0.02	0.08	0.01	0.05

* GPCA abbreviations: CUAT = Cuatro Ciénegas; CUZA = Cuchillas de la Zarca; JANO = Janos; MAPI = Mapimí; TOKI = El Tokio; VACE = Valles Centrales; VACO = Valle Colombia

Tree cover -- Tree cover was relatively uncommon in grasslands in most GPCAs (Table 5). Across GPCAs, 82% of sites had less than <1% cover. The exception was Cuchillas de la Zarca, where 47% of vegetation samples had >1% tree cover. Janos had the lowest incidence of trees, with 98% of sites essentially free of trees (<1% cover).

Table 5. Tree cover estimates in grasslands in Grassland Priority Conservation Areas (GPCAs) in Mexico.

	Proportion of sites							
Tree Cover	CUAT	CUZA	JANO	MAPI	TOKI	VACE	VACO	All GPCAs
<1%	0.87	0.53	0.98	0.83	0.85	0.90	0.94	0.82
1-3%	0.09	0.17	0.00	0.04	0.10	0.06	0.04	0.07
3-10%	0.02	0.09	0.00	0.09	0.04	0.02	0.01	0.04
10-25%	0.02	0.07	0.01	0.02	0.01	0.01	0.00	0.02
25-50%	0.00	0.07	0.01	0.01	0.00	0.02	0.00	0.02
50-75%	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.01
75%-100%	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00

* GPCA abbreviations: CUAT = Cuatro Ciénegas; CUZA = Cuchillas de la Zarca; JANO = Janos; MAPI = Mapimí; TOKI = El Tokio; VACE = Valles Centrales; VACO = Valle Colombia

Grass cover – Across all GPCAs, nearly one-fifth (19%) of sites lacked any significant (>=1%) grass cover, and less than one-third had >50% grass cover (Table 6). Estimates of grass cover were greatest in Janos, where 62% of sites had at least 50% grass cover, nearly double that of any other GPCA. El Tokio and Cuatro Ciénegas had the fewest sites with high grass cover (>50%; 5% and 10%, respectively). Cuatro Ciénegas had the highest proportion of sites with <1% grass cover (46%), suggesting nearly half of the grasslands in this GPCA lack grass. Cuchillas de la Zarca and Mapimí also had a high proportion of sites with <1% grass cover (30% and 33%, respectively). Janos and Valles Centrales had the lowest proportion of sites with <1% grass cover (3% and 7%, respectively), although 20% of sites in Valles Centrales had only 1-3% grass cover.

Table 6. Grass cover estimates in grasslands in Grassland Priority Conservation Areas (GPCAs) in Mexico.

	Proportion of sites							
Grass Cover	CUAT	CUZA	JANO	MAPI	TOKI	VACE	VACO	All GPCAs
<1%	0.46	0.30	0.03	0.33	0.14	0.12	0.07	0.19
1-3%	0.20	0.08	0.04	0.08	0.13	0.05	0.20	0.08
3-10%	0.06	0.10	0.04	0.19	0.22	0.09	0.07	0.11
10-25%	0.00	0.15	0.09	0.17	0.30	0.14	0.20	0.15
25-50%	0.19	0.16	0.18	0.12	0.17	0.26	0.15	0.19
50-75%	0.04	0.15	0.29	0.06	0.04	0.21	0.21	0.16
75%-100%	0.06	0.06	0.33	0.05	0.01	0.13	0.10	0.12

* GPCA abbreviations: CUAT = Cuatro Ciénegas; CUZA = Cuchillas de la Zarca; JANO = Janos; MAPI = Mapimí; TOKI = El Tokio; VACE = Valles Centrales; VACO = Valle Colombia

Bare ground -- As might be expected, estimates of bare ground are nearly opposite of grass cover, but they also reflect the proportion of ground area not covered by rock or vegetation other than grass, including low cactus, low yucca, herbs, and low woody cover. Across GPCAs, 30% of grassland sites had >50% bare ground (Table 7). Cuatro Ciénegas had the highest proportion of sites with >50% bare ground (59%), followed by Mapimí (55%), El Tokio (38%), Valle Colombia (32%), and Valles Centrales (30%). Janos had the highest proportion of sites (23%) with <1% bare ground, followed by Cuchillas de la Zarca (16%) and Valle Colombia (15%). Overall, Cuchillas de la Zarca and Janos had the lowest proportion of sites with more than 50% bare ground (13% and 14%, respectively).

Table 7. Estimates of bare ground in grasslands in Grassland Priority Conservation Areas (GPCAs) in Mexico.

	Proportion of sites							
Bare Ground Cover	CUAT	CUZA	JANO	MAPI	TOKI	VACE	VACO	All GPCAs
<1%	0.09	0.16	0.23	0.02	0.00	0.05	0.15	0.10
1-3%	0.06	0.17	0.20	0.01	0.03	0.09	0.11	0.10
3-10%	0.04	0.20	0.16	0.06	0.07	0.10	0.21	0.13
10-25%	0.11	0.19	0.09	0.11	0.12	0.19	0.11	0.15
25-50%	0.11	0.14	0.19	0.25	0.40	0.27	0.08	0.23
50-75%	0.15	0.10	0.08	0.26	0.23	0.22	0.21	0.18
75%-100%	0.44	0.03	0.06	0.29	0.15	0.08	0.11	0.12

* GPCA abbreviations: CUAT = Cuatro Ciénegas; CUZA = Cuchillas de la Zarca; JANO = Janos; MAPI = Mapimí; TOKI = El Tokio; VACE = Valles Centrales; VACO = Valle Colombia

Prairie Dogs -- Prairie dogs are key ecological drivers of habitat conditions important to many grassland birds. Prairie dogs (*Cynomys ludovicianus* and *C. mexicanus*) were recorded on 26 of 468 transects (~6% of sites) in two of the GPCAs, Janos and El Tokio. Most observations (81%) were from El Tokio, where prairie dogs were found on 39% of grasslands. Nineteen percent of prairie dog observations were from Janos, where they were observed on 6% of sites.

Grazing intensity – Half of the grasslands across GPCAs showed signs of high grazing pressure, while less than 1/4 of grasslands showed signs of low grazing pressure (Figure 5). Among GPCAs, high grazing pressure was most widespread in El Tokio (reported on 90% of sites) and Cuatro Ciénegas , 90% and 74% of sites, respectively,

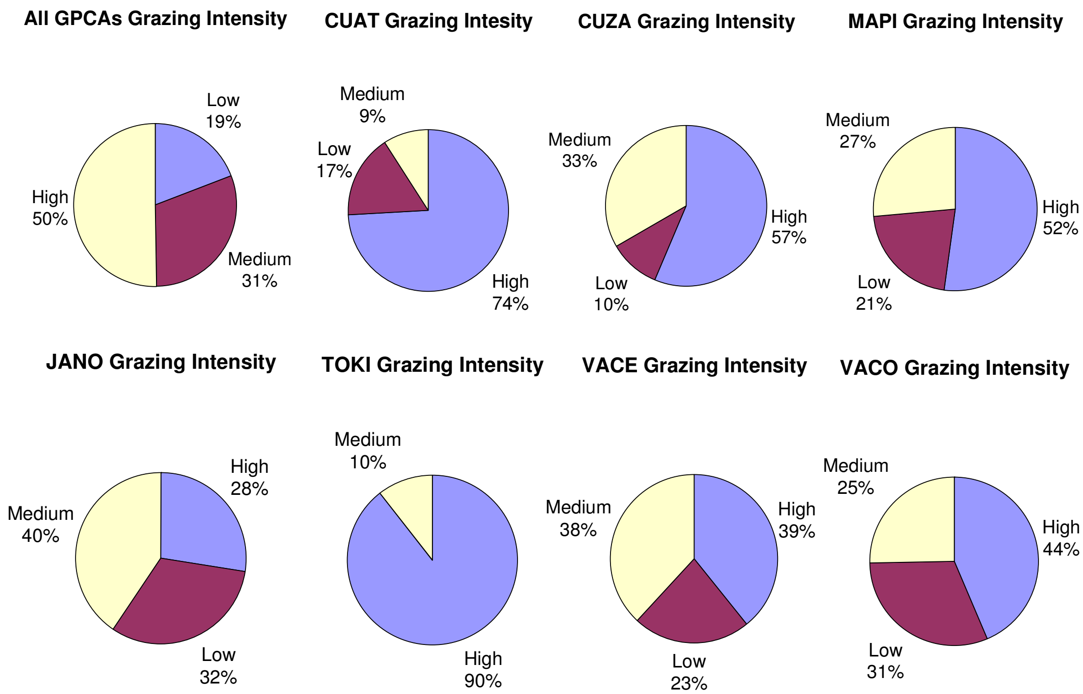
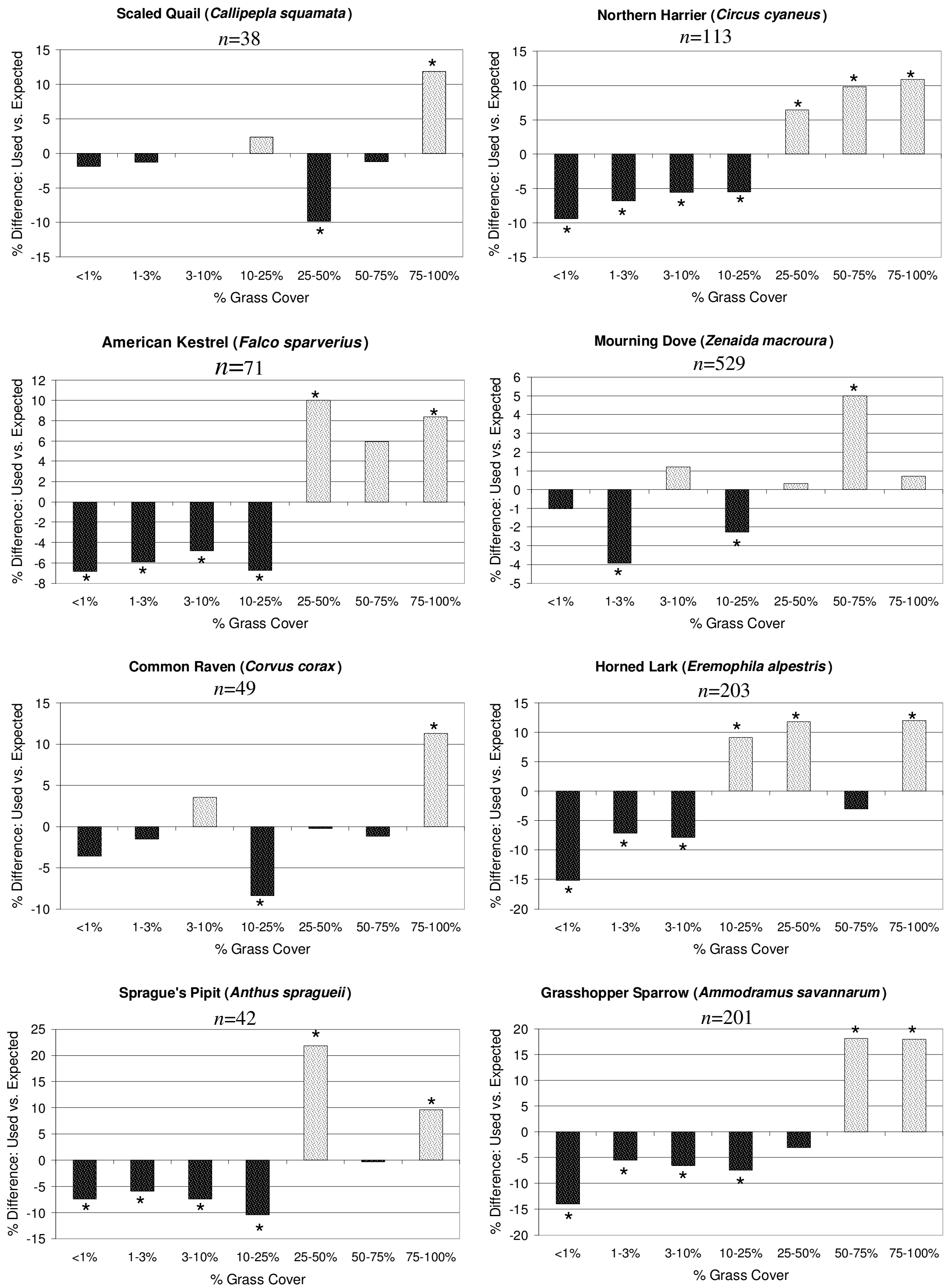


Figure 5. Visual assessments of grazing intensity in grasslands across Grassland Priority Conservation Areas (GPCAs) in Mexico.

Habitat Use

Grass cover use vs. availability -- We examined observed vs. expected use of grass cover classes for 22 species (Appendix D). At least 11 species showed a significant preference for grassland sites with a high proportion of grass cover and a significant avoidance of sites with little or no grass cover (Figure 6). These species included Scaled Quail, Northern Harrier, American Kestrel, Mourning Dove, Common Raven, Horned Lark, Sprague's Pipit, Grasshopper Sparrow, Chestnut-collared Longspur, Eastern Meadowlark, and Western Meadowlark. Five species (Red-tailed Hawk, Burrowing Owl, Say's Phoebe, Chihuahuan Raven and Clay-colored Sparrow) showed a significant preference for sites with intermediate levels of grass cover, while significantly avoiding sites with either extremely low and/or high levels of grass cover (Figure 7). Lark Sparrow avoided sites with >75% grass cover, and showed a non-significant tendency towards sites with moderate or little to no grass cover. Loggerhead Shrike showed no significant differences among any categories of grass cover, although it showed a slight tendency towards sites with 25-75% grass cover.


Scaled Quail (*Callipepla squamata*)
n=38
Northern Harrier (*Circus cyaneus*)
n=113
American Kestrel (*Falco sparverius*)
n=71
Mourning Dove (*Zenaida macroura*)
n=529
Common Raven (*Corvus corax*)
n=49
Horned Lark (*Eremophila alpestris*)
n=203
Sprague's Pipit (*Anthus spragueii*)
n=42
Grasshopper Sparrow (*Ammodramus savannarum*)
n=201
% Difference: Used vs. Expected
% Grass Cover
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
*

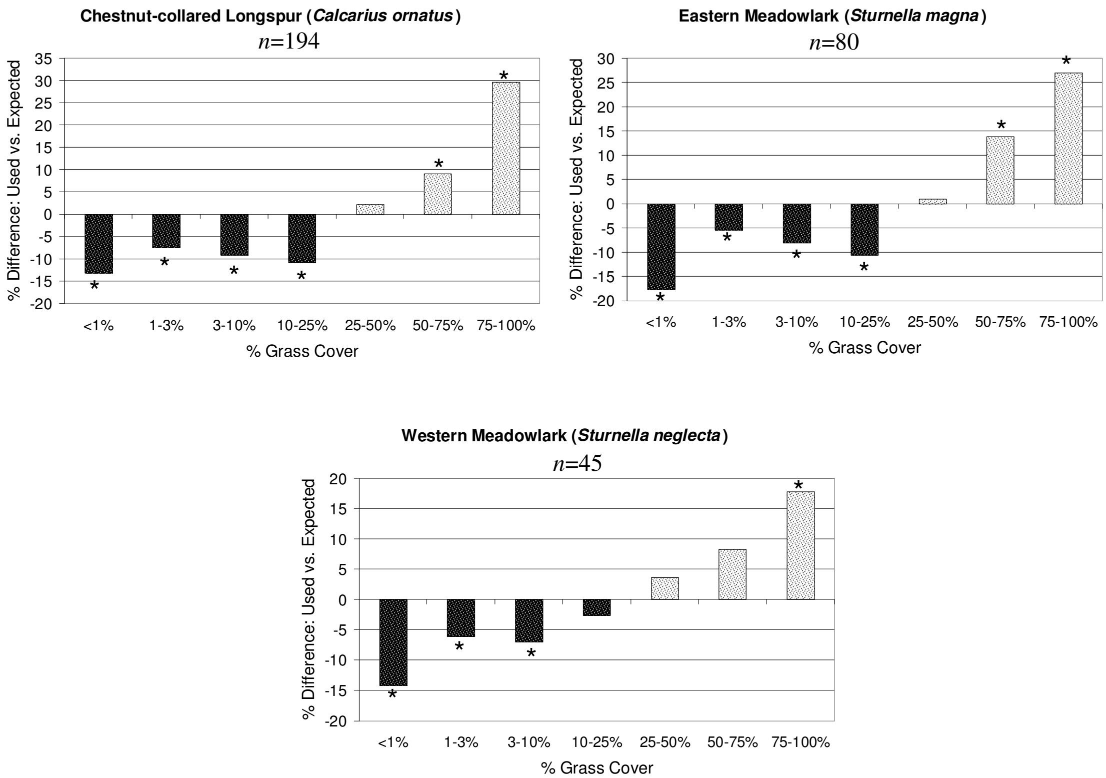
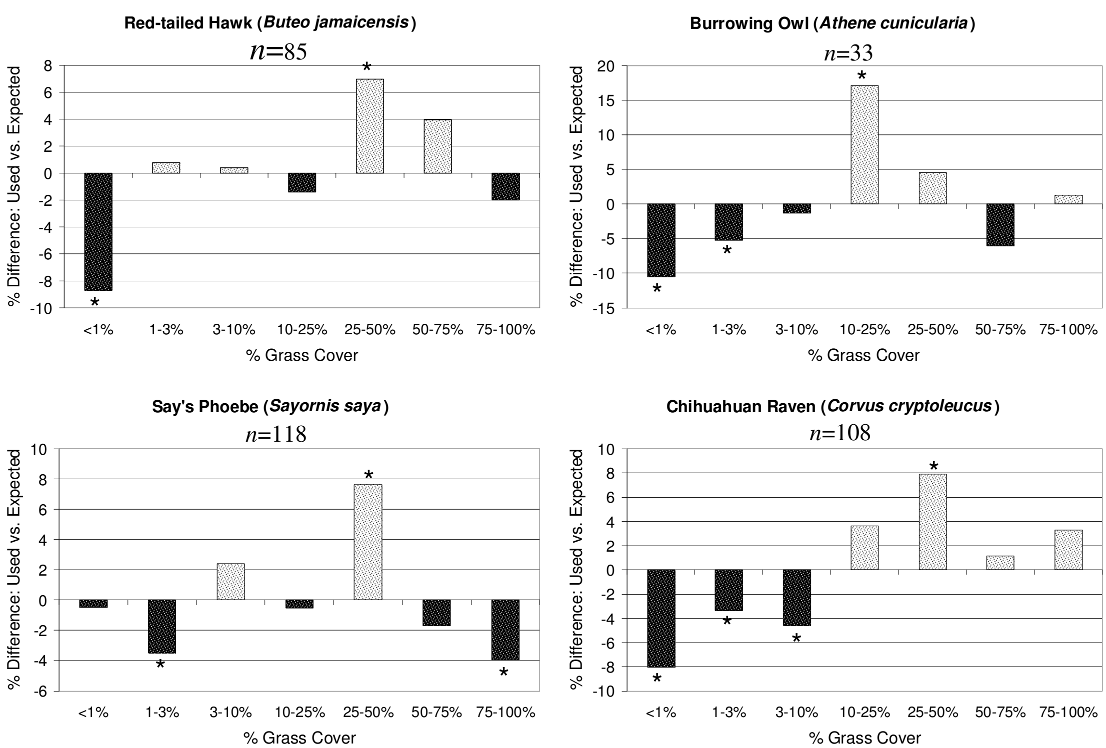


Figure 6. Wintering grassland-associated bird species that preferred sites with high grass cover and avoided sites with low grass cover in Grassland Priority Conservation Areas (GPCAs) in Mexico.



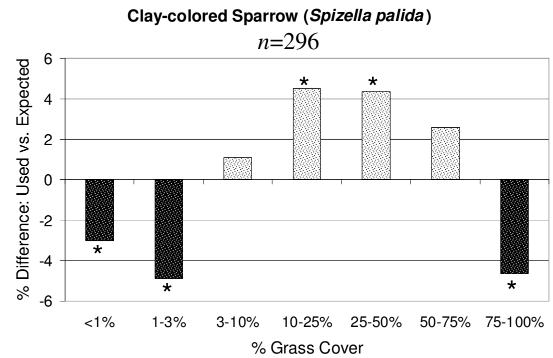
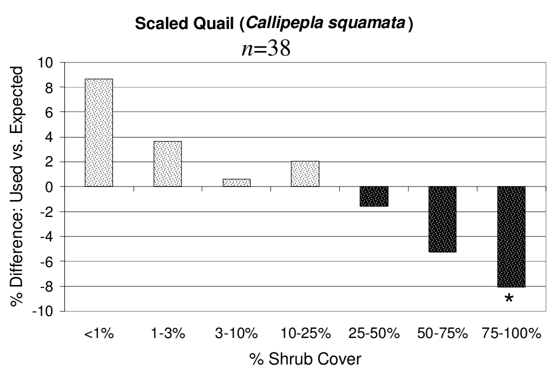
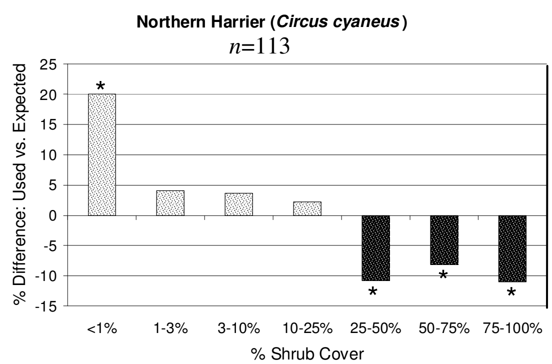
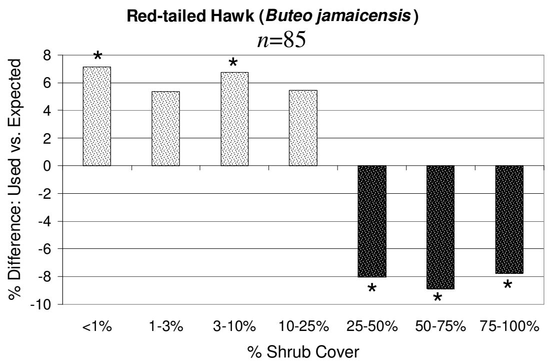


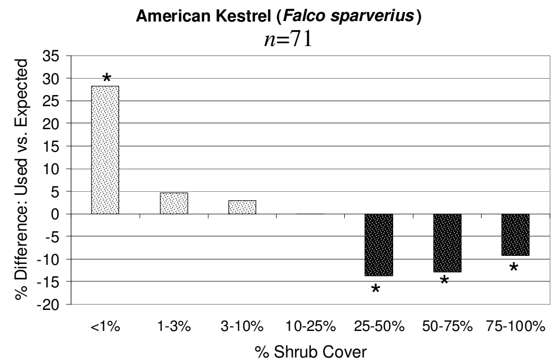
Figure 7. Wintering grassland-associated bird species that preferred sites with intermediate levels of grass cover and avoided sites with either very high and/or very low cover in Grassland Priority Conservation Areas (GPCAs) in Mexico.

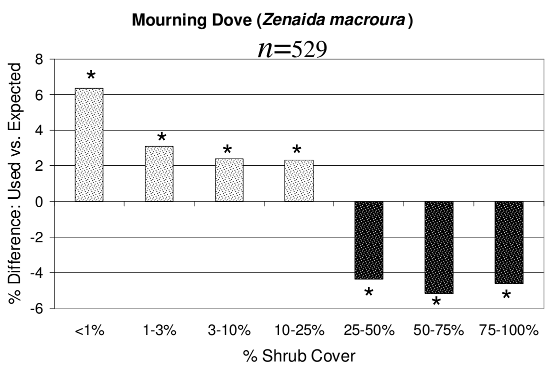
Shrub cover use vs. availability -- We examined observed vs. expected use of grass cover classes for 22 species (Appendix E). Most species avoided sites with high shrub cover. However, the threshold of shrub cover at which habitat use dropped significantly below expected levels varied among species. Sixteen species (Northern Harrier, Red-tailed Hawk, American Kestrel, Burrowing Owl, Mourning Dove, Chihuahuan Raven, Common Raven, Horned Lark, Sprague's Pipit, Vesper Sparrow, Lark Bunting, Savannah Sparrow, Grasshopper Sparrow, Chestnut-collared Longspur, Eastern Meadowlark, and Western Meadowlark) showed a strong preference for sites with <1% cover shrub cover (Figure 8). A seventeenth species, Scaled Quail, also showed a similar pattern, although their preference for open grasslands was just shy of statistical significance. For most of these species, their preference toward grasslands with <1% shrub cover was exclusive; they did not select any additional grassland types out of proportion to their availability. But, to a lesser degree, Lark Bunting, Savannah Sparrow and Eastern Meadowlark also selected grasslands with 1-3% shrub cover, and Vesper and Grasshopper sparrows also preferred grasslands with up to 10% cover. Red-tailed Hawk and Mourning Dove, showed strong preferences toward grasslands with <1% shrub cover, but they also preferred shrublands with up to 25% shrub cover.

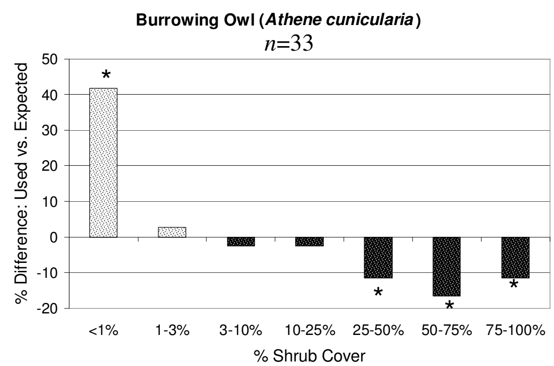


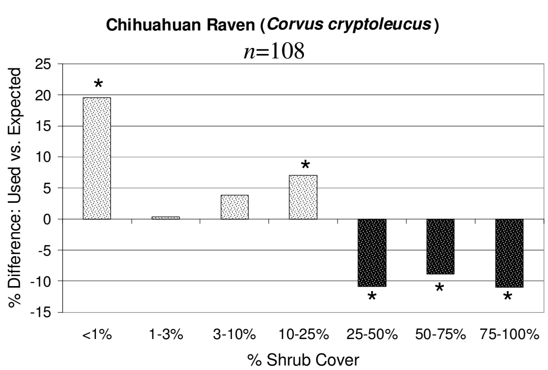


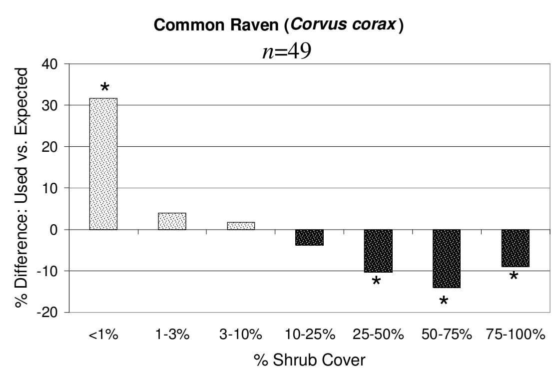

Red-tailed Hawk (Buteo jamaicensis)
n=85
% Difference: Used vs. Expected
8
6
4
2
0
-2
-4
-6
-8
-10
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover

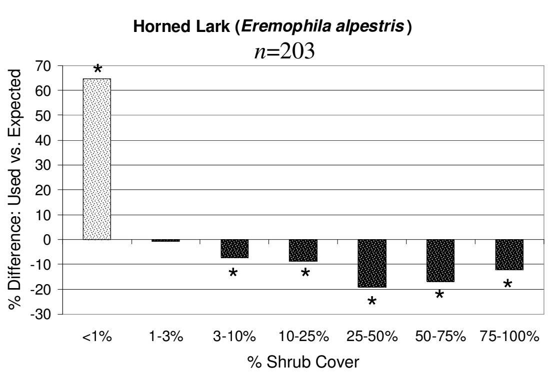

American Kestrel (Falco sparverius)
n=71
% Difference: Used vs. Expected
35
30
25
20
15
10
5
0
-5
-10
-15
-20
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover

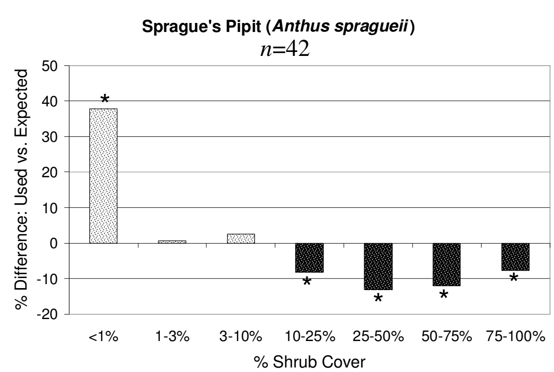

Mourning Dove (Zenaida macroura)
n=529
% Difference: Used vs. Expected
8
6
4
2
0
-2
-4
-6
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover


Burrowing Owl (Athene cunicularia)
n=33
% Difference: Used vs. Expected
50
40
30
20
10
0
-10
-20
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover


Chihuahuan Raven (Corvus cryptoleucus)
n=108
% Difference: Used vs. Expected
25
20
15
10
5
0
-5
-10
-15
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover


Common Raven (Corvus corax)
n=49
% Difference: Used vs. Expected
40
30
20
10
0
-10
-20
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover


Horned Lark (Eremophila alpestris)
n=203
% Difference: Used vs. Expected
70
60
50
40
30
20
10
0
-10
-20
-30
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover


Sprague's Pipit (Anthus spragueii)
n=42
% Difference: Used vs. Expected
50
40
30
20
10
0
-10
-20
<1%
1-3%
3-10%
10-25%
25-50%
50-75%
75-100%
% Shrub Cover

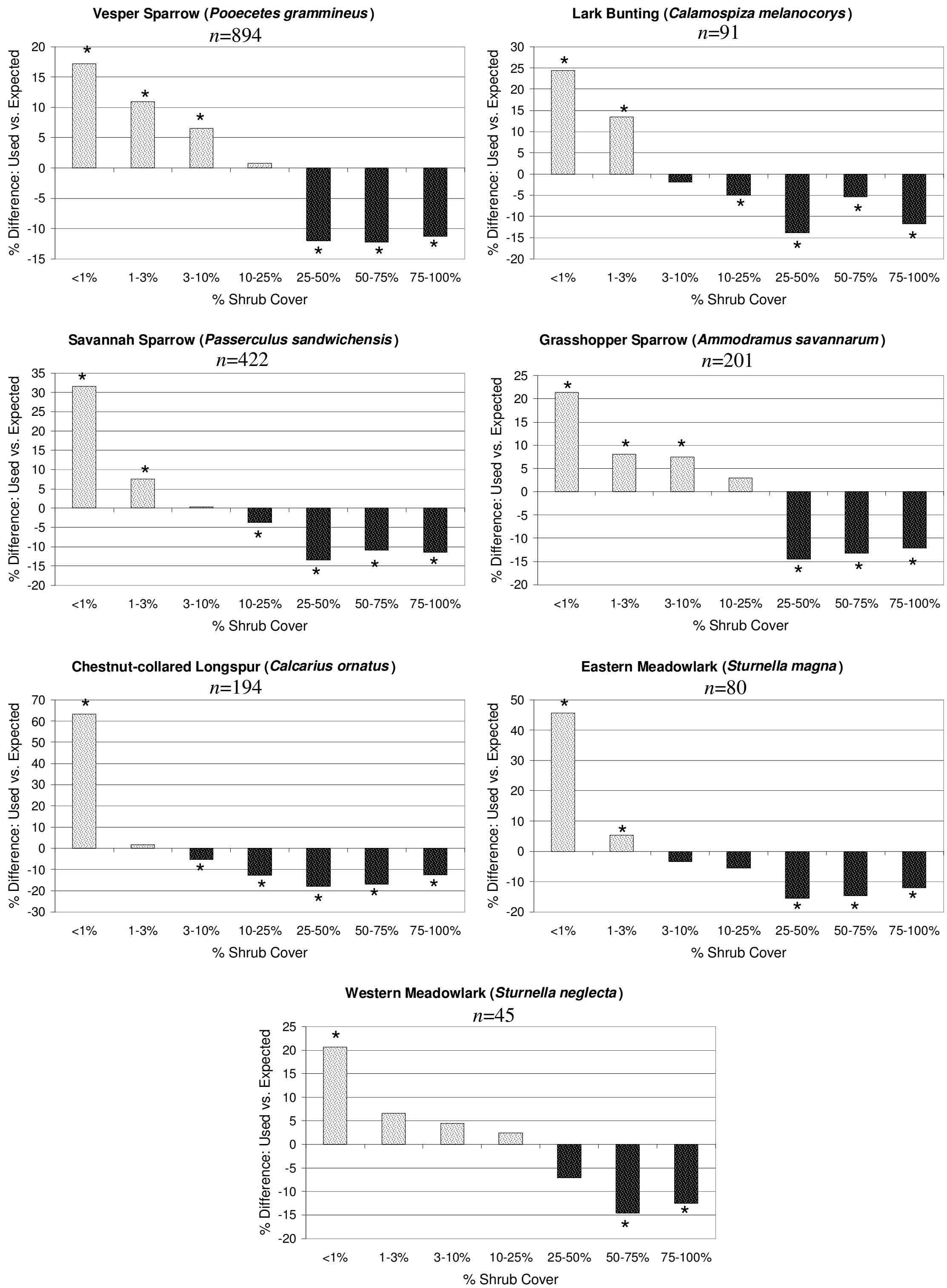


Figure 8. Wintering grassland-associated bird species that preferred sites with <1% shrub cover in Grassland Priority Conservation Areas (GPCAs) in Mexico.

Three species preferred grasslands with at least some shrubs (Figure 9). Say's Phoebe showed strongest preference toward grasslands with 3-10% shrub cover, although they also disproportionately used grasslands with 10-25% cover and <1% cover. Loggerhead Shrike showed strongest preference towards sites with 10-25% cover, although they also preferred sites with less cover (0-10%). Brewer's Sparrows most strongly preferred sites with 3-10% shrub cover, and to lesser degrees, they also preferred sites with less cover (0-3%) and up to 25% cover.

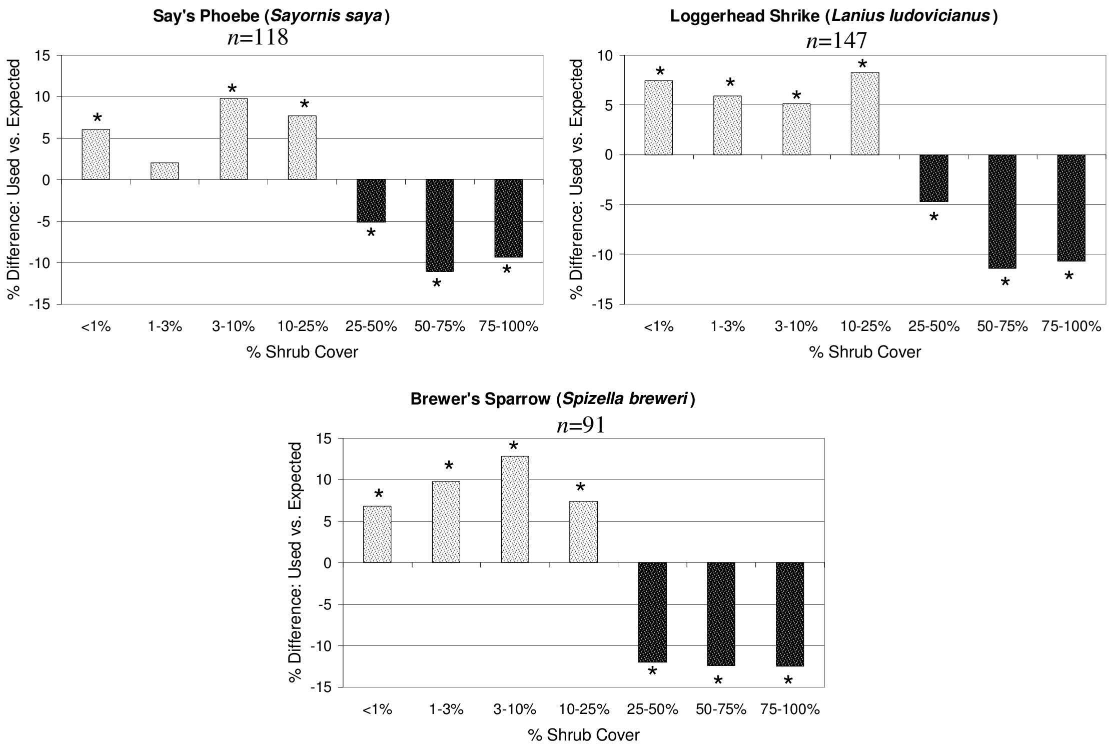


Figure 9. Wintering grassland-associated bird species that preferred sites with moderate levels of shrub cover in Grassland Priority Conservation Areas (GPCAs) in Mexico.

For at least two species, the patterns of preference or avoidance of shrub cover are equivocal. Although they avoided sites with 25-50% cover and >75% cover, Clay-colored Sparrows appeared to select sites with 50-75% shrub cover, while using other sites with less cover (0-25%) roughly in proportion to their availability. Similarly, Lark Sparrows seemed to prefer sites with 50-75% cover, while avoiding sites with more (>75%) or less (10-50%) cover, and using other sites with even less cover (0-10%) roughly in proportion to their availability.

Prairie dog town use vs. availability – At least four grassland-associated species showed strong preferences towards sites with active colonies of prairie dogs, including Mountain Plover, Burrowing Owl, Horned Lark, and Sprague's Pipit.

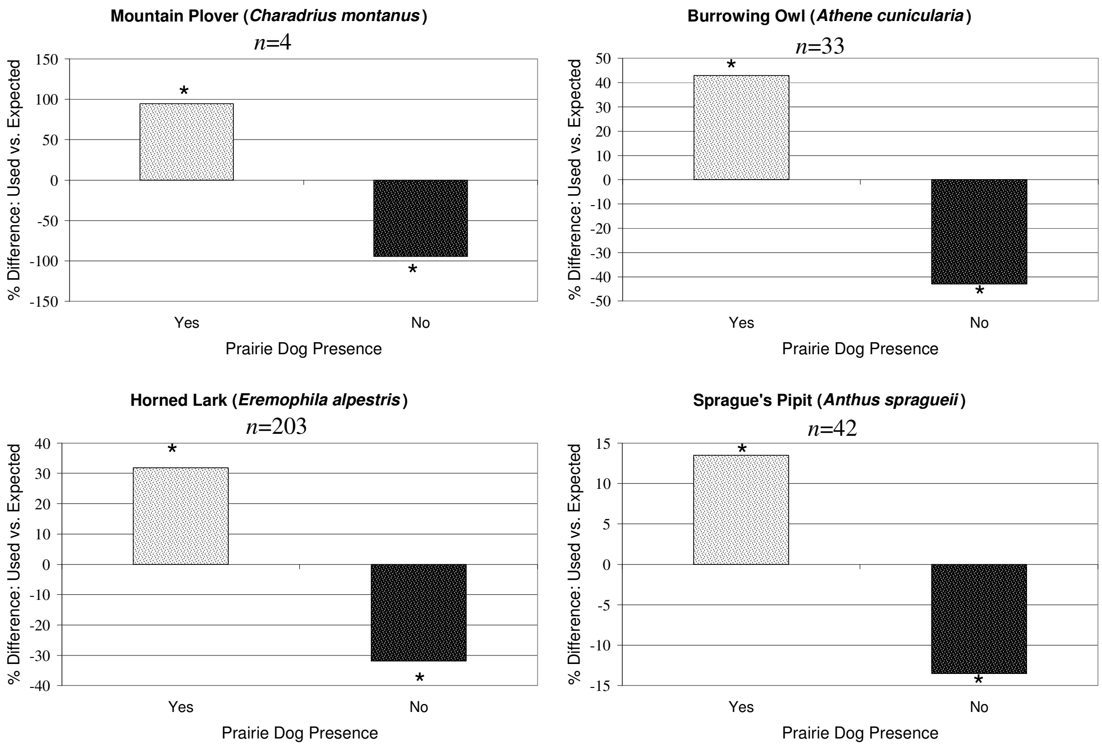


Figure 10. Wintering grassland-associated species that preferred sites with prairie dogs (*Cynomys ludovicianus* and *C. mexicanus*) in Chihuahuan desert grasslands with prairie dogs across Grassland Priority Conservation Areas in Mexico.

Discussion

We found that densities of several grassland bird species varied significantly among GPCAs, suggesting non-random wintering distribution and abundance patterns for some species in the Chihuahuan desert. For example, several migratory species, including Northern Harriers, Vesper Sparrows, Brewer's Sparrows, Lark Buntings, and Chestnut-collared Longspurs were more abundant in the most northerly GPCAs (Janos and Valles Centrales) and less abundant or absent in GPCAs further south. A few other migratory species occurred in peak densities in other, more southerly GPCAs, including Say's Phoebe in Mapimí, and Clay-colored Sparrows in Cuchillas de la Zarca. However, it will take several more years of monitoring before we can determine whether the patterns observed in 2007 are maintained over years.

We also found that most species strongly preferred areas with at least moderate, if not high grass cover, and little or no shrub cover. However, even among GPCAs, which were selected in part for their relatively good ecological health, the habitat conditions preferred by most grassland birds were uncommon. It is likely that long-term incompatible grazing, in addition to other factors such as the loss of prairie dogs and other drivers of key grassland conditions (e.g., fire), has reduced grass cover and increased shrub cover over time, degrading conditions for many grassland birds. Based on our findings of habitat use, it seems that highly degraded grasslands (such as those with high shrub cover and/or little to no grass cover) might be equally as bad, or worse, for many grassland birds as the loss of grasslands to agriculture. Fortunately, degraded grasslands could probably be more effectively restored to desirable physiognomic and structural conditions than could agricultural lands, albeit with considerable effort. Restoration of grasslands could increase the carrying capacity of this region for many wintering grassland bird species. In addition to halting the conversion of grasslands to agriculture, improving the condition of existing grasslands should be among the highest priorities for conservation action in this region.

Livestock production, particularly of cattle, is an important economic base in the region, but the productivity of cattle ranching has declined in Chihuahuan desert grasslands, likely for the same reasons that grassland birds have declined. Many of the grassland conditions required by birds, such as extensive grass cover and low shrub cover, are also preferred by cattle. Thus, conservationists should seek ways to collaborate with livestock producers to enhance rangelands in the Chihuahuan desert. The restoration of grasslands would be a win-win situation, benefiting both birds and producers.

Project evaluation and future directions

The implementation of the first year of this project was inherently complex and challenging, and not all objectives were fully achieved as intended. For example, the GIS was problematic in many ways, the driving transects were not as productive as we had hoped, some aspects of the survey design were not consistently implemented, many birds were not identified to species, and parts of the vegetation survey protocol lacked the rigor needed to confidently assess certain habitat conditions and their importance to birds. Still, many other key aspects of the project were very successful in this first year, and improvements planned for the project should rectify shortcomings. Below we discuss the challenges and successes during the first year of the project, and describe improvements to the survey design and execution that will be implemented in 2008.

Challenges

GIS – Undoubtedly, the most difficult challenge in implementing this project was the often inaccurate GIS. The project design relied heavily on GIS for identifying access to comparable grassland habitats across the GPCAs. Especially problematic was the GIS for roads, which was incomplete and outdated. Existing roads were often missing from this layer, while other roads shown were either inaccessible or had long since been obliterated. Also there was no distinction between primary, secondary, or tertiary roads. This situation, which was not fully recognized until the start of field work, forced us to adapt our sampling design in the field to maintain random placement of transect sites, as described in the Methods. Although our adaptive protocol allowed us maintain random start locations for our transects, this change in survey design likely affected the available study area from which our random sample was drawn to an unknown degree.

The GIS for vegetation types also posed some problems. Because halophytic and gypsophytic grasslands were not included with the “native grassland” layer, we added “halophytic vegetation” to our target GIS strata in order to not exclude grasslands of this type. Inclusion of this vegetation type in the GIS appeared to be particularly important in GPCAs such as El Tokio and Cuatro Ciénegas, where most of the grasslands are halophytic. However, it is unclear what, if any, other non-grassland halophytic vegetation types were also included in our vegetation stratum as a result.

A common problem that affected many selected sites was the misrepresentation of desert shrubland as grassland. Some of these areas may have been grasslands at one time, and still may have some characteristics of grasslands, but they presently do not support many grassland birds. Although protocols instructed observers to drop selected transect locations (or entire blocks) that fell in non-target habitat types and systematically replace them with new random sites, it appears this process was not always followed. Such deviations from the study design influence both the bird and vegetation data collected at sites, and the subsequent average estimates of species abundance and habitat condition for grassland birds within and across the GPCAs.

The GIS for the GPCA boundaries was also problematic in several ways. In El Tokio, for example, the boundary seems to specifically exclude some well-known sites for the critically endangered Worthen's Sparrow (presumably one of the nested targets within this GPCA), including La India and Tanque de Emergencia valleys, as well as the well-known Rancho Los Angeles experimental grasslands. The Valle de Soledad is perhaps the only extensive grassland within the present boundary of this GPCA; mostly there is very little grassland, and many areas, including some Natural Protected Areas (ANP's), have been converted to agriculture. Other grasslands of similar extent appear to exist immediately beyond the current GPCA boundary, to the east and west. These areas likely warrant inclusion in the GPCA, or at least further exploration. The seeming disconnect between the GIS for grassland vegetation and the GIS for GPCA boundaries afflicts virtually every GPCA (with the exception perhaps of Cuatro Ciénegas). Across the board, areas that appear to be suitable and often extensive grasslands are excluded from the conservation area while large areas of marginal or non-grassland habitat are often included.

For Valle Colombia, as mentioned in the results, the GPCA boundary encompassed primarily mountainous terrain and habitats, as well as some desert shrubland, but not the Valle Colombia for which it presumably was designated. This resulted in most of the survey blocks falling in marginal grasslands. Thus, results presented in this report should not be construed to represent the best grassland habitats in this area. We have corresponded with one of the editors of the technical report that defines the GPCAs regarding this problem, but it is still unclear to us why this GPCA failed to encompass the extensive grasslands of the area. Given the importance of the GPCA boundaries for conservation planning, and that the .shp files delineating the boundaries are available publicly on line (www.conserveonline.org), the boundary for Valle Colombia should be redrawn as soon as possible to avoid focusing future grassland conservation efforts on the currently delineated region.

Another problem was that in some places, habitat identified in the GIS as the targeted type had already been converted to agriculture since the creation of the layer. This generally did not cause problems in the field however, as observers simply replaced the points where habitat had been converted with the next randomly numbered point in suitable habitat, but it highlights the accelerating conversion of this habitat in northern Mexico and the need for more current and sophisticated GIS for this region. .

Data entry quality controls –We did not have a centralized data entry system with quality controls ready for operation this field season. Thus, data was entered electronically into Excel spreadsheets, without enforcement of quality controls. Had the data instead been entered into a relational database with defined fields, it would have eliminated many data entry and formatting errors. As a result, considerable data cleanup, formatting, and joining of data sets among observers would not have been needed before even the simplest analyses could be performed.

Species identification – Most observers did not have extensive experience with identifying small grassland birds prior to this project, although most observers improved their skills markedly during the field training, and presumably even more after starting field work. Still, deficiencies in identification abilities among some observers may have affected our results for some species, particularly sparrows. A large number of birds (nearly 10% of total recorded) were not identified to species, and while this may have been expected, improvements in identification ability by voice, behavior, shape, and other cues should increase the proportion of species correctly identified by observers. Two major factors limited observers in becoming proficient in bird identification: limited training and limited field time. We were only able to conduct a five-day training course this year, due to time and funding constraints. A short field training limits opportunities for in-field practice, and is more likely to be impacted by extended periods of inclement weather, as happened in 2007. Also, because of the time constraint for completing field work by the end of February, we employed a fairly large number of people in the field. This had an effect that each person received less experience in the field, after the training, in identifying grassland birds. No amount of training has the same impact on learning bird identification as having to identify them on your own, without the help of an instructor. Unfortunately, the already limited experience field observers would gain was further reduced by the participation of 10 additional observers who also conducted some surveys. Although other trained staff presumably instructed these additional observers, their ability to identify grassland birds and follow field protocols is unknown, as is whether their GPS units were set up comparably, and whether they used comparable equipment in the field (functioning binoculars, rangefinders), as these equipment were not checked or provided by us.

Particularly troublesome bird groups for observers appeared to be the sparrows (particularly *Spizella* and *Ammodramus* spp.) and meadowlarks (*Sturnella* spp.). Unfortunately, observers gained only minimal experience with all sparrows other than Savannah and Vesper sparrows during the training, likely due to the weather. Similarly, they gained little experience with separating Eastern and Western Meadowlarks in the field. In the case of *Ammodramus* sparrows however, it may be that little can be done to improve field identification via sight or sound. It may also prove necessary to further expand the "unknown *Ammodramus*" category to also include Savannah Sparrows, which is not in the genus *Ammodramus* but sometimes behaves like them when flushed. Better information on individual species within this group might only be obtained through labor-intensive flush-netting (i.e. flushing birds toward a long line of mist-nets) where proper in-hand identification can be assured.

Field Protocols – Although Spanish-language field protocols were produced and distributed at the training, these were focused on the bird and vegetation survey aspects of the field work, and likely did not cover aspects of the transect establishment protocol as explicitly as they should have. The process of eliminating randomly selected survey points due to unsuitable habitat conditions was explained mainly in-person during the field training, but in hindsight it would have been best to demonstrate this process more thoroughly in the field, and have provided more explicit written instructions in this regard. It is unclear to what extent various observers followed these procedures, as many sites were established and surveyed in what was Chihuahuan desert shrubland.

Although both the bird and vegetation survey protocols were fairly effective in characterizing their target communities at the GPCA-level, the two techniques were not well-suited to compliment each other at the same scale on individual transects. The vegetation sampling protocol was adapted from point-count techniques where birds recorded on a point could be associated with specific vegetation features also recorded at that point. However, this was not possible along 1-km transects, where vegetation samples were taken at specific intervals along transects, but bird observations from the entire transect were not assigned to specific locations along the transect. The uneven categories of vegetation cover classes were efficient in characterizing important features of grasslands at specific sites, but were not well-suited for determining average values across an entire transect. This caused some unnecessary complications in the analyses that could have been avoided with more compatible survey protocols.

Field supplies –RMBO loaned GPS units, rangefinders and compasses to all trained observers. Most observers supplied their own binoculars; RMBO provided binoculars for two observers. The quality of optics used in the field is important in allowing proper identification of grassland birds. It is not certain what field equipment was used by the additional 10 observers who participated in surveys, but not the training. Two items were lost in the field; all other equipment was returned to RMBO.

Communication – Timely communication with field observers during the field season on matters concerning survey procedures, replacement of survey sites, etc., was challenging given the short duration of the field season and remote locations of field sites. However, we did start a group email list among technicians to discuss issues as they arose in the field, and we will continue to improve our use of this and other media to communicate matters during and outside of field work in the future.

Successes

While the first year of this project had its fair share of challenges, it is worthwhile recognizing the many notable successes also achieved during this time. The broad partnership that has formed in support of the project represents the first bi-national, multi-organizational survey effort to undertake this long overdue task of inventorying wintering bird populations in this vast and important region. Project partners are enthusiastic, motivated, and committed to making the project successful.

The training session held this year, despite the adverse weather, was successful in improving observers' bird identification skills. Although in the end skill-level still varied greatly among observers, all participants improved their identification abilities measurably. Participants also came to understand and appreciate the importance of estimating detectability among species and the need for precise distance estimates in the surveys. Although perhaps better bird data could have been obtained in other ways, our investment in training local biologists in grassland bird identification and survey techniques, has given the project partners a real stake in the effort that will yield many long-term benefits.

Working with the local partners assembled by UANL also helped tremendously in locating and gaining access to the GPCA lands where we worked this year, most of which were private. This would have been much more difficult under any other scenario as these partners were familiar with the landscapes, roads, and landowners in the areas.

The field technique and level of survey effort appears to serve well as a foundation for multi-species wintering grassland bird monitoring, upon which additional complimentary techniques can be added for rare, restricted, or hard to detect species of interest. Given the room for improvements in execution of the surveys, and more time available for planning and training, the data resulting from this coarse-filter approach should improve. Information gleaned from these surveys should also help to inform development of other complimentary techniques.

Finally, it is worthwhile mentioning that by starting this effort, we have generated excitement and momentum in continuing, expanding, and enhancing this survey. There are many other potential partners with an interest in the Chihuahuan desert grasslands who could become partners in the future.

Next steps: improvements planned for 2008

Elimination of road-based driving transects -- The survey data obtained from road based driving transects, while useful for adding species to the inventory of each survey block and GPCA, were not sufficient enough to make a compelling case for continuing these surveys as designed. Although a few raptors species and Loggerhead Shrikes were fairly well-represented among samples, and a few species not detected on other surveys were recorded on driving transects (e.g., White-tailed Hawk, Aplomado Falcon), the survey did not allow additional opportunities for measuring abundance of species not already adequately covered by the off-road line transects. In addition, since these counts were inherently biased toward road-side habitats (which often have more perches and therefore can attract some species) the information they provide is more difficult to interpret and is not well-suited for Distance sampling. Driving surveys consumed more time than originally anticipated, and reducing effort toward them could allow for additional efforts on off-road surveys, such as more quantitative vegetation surveys. Observers can still keep track of and record observations of additional priority species encountered in each block for inventory purposes. Thus, in 2008, observers will simply keep a tally of additional priority species observed in the survey block outside of line transect surveys, and record these in spaces provided on the data forms.

Improved GIS – Several options for dealing with the poor GIS were discussed by project partners, but the most significant actions (i.e., extensive ground-truthing of the current grassland layers, ground-truthing of field sites prior to field work, mapping roads using the "tracks" feature of hand-held GPS, or purchasing high-quality satellite images such as SPOT) are too costly to consider under this project. However, improvements in the GIS for grasslands and roads are needed to make better use of this technology for the conservation of Chihuahuan desert grasslands in Mexico. We proposed seeking partners and financial support for improving the GIS for Chihuahuan desert grasslands in Mexico. A paid graduate assistantship in geospatial science or a similar field could go a long way in addressing this deficiency.

We obtained a more recent GIS layer for vegetation cover (INEGI series III 2006) that is similar, but sometimes more restrictive, in its interpretation of grassland land cover than the previously used Inventario Forestal (2002) layers. It also contains specific layers for halophytic and gypsophyllic grasslands, rather than for "halophytic and gypsophyllic vegetation" combined. We hope that use of this newer layer will improve our ability to locate transects in grasslands on the ground. Surprisingly, we have still not been able to find a better GIS layer for roads. Some (presumably newer) roads that are not included in the GIS layer are shown on digitized INEGI topographic maps (dated 1984), which can be viewed in GIS. Unfortunately the roads shown in these images are not .shp file that can be used in our survey design. However, for new blocks that are being added to the survey design this year, we will create our own .shp layer of these roads by essentially tracing these roads by hand in Arc Map.

Modify Valle Colombia GPCA boundary – We have realigned the Valle Colombia GPCA boundary to better overlap with the Valle Colombia. Although it is not at all clear that the current shape and size of the GPCA were designed to encompass the important grasslands in the area, we decided to retain the original shape and size of this GPCA and simply shift it about 50 km due East. The result was a fairly good boundary around most of the grasslands in Valle Colombia proper (Figure 11). The new location of the GPCA produces 12 potential grassland survey blocks, seven of which will be surveyed in 2008 (labeled in red) in order to maintain effort across the GPCAs in proportion to the availability of potential grasslands survey blocks in each. This is an increase of 3 survey blocks (18 transects) over last year's effort in this GPCA.

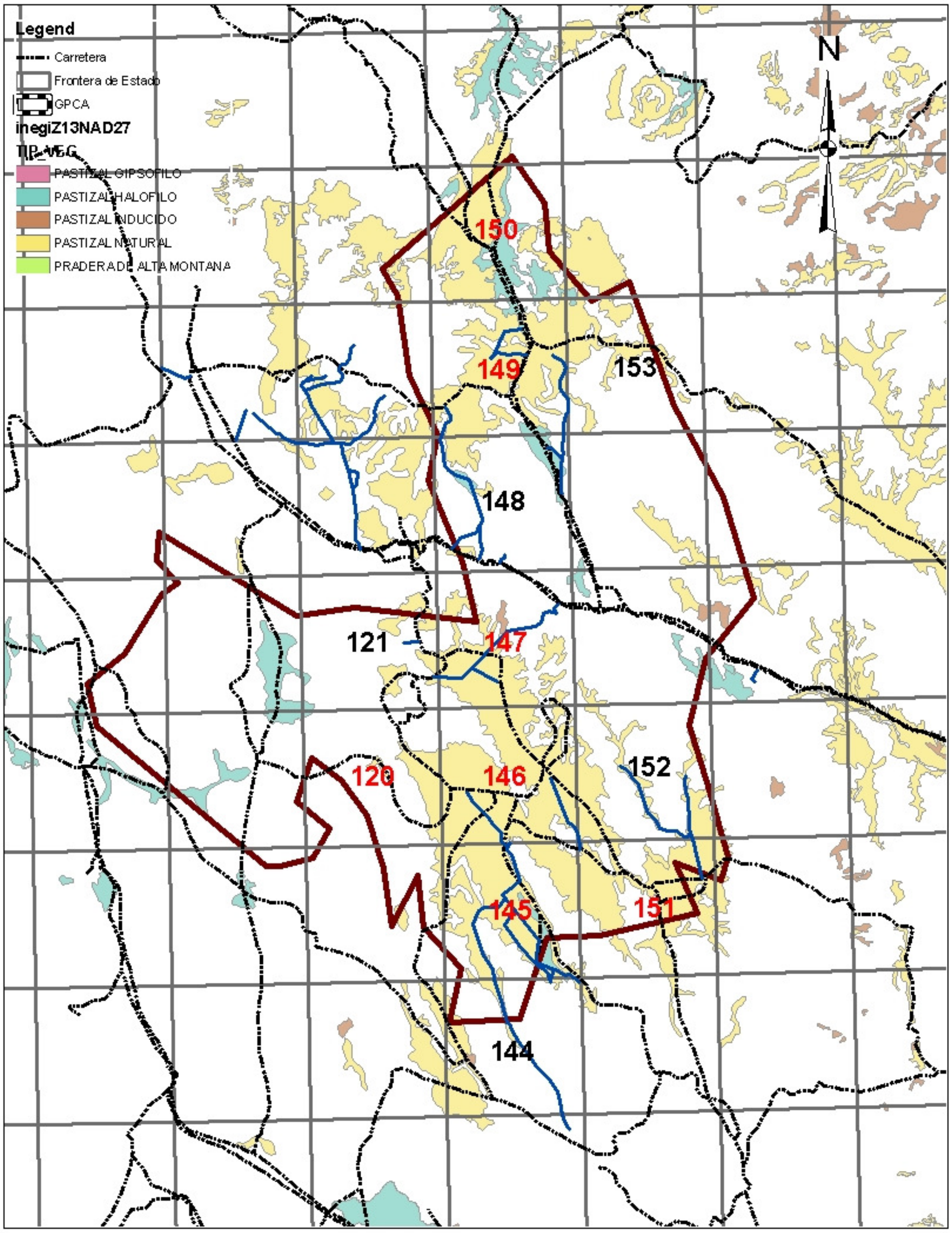


Figure 11. Revised alignment of Valle Colombia GPCA boundary and potential and selected (red labels) survey blocks for 2008.

Improve transect locations – We have eliminated survey blocks from each GPCA where none of the three transect were located in suitable grassland habitat. We have been in communication with field crews from each area to identify potential back-up survey blocks to replace these. In cases where back-up survey blocks have already been exhausted we have identified additional blocks outside, but close to, the GPCA and will expand the survey area to include these new areas. Such expansion beyond the current GPCA boundary will likely occur in El Tokio, Mapimí, and Cuchillas de la Zarca in

2008. We will retain survey blocks where at least one of the transects established in 2007 was in suitable grassland habitat, and modify locations of individual transects within these blocks if they were not in suitable habitat.

Table 8. Numbers of transects that will be maintained or relocated in 2008, and the number of survey blocks that need to be replaced entirely in each Grassland Priority Conservation Area (GPCA).

GPCA	*Transects within Blocks to be maintained*		*Entire Blocks*
	Keep	***Replace***	***Replace***
Cuatro Ciénegas	18	0	0
Cuchillas de la Zarca	24	18	9
Janos	72	6	0
Mapimí	21	21	5
El Tokio	9	15	5
Valles Centrales	58	38	5
Valle Colombia	5	1	3
Total	207	99	27

Modify bird and vegetation survey protocols – We will modify our survey protocols in order to improve performance of bird, vegetation and atmospheric/temporal data when analyzed in relation to each other. Specifically, for all birds observed along transects, we will note in which segment of the transect they were observed (i.e., 0-250m, 251-500m, 501-750 m, and 751-1000 m) in order to allows more flexibility in the analyses of bird-vegetation relationships.

Vegetation sampling will rely less on visual estimates and more on quantitative measures of cover and species abundance. Specifically, we will use point- and line-intercept methods (adapted from Bonham 1989) to quantify abundance of ground and shrub cover types, respectively, along transects. The line-intercept method will also be used to identify the proportion of shrub species contributing to the overall shrub cover. Presence-absence of other coarse features (trees, prairie dogs, surface water) will also be noted out to 100m on either side of the transect.

We will also record specific start and end times, temperatures, sky and wind conditions for individual transects, rather than for the entire set of transects in a given block to better relate these conditions to the birds recorded on any individual transect.

Extend and improve training course – We will extend the training session by three days to allow more in-field instruction and practice in grassland bird identification, vegetation sampling, and establishing transects. We will provide each participant with a CD of grassland bird songs and calls, specific to the Chihuahuan desert in winter. We will enhance the in-class instruction in species identification, with an Extended PowerPoint presentation that thoroughly covers field identification for difficult to identify species, and provides bulleted species by species comparisons of similar species. We will also provide classroom and field instruction and practice in the use of the hand-held GPS to establish new transects, follow bearings, locate existing transects, and log new start and end points for transects. We will test students daily in field identification of grassland birds and distance estimation, and use the results to evaluate observers and their progress during training. We will carefully explain the requirements to conduct surveys only in the mornings, to scout new transect locations and travel routes prior to conducting field surveys, and replace transect start points where the habitat is not grassland with new random points.

Reduced number of observers – We will limit the number of observers to 10 people in total, two for Janos and Sonorita, two for Valles Centrales, two for Cuchillas de la Zarca, two for Mapimí, and two for Valle Colombia, Cuatro Ciénegas, and El Tokio.

Earlier start date – We will complete our field training course 12 days earlier than last year, allowing more time to complete field surveys before the end of February.

On-line database and data entry portal – An on-line, password-protected data entry portal is now operational (http://rmbo.org/dataentry/line). All data collected in 2008 will be entered by observers directly into this database via the World Wide Web. The data entry portal will use a relational database structure, drop-down menus, forced data review, and other quality control checks to reduce errors and data incompatibility.

Field Equipment – We will provide new and better equipment for observers in 2008, including more sophisticated GPS units, rangefinders and high-quality binoculars.

Improved precision of estimates – In 2008 we will modify transect locations to better restrict samples to grasslands and avoid sampling in extensive shrublands. The adjustment of transect locations should increase the number and evenness of detections of many grassland bird species across transects, thereby increasing the precision of density estimates for many species, and the number of species effectively covered by this survey.

Supplemental surveys -- In addition to improving our sampling scheme in native grasslands, a high priority for improving species coverage would be to determine use of other habitats, particularly agricultural lands, for various grassland species. Such complimentary information would be important in determining which species are most strongly affected by agricultural conversion, and which can adapt. Many grassland specialists, including species such as Mountain Plover and Long-billed Curlew, use agricultural habitats in other wintering areas (i.e. California), and it would be important to determine the extent of such use, if any, in agricultural lands in Mexico to better evaluate threats, wintering habitat needs, and overall conservation status. We anticipate that in surveys in Janos and Sonorita can be completed by mid-February, allowing roughly 2 weeks for some supplemental exploratory surveys in grasslands and agricultural lands in Chihuahua and Durango.

Secretive species like Baird's Sparrow and Grasshopper Sparrow were not well sampled by our audio-visual surveys because of their elusive behavior and difficulty of in-flight identification. Although many Grasshopper Sparrows were recorded, accurate identification of many of these is dubious given the infrequency of opportunities for adequate visual inspection of individuals, and the similarity of Baird's, and sometimes Savannah sparrows, with this species, especially when flushed. As evidenced by the analyses presented in this report, these species do have similar requirements in winter with respect to basic habitat features such as shrub and grass cover, although Savannah is typically more plastic. For conservation purposes, it may suffice to know whether the habitat in a given area supports any of these three species, and assess potential value of habitat for Baird's Sparrow based on its more restricted range. However, if better species-specific information is needed, it would have to be obtained through a different kind of survey, likely involving more labor-intensive mist-netting. With some experimentation, it might be possible to develop a flush-netting technique that incorporates rope dragging to reduce the number of people needed to flush birds into mist nets. Such techniques would likely be most effective if conducted in the early morning before sunrise, or under cloudy conditions.

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Appendix A. Total number of individuals (N) and detections (n) of bird species recorded on off-road line-transect surveys.

Appendix A. Total number of individuals (N) and detections (n) of bird species recorded on off-road line-transect surveys in Grassland Priority Conservation Areas in the Chihuahuan desert of northern Mexico. Species in bold are considered grassland-associated species.

Species		Cuatro Ciénegas		Cuchillas de la Zarca		Janos		Mapimí		El Tokio		Valles Centrales		Valle Colombia		All GPCAs	
Common Name	Scientific Name	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*
Gadwall	*Anas strepera*	0	0	63	3	0	0	0	0	0	0	0	0	0	0	63	3
Mallard	*Anas platyrhynchos*	0	0	0	0	4	1	0	0	0	0	23	3	0	0	27	4
Blue-winged Teal	*Anas discors*	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2
Northern Shoveler	*Anas clypeata*	0	0	0	0	0	0	0	0	0	0	133	4	0	0	133	4
Northern Pintail	*Anas acuta*	0	0	5	5	0	0	0	0	0	0	1	1	0	0	6	6
Green-winged Teal	*Anas crecca*	0	0	0	0	0	0	18	2	0	0	1	1	0	0	19	3
Anas spp.	*Anas spp.*	0	0	0	0	0	0	4	1	0	0	20	1	0	0	24	2
Ring-necked Duck	*Aythya collaris*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Lesser Scaup	*Aythya affinis*	0	0	1	1	0	0	0	0	0	0	15	1	0	0	16	2
Bufflehead	*Bucephala albeola*	0	0	1	1	0	0	0	0	0	0	22	3	0	0	23	4
Unidentified Duck	*Anatinae*	0	0	0	0	16	2	0	0	0	0	10	1	0	0	26	3
Scaled Quail	***Callipepla squamata***	0	0	108	9	54	9	15	4	1	1	89	13	4	2	271	38
Gambel's Quail	***Callipepla gambelii***	0	0	0	0	8	2	0	0	0	0	0	0	0	0	8	2
Great Blue Heron	*Ardea herodias*	0	0	1	1	0	0	0	0	0	0	5	2	0	0	6	3
Cattle Egret	*Bubulcus ibis*	0	0	0	0	0	0	2	1	0	0	0	0	0	0	2	1
Black Vulture	*Coragyps atratus*	0	0	18	4	0	0	0	0	0	0	0	0	0	0	18	4
Turkey Vulture	*Cathartes aura*	0	0	244	153	3	3	59	32	27	13	2	2	0	0	335	203
White-tailed Kite	***Elanus leucurus***	0	0	2	1	3	3	2	2	0	0	5	4	0	0	12	10
Northern Harrier	***Circus cyaneus***	0	0	4	4	34	32	16	16	4	4	58	57	0	0	116	113
Sharp-shinned Hawk	*Accipiter striatus*	0	0	2	2	0	0	0	0	0	0	1	1	0	0	3	3
Cooper's Hawk	*Accipiter cooperii*	0	0	1	1	0	0	0	0	1	1	0	0	0	0	2	2
Harris's Hawk	***Parabuteo unicinctus***	0	0	7	7	2	2	0	0	12	5	3	2	0	0	24	16
Red-tailed Hawk	***Buteo jamaicensis***	1	1	17	17	14	12	10	10	2	2	40	37	6	6	90	85
Ferruginous Hawk	***Buteo regalis***	0	0	12	11	1	1	0	0	3	3	1	1	0	0	17	16
Buteo spp.	*Buteo spp.*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Golden Eagle	***Aquila chrysaetos***	0	0	0	0	0	0	0	0	1	1	3	2	0	0	4	3
Unidentified Hawk	*Accipitrinae*	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2
Crested Caracara	*Caracara cheriway*	0	0	0	0	0	0	0	0	5	4	0	0	0	0	5	4
American Kestrel	***Falco sparverius***	0	0	17	15	16	15	10	9	3	3	29	27	2	2	77	71
Merlin	***Falco columbarius***	0	0	15	15	4	4	1	1	0	0	2	2	0	0	22	22
Prairie Falcon	***Falco mexicanus***	0	0	1	1	1	1	1	1	0	0	3	3	0	0	6	6

Appendix A. Total number of individuals (N) and detections (n) of bird species recorded on off-road line-transect surveys.

Species		Cuatro Ciénegas		Cuchillas de la Zarca		Janos		Mapimí		El Tokio		Valles Centrales		Valle Colombia		All GPCAs	
Common Name	Scientific Name	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*
Sandhill Crane	***Grus canadensis***	0	0	330	6	3	1	256	13	0	0	0	0	0	0	589	20
Killdeer	*Charadrius vociferus*	0	0	0	0	1	1	0	0	0	0	2	2	0	0	3	3
Mountain Plover	***Charadrius montanus***	0	0	0	0	0	0	0	0	8	4	0	0	0	0	8	4
American Avocet	*Recurvirostra americana*	0	0	0	0	0	0	0	0	0	0	10	1	0	0	10	1
Long-billed Curlew	***Numenius americanus***	0	0	0	0	12	4	24	3	127	2	1	1	0	0	164	10
Western Sandpiper	*Calidris mauri*	0	0	0	0	0	0	0	0	0	0	3	1	0	0	3	1
Stilt Sandpiper	*Calidris himantopus*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Long-billed Dowitcher	*Limnodromus scolopaceus*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Eurasian Collared-Dove	*Streptopelia decaocto*	0	0	0	0	7	5	0	0	0	0	0	0	0	0	7	5
White-winged Dove	*Zenaida asiatica*	0	0	126	41	0	0	1	1	24	4	1	1	1	1	153	48
Mourning Dove	***Zenaida macroura***	5	2	562	206	799	100	329	81	10	3	1016	135	2	2	2723	529
Inca Dove	*Columbina inca*	0	0	8	5	0	0	0	0	7	1	0	0	0	0	15	6
Greater Roadrunner	*Geococcyx californianus*	0	0	3	3	10	10	1	1	0	0	3	2	0	0	17	16
Barn Owl	***Tyto alba***	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
Burrowing Owl	***Athene cunicularia***	0	0	0	0	12	12	8	8	12	12	1	1	0	0	33	33
Long-eared Owl	***Asio otus***	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Short-eared Owl	***Asio flammeus***	0	0	0	0	5	3	2	2	0	0	6	6	0	0	13	11
Acorn Woodpecker	*Melanerpes formicivorus*	0	0	4	3	1	1	0	0	0	0	0	0	0	0	5	4
Golden-fronted Woodpecker	*Melanerpes aurifrons*	0	0	11	8	0	0	0	0	0	0	0	0	0	0	11	8
Yellow-bellied Sapsucker	*Sphyrapicus varius*	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2
Ladder-backed Woodpecker	*Picoides scalaris*	1	1	6	6	12	12	4	4	4	4	4	4	1	1	32	32
Arizona Woodpecker	*Picoides arizonae*	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
Northern Flicker	*Colaptes auratus*	0	0	9	8	17	13	0	0	7	5	0	0	1	1	34	27
Gray Flycatcher	*Empidonax wrightii*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Empidonax spp.	*Empidonax spp.*	0	0	17	15	0	0	0	0	0	0	0	0	0	0	17	15
Black Phoebe	*Sayornis nigricans*	0	0	19	14	0	0	0	0	0	0	0	0	0	0	19	14
Eastern Phoebe	*Sayornis phoebe*	0	0	0	0	0	0	0	0	1	1	0	0	2	2	3	3
Say's Phoebe	***Sayornis saya***	2	2	13	13	8	8	53	47	9	9	37	37	2	2	124	118
Vermilion Flycatcher	*Pyrocephalus rubinus*	0	0	5	5	1	1	0	0	2	2	1	1	0	0	9	9
Cassin's Kingbird	*Tyrannus vociferans*	0	0	1	1	0	0	0	0	0	0	1	1	0	0	2	2
Western Kingbird	*Tyrannus verticalis*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
Loggerhead Shrike	***Lanius ludovicianus***	3	3	19	19	34	32	38	37	25	24	33	31	1	1	153	147
Mexican Jay	*Aphelocoma ultramarina*	0	0	37	8	14	3	0	0	3	1	0	0	0	0	54	12
Chihuahuan Raven	***Corvus cryptoleucus***	5	4	45	29	39	26	8	4	19	13	35	18	42	14	193	108

Appendix A. Total number of individuals (N) and detections (n) of bird species recorded on off-road line-transect surveys.

Species		Cuatro Ciénegas		Cuchillas de la Zarca		Janos		Mapimí		El Tokio		Valles Centrales		Valle Colombia		All GPCAs	
Common Name	Scientific Name	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*
Common Raven	*Corvus corax*	0	0	20	12	18	18	15	11	4	3	8	5	0	0	65	49
Corvus sp.	*Corvus spp.*	0	0	0	0	14	9	0	0	0	0	0	0	0	0	14	9
Horned Lark	***Eremophila alpestris***	7	4	0	0	203	69	0	0	196	89	129	36	13	5	548	203
Tree Swallow	*Tachycineta bicolor*	0	0	0	0	1	1	0	0	0	0	5	2	0	0	6	3
Bridled Titmouse	*Baeolophus wollweberi*	0	0	5	3	2	1	0	0	0	0	0	0	0	0	7	4
Verdin	*Auriparus flaviceps*	0	0	14	11	3	2	6	4	3	3	1	1	0	0	27	21
Bushtit	*Psaltriparus minimus*	0	0	25	10	13	4	0	0	0	0	0	0	0	0	38	14
Cactus Wren	*Campylorhynchus brunneicapillus*	1	1	43	34	55	44	16	16	30	27	11	11	2	2	158	135
Rock Wren	*Salpinctes obsoletus*	0	0	4	4	5	5	2	2	0	0	0	0	0	0	11	11
Canyon Wren	*Catherpes mexicanus*	0	0	4	4	2	2	0	0	0	0	0	0	0	0	6	6
Bewick's Wren	*Thryomanes bewickii*	0	0	8	8	11	11	0	0	3	2	2	2	2	1	26	24
House Wren	*Troglodytes aedon*	0	0	3	3	0	0	1	1	0	0	0	0	0	0	4	4
Ruby-crowned Kinglet	*Regulus calendula*	0	0	33	30	2	2	5	4	4	3	0	0	0	0	44	39
Blue-gray Gnatcatcher	*Polioptila caerulea*	0	0	12	10	0	0	10	6	0	0	5	5	0	0	27	21
Black-tailed Gnatcatcher	*Polioptila melanura*	0	0	1	1	2	2	24	16	17	13	5	4	0	0	49	36
Eastern Bluebird	*Sialia sialis*	0	0	4	4	0	0	0	0	0	0	0	0	0	0	4	4
Western Bluebird	*Sialia mexicana*	0	0	8	5	0	0	0	0	2	1	0	0	0	0	10	6
Mountain Bluebird	***Sialia currucoides***	19	5	34	5	21	10	112	32	6	4	23	8	19	4	234	68
Bluebird spp.	*Sialia spp.*	0	0	0	0	3	1	0	0	2	2	0	0	0	0	5	3
American Robin	*Turdus migratorius*	0	0	4	4	0	0	0	0	0	0	0	0	0	0	4	4
Northern Mockingbird	*Mimus polyglottos*	3	3	7	7	0	0	29	27	16	16	3	3	3	3	61	59
Sage Thrasher	*Oreoscoptes montanus*	1	1	0	0	1	1	16	15	0	0	1	1	0	0	19	18
Curve-billed Thrasher	*Toxostoma curvirostre*	0	0	66	56	37	37	19	15	33	30	5	3	0	0	160	141
Crissal Thrasher	*Toxostoma crissale*	0	0	0	0	1	1	0	0	0	0	2	2	0	0	3	3
European Starling	*Sturnus vulgaris*	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1
American Pipit	*Anthus rubescens*	2	1	7	6	0	0	1	1	635	4	0	0	0	0	645	12
Sprague's Pipit	***Anthus spragueii***	2	2	5	5	11	11	10	6	21	9	9	9	0	0	58	42
Phainopepla	*Phainopepla nitens*	56	3	5	5	0	0	1	1	0	0	7	2	0	0	69	11
Orange-crowned Warbler	*Vermivora celata*	0	0	0	0	0	0	0	0	3	2	0	0	0	0	3	2
Yellow-rumped Warbler	*Dendroica coronata*	14	8	9	6	0	0	6	2	7	1	0	0	0	0	36	17
Hepatic Tanager	*Piranga flava*	0	0	2	2	0	0	0	0	0	0	0	0	0	0	2	2
Olive Sparrow	*Arremonops rufivirgatus*	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
Green-tailed Towhee	*Pipilo chlorurus*	0	0	12	9	23	23	1	1	1	1	6	6	3	3	46	43
Spotted Towhee	*Pipilo maculatus*	0	0	0	0	5	3	3	3	0	0	0	0	0	0	8	6

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Species		Cuatro Ciénegas		Cuchillas de la Zarca		Janos		Mapimí		El Tokio		Valles Centrales		Valle Colombia		All GPCAs	
Common Name	Scientific Name	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*
Canyon Towhee	*Pipilo fuscus*	0	0	40	33	10	9	0	0	30	24	0	0	2	2	82	68
Cassin's Sparrow	***Aimophila cassinii***	0	0	6	4	8	8	0	0	1	1	6	5	0	0	21	18
Botteri's Sparrow	***Aimophila botterii***	0	0	14	9	0	0	0	0	0	0	0	0	0	0	14	9
Rufous-crowned Sparrow	*Aimophila ruficeps*	0	0	6	6	4	3	0	0	0	0	0	0	1	1	11	10
Chipping Sparrow	*Spizella passerina*	0	0	670	112	204	22	20	10	0	0	132	19	15	1	1041	164
Clay-colored Sparrow	***Spizella pallida***	0	0	1214	199	127	19	429	52	7	3	83	22	1	1	1861	296
Brewer's Sparrow	***Spizella breweri***	0	0	42	11	186	29	34	6	1	1	168	44	0	0	431	91
Black-chinned Sparrow	*Spizella atrogularis*	0	0	21	5	0	0	0	0	0	0	0	0	0	0	21	5
Spizella spp.	*Spizella spp.*	0	0	2	2	450	45	3	2	5	4	9	2	0	0	469	55
Vesper Sparrow	***Pooecetes gramineus***	1	1	89	56	804	265	150	59	7	3	1058	496	43	14	2152	894
Lark Sparrow	***Chondestes grammacus***	0	0	150	47	1	1	3	2	0	0	8	3	0	0	162	53
Black-throated Sparrow	*Amphispiza bilineata*	0	0	330	154	156	107	241	89	106	69	225	116	52	26	1110	561
Sage Sparrow	*Amphispiza belli*	0	0	0	0	0	0	0	0	0	0	2	1	0	0	2	1
Lark Bunting	***Calamospiza melanocorys***	0	0	43	10	2556	50	276	17	0	0	139	14	0	0	3014	91
Savannah Sparrow	***Passerculus sandwichensis***	0	0	98	57	516	126	98	25	25	3	432	205	9	6	1178	422
Grasshopper Sparrow	***Ammodramus savannarum***	0	0	93	65	87	73	47	42	0	0	22	18	3	3	252	201
Baird's Sparrow	***Ammodramus bairdii***	0	0	5	5	1	1	0	0	0	0	5	5	1	1	12	12
Ammodramus spp.	*Ammodramus spp.*	0	0	4	2	31	29	1	1	0	0	68	63	10	10	114	105
Song Sparrow	*Melospiza melodia*	0	0	3	3	0	0	5	2	0	0	1	1	0	0	9	6
Lincoln's Sparrow	*Melospiza lincolnii*	0	0	31	15	10	8	0	0	2	2	7	7	0	0	50	32
White-throated Sparrow	*Zonotrichia albicollis*	0	0	0	0	0	0	0	0	0	0	2	1	0	0	2	1
White-crowned Sparrow	*Zonotrichia leucophrys*	0	0	0	0	43	18	7	3	1	1	52	13	0	0	103	35
Unidentified Sparrow	*Emberizidae*	0	0	187	91	722	213	0	0	2	1	43	27	0	0	954	332
Dark-eyed Junco	*Junco hyemalis*	0	0	2	2	24	1	0	0	0	0	0	0	0	0	26	3
Yellow-eyed Junco	*Junco phaeonotus*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
McCown's Longspur	***Calcarius mccownii***	0	0	0	0	7	3	0	0	0	0	16	6	0	0	23	9
Chestnut-collared Longspur	***Calcarius ornatus***	0	0	0	0	1403	120	23	5	0	0	1148	67	12	2	2586	194
Longspur spp.	*Cacarius spp.*	0	0	0	0	501	3	172	7	0	0	0	0	0	0	673	10
Northern Cardinal	*Cardinalis cardinalis*	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
Pyrrhuloxia	*Cardinalis sinuatus*	0	0	52	37	4	4	12	10	0	0	0	0	1	1	69	52
Eastern Meadowlark	***Sturnella magna***	0	0	9	8	74	48	1	1	2	2	32	21	0	0	118	80
Western Meadowlark	***Sturnella neglecta***	1	1	12	6	12	8	65	15	0	0	12	10	5	5	107	45
Meadowlark spp.	*Sturnella spp.*	0	0	0	0	154	31	0	0	11	7	64	41	0	0	229	79
Great-tailed Grackle	*Quiscalus mexicanus*	0	0	0	0	0	0	0	0	19	2	0	0	0	0	19	2

Appendix A. Total number of individuals (N) and detections (n) of bird species recorded on off-road line-transect surveys.

Species		Cuatro Ciénegas		Cuchillas de la Zarca		Janos		Mapimí		El Tokio		Valles Centrales		Valle Colombia		All GPCAs	
Common Name	Scientific Name	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*	*N*	*n*
Brown-headed Cowbird	*Molothrus ater*	0	0	62	3	0	0	20	2	0	0	0	0	0	0	82	5
Cowbird spp.	*Molothrus spp.*	0	0	0	0	0	0	1	1	6	1	0	0	0	0	7	2
House Finch	*Carpodacus mexicanus*	0	0	9	5	55	21	0	0	90	10	2	2	0	0	156	38
Lesser Goldfinch	*Carduelis psaltria*	0	0	49	2	0	0	0	0	2	1	0	0	0	0	51	3
House Sparrow	*Passer domesticus*	0	0	0	0	6	1	0	0	0	0	0	0	0	0	6	1
Unidentified Bird	*Aves*	0	0	23	1	4	4	0	0	0	0	0	0	0	0	27	5
All species		124	43	5343	1843	9733	1851	2749	796	1618	468	5581	1722	261	125	25409	6848

Appendix B. Average densities of grassland species in each GPCA.

Common Name Scientific Name	*GPCA*	*D*	*CV*	*LCL*	*UCL*	*n*	*Prop. Of Transects*
Scaled Quail *Callipepla squamata*	CUAT	-	-	-	-	-	-
	CUZA	12.73	60.1	4.05	40.03	9	0.09
	JANO	20.48	75.5	5.18	80.96	9	0.08
	MAPI	16.53	125.0	1.57	174.02	4	0.03
	TOKI	0.30	97.8	0.06	1.52	1	0.02
	VACE	14.54	49.9	5.62	37.57	13	0.10
	VACO	2.66	87.7	0.47	15.06	2	0.08
Northern Harrier *Circus cyaneus*	CUAT	-	-	-	-	-	-
	CUZA	0.23	48.2	0.09	0.58	4	0.04
	JANO	1.91	24.1	1.19	3.06	24	0.33
	MAPI	0.77	39.8	0.36	1.66	10	0.18
	TOKI	0.42	49.1	0.17	1.06	4	0.07
	VACE	1.56	19.7	1.06	2.29	34	0.36
	VACO	-	-	-	-	-	-
Red-tailed Hawk *Buteo jamaicensis*	CUAT	0.14	100.5	0.02	0.79	1	0.06
	CUZA	0.44	28.5	0.25	0.76	17	0.14
	JANO	0.35	36.0	0.17	0.70	10	0.13
	MAPI	0.27	34.4	0.14	0.53	8	0.14
	TOKI	0.09	76.2	0.02	0.36	2	0.04
	VACE	0.48	23.9	0.30	0.77	25	0.24
	VACO	0.52	53.4	0.18	1.46	5	0.21
American Kestrel *Falco sparverius*	CUAT	-	-	-	-	-	-
	CUZA	0.80	28.9	0.46	1.40	15	0.14
	JANO	0.89	27.8	0.52	1.53	14	0.17
	MAPI	0.37	40.5	0.17	0.80	6	0.11
	TOKI	0.25	56.3	0.09	0.72	3	0.06
	VACE	0.93	23.4	0.59	1.46	24	0.18
	VACO	0.38	69.0	0.10	1.36	2	0.08
Sandhill Crane *Grus canadensis*	CUAT	-	-	-	-	-	-
	CUZA	2.69	75.2	0.66	10.91	6	0.04
	JANO	0.02	100.2	0.00	0.09	1	0.01
	MAPI	1.25	62.3	0.40	3.91	13	0.07
	TOKI	-	-	-	-	-	-
	VACE	-	-	-	-	-	-
	VACO	-	-	-	-	-	-
Mourning Dove *Zenaida macroura*	CUAT	4.01	71.1	1.05	15.39	2	0.11
	CUZA	72.11	14.2	54.63	95.19	202	0.73
	JANO	117.79	25.1	72.31	191.88	87	0.46
	MAPI	36.50	35.5	18.43	72.28	60	0.39
	TOKI	2.18	102.3	0.18	27.03	2	0.06
	VACE	38.48	21.4	25.38	58.33	121	0.42
	VACO	1.22	68.8	0.34	4.43	2	0.08

Appendix B. Average densities of grassland species in each GPCA.

Common Name Scientific Name	*GPCA*	*D*	*CV*	*LCL*	*UCL*	*n*	*Prop. Of Transects*
Burrowing Owl *Athene cunicularia*	CUAT	-	-	-	-	-	-
	CUZA	-	-	-	-	-	-
	JANO	3.13	66.9	0.93	10.48	10	0.10
	MAPI	2.69	57.4	0.92	7.84	8	0.11
	TOKI	4.10	59.7	1.36	12.37	9	0.17
	VACE	0.19	111.0	0.03	1.13	1	0.01
	VACO	-	-	-	-	-	-
Say's Phoebe *Sayornis saya*	CUAT	0.68	69.3	0.18	2.55	0	0.11
	CUZA	0.84	31.6	0.46	1.55	57	0.11
	JANO	0.48	57.0	0.17	1.37	122	0.08
	MAPI	4.20	17.5	2.98	5.94	21	0.40
	TOKI	1.04	34.6	0.53	2.04	3	0.15
	VACE	1.71	20.2	1.15	2.54	192	0.23
	VACO	0.52	68.8	0.14	1.89	6	0.08
Loggerhead Shrike *Lanius ludovicianus*	CUAT	0.81	54.1	0.28	2.35	3	0.17
	CUZA	0.97	26.1	0.58	1.62	19	0.16
	JANO	1.97	20.3	1.32	2.93	30	0.29
	MAPI	2.61	19.1	1.79	3.80	36	0.38
	TOKI	2.24	25.7	1.35	3.72	23	0.31
	VACE	1.12	20.3	0.76	1.67	28	0.20
	VACO	0.21	99.3	0.04	1.14	1	0.04
Chihuahuan Raven *Corvus cryptoleucus*	CUAT	2.53	60.7	0.79	8.16	4	0.17
	CUZA	2.43	32.2	1.31	4.53	21	0.20
	JANO	2.44	29.2	1.38	4.29	18	0.27
	MAPI	0.26	109.2	0.04	1.51	2	0.04
	TOKI	1.99	39.4	0.93	4.25	8	0.22
	VACE	0.74	35.4	0.38	1.47	11	0.13
	VACO	7.44	53.4	2.66	20.82	12	0.38
Common Raven *Corvus corax*	CUAT	-	-	-	-	-	-
	CUZA	0.84	41.0	0.39	1.84	12	0.08
	JANO	0.62	30.9	0.34	1.13	14	0.17
	MAPI	0.61	43.2	0.27	1.39	8	0.13
	TOKI	0.19	77.3	0.05	0.80	2	0.06
	VACE	0.17	59.2	0.06	0.51	5	0.03
	VACO	-	-	-	-	-	-
Horned Lark *Eremophila alpestris*	CUAT	5.11	88.9	1.02	25.67	4	0.11
	CUZA	-	-	-	-	-	-
	JANO	21.99	26.2	13.20	36.63	69	0.32
	MAPI	-	-	-	-	-	-
	TOKI	30.24	33.7	15.70	58.22	81	0.39
	VACE	5.93	34.9	3.04	11.58	35	0.13
	VACO	2.21	84.3	0.49	9.96	4	0.13

Appendix B. Average densities of grassland species in each GPCA.

Common Name Scientific Name	*GPCA*	*D*	*CV*	*LCL*	*UCL*	*n*	*Prop. Of Transects*
Mountain Bluebird *Sialia currucoides*	CUAT	9.17	121.3	0.86	97.66	5	0.17
	CUZA	2.94	98.0	0.38	22.54	5	0.04
	JANO	1.30	60.7	0.42	3.97	9	0.08
	MAPI	3.91	39.2	1.85	8.27	26	0.18
	TOKI	0.73	80.1	0.17	3.14	4	0.06
	VACE	0.72	49.0	0.29	1.82	8	0.05
	VACO	14.45	125.8	1.20	173.71	4	0.08
Sprague's Pipit *Anthus spragueii*	CUAT	1.67	70.1	0.44	6.29	2	0.11
	CUZA	0.63	80.4	0.16	2.58	4	0.03
	JANO	2.14	38.8	1.02	4.49	11	0.12
	MAPI	8.12	87.9	1.29	51.00	5	0.08
	TOKI	6.87	66.2	2.04	23.21	9	0.07
	VACE	1.08	40.1	0.50	2.31	9	0.06
	VACO	-	-	-	-	-	-
Clay-colored Sparrow *Spizella pallida*	CUAT	-	-	-	-	-	-
	CUZA	239.08	21.2	158.10	361.54	191	0.63
	JANO	36.92	40.0	17.10	79.72	18	0.18
	MAPI	79.69	40.9	36.53	173.86	36	0.31
	TOKI	2.47	104.5	0.43	14.02	2	0.04
	VACE	12.91	39.6	6.02	27.69	20	0.13
	VACO	-	-	-	-	0	0.04
Brewer's Sparrow *Spizella breweri*	CUAT	-	-	-	-	-	-
	CUZA	2.54	61.9	0.80	8.01	10	0.07
	JANO	27.24	35.3	13.73	54.05	27	0.29
	MAPI	10.82	97.6	1.52	77.17	6	0.07
	TOKI	0.29	99.0	0.06	1.52	1	0.02
	VACE	19.70	32.9	10.47	37.07	42	0.18
	VACO	-	-	-	-	-	-
Spizella spp.	CUAT	-	-	-	-	-	-
	CUZA	362.43	17.4	257.67	509.79	313	1.16
	JANO	217.02	21.3	143.17	328.96	99	1.08
	MAPI	77.44	32.9	41.09	145.92	51	0.47
	TOKI	5.41	55.8	1.90	15.40	7	0.13
	VACE	62.08	25.8	37.64	102.41	82	0.43
	VACO	13.03	99.4	2.35	72.41	1	0.08
Vesper Sparrow *Pooecetes gramineus*	CUAT	1.37	101.6	0.23	8.07	1	0.06
	CUZA	18.11	19.8	12.29	26.68	56	0.32
	JANO	231.24	13.1	178.83	299.00	247	0.79
	MAPI	33.94	26.5	20.25	56.90	53	0.36
	TOKI	2.78	98.9	0.53	14.57	2	0.04
	VACE	174.56	11.5	139.39	218.61	466	0.73
	VACO	22.14	68.8	6.22	78.76	13	0.21

Appendix B. Average densities of grassland species in each GPCA.

Common Name Scientific Name	*GPCA*	*D*	*CV*	*LCL*	*UCL*	*n*	*Prop. Of Transects*
Lark Sparrow *Chondestes grammacus*	CUAT	-	-	-	-	-	-
	CUZA	25.88	36.9	12.80	52.34	43	0.23
	JANO	0.26	101.7	0.05	1.40	1	0.01
	MAPI	0.56	103.2	0.10	3.07	1	0.03
	TOKI	-	-	-	-	-	-
	VACE	2.10	93.3	0.36	12.35	3	0.02
	VACO	-	-	-	-	-	-
Lark Bunting *Calamospiza melanocorys*	CUAT	-	-	-	-	-	-
	CUZA	3.86	67.1	1.10	13.62	10	0.06
	JANO	196.83	53.0	73.55	526.73	47	0.23
	MAPI	19.79	62.8	6.14	63.73	14	0.15
	TOKI	-	-	-	-	-	-
	VACE	1.33	56.5	0.47	3.82	11	0.08
	VACO	-	-	-	-	-	-
Savannah Sparrow *Passerculus sandwichensis*	CUAT	-	-	-	-	-	-
	CUZA	21.62	24.4	13.44	34.80	57	0.29
	JANO	159.70	24.3	99.34	256.73	122	0.38
	MAPI	20.15	42.3	8.97	45.26	21	0.17
	TOKI	95.74	79.9	22.58	405.95	3	0.04
	VACE	61.03	20.6	40.83	91.22	192	0.43
	VACO	7.51	55.4	2.59	21.76	6	0.17
Grasshopper Sparrow *Ammodramus savannarum*	CUAT	-	-	-	-	-	-
	CUZA	50.59	26.7	30.10	85.03	63	0.25
	JANO	70.58	23.7	44.41	112.17	70	0.35
	MAPI	41.29	29.6	23.21	73.47	40	0.22
	TOKI	-	-	-	-	-	-
	VACE	7.69	28.8	4.41	13.41	15	0.12
	VACO	8.60	55.7	2.95	25.09	3	0.13
Ammodramus spp.	CUAT	-	-	-	-	-	-
	CUZA	55.99	27.1	33.05	94.85	70	0.29
	JANO	99.17	21.3	65.30	150.60	99	0.54
	MAPI	42.44	27.9	24.63	73.12	40	0.24
	TOKI	-	-	-	-	-	-
	VACE	45.34	20.0	30.68	67.01	81	0.41
	VACO	41.10	49.1	15.78	107.06	14	0.38
Chestnut-collared Longspur *Calcarius ornatus*	CUAT	-	-	-	-	-	-
	CUZA	-	-	-	-	-	-
	JANO	178.00	27.4	104.68	302.67	113	0.45
	MAPI	3.08	118.4	0.46	20.56	5	0.01
	TOKI	-	-	-	-	-	-
	VACE	48.94	35.1	24.97	95.92	64	0.15
	VACO	5.12	104.7	0.86	30.47	2	0.04

Appendix B. Average densities of grassland species in each GPCA.

Common Name Scientific Name	*GPCA*	*D*	*CV*	*LCL*	*UCL*	*n*	*Prop. Of Transects*
Longspur spp. *Calcarius spp.*	CUAT	-	-	-	-	-	-
	CUZA	-	-	-	-	-	-
	JANO	183.87	27.8	107.44	314.68	124	0.50
	MAPI	9.00	71.6	2.48	32.60	72	0.04
	TOKI	-	-	-	-	-	-
	VACE	42.59	35.0	21.80	83.18	71	0.19
	VACO	4.98	104.7	0.84	29.66	2	0.04
Eastern Meadowlark *Sturnella magna*	CUAT	-	-	-	-	-	-
	CUZA	0.49	49.5	0.19	1.25	8	0.05
	JANO	5.18	27.3	3.05	8.82	37	0.33
	MAPI	-	-	-	-	0	0.01
	TOKI	0.23	70.0	0.07	0.82	2	0.04
	VACE	1.68	37.4	0.82	3.44	21	0.10
	VACO	-	-	-	-	-	-
Western Meadowlark *Sturnella neglecta*	CUAT	0.43	99.9	0.07	2.48	1	0.06
	CUZA	0.39	51.1	0.15	1.03	6	0.05
	JANO	1.44	50.9	0.55	3.77	8	0.08
	MAPI	9.73	56.5	3.39	27.89	14	0.13
	TOKI	-	-	-	-	-	-
	VACE	0.81	39.5	0.38	1.72	10	0.06
	VACO	1.64	58.0	0.54	4.98	5	0.13
Meadowlark spp. *Sturnella spp.*	CUAT	0.35	99.7	0.06	2.04	1	0.06
	CUZA	0.90	35.4	0.46	1.78	14	0.10
	JANO	19.06	20.6	12.74	28.52	87	0.69
	MAPI	8.46	52.2	3.17	22.57	15	0.14
	TOKI	1.54	72.6	0.42	5.66	9	0.07
	VACE	5.19	20.2	3.50	7.70	72	0.37
	VACO	1.35	57.6	0.45	4.07	5	0.13

GPCA=Grassland priority conservation area; D=Avg. density (birds/km^2); CV=Coefficient of Variation (%); LCL=lower confidence limit on D; UCL=upper confidence limit on D; n=number of independent observations used to estimate D (after truncation); Prop. of Transects=proportion of transects on which species was detected

Appendix C. Target species and numbers of individuals observed on road-based line transect surveys conducted from vehicles (species in **bold** are considered priority species according to PIF, USFWS, and/or TNC).

Common Name	*Scientific name*	N
Scaled Quail	***Callipepla squamata***	40
White-tailed Kite	*Elanus leucurus*	6
Bald Eagle	*Haliaeetus leucocephalus*	2
Northern Harrier	***Circus cyaneus***	114
Sharp-shinned Hawk	*Accipter striatus*	10
Cooper's Hawk	*Accipter cooperii*	5
Harris' Hawk	***Parabuteo unicinctus***	26
White-tailed Hawk	*Buteo albicaudatus*	2
Red-tailed Hawk	*Buteo jamaicensis*	118
Ferruginous Hawk	***Buteo regalis***	22
Golden Eagle	***Aquila chrysaetos***	4
Crested Caracara	*Caracara cheriway*	3
American Kestrel	*Falco sparverius*	110
Merlin	*Falco columbarius*	17
Aplomado Falcon	***Falco femoralis***	2
Prairie Falcon	***Falco mexicanus***	7
Sandhill Crane	*Grus canadensis*	398
Mountain Plover	***Charadrius montanus***	0
Long-billed Curlew	***Numenius americanus***	0
Barn Owl	*Tyto alba*	1
Great Horned Owl	*Bubo virginianus*	2
Burrowing Owl	*Athene cunicularia*	7
Short-eared Owl	***Asio flammeus***	2
Loggerhead Shrike	***Lanius ludovicianus***	126

Appendix D. Proportion of observed vs. expected use among grass coverage classes by wintering grassland-associated birds in Chihuahuan desert Grassland Priority Conservation Areas (GPCAs) in Mexico. Values in **bold** indicate significant differences.

Species	% Grass Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Scaled Quail	<1%	0.17	0.08	0.25	0.19	-1.88
Callipepla squamata	1-3%	0.07	0.01	0.13	0.08	-1.26
n = 38	3-10%	0.11	0.04	0.19	0.11	-0.01
χ^2 = 20.39	10-25%	0.18	0.09	0.26	0.15	2.35
df = 6	25-50%	0.09	0.02	0.15	0.19	**-9.84**
p < 0.01	50-75%	0.15	0.07	0.23	0.16	-1.21
	75-100%	0.24	0.14	0.33	0.12	**11.84**
Northern Harrier	<1%	0.09	0.05	0.13	0.19	**-9.4**
Circus cyaneus	1-3%	0.01	0	0.03	0.08	**-6.8**
n = 113	3-10%	0.06	0.03	0.09	0.11	**-5.51**
χ^2 = 112.57	10-25%	0.1	0.06	0.14	0.15	**-5.46**
df = 6	25-50%	0.25	0.19	0.31	0.19	**6.46**
p < 0.01	50-75%	0.26	0.2	0.32	0.16	**9.84**
	75-100%	0.23	0.17	0.28	0.12	**10.87**
Red-tailed Hawk	<1%	0.1	0.05	0.14	0.19	**-8.7**
Buteo jamaicensis	1-3%	0.09	0.05	0.13	0.08	0.78
n = 85	3-10%	0.12	0.07	0.17	0.11	0.4
χ^2 = 20.89	10-25%	0.14	0.08	0.19	0.15	-1.41
df = 6	25-50%	0.26	0.19	0.32	0.19	**6.97**
p < 0.01	50-75%	0.2	0.14	0.26	0.16	3.96
	75-100%	0.1	0.05	0.14	0.12	-2
American Kestrel	<1%	0.12	0.06	0.17	0.19	**-6.81**
Falco sparervius	1-3%	0.02	0	0.05	0.08	**-5.93**
n = 71	3-10%	0.07	0.02	0.11	0.11	**-4.84**
χ^2 = 53.81	10-25%	0.08	0.04	0.13	0.15	**-6.74**
df = 6	25-50%	0.29	0.21	0.36	0.19	**10.02**
p < 0.01	50-75%	0.22	0.15	0.29	0.16	5.95
	75-100%	0.2	0.13	0.27	0.12	**8.35**
Mourning Dove	<1%	0.18	0.15	0.2	0.19	-1.02
Zenaida macroura	1-3%	0.04	0.03	0.06	0.08	**-3.92**
n = 529	3-10%	0.13	0.11	0.15	0.11	1.2
χ^2 = 63.12	10-25%	0.13	0.11	0.15	0.15	**-2.27**
df = 6	25-50%	0.19	0.17	0.21	0.19	0.3
p < 0.01	50-75%	0.21	0.19	0.24	0.16	**5**
	75-100%	0.13	0.11	0.15	0.12	0.71

Appendix D. Proportion of observed vs. expected use among grass coverage classes.

Species	% Grass Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Burrowing Owl	<1%	0.08	0.01	0.15	0.19	**-10.46**
Athene cunicularia	1-3%	0.03	-0.01	0.07	0.08	**-5.24**
n = 33	3-10%	0.1	0.03	0.18	0.11	-1.31
χ^2 = 31.9	10-25%	0.32	0.21	0.44	0.15	**17.13**
df = 6	25-50%	0.23	0.13	0.34	0.19	4.62
p < 0.01	50-75%	0.1	0.03	0.18	0.16	-6.02
	75-100%	0.13	0.05	0.21	0.12	1.29
Say's Phoebe	<1%	0.18	0.13	0.23	0.19	-0.47
Sayornis saya	1-3%	0.05	0.02	0.08	0.08	**-3.47**
n = 118	3-10%	0.14	0.09	0.18	0.11	2.43
χ^2 = 23.49	10-25%	0.15	0.1	0.19	0.15	-0.5
df = 6	25-50%	0.26	0.21	0.32	0.19	**7.65**
p < 0.01	50-75%	0.14	0.1	0.19	0.16	-1.71
	75-100%	0.08	0.04	0.11	0.12	**-3.93**
Loggerhead Shrike	<1%	0.15	0.11	0.19	0.19	-3.35
Lanius ludovicianus	1-3%	0.07	0.04	0.09	0.08	-1.7
n = 147	3-10%	0.12	0.08	0.16	0.11	0.61
χ^2 = 14.58	10-25%	0.13	0.09	0.17	0.15	-1.81
df = 6	25-50%	0.22	0.17	0.27	0.19	3.38
p = 0.02	50-75%	0.21	0.16	0.25	0.16	4.52
	75-100%	0.1	0.07	0.14	0.12	-1.64
Chihuahuan Raven	<1%	0.1	0.06	0.15	0.19	**-8.05**
Corvus cryptoleucus	1-3%	0.05	0.02	0.08	0.08	**-3.34**
n = 108	3-10%	0.07	0.03	0.1	0.11	**-4.62**
χ^2 = 38.72	10-25%	0.19	0.14	0.24	0.15	3.63
df = 6	25-50%	0.27	0.21	0.33	0.19	**7.93**
p < 0.01	50-75%	0.17	0.12	0.22	0.16	1.16
	75-100%	0.15	0.1	0.2	0.12	3.28
Common Raven	<1%	0.15	0.08	0.22	0.19	-3.58
Corvus corax	1-3%	0.07	0.02	0.12	0.08	-1.47
n = 49	3-10%	0.15	0.08	0.22	0.11	3.55
χ^2 = 25.79	10-25%	0.07	0.02	0.12	0.15	**-8.39**
df = 6	25-50%	0.18	0.11	0.26	0.19	-0.25
p < 0.01	50-75%	0.15	0.08	0.22	0.16	-1.15
	75-100%	0.23	0.15	0.32	0.12	**11.29**
Horned Lark	<1%	0.03	0.02	0.05	0.19	**-15.09**
Eremophila alpestris	1-3%	0.01	0	0.02	0.08	**-7.12**
n = 203	3-10%	0.04	0.02	0.05	0.11	**-7.79**
χ^2 = 300.73	10-25%	0.24	0.2	0.29	0.15	**9.15**
df = 6	25-50%	0.3	0.26	0.35	0.19	**11.81**
p < 0.01	50-75%	0.13	0.1	0.17	0.16	-2.96
	75-100%	0.24	0.2	0.28	0.12	**12.01**

Appendix D. Proportion of observed vs. expected use among grass coverage classes.

Species	% Grass Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Sprague's Pipit	<1%	0.11	0.04	0.18	0.19	**-7.43**
Anthus spragueii	1-3%	0.02	-0.01	0.06	0.08	**-5.89**
n = 42	3-10%	0.04	0	0.08	0.11	**-7.44**
χ^2 = 66.32	10-25%	0.05	0	0.09	0.15	**-10.43**
df = 6	25-50%	0.4	0.3	0.51	0.19	**21.86**
p < 0.01	50-75%	0.16	0.08	0.24	0.16	-0.25
	75-100%	0.21	0.12	0.3	0.12	**9.59**
Clay-colored Sparrow	<1%	0.16	0.13	0.19	0.19	**-3**
Spizella palida	1-3%	0.03	0.02	0.05	0.08	**-4.9**
n = 296	3-10%	0.13	0.1	0.15	0.11	1.09
χ^2 = 71.68	10-25%	0.2	0.16	0.23	0.15	**4.51**
df = 6	25-50%	0.23	0.2	0.26	0.19	**4.36**
p < 0.01	50-75%	0.19	0.15	0.22	0.16	2.57
	75-100%	0.07	0.05	0.09	0.12	**-4.63**
Brewer's Sparrow	<1%	0.02	0	0.04	0.19	**-16.71**
Spizella breweri	1-3%	0.02	0	0.04	0.08	**-6.07**
n = 91	3-10%	0.05	0.02	0.08	0.11	**-6.27**
χ^2 = 65.81	10-25%	0.17	0.12	0.23	0.15	2.09
df = 6	25-50%	0.24	0.17	0.3	0.19	4.91
p < 0.01	50-75%	0.39	0.31	0.46	0.16	**22.48**
	75-100%	0.11	0.07	0.16	0.12	-0.44
Vesper Sparrow	<1%	0.03	0.02	0.03	0.19	**-15.82**
Pooecetes grammineus	1-3%	0.03	0.02	0.03	0.08	**-5.73**
n = 893	3-10%	0.05	0.04	0.07	0.11	**-5.92**
χ^2 = 1254.81	10-25%	0.11	0.09	0.12	0.15	**-4.25**
df = 6	25-50%	0.26	0.23	0.28	0.19	**6.93**
p < 0.01	50-75%	0.28	0.26	0.31	0.16	**12.37**
	75-100%	0.24	0.22	0.26	0.12	**12.43**
Lark Sparrow	<1%	0.25	0.16	0.33	0.19	5.98
Chondestes grammacus	1-3%	0.13	0.06	0.19	0.08	4.3
n = 53	3-10%	0.13	0.06	0.19	0.11	1.17
χ^2 = 28.72	10-25%	0.11	0.05	0.17	0.15	-4.5
df = 6	25-50%	0.26	0.18	0.35	0.19	7.8
p < 0.01	50-75%	0.11	0.05	0.17	0.16	-5.43
	75-100%	0.03	-0.01	0.06	0.12	**-9.32**
Lark Bunting	<1%	0.04	0.01	0.07	0.19	**-14.13**
Calamospiza melanocorys	1-3%	0.07	0.03	0.11	0.08	-1.29
n = 91	3-10%	0.08	0.04	0.12	0.11	-3.69
χ^2 = 103.56	10-25%	0.08	0.04	0.12	0.15	**-7.47**
df = 6	25-50%	0.23	0.17	0.29	0.19	4.18
p < 0.01	50-75%	0.24	0.18	0.31	0.16	**8.14**
	75-100%	0.26	0.2	0.33	0.12	**14.26**

Appendix D. Proportion of observed vs. expected use among grass coverage classes.

Species	% Grass Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Savannah Sparrow	<1%	0.03	0.02	0.04	0.19	**-15.7**
Passerculus sandwichensis	1-3%	0.02	0.01	0.03	0.08	**-5.9**
n = 422	3-10%	0.05	0.03	0.06	0.11	**-6.91**
χ^2 = 774.47	10-25%	0.1	0.08	0.12	0.15	**-5.4**
df = 6	25-50%	0.21	0.18	0.24	0.19	2.24
p < 0.01	50-75%	0.31	0.28	0.34	0.16	**15.16**
	75-100%	0.28	0.25	0.31	0.12	**16.52**
Grasshopper Sparrow	<1%	0.05	0.03	0.07	0.19	**-13.9**
Ammodramus savannarum	1-3%	0.03	0.01	0.04	0.08	**-5.45**
n = 201	3-10%	0.05	0.03	0.07	0.11	**-6.44**
χ^2 = 420.33	10-25%	0.08	0.05	0.1	0.15	**-7.4**
df = 6	25-50%	0.16	0.12	0.19	0.19	-3.03
p < 0.01	50-75%	0.34	0.3	0.39	0.16	**18.21**
	75-100%	0.3	0.25	0.34	0.12	**18.01**
Ammodramus sp.	<1%	0.04	0.02	0.05	0.19	**-14.66**
	1-3%	0.02	0.01	0.03	0.08	**-6.07**
n = 318	3-10%	0.03	0.02	0.05	0.11	**-8.16**
χ^2 = 426.34	10-25%	0.08	0.06	0.1	0.15	**-6.9**
df = 6	25-50%	0.16	0.13	0.19	0.19	-2.35
p < 0.01	50-75%	0.35	0.31	0.39	0.16	**19.14**
	75-100%	0.31	0.27	0.35	0.12	**19.01**
Chestnut-collared Longspur	<1%	0.05	0.03	0.08	0.19	**-13.22**
Calcarius ornatus	1-3%	0.01	0	0.02	0.08	**-7.59**
n = 194	3-10%	0.02	0.01	0.04	0.11	**-9.18**
χ^2 = 645.16	10-25%	0.04	0.02	0.06	0.15	**-10.9**
df = 6	25-50%	0.21	0.17	0.25	0.19	2.17
p < 0.01	50-75%	0.25	0.21	0.3	0.16	**9.14**
	75-100%	0.41	0.36	0.46	0.12	**29.57**
Calcarius sp.	<1%	0.07	0.05	0.1	0.19	**-11.5**
	1-3%	0.01	0	0.02	0.08	**-7.02**
n = 213	3-10%	0.03	0.01	0.04	0.11	**-8.6**
χ^2 = 608.38	10-25%	0.04	0.02	0.06	0.15	**-10.97**
df = 6	25-50%	0.21	0.17	0.25	0.19	2.2
p < 0.01	50-75%	0.25	0.21	0.29	0.16	**8.61**
	75-100%	0.39	0.34	0.44	0.12	**27.28**
Eastern Meadowlark	<1%	0.01	-0.01	0.02	0.19	**-17.71**
Sturnella magna	1-3%	0.03	0	0.06	0.08	**-5.36**
n = 80	3-10%	0.03	0	0.06	0.11	**-8.08**
χ^2 = 256.02	10-25%	0.05	0.01	0.08	0.15	**-10.61**
df = 6	25-50%	0.2	0.13	0.26	0.19	0.97
p < 0.01	50-75%	0.3	0.23	0.37	0.16	**13.88**
	75-100%	0.39	0.31	0.46	0.12	**26.91**

Appendix D. Proportion of observed vs. expected use among grass coverage classes.

Species	% Grass Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Western Meadowlark	<1%	0.04	0	0.09	0.19	**-14.1**
Sturnella neglecta	1-3%	0.02	-0.01	0.05	0.08	**-6.05**
n = 45	3-10%	0.04	0	0.09	0.11	**-6.97**
χ^2 = 69.62	10-25%	0.13	0.06	0.2	0.15	-2.6
df = 6	25-50%	0.22	0.13	0.31	0.19	3.61
p < 0.01	50-75%	0.24	0.15	0.34	0.16	8.32
	75-100%	0.3	0.2	0.39	0.12	**17.79**
Sturnella sp.	<1%	0.03	0.02	0.05	0.19	**-15.11**
	1-3%	0.02	0.01	0.04	0.08	**-5.99**
n = 204	3-10%	0.04	0.02	0.06	0.11	**-7.49**
χ^2 = 524.9	10-25%	0.08	0.05	0.11	0.15	**-7.35**
df = 6	25-50%	0.2	0.16	0.24	0.19	1.65
p < 0.01	50-75%	0.25	0.2	0.29	0.16	**8.55**
	75-100%	0.38	0.33	0.42	0.12	**25.74**

*Lower (LCL) and upper (UCL) Bonferroni-adjusted confidence limits on proportion of observed use

Appendix E. Proportion of observed vs. expected use among shrub coverage classes by wintering grassland-associated birds in Chihuahuan desert Grassland Priority Conservation Areas (GPCAs) in Mexico. Values in **bold** indicate significant differences.

Species	% Shrub Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Scaled Quail	<1%	0.18	0.10	0.27	0.10	8.65
Callipepla squamata	1-3%	0.14	0.06	0.22	0.10	3.62
n = 38	3-10%	0.13	0.05	0.21	0.13	0.60
χ^2 = 18.43	10-25%	0.17	0.08	0.25	0.15	2.04
df = 6	25-50%	0.21	0.12	0.30	0.23	-1.56
p = 0.01	50-75%	0.12	0.05	0.20	0.18	-5.27
	75-100%	0.04	0.00	0.09	0.12	**-8.10**
Northern Harrier	<1%	0.30	0.24	0.36	0.10	**20.02**
Circus cyaneus	1-3%	0.14	0.10	0.19	0.10	4.04
n = 114	3-10%	0.16	0.11	0.21	0.13	3.67
χ^2 = 212.26	10-25%	0.17	0.12	0.22	0.15	2.19
df = 6	25-50%	0.12	0.08	0.16	0.23	**-10.81**
p < 0.01	50-75%	0.09	0.06	0.13	0.18	**-8.11**
	75-100%	0.01	0.00	0.03	0.12	**-11.01**
Red-tailed Hawk	<1%	0.17	0.11	0.23	0.10	**7.16**
Buteo jamaicensis	1-3%	0.16	0.10	0.21	0.10	5.33
n = 114	3-10%	0.19	0.13	0.25	0.13	**6.74**
χ^2 = 65.56	10-25%	0.20	0.14	0.26	0.15	5.46
df = 6	25-50%	0.15	0.09	0.20	0.23	**-8.04**
p < 0.01	50-75%	0.09	0.04	0.13	0.18	**-8.88**
	75-100%	0.05	0.01	0.08	0.12	**-7.76**
American Kestrel	<1%	0.38	0.30	0.46	0.10	**28.26**
Falco sparervius	1-3%	0.15	0.09	0.21	0.10	4.61
n = 71	3-10%	0.15	0.09	0.22	0.13	2.94
χ^2 = 231.99	10-25%	0.15	0.09	0.20	0.15	-0.07
df = 6	25-50%	0.09	0.04	0.14	0.23	**-13.69**
p < 0.01	50-75%	0.05	0.01	0.08	0.18	**-12.85**
	75-100%	0.03	0.00	0.06	0.12	**-9.20**
Mourning Dove	<1%	0.16	0.14	0.18	0.10	**6.37**
Zenaida macroura	1-3%	0.13	0.11	0.16	0.10	**3.08**
n = 529	3-10%	0.15	0.13	0.17	0.13	**2.39**
χ^2 = 158.17	10-25%	0.17	0.15	0.19	0.15	**2.34**
df = 6	25-50%	0.18	0.16	0.21	0.23	**-4.39**
p < 0.01	50-75%	0.12	0.10	0.14	0.18	**-5.19**
	75-100%	0.08	0.06	0.10	0.12	**-4.60**

Appendix E. Proportion of observed vs. expected use among shrub coverage classes.

Species	% Shrub Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Burrowing Owl	<1%	0.52	0.39	0.64	0.10	**41.74**
Athene cunicularia	1-3%	0.13	0.05	0.21	0.10	2.72
n = 33	3-10%	0.10	0.03	0.18	0.13	-2.45
χ^2 = 209.79	10-25%	0.12	0.04	0.20	0.15	-2.50
df = 6	25-50%	0.11	0.03	0.19	0.23	**-11.50**
p < 0.01	50-75%	0.01	-0.01	0.03	0.18	**-16.54**
	75-100%	0.01	-0.01	0.03	0.12	**-11.47**
Say's Phoebe	<1%	0.16	0.11	0.21	0.10	**6.05**
Sayornis saya	1-3%	0.12	0.08	0.17	0.10	2.02
n = 118	3-10%	0.22	0.17	0.28	0.13	**9.76**
χ^2 = 109.46	10-25%	0.22	0.17	0.28	0.15	**7.69**
df = 6	25-50%	0.18	0.13	0.22	0.23	**-5.10**
p < 0.01	50-75%	0.06	0.03	0.10	0.18	**-11.05**
	75-100%	0.03	0.01	0.05	0.12	**-9.37**
Loggerhead Shrike	<1%	0.17	0.13	0.22	0.10	**7.46**
Lanius ludovicianus	1-3%	0.16	0.12	0.21	0.10	**5.91**
n = 147	3-10%	0.18	0.13	0.22	0.13	**5.13**
χ^2 = 147.18	10-25%	0.23	0.18	0.28	0.15	**8.28**
df = 6	25-50%	0.18	0.13	0.22	0.23	**-4.70**
p < 0.01	50-75%	0.06	0.03	0.09	0.18	**-11.42**
	75-100%	0.02	0.00	0.03	0.12	**-10.67**
Chihuahuan Raven	<1%	0.29	0.23	0.36	0.10	**19.55**
Corvus cryptoleucus	1-3%	0.11	0.07	0.15	0.10	0.39
n = 108	3-10%	0.16	0.11	0.21	0.13	3.80
χ^2 = 203.97	10-25%	0.22	0.16	0.27	0.15	**6.98**
df = 6	25-50%	0.12	0.07	0.16	0.23	**-10.88**
p < 0.01	50-75%	0.09	0.05	0.12	0.18	**-8.90**
	75-100%	0.02	0.00	0.03	0.12	**-10.94**
Common Raven	<1%	0.41	0.32	0.51	0.10	**31.72**
Corvus corax	1-3%	0.14	0.07	0.21	0.10	3.87
n = 49	3-10%	0.14	0.07	0.21	0.13	1.73
χ^2 = 188.74	10-25%	0.11	0.05	0.17	0.15	-3.74
df = 6	25-50%	0.12	0.06	0.19	0.23	**-10.37**
p < 0.01	50-75%	0.03	0.00	0.07	0.18	**-14.15**
	75-100%	0.03	0.00	0.07	0.12	**-9.08**
Horned Lark	<1%	0.75	0.70	0.79	0.10	**64.90**
Eremophila alpestris	1-3%	0.10	0.07	0.13	0.10	-0.71
n = 203	3-10%	0.05	0.03	0.07	0.13	**-7.29**
χ^2 = 2947.63	10-25%	0.06	0.04	0.08	0.15	**-8.70**
df = 6	25-50%	0.03	0.02	0.05	0.23	**-19.16**
p < 0.01	50-75%	0.01	0.00	0.01	0.18	**-16.89**
	75-100%	0.00	0.00	0.01	0.12	**-12.15**

Appendix E. Proportion of observed vs. expected use among shrub coverage classes.

Species	% Shrub Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Sprague's Pipit	<1%	0.48	0.37	0.59	0.10	**37.85**
Anthus spragueii	1-3%	0.11	0.04	0.18	0.10	0.70
n = 42	3-10%	0.15	0.07	0.23	0.13	2.53
χ^2 = 217.18	10-25%	0.06	0.01	0.12	0.15	**-8.27**
df = 6	25-50%	0.10	0.03	0.16	0.23	**-13.09**
p < 0.01	50-75%	0.06	0.01	0.11	0.18	**-11.99**
	75-100%	0.05	0.00	0.09	0.12	**-7.72**
Clay-colored Sparrow	<1%	0.12	0.09	0.14	0.10	1.83
Spizella pallida	1-3%	0.09	0.06	0.11	0.10	-1.74
n = 296	3-10%	0.15	0.12	0.18	0.13	2.20
χ^2 = 67.14	10-25%	0.18	0.15	0.21	0.15	3.06
df = 6	25-50%	0.18	0.15	0.21	0.23	**-4.82**
p < 0.01	50-75%	0.23	0.20	0.27	0.18	**5.65**
	75-100%	0.06	0.04	0.08	0.12	**-6.18**
Brewer's Sparrow	<1%	0.17	0.11	0.22	0.10	**6.77**
Spizella breweri	1-3%	0.20	0.14	0.26	0.10	**9.81**
n = 91	3-10%	0.25	0.19	0.32	0.13	**12.81**
χ^2 = 158.71	10-25%	0.22	0.16	0.28	0.15	**7.44**
df = 6	25-50%	0.11	0.06	0.15	0.23	**-11.95**
p < 0.01	50-75%	0.05	0.02	0.08	0.18	**-12.40**
	75-100%	0.00	0.00	0.00	0.12	**-12.48**
Vesper Sparrow	<1%	0.27	0.25	0.29	0.10	**17.23**
Pooecetes grammineus	1-3%	0.21	0.19	0.23	0.10	**10.98**
n = 894	3-10%	0.19	0.17	0.21	0.13	**6.53**
χ^2 = 1888.77	10-25%	0.15	0.14	0.17	0.15	0.80
df = 6	25-50%	0.11	0.09	0.12	0.23	**-12.01**
p < 0.01	50-75%	0.05	0.04	0.06	0.18	**-12.21**
	75-100%	0.01	0.01	0.02	0.12	**-11.32**
Lark Sparrow	<1%	0.13	0.07	0.20	0.10	3.44
Chondestes grammacus	1-3%	0.14	0.08	0.21	0.10	4.05
n = 53	3-10%	0.15	0.08	0.22	0.13	2.54
χ^2 = 53.73	10-25%	0.06	0.02	0.11	0.15	**-8.33**
df = 6	25-50%	0.14	0.07	0.21	0.23	**-8.77**
p < 0.01	50-75%	0.34	0.25	0.43	0.18	**16.42**
	75-100%	0.03	0.00	0.07	0.12	**-9.34**
Lark Bunting	<1%	0.34	0.27	0.41	0.10	**24.42**
Calamospiza melanocorys	1-3%	0.24	0.18	0.30	0.10	**13.48**
n = 91	3-10%	0.11	0.06	0.15	0.13	-1.89
χ^2 = 276.49	10-25%	0.10	0.05	0.14	0.15	**-5.06**
df = 6	25-50%	0.09	0.05	0.13	0.23	**-13.79**
p < 0.01	50-75%	0.12	0.07	0.17	0.18	**-5.41**
	75-100%	0.01	-0.01	0.02	0.12	**-11.75**

Appendix E. Proportion of observed vs. expected use among shrub coverage classes.

Species	% Shrub Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Savannah Sparrow	<1%	0.41	0.38	0.45	0.10	**31.54**
Passerculus sandwichensis	1-3%	0.18	0.15	0.21	0.10	**7.60**
n = 422	3-10%	0.13	0.11	0.15	0.13	0.32
χ^2 = 1690.74	10-25%	0.11	0.09	0.13	0.15	**-3.64**
df = 6	25-50%	0.09	0.07	0.11	0.23	**-13.45**
p < 0.01	50-75%	0.07	0.05	0.08	0.18	**-10.91**
	75-100%	0.01	0.00	0.02	0.12	**-11.46**
Grasshopper Sparrow	<1%	0.31	0.27	0.36	0.10	**21.41**
Ammodramus savannarum	1-3%	0.18	0.15	0.22	0.10	**7.99**
n = 201	3-10%	0.20	0.16	0.24	0.13	**7.51**
χ^2 = 537.94	10-25%	0.18	0.14	0.21	0.15	2.96
df = 6	25-50%	0.08	0.05	0.11	0.23	**-14.48**
p < 0.01	50-75%	0.04	0.02	0.06	0.18	**-13.23**
	75-100%	0.00	0.00	0.01	0.12	**-12.15**
Ammodramus sp.	<1%	0.35	0.31	0.39	0.10	**25.49**
	1-3%	0.20	0.16	0.23	0.10	**9.10**
n = 318	3-10%	0.21	0.17	0.24	0.13	**8.12**
χ^2 = 1087.27	10-25%	0.14	0.11	0.17	0.15	-0.46
df = 6	25-50%	0.07	0.05	0.08	0.23	**-16.10**
p < 0.01	50-75%	0.03	0.02	0.05	0.18	**-14.19**
	75-100%	0.01	0.00	0.01	0.12	**-11.96**
Chestnut-collared Longspur	<1%	0.73	0.69	0.78	0.10	**63.25**
Calcarius ornatus	1-3%	0.12	0.09	0.16	0.10	1.79
n = 194	3-10%	0.07	0.05	0.10	0.13	**-5.34**
χ^2 = 2708.88	10-25%	0.02	0.01	0.03	0.15	**-12.73**
df = 6	25-50%	0.05	0.03	0.07	0.23	**-17.80**
p < 0.01	50-75%	0.01	0.00	0.02	0.18	**-16.86**
	75-100%	0.00	0.00	0.01	0.12	**-12.31**
Calcarius sp.	<1%	0.72	0.67	0.76	0.10	**62.06**
	1-3%	0.12	0.09	0.15	0.10	1.48
n = 213	3-10%	0.08	0.05	0.10	0.13	**-4.89**
χ^2 = 2861.86	10-25%	0.03	0.01	0.04	0.15	**-11.96**
df = 6	25-50%	0.05	0.03	0.07	0.23	**-17.76**
p < 0.01	50-75%	0.01	0.00	0.02	0.18	**-16.61**
	75-100%	0.00	0.00	0.01	0.12	**-12.33**
Eastern Meadowlark	<1%	0.55	0.48	0.63	0.10	**45.64**
Sturnella magna	1-3%	0.16	0.10	0.22	0.10	**5.42**
n = 80	3-10%	0.09	0.05	0.14	0.13	-3.39
χ^2 = 608.41	10-25%	0.09	0.05	0.14	0.15	-5.46
df = 6	25-50%	0.07	0.03	0.11	0.23	**-15.53**
p < 0.01	50-75%	0.03	0.00	0.06	0.18	**-14.63**
	75-100%	0.00	-0.01	0.01	0.12	**-12.07**

Appendix E. Proportion of observed vs. expected use among shrub coverage classes.

Species	% Shrub Cover	Proportion Used	LCL*	UCL*	Expected Use	Difference (%)
Western Meadowlark	<1%	0.30	0.21	0.40	0.10	**20.60**
Sturnella neglecta	1-3%	0.17	0.09	0.25	0.10	6.62
n = 45	3-10%	0.17	0.09	0.25	0.13	4.48
χ^2 = 103.19	10-25%	0.17	0.09	0.25	0.15	2.42
df = 6	25-50%	0.16	0.08	0.23	0.23	-7.06
p < 0.01	50-75%	0.03	-0.01	0.07	0.18	**-14.58**
	75-100%	0.00	0.00	0.00	0.12	**-12.48**
Sturnella sp.	<1%	0.43	0.38	0.48	0.10	**33.37**
	1-3%	0.18	0.14	0.22	0.10	**7.89**
n = 204	3-10%	0.14	0.10	0.17	0.13	1.17
χ^2 = 922.45	10-25%	0.11	0.08	0.14	0.15	-3.35
df = 6	25-50%	0.09	0.06	0.12	0.23	**-13.30**
p < 0.01	50-75%	0.02	0.01	0.04	0.18	**-15.10**
	75-100%	0.02	0.00	0.03	0.12	**-10.68**

*Lower (LCL) and upper (UCL) Bonferroni-adjusted confidence limits on proportion of observed us