Wintering Bird Density and Habitat Use in Chihuahuan Desert Grasslands

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Cover Photo*:* Chihuahuan Desert grasslands being converted to cropland on Colonia El Cuervo, near Janos, Chihuahua. Photo by Gregory Levandoski.

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EXECUTIVE SUMMARY

Many grassland bird species are of high conservation concern due to major population declines and continuing habitat loss and degradation over much of their range. More than 80% of grassland bird species breeding in western North America overwinter in the Chihuahuan Desert grasslands of the southwestern U.S. and northern Mexico. These grasslands are increasingly being lost and degraded through agricultural conversion, desertification and shrub encroachment, especially in Mexico. However, there is little information on wintering grassland bird distribution, abundance, habitat use and spatiotemporal patterns to guide strategic habitat conservation in the region.

In January 2007, Rocky Mountain Bird Observatory (RMBO), together with Universidad Autónoma de Nuevo Leon, initiated a first-ever, region-wide pilot survey to inventory, research and monitor wintering birds in Chihuahuan Desert Grassland Priority Conservation Areas (GPCAs) in Mexico. This effort was refined and expanded in January and February of 2008 and 2009.

In 2009 we conducted 682 one-kilometer line transects at randomly-selected grassland sites across 10 current or potential GPCAs. At each site we used distance sampling to quantify bird populations and visual habitat assessments to characterize vegetation types and conditions. These surveys generated abundance and distribution information on 34 grassland associated species, including 30 priority species of high regional or continental conservation interest. We obtained reasonably precise annual estimates of density for 33 species or species groupings, including 19 priority species, across GPCAs. We determined habitat relationships for 16 species using generalized linear models.

Species density varied among the 10 GPCAs, but the degree to which densities differed varied among species. For example, Baird’s Sparrow density in Cuchillas de la Zarca, a GPCA in northern Durango and southern Chihuahua, far exceeds that in any other GPCA. Other species like Sprague’s Pipit were more evenly distributed, although some GPCAs still appeared to be more important than others. Some species showed broader regional patterns of abundance. For example, Chestnut-collared Longspur was most abundant in the northern Chihuahuan Desert GPCAs in most years. In 2008, densities dropped in the north and increased in the south, and most other species also showed evidence of inter-annual shifts in population density, both locally and across the region. Continued monitoring is needed to further evaluate these patterns.

Grass cover, shrub cover, and/or other cover were important habitat variables that influenced the abundance of most grassland species. Several species of high concern, including Sprague’s Pipit, Baird’s Sparrow, Grasshopper Sparrow and Chestnut-collared Longspur, were negatively affected by shrub cover and positively affected by grass cover. Grasslands with low shrub cover and high grass cover were uncommon in many of the GPCAs. However, these conditions can be promoted through management and restoration.

The identification of high-quality Chihuahuan Desert grasslands is impeded by a lack of resolution among grassland types in the available GIS. A refinement of the grassland classification, through an analysis of remote sensing data coupled with extensive ground-

truthing, is needed in order to distinguish among shrub-infested grasslands, which have little to no present value for most grassland species of concern, and open grasslands that provides critical habitat for these species.

Rapid agricultural expansion is threatening to severely reduce the availability of grasslands in the Chihuahuan Desert, particularly in flatland areas that appear to be important for many grassland birds of concern. Rates of grassland conversion to agriculture are not known, but they are increasing and appear to be unsustainable. Shrub encroachment is also reducing the availability of suitable habitat for open-grassland obligates. Given that migratory grassland birds from western North America concentrate in the limited grasslands of northern Mexico and southwestern U.S., continued loss of Chihuahuan Desert grasslands will create a wintering habitat bottleneck that will further limit population sizes of many grassland-obligate bird species.

An immediate and broad array of conservation solutions are needed to slow and reverse current trends in Chihuahuan Desert grassland loss. Continued avian inventories and monitoring will allow us identify spatiotemporal patterns of abundance, species habitat requirements, important wintering areas and land use changes, while continuing to provide an avenue for outreach and education. Once we can determine key regions, habitat conditions, and other variables that affect distribution and abundance, efforts to protect, manage and restore habitat and build public support for conservation must be dramatically increased in these areas. RMBO would like to deploy stewardship biologists in the GPCAs to reach out to local communities and landowners, develop partnerships and deliver on the ground conservation. Together these strategies could help mitigate the loss of grasslands and improve the region's carrying capacity for grassland species.

RESUMEN EJECUTIVO

Numerosas especies de aves de pastizal son de alto interés de conservación debido a sus disminuciones poblacionales mayores y a la pérdida y degradación continua de sus hábitats a través de su rango de distribución. Más del 80% de las especies de aves de pastizal reproduciéndose en el oeste de Norteamérica pasan el invierno en los pastizales desérticos del Desierto Chihuahuense del suroeste de EE.UU. y norte de México. Estos pastizales están siendo perdidos y degradados crecientemente por su conversión agrícola, desertificación, e invasión de plantas arbustivas, especialmente en México. Sin embargo, existe poca información sobre la abundancia, distribución, uso de hábitat y patrones espacio-temporales de las aves de pastizal para dirigir la conservación estratégica de hábitats en la región.

En enero de 2007, Rocky Mountain Bird Observatory, junto a la Universidad Autónoma de Nuevo León, inició el primer conteo piloto regional para inventariar, investigar y monitorear aves durante el invierno en Áreas Prioritarias para la Conservación de Pastizales (GPCA, por sus siglas en inglés) en México. Este esfuerzo fue refinado y expandido en enero y febrero de 2008 y de 2009.

En 2009, realizamos conteos en 682 transectos lineales de un kilómetro cada uno en sitios de pastizal seleccionados aleatoriamente a través de 10 GPCAs actuales o potenciales. En cada sitio utilizamos el muestreo de distancia para cuantificar las poblaciones de aves y estimaciones visuales del hábitat para caracterizar los tipos de vegetación y su condición. Estos conteos generaron información sobre la abundancia y distribución de 34 especies asociadas a pastizales, incluyendo 30 especies prioritarias de alto interés regional y continental de conservación. Obtuvimos estimaciones de densidad anual razonablemente precisos de 33 especies o grupos de especies, incluyendo 19 especies prioritarias a través de las GPCAs. Determinamos relaciones abundancia-hábitat para 16 especies utilizando modelos lineales generalizados.

La densidad de especies varió entre las 10 GPCAs, pero el grado en el que las densidades se diferenciaron varió entre especies. Por ejemplo, la densidad del Gorrión de Baird en Cuchillas de la Zarca, una GPCA que comprende el norte de Durango y el sur de Chihuahua, excede por mucho la densidad en cualquier otra GPCA. Otras especies, como la Bisbita Llanera, estuvieron más uniformemente distribuidas, aunque aún algunas GPCAs parecieron ser más importantes que otras. Algunas especies mostraron patrones de abundancia regional más amplios. Por ejemplo, el Escribano de Collar Castaño fue más abundante en las GPCAs del norte de Chihuahua – en la mayoría de los años. En 2008, las densidades cayeron en el norte y se incrementaron en el sur, y la mayoría de las especies también mostraron evidencia de cambios interanuales en la densidad, tanto localmente como a través de la región. Se requiere un monitoreo continuo para evaluar mejor estos patrones.

La cobertura de pastos, de arbustos, y/o de otras clases de cobertura fueron variables del hábitat importantes que influenciaron la abundancia de la mayoría de las especies de pastizal. Algunas especies de alta preocupación, incluyendo a la Bisbita Llanera, el Gorrión Chapulín, y el Escribano de Collar Castaño, parecen requerir pastizales con pocos o ningún arbusto, y para al menos nueve especies, la cobertura de pastos tuvo un efecto fuertemente positivo en sus abundancias, al menos hasta cierto punto. Desafortunadamente, los pastizales con poca cobertura de arbustos y con moderada o alta cobertura de pastos son raros en muchas de las GPCAs. Sin embargo, estas condiciones pueden ser promovidas a través de manejo y restauración.

La identificación de pastizales chihuahuenses de alta calidad es dificultada por la carencia de resolución entre los tipos de pastizales en los SIG disponibles. Un refinamiento de la clasificación de los pastizales, quizá a través de un análisis de datos de sensoria remota acoplado con una extensiva verificación de campo, es necesaria para distinguir entre pastizales invadidos por arbustivas, los cuales tienen poco o ningún valor presente para la mayoría de las especies de pastizal de preocupación, y los pastizales abiertos, que proveen hábitat crítico para estas especies.

La rápida expansión agrícola está amenazando a reducir severamente la disponibilidad de pastizales en el Desierto Chihuahuense, particularmente en las áreas de planicies que parecen ser importantes para muchas aves de pastizal de preocupación. Las tasas de conversión de pastizales a agricultura son desconocidas, pero parecen estarse incrementando y ser insostenibles. La proliferación de plantas arbustivas también está reduciendo la disponibilidad de hábitat adecuado para especies dependientes de pastizales abiertos. Dado que las aves de pastizal migratorias provenientes del oeste de Norteamérica se concentran en los pastizales limitados en el norte de México y suroeste de EE.UU., la pérdida continua de pastizales del Desierto Chihuahuense muy probablemente creará un cuello de botella invernal que reducirá la sobrevivencia invernal y limitará aún más el tamaño poblacional de muchas especies de aves dependientes de pastizales.

Se requiere un inmediato y extenso arreglo de soluciones para disminuir o revertir las tendencias actuales en la pérdida de los pastizales chihuahuenses. Inventarios y monitoreos continuos son necesarios para identificar los patrones espacio-temporales de distribución y abundancia de aves de pastizales en el invierno, para determinar los requerimientos de hábitat de las especies, para identificar áreas importantes durante el invierno, y para rastrear los cambios en el uso del suelo. Una vez que se han identificado regiones y hábitats clave, los esfuerzos de protección de hábitat, de manejo y de conservación deben ser incrementados en estas áreas, así como los esfuerzos para construir apoyo público para la conservación de pastizales, especialmente involucrando a los propietarios y administradores de pastizales. Biólogos supervisores podrían ser comisionados a estas áreas para la vinculación con las comunidades locales y los propietarios y ayudarlos a instrumentar acciones de conservación. En conjunto, estas estrategias podrían ayudar a mitigar la pérdida de pastizales y mejorar la capacidad de carga de la región para las especies de pastizal.

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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 steep, widespread and long-term population declines (Sauer et al. 2008). Reasons for many declines are still poorly understood, but likely are related to past and 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 western 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 this area are migratory. The greatest number of migratory grassland species in the region over-winter in the Chihuahuan Desert of northern Mexico and the southwestern United States, a globally important region for these birds (Figure 1B). Native grasslands in this region are restricted in distribution, and while the current extent of relatively intact desert grasslands is not known, it likely occupies less than 12% of the Chihuahuan Desert (Bird Conservation Region 35) in Mexico. However, little information exists on the distribution, abundance, habitat use, and spatiotemporal patterns of wintering grassland birds in this region, or on trends in grassland extent and condition. This information is urgently needed to advance strategic conservation actions for priority species and evaluate impacts from continuing grassland loss and climate change, as well as conservation actions, in the Chihuahuan Desert. The goal of this project is to provide this information through a random-sampling design that allows for local and regional inference to populations, prioritization of conservation areas based on species abundance, and insight into species-specific habitat requirements.

A B

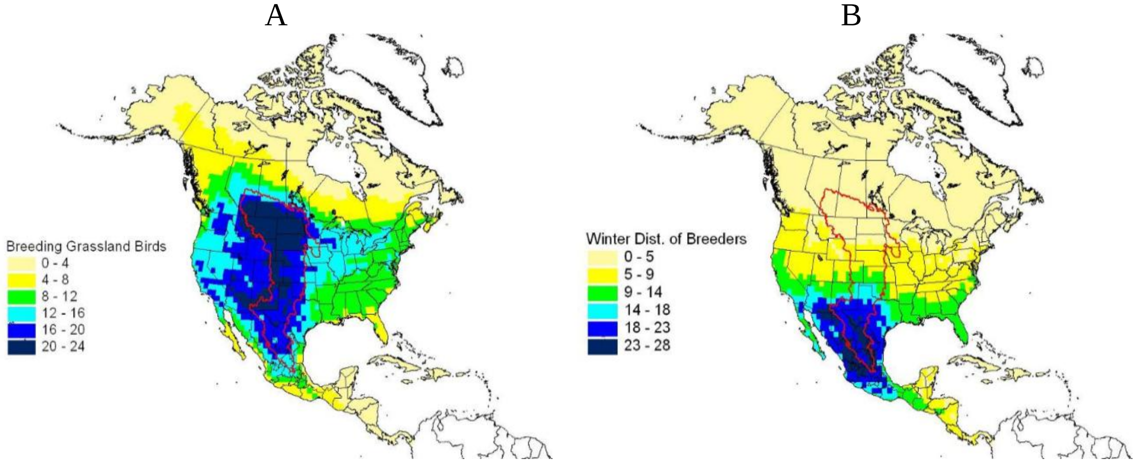

Figure 1. Overlay of breeding (A) and wintering (B) ranges for grassland bird species of the western Great Plains (from Blancher 2003).

In cooperation with the Universidad Autónoma de Nuevo León (UANL), and Sul Ross State University (SRSU), we implemented avian surveys across nine Grassland Priority Conservation Areas (GPCAs) in the Chihuahuan Desert of Mexico in January and February of 2007, 2008 and 2009 (some surveys in one GPCA occurred in March, 2009). With additional funding from the Rio Grande Research Center at SRSU we expanded the project into southeastern Chihuahua and western Texas with logistical assistance from SRSU. UANL coordinated field survey teams in Mexico through a network of regional partners, including Pronatura Noreste, Profauna Coahuila, Universidad Juárez de Durango, and RMBO. UANL was also responsible for data collection in the three easternmost GPCAs. Additional partners in field efforts have included Profauna Chihuahua, Pronatura Noroeste and TNC Chihuahua. According to the most recent GIS available (INEGI 2003), the survey blocks in these nine GPCAs in Mexico (Sonoita[1], Janos, Valles Centrales, Valle Colombia, Cuchillas de la Zarca, Mapimí, Cuatro Ciénegas, and El Tokio) encompass 22,619 km^2 of grassland in seven Mexican states: Sonora, Chihuahua, Coahuila, Durango, Zacatecas, Nuevo León and San Luís Potosí. This is equivalent to an area roughly the size of the state of New Jersey.

The goals and objectives of this project were identified with participation from over 20 partners from universities, NGO's, and federal and state agencies in the U.S. and Mexico, at the 3rd International Symposium on Grasslands, in Ciudad Chihuahua, Chihuahua, Mexico, in August 2006. Our primary objective was to estimate abundance of all grassland birds in these GPCAs, emphasizing priority species as identified by major bird conservation initiatives including (but not limited to) PIF, TNC, USFWS and INE. A detailed account of the program goals, study design, and methodology are given by Panjabi et al. (2006) and updated by Levandoski et al. (2008).

New study sites in 2009 included the grasslands in and around the Marfa GPCA in western Texas and Lagunas del Este, a significant grassland area in eastern Chihuahua (CEC and TNC 2005). The Lagunas del Este grasslands are located 20-150 km east, southeast and northeast of Delicias, Chihuahua. Lagunas del Este includes parts of Camargo, Saucillo, La Cruz, Julimes, and Ojinaga municipalities. An isolated block to the north in Manuel Benavides municipality was also included the Lagunas del Este stratum. Lagunas del Este was considered but not selected as a final GPCA; inclusion of this area helps fills a spatial gap in our study area and provides comparable bird abundance and habitat use data for a relatively large yet poorly known Chihuahuan Desert grassland area that may have significant conservation value and could be threatened. The same sampling design and methodology were employed in these areas as in other GPCAs, although limited landowner cooperation in Marfa restricted surveys to a relatively small proportion of the landscape.

METHODS

Study Design

We used a grid of roughly 18 x 18 km^2 cell blocks to create a sampling frame for Chihuahuan Desert grasslands and GPCAs. Potential samples were cells that intersected with GPCAs and had at least 5 km of road access to grasslands as identified in the GIS (INEGI 2003). Due to limited grassland area within some GPCAs, we added additional cell blocks to the sampling pool that met the aforementioned criteria, but were outside the boundaries of the GPCA. In each sampling block we established randomly numbered points at 500 m intervals along roads intersecting grasslands, and established six paired transects in each block, starting at the three lowest numbered points that met our habitat requirements of native grasslands with <25% shrub cover. This sampling design was described in detail by Panjabi et al. (2006), and modified by Levandoski et al. (2008).

In order to more thoroughly cover the available grasslands in the Chihuahuan Desert and in the area of each GPCA, we added two additional large grassland areas, Marfa and Lagunas del Este, into the

[1] In the past we have referred to the Mexican portion of this GPCA as "Sonorita", due to a typographic error in the GIS files we used to establish the sampling design.

sampling frame and expanded our sampling effort in two other GPCAs in 2009. We added three new survey blocks in Sonoita, one in El Tokio, 14 in the Marfa area and 13 in Lagunas del Este. Due to accessibility concerns, technicians in Valles Centrales replaced one block near Villa Ahumada that had been surveyed in 2008. In Mapimí, technicians replaced two blocks due to insufficient grassland area. These changes brought our total sampling effort in 2009 to 682 1-km transects in 112 sampling blocks in 10 grassland regions (Figure 2).

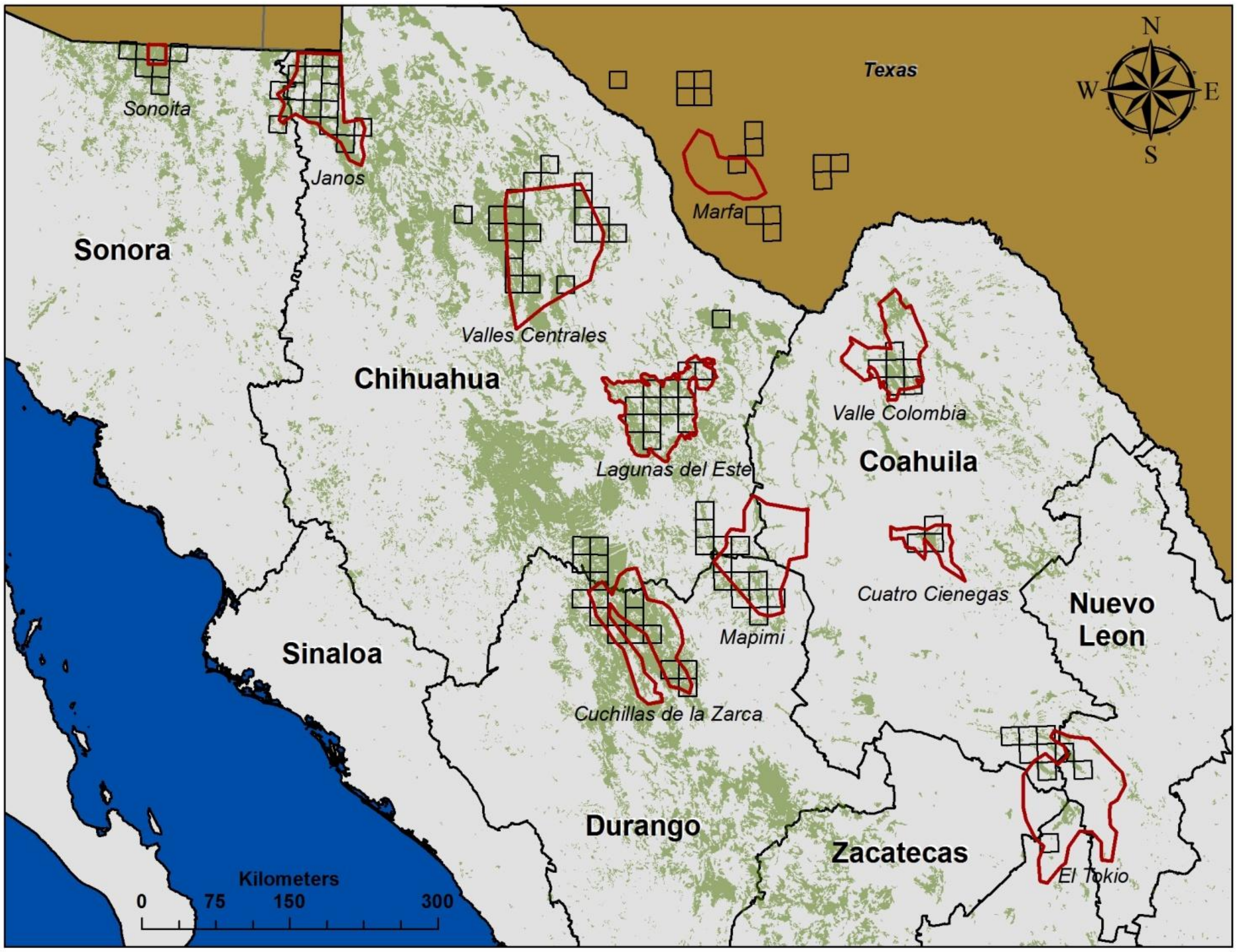

Figure 2. Chihuahuan Desert grasslands (shown in green), GPCA boundaries and blocks surveyed in 2009.

Line-transect Protocol

Our bird survey methodology followed Buckland (2001), modified slightly for this study as described by Panjabi et al. (2007) and Levandoski et al. (2008). We initiated surveys on January 19th and ended on or before March 5th, with the exception of Marfa where transects were conducted through March. We paired six one-kilometer line transects within each block, with each pair starting from a random point along a road and heading in opposite directions perpendicular to the road. In a few occasions where available grasslands were limited within the survey block, we did not pair transects. During the course of the day, each pair of technicians surveyed the six transects in each block starting at sunrise and continuing until completion, which was generally before 1300 hours. Sometimes, due to weather, road conditions, and variability in the time needed to complete both bird and vegetation surveys, finishing all transects within six hours was not possible. We recorded start and end times for each transect survey. We used Beaufort scales to categorize atmospheric conditions (sky, wind, precipitation, etc.) at the start and end of each transect. We did not conduct surveys during winds higher than category 4 (20-29 kph) or during any precipitation greater than drizzle. We noted incidental observations of a subset of priority species observed in between transects in each survey block in order to provide a more complete inventory of grassland birds in each survey block (see Levandoski et al. 2008).

From each starting point, technicians used Garmin E-trex Vista GPS units to establish the end point of the transect 1000 m away and maintain their position on the line while conducting the survey. Observers used a sighting compass to help select a point on the horizon that corresponded with the direction of the transect end point, and used this bearing to help visualize the transect line in front of them. Observers recorded all birds detected during each survey and used laser rangefinders to estimate lateral distances from the transect line to each bird or bird cluster detected. Bird clusters were defined as groups of two or more individuals of the same species occurring within 25 m of the first individual detected. For each detection, we recorded the cluster size, detection method (visual, song, call, wing-noise, pecking/drumming, or other), and transect segment where the bird was located (0–250 m, 250–500 m, 500–750 m, or 750–1000 m). If observers encountered a major obstacle, such as an international border, cliff or other impassable terrain, or if the transect would otherwise bisect a large area (>250 m) of non-grassland habitat, they turned the transect 90° in a randomly chosen direction to avoid the obstacle. This affected nearly 9% of transects in 2009.

Vegetation Protocol

Due to time constraints for data collection, we changed our vegetation sampling protocol from the 2008 protocol that used a modified line-intercept approach to sample ground and shrub cover parameters (Levandoski et al. 2008) to one in 2009 that relied on ocular estimates of these same parameters by trained observers. In order to minimize potential bias and calibrate observers' estimation skills, we trained observers in estimating vegetation cover on plots where all parameters had been either measured directly or estimated through quantitative sampling. An analysis of shrub cover estimates from 2008 and 2009 using the two different approaches revealed no significant differences in most GPCAs (Panjabi in prep). A comparison of ocular vs. quantitative sampling methods for the same ground and shrub cover parameters in shortgrass prairie in Colorado found that ocular sampling provides similar results (i.e., within 2%) as quantitative sampling for grass and shrub cover, whereas ocular estimates of bare ground were 2-5% higher than quantitative estimates and ocular estimates of 'other' cover were 6-7% lower than quantitatively sampled estimates (Panjabi in prep.). These findings suggest that ocular sampling of vegetation cover parameters provide a reasonably accurate picture of grassland vegetation conditions.

In 2009 we estimated vegetation parameters at 10 sub-sampling stations at 100 m intervals along each 1 km bird transect (Figure 3). These surveys were conducted immediately following each bird survey. At each sub-sampling station we made ocular estimates of ground cover within 5 m radius circular plots. To estimate ground cover, technicians looked directly down to the ground out to 2 m in four cardinal directions, estimated the percent cover in each direction, averaged these, and then extrapolated the estimate out to 5 m, adjusting it only for obvious and large variances. Ground cover estimates were broken down into four categories: bare ground, grass, herbaceous, and 'other' cover types. Up to three 'other' ground cover types were identified and listed in rank-order of dominance. 'Other' cover categories were: loose vegetation, cactus, woody vegetation, rock, yucca, animal excrement, and cryptobiotic crust. Average height was recorded for grass and herbaceous cover. Shrub cover was estimated within 50 m of each sampling station using a similar approach. The habitat assessment also included characterizations of landscape-level site attributes including topography (flatland, rolling hills, foothills, montane valleys, desert valleys, steep slopes, mesa top and uneven terrain), adjacent habitats, landownership, and dominant grassland type ('natural', halophytic, gypsophytic, induced or exotic grasslands). Presence or absence of prairie dogs was also recorded.

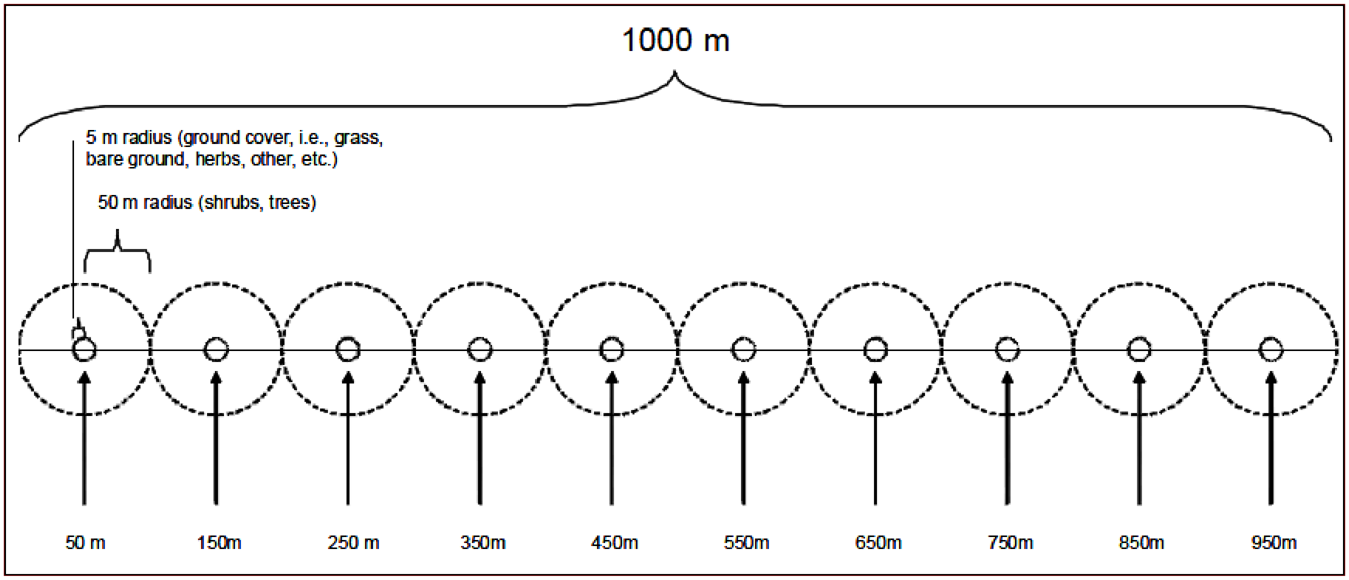

Figure 3. Design of vegetation survey transects for ground and shrub cover.

Training

We held a mandatory week-long training session for all technicians to explain, practice and review all field protocols. Most technicians also participated in a volunteer week-long effort to capture and band grassland birds prior to the training for another project. The great abundance of grassland birds around Janos in 2009 contributed to the ease and effectiveness of the training. Together with feedback incorporated from post-field season questionnaires in 2008, the large number and diversity of birds present helped us deliver our most successful training program yet.

As in previous years, we conducted extensive in-class and field training. In-class training utilized PowerPoint presentations and hand-outs to cover sampling theory and project design, data collection and analysis, bird identification and past years' projects results. We distributed written protocols detailing block and transect selection, avian and vegetation surveys and a user's guide detailing the exact steps in laying-out transects with the GPS unit. We also gave out copies of a PowerPoint presentation of useful identification tips and a compact disc with relevant vocalizations of all commonly encountered grassland species.

Field training covered grassland bird identification by sight and sound, lateral distance estimation, site selection and transect establishment, vegetation sampling and estimation of vegetation parameters, GPS use, as well as in-hand study of grassland birds captured in mist nets. We conducted daily bird identification quizzes in the field and used mean scores to evaluate and track technicians' bird identification skills over the course of the training program. All technicians were required to achieve at least an 80% average score across all bird identification quizzes in order to pass the training class and conduct bird surveys. We conducted field tests of distance estimation skills by walking along the edge of a two-track road and having technicians estimate lateral distance from the edge of the road to shrubs and other notable objects in front of us. When we advanced to the point nearest to the object, we measured to the object from the line to obtain the actual perpendicular distance. Technicians quickly improved accuracy of their lateral distance estimation skills in this way. We also conducted mock transects in small groups so trainees could learn survey procedures and ask questions as they arose.

Data entry

All data was entered directly by technicians into RMBO's online database. The data entry website was updated and improved in 2009 to improve functionality, user friendliness, and data quality controls.

Density Analyses

All density analyses were performed using program Distance 5.0, Release 2 (Thomas et al. 2006). We pooled data from 2007, 2008 and 2009 to augment species' sample sizes and create more robust detection functions. We ran analyses for all grassland-associated species or species groups with at least 25 independent observations across all transects in all years; 6 of 33 species or species groups had < 60 observations. Although analysis of data based on <60 samples is not recommended by the authors of program Distance, some species for which we obtained relatively small sample sizes are of conservation interest (e.g., Long-billed Curlew, Burrowing Owl, and Short-eared Owl). Thus, given the relevance of the information on these scarce species, we decided to present density estimates for them in a manner consistent with other species that considers detection probability and provides comparable measures of precision, instead of presenting unadjusted indices of abundance. However, caution should be used in interpreting these density estimates and special attention should be paid to associated measures of error.

In most cases, we right-truncated the furthest detections (those above the 85-95th percentile) of each species to eliminate outliers from the dataset and improve model performance. Truncation points were principally selected using Kolmogorov-Smirnov goodness-of-fit tests and visual assessments of model fit of the detection function. In a few cases, specific truncation points were chosen to correspond to where detectability dropped to 15% as recommended by Buckland (2001). In a few instances, heaping of recorded distances around commonly used distances (e.g., 25 m, 50 m, etc.) caused poor model fit. In these cases, we grouped observations into distance bins to improve performance of models and used a chi-square Goodness-of-Fit test to determine the truncation point.

We used global detection functions to model detectability of each species and post-stratified density estimates by GPCA-Year. We used the following function/expansion combinations to model the detection function for each bird species: Half-normal/Cosine, Hazard-rate/Simple-polynomial, Hazard-rate/Cosine and Uniform/Cosine. In general, we used Akaike's Information Criterion adjusted for small sample sizes (AICc) to select the highest ranking model (Burnham and Anderson 2002). When AICc was similar among two competing models (generally within 2 points), but the variance around the density point estimate differed substantially, we considered the default AIC selection of sequential adjustment terms for each model and selected the model with the fewest parameters.

We used the delta method (Powell 2007) to calculate the effect size between yearly global density estimates. The method we used to approximate the sampling variance of the effect sizes performs well when the coefficients of variation are low. Our application of the delta method assumed the estimates of density for each year were uncorrelated. However, because our estimates were calculated using a common (global) detection function, some degree of covariance likely exists. When the degree of covariance is small, assuming independence of density estimates will have little effect on the results:

$var(\theta_i - \theta_j) = var(\theta_i) + var(\theta_j) – 2cov(\theta_i\ \theta_j)$

When density estimates exhibit large positive covariance, the delta method may overestimate the sampling variance of the effect sizes. Under these conditions, the estimated effect sizes will be conservative and may occasional fail to detect a difference when one exists (Type II Error).

Habitat Relationship Analyses

Habitat relationships analyses were conducted using data collected on 370 transects in the 2008 field season (Levandoski et al. 2008). Data from Valles Centrales GPCA was not used in these analyses due to differences in the methodologies used. Although data from the 2009 field season was not included in these analyses we included these results in this report given the near complete overlap in survey locations and field methodologies for the collection of the avian data. Further habitat relationship analyses are planned using the 2009 and 2010 data.

Statistical models were generated using R version 2.8.1 (R Development Core Team 2008). We used a generalized linear model (GLM) (McCullagh and Nelder 1989) to model the effects of transect vegetation covariates on bird cluster counts. We were interested in covariate effects and predicting species response to transect level vegetation measurements. The covariate ‘bare ground’ was dropped due to correlation with other covariates. We modeled the effects of ‘grass cover’, ‘other cover’, and ‘shrub cover’. The quadratic terms of ‘grass cover’ and ‘other cover’ were included in GLM models to observe an optimal response in relation to bird abundance. Quadratic relationships are useful in identifying thresholds at which a continued increase in a parameter is no longer beneficial to the species. We did not include a quadratic term for ‘shrub cover’ since the number of samples across the ‘shrub cover’ continuum was low. We assumed that the cluster count $Count_i$ for species *i* had a Poisson (Pois) or negative binomial (NB) distribution with the expected mean count μ_i as;

$Count_i \sim Pois(\mu_i\ )$
$Count_i \sim NB(\mu_{i,}\theta)$

The negative binomial distribution incorporates a dispersion parameter θ which accounts for extra variance ($var(Count_i) = \mu_i\ +(u^2_i/\ \theta)$) (Venables and Ripley 2002) present in count models. We evaluated models for the expected mean cluster count μ_i using a log-link as:

$$\log(\mu_i) = \beta_0 + \beta_1\,(grass) + \beta_2\,(other) + \beta_3\,(shrub)$$

or using a quadratic as;

$$\log(\mu_i) = \beta_0 + \beta_1\,(grass^2) + \beta_2\,(other^2) + \beta_3\,(shrub)$$

We used a likelihood-ratio test to detect extra Poisson variation in the bird count data using a Poisson distribution versus a negative binomial distribution. A deviance statistic was then performed to test the adequacy of the distribution used in the GLM, (Lawless 1987; McCullagh and Nelder 1989). The

Poisson and negative binomial model was evaluated using the MASS package, glm and glm.nb functions (Venables and Ripley 2002).

We used Multi-model inference to rank competing models and acknowledged model uncertainty using AIC with a bias correction term for small sample size, AICc (Hurvich and Tsai 1989) and AICc weights, w_i (Burnham and Anderson 2002). Models were considered to be competing if they were within a ΔAICc of < 4. The criteria of ΔAICc between 4-7 corresponds to an approximately 95% confidence set of models (Burnham and Anderson 2002). Inferences were made to model averaged GLM parameters and predictions providing unconditional standard errors and 95% confidence intervals (Burnham and Anderson 2002) when there was more than one model within the competing set of models. Competing models with two functional forms of a variable, linear and quadratic, were averaged separately with their equivalent form since averaging a linear coefficient with a quadratic coefficient has no real meaning. We identified vegetation parameters that most strongly influenced species abundance in the top models as those with 95% confidence intervals that did not overlap zero and where the coefficient of variation (CV) was less than or equal to 40%.

RESULTS

Survey Effort

Sixteen technicians completed 682 1-km transects in 112 survey blocks in nine GPCAs plus the Lagunas del Este grasslands of southeastern Chihuahua (Table 1). The number of transects in each GPCA range from 18 in Cuatro Ciénegas to 126 in Valles Centrales. Increases in survey effort from 2008 to 2009 included the addition of 76 transects in 13 blocks in Lagunas del Este, 78 transects in 14 blocks in Marfa, 5 transects in one block in Mapimí, 24 transects in three blocks in Sonoita, and 2 transects in one block in El Tokio. Ninety percent of transects were finished by 1300 hours, and 97% were completed by 1400 hours. On average, technicians completed each 1-km line transect in 54±16.3 minutes.

Table 1. Annual survey effort in each Chihuahuan Desert Grassland Priority Conservation Area (GPCA).

Grassland Priority Conservation Area	Abbreviation	2007		2008		2009	
		Blocks	Transects	Blocks	Transects	Blocks	Transects
Cuatro Ciénegas	CUAT	3	18	3	18	3	18
Cuchillas de la Zarca	CUZA	16	24	16	96	16	96
Janos	JANO	13	73	13	78	13	78
Lagunas del Este*	LAGU					13	76
Mapimí	MAPI	12	23	12	71	13	76
Marfa	MARF					14	78
Sonoita	SONO			2	12	5	36
El Tokio	TOKI	9	9	7	60	8	62
Valles Centrales	VACE	21	58	21	126	21	126
Valle Colombia**	VACO	4	5	6	36	6	36
All GPCAs		78	210	80	497	112	682

*Lagunas del Este was not selected as a final GPCA by CEC and TNC (2005).
**Most sampling locations and data from 2007 were not retained due to a later realignment of GPCA boundary

Bird Density and Distribution

Technicians recorded 65,276 birds of 126 species through 13,317 independent observations (Appendix A). This figure is 246% higher than the total number of birds recorded in 2008 (179% higher when adjusted for increased effort). The average number of birds recorded per transect in 2009 was 95.7. Vesper Sparrow (all scientific names given in Appendix A) was by far the most widespread and commonly encountered species, with 2,543 observations on 60.6% of transect surveys. Chestnut-collared Longspur was the most numerous species observed with 15,246 individuals counted on 23% of transects.

We estimated annual densities for 33 grassland-associated species or species groups, including 19 priority species, within and across all GPCAs (Appendix B). Across all GPCAs, 52% of species and species groups analyzed showed some significant change in global density between 2008 and 2009 (Appendix C). Of those, 9% (3) decreased and 42% (14) increased. This compares to 42% of species with significant changes in density between 2007 and 2008. Of those, 24% (8) decreased and 18% (6) increased. When analyzing density changes across the duration of the project (2007 - 2009), we observed 33% of species showing a significant change in density. Of those, 6% (2) decreased and 27% (9) increased.

Of the eight species and species groups (Mountain Bluebird, Clay-colored Sparrow, Grasshopper Sparrow, *Ammodramus* spp., *Ammodramus* spp. and Savannah Sparrow, Savannah Sparrow, and Vesper Sparrow) that declined from 2007 to 2008, only Mourning Dove did not show a significant increase from 2008 to 2009. The three species that increased from 2007-2008 (Scaled Quail, Red-tailed Hawk, and Horned Lark), also decreased from 2008 to 2009. There were no species or species groupings that declined from 2007 to 2008 as well as from 2008 to 2009. Similarly, there were no species or species groupings that increased across both pairs of years.

Several species or species groupings did not show significant changes in density between two successive years, yet did show a significant change from 2007 to 2009. Four showed increases (Baird's Sparrow, Chipping Sparrow, *Spizella sp.*, and Eastern Meadowlark) and two showed decreases (Mourning Dove and Mountain Bluebird). Apparent increases in Baird's Sparrow and Eastern Meadowlark densities may reflect, in part, improvements in observers' identification abilities.

We did not detect significant changes between any pair-wise comparisons among years for seven species. For four of these species (White-tailed Kite, Long-billed Curlew, Burrowing Owl, and Short-eared Owl), the inability to detect any changes in density may simply reflect small samples size and high variance. However, three species (Northern Harrier, American Kestrel and Sprague's Pipit) likely did have relatively stable population densities across the region during the three years.

Nearly all species showed inter-annual changes in density in one or more GPCAs, but a thorough treatment of these changes is beyond the scope of this report. However such an analysis is planned. Nonetheless, patterns of distributional shifts were evident for some species, and in some cases, were shared by similar species. From 2008 to 2009, we documented a general northwest to southeast shift for several species, including Northern Harrier, American Kestrel, Short-eared Owl, Horned Lark, and Chestnut-collared Longspur. Savannah Sparrow occurred in very high density in Valle Colombia and relatively low densities elsewhere in 2009, possibly indicating that the bulk of their population wintered further to the north and/or east than in 2007 or 2008. Lark Bunting had a high density in Janos in 2007, but was not present in large numbers anywhere within our survey region in 2008. In addition, Lark Buntings were abundant in Mapimí in 2009, but scarce elsewhere.

Habitat Relationships

We developed GLM models for 17 species: Scaled Quail, Northern Harrier, American Kestrel, Mourning Dove, Say's Phoebe, Loggerhead Shrike, Chihuahuan Raven, Horned Lark, Sprague's Pipit, Clay-colored Sparrow, Brewer's Sparrow, Vesper Sparrow, Lark Bunting, Savannah Sparrow, Grasshopper Sparrow, Baird's Sparrow, Chestnut-collared Longspur, and Eastern Meadowlark. The Poisson distribution was used in the GLM for one species, American Kestrel.

Consistent with our expectations, shrub cover positively influenced the abundance of Scaled Quail. All competing models contained shrub cover ($w_+[j]=0.95$) suggesting an important relationship between Scaled Quail abundance and shrub cover (Appendix D), and the model averaged parameter estimates indicated shrub cover had a large positive effect (Table 2, Fig. 4). The most parsimonious model also included a modest effect of grass cover (Appendix D), although the standard error was large (Table 2). The second best model included other cover but did not improve the log likelihood (Appendix D) and the confidence interval for the parameter estimate included zero (Table 2). The quadratic coefficient estimate of grass cover was positive, making it an implausible relationship with bird abundance.

Table 2. Model averaged GLM vegetation parameters influencing grassland bird species' 2008 winter abundance.

Parameter Estimate		Species																
		American Kestrel	Baird's Sparrow	Brewer's Sparrow	Chestnut-collared Longspur	Clay-colored Sparrow	Eastern Meadowlark	Grasshopper Sparrow	Horned Lark	Lark Bunting	Loggerhead Shrike	Mourning Dove	Northern Harrier	Savannah Sparrow	Say's Phoebe	Scaled Quail	Sprague's Pipit	Vesper Sparrow
n (# of observations)		98	42	313	135	58	128	64	452	61	214	222	113	173	122	34	51	692
Grass	Estimate	**1.35**	9.13	**2.36**	**5.29**	2.41		**7.77**	**-2.8**	-0.7	0.43	0.86	2.8		1.18	2.23	1.04	
	Std. Error	0.53	2.51	0.61	1.37	1.41		1.48	0.59	1.09	0.41	0.73	0.76		0.52	1.25	0.89	
	LCL	0.3	4.21	1.16	2.59	-0.4		4.87	-4	-2.8	-0.4	-0.6	1.31		0.15	-0.2	-0.7	
	UCL	2.39	14.1	3.56	7.98	5.18		10.7	-1.7	1.43	1.23	2.3	4.29		2.21	4.69	2.78	
Grass^2	Estimate	0.54	**-32**	-0.2	-3.4	7.59	**-16**	-7	-2.7	-9.8	-3.5	-7.6	-7.1	**-22**	-1.1	5.35	1.63	**-12**
	Std. Error	2.53	12.3	2.95	6.57	6.88	4.88	7.39	3.12	6.14	2.2	3.84	4.01	5.25	2.64	5.6	4.43	2.44
	LCL	-4.4	-56	-6	-16	-5.9	-26	-21	-8.8	-22	-7.8	-15	-15	-32	-6.3	-5.6	-7.1	-17
	UCL	5.5	-7.8	5.54	9.51	21.1	-6.5	7.48	3.39	2.24	0.84	-0.1	0.72	-12	4.07	16.3	10.3	-7.1
Other	Estimate	0.63	**8.89**			3.42	**2.63**	2.09		-0.4	**1.03**	1.61	2.25	0.19	1.17	1.34	1.03	**2.46**
	Std. Error	0.65	2.82			1.63	0.98	1.68		1.22	0.28	0.84	0.86	1.02	0.59	1.5	1.02	0.54
	LCL	-0.6	3.36			0.22	0.71	-1.2		-2.7	0.48	-0	0.57	-1.8	0.01	-1.6	-1	1.41
	UCL	1.9	14.4			6.61	4.55	5.39		2.02	1.57	3.25	3.94	2.19	2.33	4.27	3.03	3.52
Other^2	Estimate	-1.17*	-11	**-13**	**-41**	-16	1.02	-10	**-19**	-3.6	-2.1	-8.3	-11	2.36	0.14	-4	-10	1.84
	Std. Error	3.63	10.9	4.02	11.6	9.32	4.99	9.56	4.1	6.5	2.51	4.58	5.31	5.53	3.15	7.81	6.77	2.77
	LCL	-8.3	-33	-21	-63	-34	-8.8	-29	-27	-16	-7	-17	-22	-8.5	-6	-19	-24	-3.6
	UCL	5.94	10.2	-5.5	-18	2.48	10.8	8.28	-11	9.1	2.81	0.73	-0.9	13.2	6.17	11.3	2.78	7.27
Shrub	Estimate	-7.5	-7.3	**6.56**	**-15**	**20.6**	0.6	-11	**-25**	**9.94**	2.04	4.14	1.63	**-11**	2.97	**15.7**	**-27**	0.09
	Std. Error	3.34	8.26	2.49	6.3	5.28	3.65	7.1	3.86	4.47	1.75	3.14	3.16	4.67	2.21	4.73	8.46	2.12
	LCL	-14	-24	1.67	-27	10.3	-6.6	-25	-33	1.18	-1.4	-2	-4.6	-20	-1.4	6.37	-44	-4.1
	UCI	-0.9	8.86	11.5	-2.7	31	7.75	3.24	-18	18.7	5.47	10.3	7.83	-2.1	7.31	24.9	-11	4.24

Strongly influential parameters identified in **bold**; n=number of independent detections from 2008 used in the analyses; [2]Indicates quadratic function; LCL – 95% lower confidence limit; UCL – 95% upper confidence limit

The top model for Morning Dove included one covariate, the quadratic of other cover (Appendix D). There was nearly equal support for the second best model, which included the quadratic of other cover and grass cover (ΔAICc=0.26). Shrub cover and the quadratic of other cover were selected in the third best model (ΔAICc=0.51). All covariate coefficients had large standard errors and small effect sizes (Table 2).

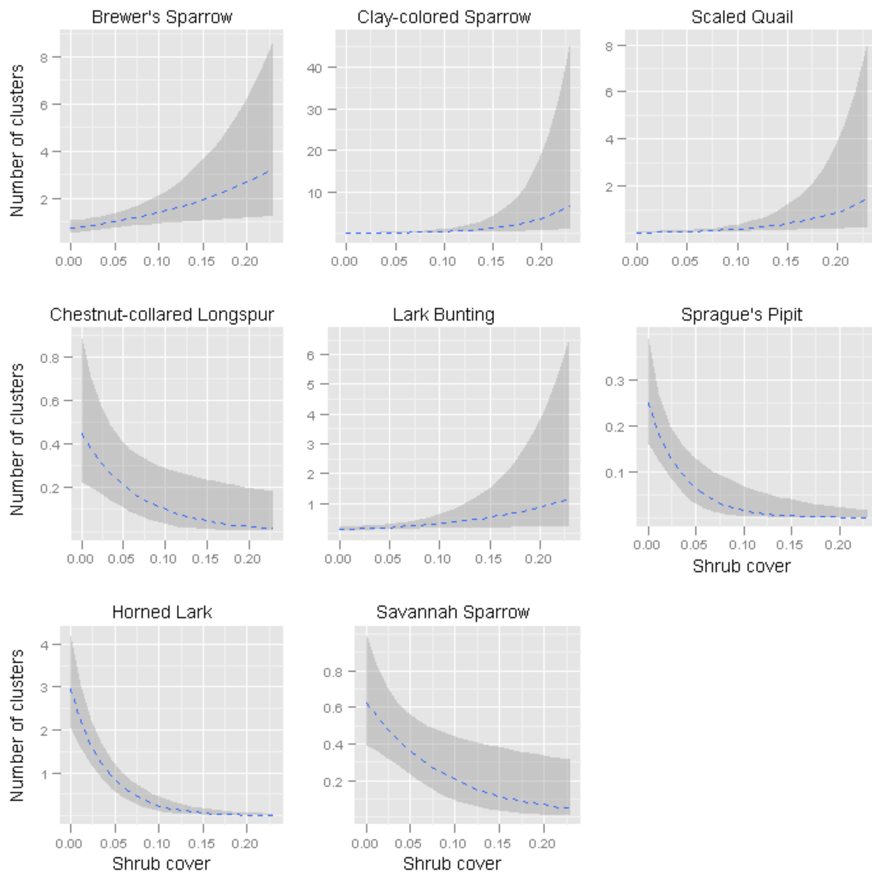

Figure 4. Effects of shrub cover on wintering grassland bird abundance in 2008.

The top model for Northern Harrier included the quadratic term for grass cover and other cover (Appendix D). The second best model also had strong support (ΔAICc=0.96) and included grass cover and the quadratic of other cover. The third best model included shrub cover but did not improve the log likelihood (Appendix D) and the confidence interval for the parameter estimate included zero (Table 2). Based on model weights, the quadratic terms for grass cover ($w_+[j]=0.6$) and other cover ($w_+[j]=0.8$) had more support than their linear terms ($w_+[j]=0.11$ and $w_+[j]=0.31$, respectively). However, the coefficient of variation was smaller for the linear covariate coefficients of grass and other cover than their corresponding quadratic terms (Table 2). The effect for shrub cover was not supported as the confidence intervals included zero (Table 2).

The best model for the American Kestrel included grass cover ($w_+[j]=0.64$) and shrub cover ($w_+[j]=0.78$, Appendix D). The second best model included other cover which did not improve model fit and the confidence interval for the effect included zero. The third best model included the addition of the quadratic of grass but also did not improve the model fit. There was strong support for a small positive effect of grass cover (Table 2, Fig. 5). In contrast to the Northern Harrier, there was a negative relationship with shrub cover, and although the confidence interval around the parameter estimate did not include zero, the standard error was large (Table 2). The quadratic term for grass cover was positive and was not viewed as a meaningful relationship with bird abundance.

The most parsimonious model for Say's Phoebe included the linear term of grass cover and other cover (Appendix D). Both of these had small positive effects on abundance, although standard errors were large (Table 2).

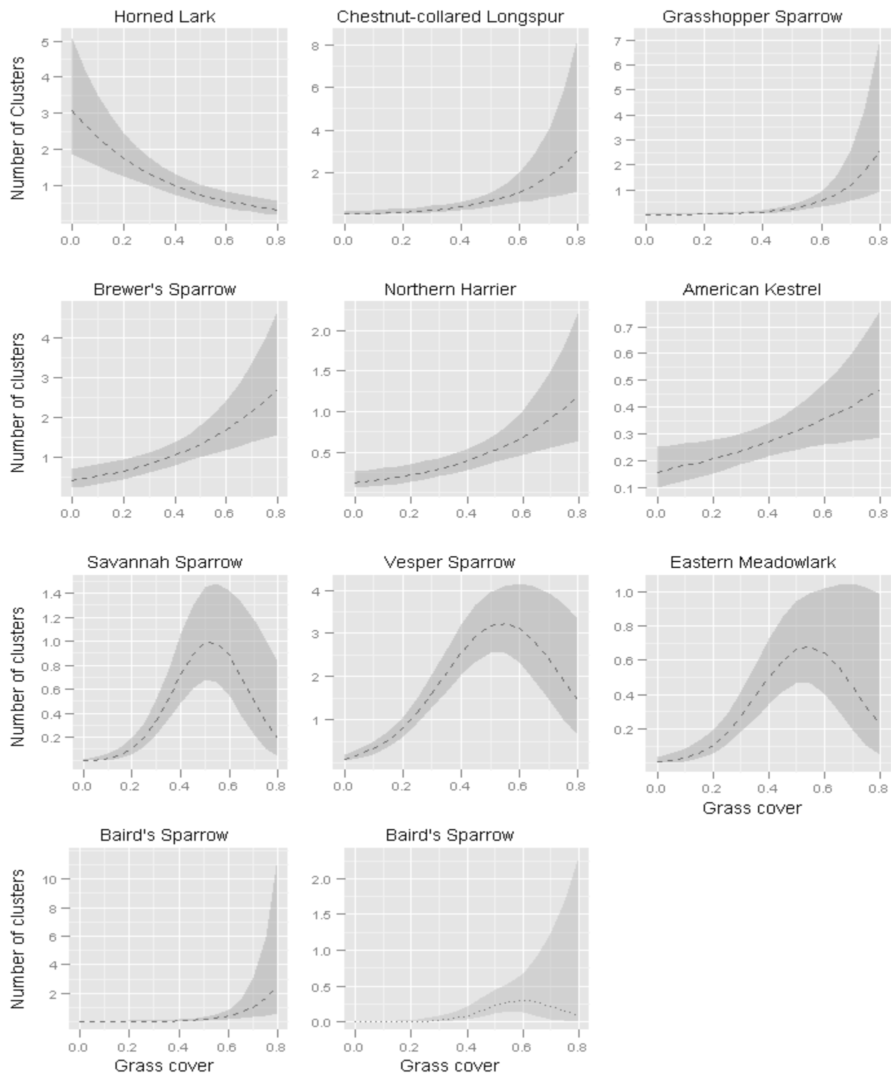

Figure 5. Effects of grass cover on wintering grassland bird abundance in 2008.

The top model for Loggerhead Shrike included one covariate, the linear term of other cover (Appendix D). The quadratic of grass cover and the linear term of other cover were in the second best model (ΔAICc =0.61). The third best model included the linear terms of grass cover and other cover (ΔAICc=0.84) but did not improve the model fit. The model averaged parameter estimates indicated a small positive effect for other cover (Table 2, Fig. 6) and a marginal effect for the quadratic of grass (Table 2). Other cover had a moderate probability of occurring in the best model ($w_+[j]$=0.58).

The top model for the Chihuahuan Raven included the linear term of other cover (Appendix D). There was weak support for models that included shrub cover ($w_+[j]$=0.25). The second best model included the quadratic of other cover (ΔAICc=1.09) but did not improve the model fit. The covariate coefficients had large standard errors and small effect sizes (Table 2), suggesting little importance of any of these variables.

Horned Lark had little model selection uncertainty with two competing models. The top model ($w_+[j]$=0.66) included grass cover, the quadratic of other cover and shrub cover (Appendix D). The second best model (ΔAICc=1.36) included the quadratic of grass cover, the quadratic of other cover and shrub cover, however the addition of the quadratic of grass cover did not improve the log likelihood, and based on model weights, the top model was 5 times more likely than the second best model (Appendix D). There was strong support for a large negative effect of shrub cover (Fig 4.), a modest negative effect of grass cover (Fig. 5), and a large effect of the quadratic term of other cover (Fig. 6).

The top model for Sprague's Pipit included one covariate, shrub cover (Appendix D). The second best model (ΔAICc=0.23) included the quadratic of other cover and shrub cover. The third top model

(ΔAICc=0.27) included the linear term of grass cover and shrub cover, however it did not improve the log likelihood and it added an additional parameter to the model. All competing models included shrub cover ($w_+[j]=1$) and model averaged parameter estimates indicated strong support for a large negative effect of shrub cover on Sprague's Pipit abundance (Table 2, Fig. 4). There was weak support for a small positive effect of grass cover and the quadratic of other cover, although the standard errors were large and the confidence intervals included zero (Table 2). The quadratic term of grass cover was positive so it was not viewed as having a meaningful relationship to bird abundance.

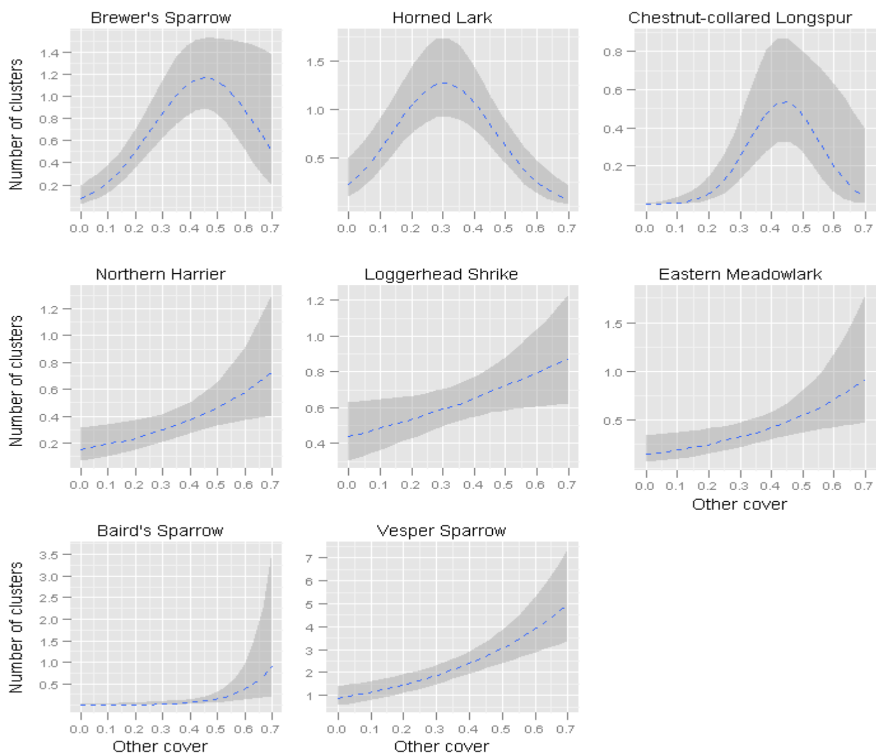

Figure 6. Effects of other ground cover on wintering grassland bird abundance in 2008.

The abundance of sparrows (Emberizidae) was usually influenced by shrub cover; all species except Vesper Sparrow and Baird's Sparrow contained shrub cover in their top model (Appendix D). Both Brewer's Sparrow and Clay-colored Sparrow were positively influenced by shrub cover, although the effect size was more than three times greater in Clay-colored (Table 2, Fig. 4). There was also strong support for a positive and moderately large effect of shrubs on Lark Bunting abundance (Table 2). Savannah Sparrow and Chestnut-collared Longspur showed the opposite effect; abundance of both these species was strongly negatively influenced by shrub cover (Table 2). Models for Grasshopper and Baird's Sparrow showed weak evidence of a negative shrub cover effect as the parameter estimate had large standard errors and confidence intervals that included zero (Table 2). Vesper Sparrow abundance did not appear to be strongly influenced by shrub cover, although it was included in competing models with lower support (ΔAICc>2.05, $w_+[j]=.26$; Table 2).

Grass cover, in either its linear or quadratic form, was retained in the top model for all Emberizids except Lark Bunting. There was strong support for a positive linear relationship between the abundance of Brewer's Sparrow, Grasshopper Sparrow and Chestnut-collared Longspur and grass cover (Table 2, Fig. 5). Based on model weights, Baird's Sparrow had weak support for a linear effect of grass cover (Appendix D), however the parameter estimate had narrow confidence intervals (Table 2, Fig. 5). There was strong support for a quadratic relationship with grass cover for Vesper Sparrow, Savannah Sparrow and Baird's Sparrow (Table 2, Fig. 5). While grass cover was retained in six of the competing models for both Clay-colored Sparrow and Lark Bunting (Appendix D), both the linear and quadratic terms had large standard errors and confidence intervals that overlapped zero (Table 2).

Other cover, in either its quadratic or linear form, was included in the top model for five Emberizid species analyzed, including Clay-colored Sparrow, Brewer's Sparrow, Vesper Sparrow, Baird's Sparrow and Chestnut-collared Longspur, and was retained in competing models for all other Emberizids analyzed (Appendix D). There was strong support for a large positive effect of other cover on Baird's Sparrow and Vesper Sparrow abundance and a quadratic effect on Brewer's Sparrow and Chestnut-collared Longspur abundance (Table 2, Fig. 6).

Eastern Meadowlark had 3 competing models, although each one included the quadratic term of grass cover, suggesting an optimal grass cover range (Appendix D). The top model included the quadratic term of grass cover and the linear term of other cover. There was a strong quadratic grass cover effect (Fig.5) and a positive effect for other cover (Fig. 6). The second top model added the quadratic term of other cover (ΔAICc = 2.02) but did not improve model fit.

Vegetation

We averaged the 10 vegetation cover estimates from each transect's sub-sampling stations to obtain an average value and its associated measure of variance for each vegetation parameter on each transect. These transect level values were averaged again to obtain the values for each GPCA. We did not include Marfa or Lagunas del Este in these analyses, due to differences in the vegetation protocol used in Marfa, and the late receipt of data from Lagunas del Este.

Grass cover was highest in Cuchillas de la Zarca, Janos, Sonoita, and Valles Centrales (Figure 7) while bare ground cover was highest in Cuatro Ciénegas, Mapimí, and El Tokio (Figure 8). Valle Colombia had the tallest grass and forbs (herbaceous) heights whereas El Tokio had the lowest (Figure 9).

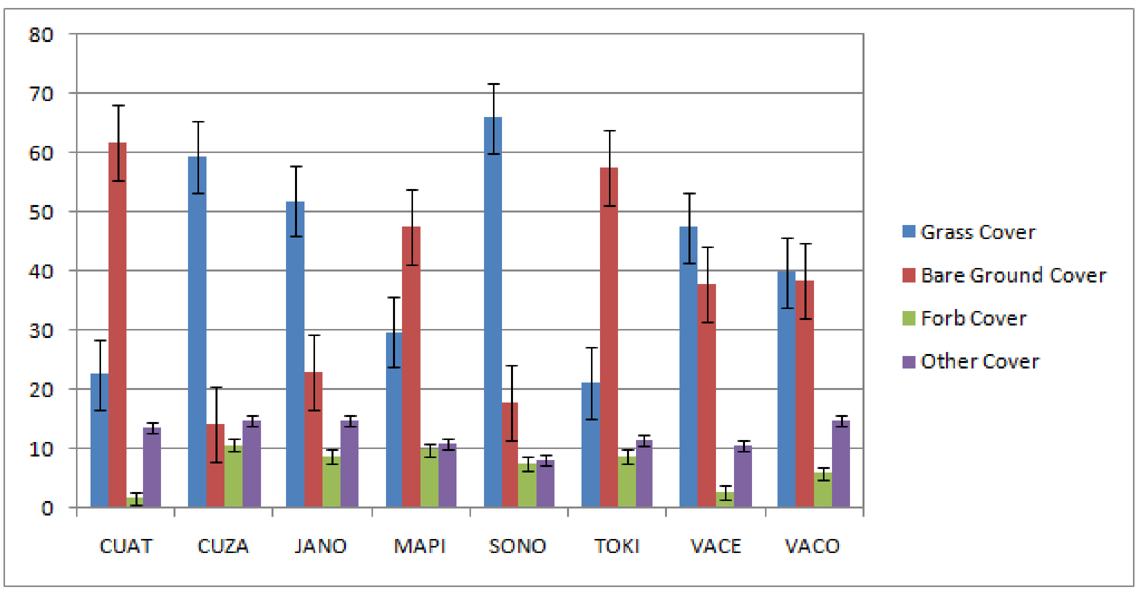

Figure 7. Average percent of ground cover types in GPCAs in 2009 (error bars represent sample standard error).

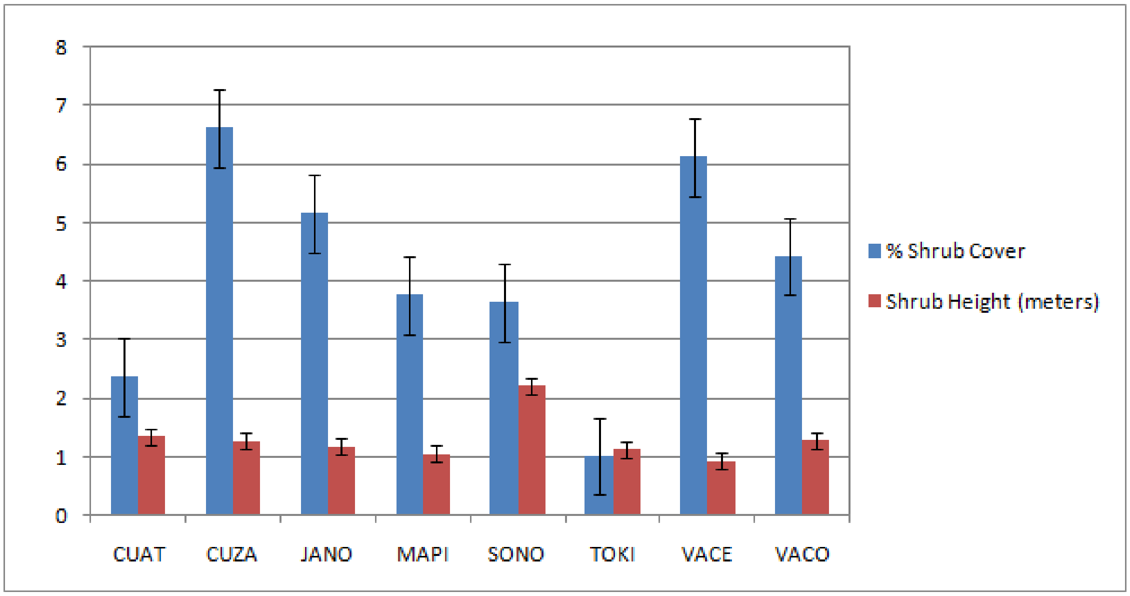

Figure 8. Average percent shrub cover and shrub height (m) in GPCAs in 2009 (error bars represent sample standard error).

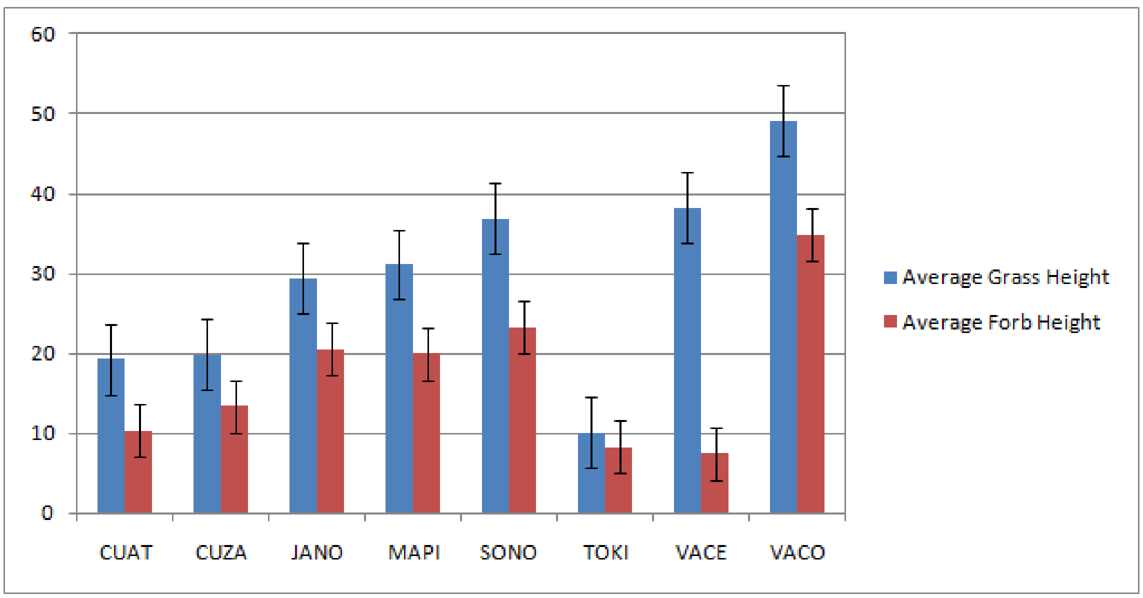

Figure 9. Average grass and forbs height (cm) in GPCAs in 2009 (error bars represent sample standard error).

Topography

Two-thirds of grassland study sites in 2009 were in flatlands while roughly one-fifth were in rolling hills (Figure 10). The remaining 12.5% were in montane valleys, foothills, steep slopes, desert valleys or uneven terrain. Most grassland birds were found in multiple topographic environments, although several species of high concern, including Aplomado Falcon, Mountain Plover and Long-billed Curlew, were found only in flatland areas. Ten additional grassland species, including Northern Harrier, Ferruginous Hawk, Prairie Falcon, Burrowing Owl, Short-eared Owl, Horned Lark, Clay-colored

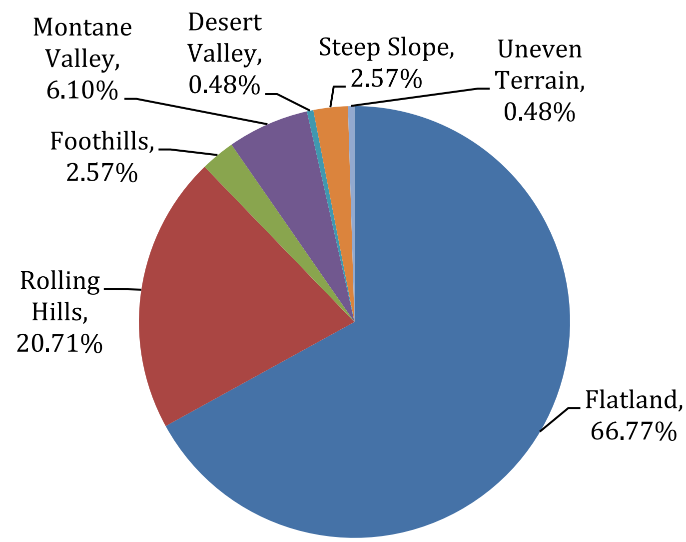

Figure 10. Predominant topography of grasslands surveyed in GPCAs in 2009.

Table 3. Proportion of species observations by topographic landscape classification.

Species	Flatland	Rolling Hills	Foothills	Montane Valley	Desert Valley	Steep Slope	Uneven Terrain	Mesa Top	n*
Scaled Quail	0.42	0.33	0.08	0.06	--	0.03	0.08	--	36
Northern Harrier	0.77	0.10	0.01	0.08	0.01	0.01	0.01	--	201
Ferruginous Hawk	0.78	0.14	0.03	0.03	--	0.03	--	--	37
Golden Eagle	0.63	0.38	--	--	--	--	--	--	8
American Kestrel	0.43	0.33	0.02	0.16	--	0.05	0.01	--	174
Aplomado Falcon	1.0	--	--	--	--	--	--	--	2
Prairie Falcon	0.75	0.25	--	--	--	--	--	--	4
Mountain Plover	1.0	--	--	--	--	--	--	--	2
Long-billed Curlew	1.0	--	--	--	--	--	--	--	13
Mourning Dove	0.59	0.32	0.03	0.04	0.01	0.01	--	--	390
Burrowing Owl	0.83	0.17	--	--	--	--	--	--	18
Short-eared Owl	0.92	0.08	--	--	--	--	--	--	12
Say's Phoebe	0.72	0.20	0.04	0.02	<0.01	0.01	<0.01	--	238
Loggerhead Shrike	0.66	0.18	0.03	0.11	0.01	0.01	--	--	296
Horned Lark	0.87	0.06	0.03	0.01	--	0.04	--	--	1099
Mountain Bluebird	0.48	0.19	0.17	0.02	--	0.14	--	--	42
Sprague's Pipit	0.49	0.29	--	0.16	--	0.06	--	--	106
Cassin's Sparrow	0.47	0.18	--	0.29	--	0.05	--	--	55
Clay-colored Sparrow	0.80	0.13	0.01	0.01	0.04	--	--	--	153
Brewer's Sparrow	0.80	0.17	0.01	0.01	--	<0.01	--	--	650
Vesper Sparrow	0.62	0.21	0.02	0.12	0.01	0.01	<0.01	--	2075
Lark Sparrow	0.24	0.68	0.05	0.02	--	--	--	--	41
Lark Bunting	0.97	--	0.01	0.01	<0.01	--	--	--	270
Savannah Sparrow	0.50	0.13	0.01	0.32	0.01	0.01	0.01	--	1024
Grasshopper Sparrow	0.55	0.17	0.02	0.22	<0.01	0.02	0.01	--	413
Baird's Sparrow	0.59	0.38	--	0.03	--	--	--	--	90

Species	Flatland	Rolling Hills	Foothills	Montane Valley	Desert Valley	Steep Slope	Uneven Terrain	Mesa Top	n*
Chestnut-collared Longspur	0.88	0.07	--	0.01	--	0.04	--	--	542
Eastern Meadowlark	0.60	0.25	0.02	0.09	--	0.03	<0.01	--	432
Western Meadowlark	0.63	0.12	0.02	0.10	0.05	0.07	0.02	--	264

*n reflects 2009 observations

Sparrow, Brewer's Sparrow, Lark Bunting and Chestnut-collared Longspur had at least 75% of all observations in flatland areas. Nine species, including Scaled Quail, Golden Eagle, American Kestrel, Prairie Falcon, Mourning Dove, Sprague's Pipit, Lark Sparrow, Baird's Sparrow and Eastern Meadowlark had at least 25% or more of observations in grassland areas of rolling hills.

Species Accounts

In Appendix E we provide individual species accounts for grassland obligate and facultative species that were detected in sufficient numbers to estimate densities. Each account summarizes, interprets and displays key findings in this report and compiles it in a single location for easy reference.

DISCUSSION AND RECOMMENDATIONS

Density and Distribution

Wintering grassland bird density and distribution in the Chihuahuan Desert is characterized by significant variation across areas and over time. In many cases, differences among years and GPCAs may not necessarily reflect trends in population size, but rather 'normal' spatiotemporal variation in wintering distribution. Qualitative synopses of inter-annual changes in species-species density and distribution are given in the species accounts in Appendix E. A rigorous analysis of these patterns could reveal important ecological patterns, especially in relation to climate, vegetation and other environmental factors, but is beyond the scope of this report.

Insight into patterns of wintering density and distribution is important not only in identifying core wintering areas for species, but also in identifying peripheral areas that may be used less regularly. Insufficient habitat in peripheral areas could limit populations when species are forced to expand beyond core areas. Understanding the proximate and ultimate factors that drive such population shifts, how these factors relate to climate change, and how birds will respond to these changes are important next steps in identifying and prioritizing grassland areas for protection and management. In the absence of such insight, the observed high spatiotemporal variability in winter distribution and abundance appears to support a strategy that includes a broad geographic network of protected and well-managed grassland landscapes in the Chihuahuan Desert to conserve wintering habitat for the full diversity of North America's grassland-dependent birds.

Habitat Relationships

Our analyses of 2008 bird abundance and vegetation cover revealed that shrubs were a common factor limiting winter abundance of several species in Chihuahuan Desert grasslands, including Sprague's Pipit and Chestnut-collared Longspur, two that are experiencing steep population declines (Sauer et al. 2008). Horned Lark and Savannah Sparrow abundance was also strongly negatively affected by shrub cover, as were Grasshopper and Baird's sparrows, albeit more tenuously. Mountain Plover was detected too infrequently to analyze using GLMs, but average shrub cover on sites where we found it in 2007-2009 was less than 0.28% (RMBO unpublished data). Our findings highlight the importance of Chihuahuan Desert grasslands with few or no shrubs for some of North America's most vulnerable grassland birds.

Grass cover influenced the abundance of species perhaps more than any other vegetation parameter. Thirteen species analyzed had grass cover retained in the top model, and two more had grass cover in competing models within $\Delta AICc=0.3$. Only one species, Horned Lark, had a negative relationship with grass cover. Thus, grass cover is a key parameter that positively affects habitat suitability for most species of grassland birds in winter. Although our analysis does not reveal the causes of this response, grass may provide food (i.e. seeds), roost and escape cover, shade, and habitat for prey. Average grass cover in Chihuahuan Desert GPCAs ranged from roughly 20 - 65%, although Cuatro Ciénegas, El Tokio and Mapimí all had average grass cover below 30%. Based on our findings, this level of grass cover is insufficient to support species like Baird's Sparrows, Grasshopper Sparrows or Chestnut-collared Longspurs.

'Other' cover appeared as a significant variable among the top models for many species, but due to the nature of this combined category it is difficult to interpret what about this variable was important. We suspect that in some cases herbaceous vegetation may have been driving these relationships, while in other cases it may have been something else, such as duff or woody ground cover. Vegetation data collected in 2009, when herbaceous vegetation was estimated separately from 'other' ground cover types, suggest that up to half the other ground cover estimates in 2008 may have been herbaceous vegetation (Figure 7). However, the proportion of other cover represented by herbaceous cover varied by GPCA, and herbaceous vegetation cover may vary across years. A further division of the 'other' ground cover category was implemented in 2010, separating duff from the remaining ground cover types. Tumbleweed (*Salsola* sp.) was also separated from herbs in 2010, due to its distinct growth form and abundant seeds that are a potential food source for some birds. When analyzed, these data should help identify what other ground cover types are important for various species.

Management and Conservation Implications

A large proportion of Chihuahuan Desert grasslands have been impacted by shrub encroachment, poor grazing management or farming, and as a result, grasslands with high grass cover and low shrub cover are uncommon. Increasing grass cover and reducing shrub cover through restoration and appropriate management should increase carrying capacity for grassland birds in the Chihuahuan Desert and should therefore be a priority. These conditions will not only serve the needs of declining grassland birds but also those of livestock producers.

Because vegetation parameters were averaged over each 1-km transect, and bird response was examined at that scale, it is important to note that the species-habitat relationships identified reflect bird abundance and habitat conditions at this larger scale, rather than at the precise locations where species were observed. Many transects covered a range of grassland conditions, including both shrubby and open areas, and some species may have been responding to habitat structure at smaller scales. Nonetheless, this broader view of habitat suitability should be useful from a multi-species, landscape-scale habitat management perspective.

Successes

Improved Training

The 2009 training session greatly benefitted from a concurrent RMBO project focusing on overwinter survival and home range use of grassland birds. Most technicians were able to assist in the mist-netting and banding of more than 250 grassland birds of over a dozen species the week prior to the official training session. The additional time in the field, combined with significant in-hand observation, aided in the development of technicians' identification skills.

Each year we have conducted a post-field season survey of our field technicians seeking feedback on many aspects of the program, especially the training. The overwhelming majority of responses have indicated that the training has been effective, but based on the feedback we spent more time on field identification of birds and review of the vegetation protocol in the 2009 training.

The continued high rate of return among institutions and individuals, coupled with annual training, has undoubtedly contributed to a decreasing rate of unidentified birds on surveys. The average number of unidentified birds per transect in the seven most common categories of unidentified birds (Unidentified

Bird, Unidentified Sparrow, *Spizella sp.*, *Ammodramus sp.*, *Ammodramus sp.* / *Passerculus sandwichensis, Calcarius sp.,* and *Sturnella sp.*) were 10.4 in 2007, 2.9 in 2008, and 2.4 in 2009. While the 2009 rate may still seem high, it represents only 2.5% of all individual birds detected. Technicians are instructed to never guess on a bird's identification, thus occasions where positive identification is not possible are unavoidable.

Expanded Effort

In 2009, we increased our sampling effort by 37%, adding two major grassland areas into the sampling frame (Lagunas del Este and Marfa), and adding additional samples in three others (Mapimí, Sonoita and El Tokio). This expanded regional coverage improves our ability to evaluate species distribution, abundance and inter-annual movements and identify key areas and habitats for conservation.

Outreach

The Chihuahuan Desert grassland bird monitoring provides an excellent opportunity to conduct outreach to private grassland owners and managers during visits to request permission to survey on private lands. As in 2008, we provided each landowner or manager with a summary of the bird data collected on their property the year before, along with a copy of our "Guia de Bolsillo para Aves de Pastizal del Desierto Chihuahuense" (a pocket guide to Chihuahuan Desert grassland birds). By providing these resources we hope to increase landowner awareness of the grassland birds on their property and their conservation status and needs. The pocket guides have been especially popular and useful, and also have been distributed to ranch-hands, ejiditarios (members of communally owned properties), students and other interested parties. In 2009, approximately 500 were distributed in Janos, 260 in Mapimí, 260 in Cuchillas de la Zarca, 260 between the GPCAs of Valle Colombia, Cuatro Ciénegas, and El Tokio, 120 in Valles Centrales, and 60 in Sonoita. Five-hundred pocket guides were also given to managers at the TNC El Uno Ecological Reserve in Chihuahua to distribute to partners and use in environmental education efforts. The pocket guides served well as a conversation starter and technicians frequently engaged locals in conversation regarding which birds they had each seen on a property, what conservation status each bird had and what type of habitat they required. The production of the pocket guides was made possible by funding from the USDA Forest Service International Program, The Nature Conservancy, and Pronatura Noreste, A.C.

Additional Research

We devoted two days to evaluating grassland bird response on two restoration projects done by the Cuenca Los Ojos Foundation (CLO) on their San Bernardino Ranch in northeastern Sonora. We were amazed to find that after three years, the restored tracts of grassland, which previously had been desert shrubland "without a blade of grass", now supported a large number of grassland birds, including species such as Baird's Sparrow and Sprague's Pipit. We look forward to continuing to collaborate with CLO and other organizations conducting grassland restoration to evaluate the success of restoration projects and further the science behind this important activity in the Chihuahuan Desert.

Challenges

Habitat Loss

Agricultural expansion in the Chihuahuan Desert appears to be increasing at an alarming rate. Although rates of conversion are not available, many large ranches, especially in Chihuahua, have recently been purchased or leased by farmers and converted to cropland. Since 2005, agricultural expansion in the

Valles Centrales GPCA has lead to the near extirpation of the Aplomado Falcon, a flagship species for high-quality grasslands. The massive agricultural expansion has also forced us to reselect a significant proportion of our samples each year in order to keep our sampling effort in grasslands. We have observed the conversion of grassland to cropland on our randomly selected study sites in Janos, Valles Centrales, Cuchillas de la Zarca, El Tokio and Mapimí. As a result, we have been forced to replace transect sites and even entire sampling blocks. While such replacement of samples limits our ability to identify population trends in wintering bird populations, trend estimation is not a primary goal of this program. Continued and expanded sampling of grasslands in the GPCAs will better help us identify key sites and habitats for priority species, understand spatiotemporal variation in population dynamics, and guide strategic habitat conservation for wintering grassland birds in the Chihuahuan Desert.

Timing of Surveys

The annual timing of surveys is important not only in questions of detectability, but also in regards to population dynamics. Wintering grassland bird density should decrease over the winter due to loss of individuals to predation, weather and other sources of mortality. However, birds may become more detectable as spring approaches and local population size may change due to the influx and egress of migratory individuals. Teasing apart these potentially confounding effects from real differences in population size becomes more complex if the annual timing of surveys is not relatively constant. Similarly, densities estimated in one area may not be comparable to densities from another area if timing is not also comparable. For this reason we try to ensure that all surveys are completed within a fairly narrow window of time from mid-January through February. Surveys from all GPCAs except two were conducted during this sampling window. Surveys conducted in Lagunas del Este and Marfa were conducted partially in December and March, respectively. We will strive to improve the consistency of timing of surveys among the GPCAs in future years, although some adjustments to the sampling window may be needed if survey effort increases substantially.

Access

In most places in Mexico access to private lands was not an issue. However, in Texas observers were forced to survey grasslands on only a small portion of the available habitat where landowners granted permission. Still, the same sampling design protocols were applied, although the survey blocks and random points that were available were limited to those where permission had been granted. Some Chihuahuan Desert grassland areas were inaccessible due to safety concerns. In particular, the mountainous regions of Chihuahua and Durango, and areas along the U.S. border in Sonora and Chihuahua pose significant challenges for conducting field work. We rely heavily on local partners in evaluating risks and determining survey plans. As of yet partners feel it is still possible to conduct the survey work with minimal risk.

Annual survey effort and extent

Each year the number of transects we have surveyed has increased, and the extent of the study area has changed. These changes in effort complicate interpretation of the results for some species.

Vegetation Protocol

Vegetation surveys in Lagunas del Este followed the protocol from 2008. This was due to the start of surveys in Lagunas del Este in December, well before the start date of January 19th that the rest of the field teams observed.

Analysis

As mentioned earlier, co-variance exists in the calculation of effect size for annual global density changes. The presence of co-variance is due to the fact that each global annual estimate of density uses the same detection function, created from data across all years. Although its influence is likely minimal, it has not been accounted for due to time constraints. We will seek to address this issue in the future.

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APPENDIX A. NUMBERS OF BIRD SPECIES OBSERVED IN EACH GPCA FROM 2007-2009.

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Black-bellied Whistling-Duck	*Dendrocygna autumnalis*	2009									2		2
Greater White-fronted Goose	*Anser albifrons*	2009		5,192									5,192
Snow Goose	*Chen caerulescens*	2008		2,036	100								2,136
		2009		2,985	1						105		3,091
Gadwall	*Anas strepera*	2007		55									55
		2008		4									4
		2009		17									17
American Wigeon	*Anas americana*	2008		7									7
		2009			6				1				7
Mallard	*Anas platyrhynchos*	2007			4						21		25
		2008			1								1
		2009			2				3				5
Blue-winged Teal	*Anas discors*	2007		2									2
Northern Shoveler	*Anas clypeata*	2007									130		130
		2008		35	3								38
		2009		41					353				394
Northern Pintail	*Anas acuta*	2007		3									3
		2008		2									2
		2009		23									23
Green-winged Teal	*Anas crecca*	2007					18						18
		2008		35									35
		2009		71							17		88
Anas sp.	*Anas sp.*	2007					4				20		24
		2009		10				8					18
Ring-necked Duck	*Aythya collaris*	2008		1									1
		2009		23									23
Lesser Scaup	*Aythya affinis*	2007									15		15
		2008							1				1
Bufflehead	*Bucephala albeola*	2007		1							20		21
		2008		40									40
		2009		15									15
Unidentified Duck	*Anatinae*	2007			16						10		26
		2008	1		1								2
		2009							14				14
Common	*Mergus*	2009							5				5

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Merganser	*merganser*												
Ruddy Duck	*Oxyura jamaicensis*	2009							2				2
Scaled Quail	*Callipepla squamata*	2007		22	54		9				25		110
		2008		186	95		65		2	5	450		803
		2009		126	58	42	44	42	14	1	61	10	398
Gambel's Quail	*Callipepla gambelii*	2007			8								8
		2008			26				1				27
		2009			25								25
Montezuma Quail	*Cyrtonyx montezumae*	2009			4								4
Western Grebe	*Aechmophorus occidentalis*	2009		31					1				32
Great Blue Heron	*Ardea herodias*	2009							1				1
Great Egret	*Ardea alba*	2009		1					1				2
Black Vulture	*Coragyps atratus*	2008		7									7
Turkey Vulture	*Cathartes aura*	2007		57	3		14			1			75
		2008		135	11		47			1	14		208
		2009		51	5	4	56	4		18	1		139
White-tailed Kite	*Elanus leucurus*	2007		2	3						3		8
		2008			11		6				2		19
		2009				5	4				1		10
Northern Harrier	*Circus cyaneus*	2007		3	34		9				34		80
		2008	1	12	76		22		13	5	60	1	190
		2009		17	44	42	32	30	14	7	39	17	242
Sharp-shinned Hawk	*Accipiter striatus*	2007		1									1
		2008		1	1								2
		2009									1		1
Cooper's Hawk	*Accipiter cooperii*	2007		1									1
		2008		2	1		1						4
		2009		3	1	4							8
Harris's Hawk	*Parabuteo unicinctus*	2007		5	2						1		8
		2008		5	15								20
		2009		3			1				2	2	8
Red-tailed Hawk	*Buteo jamaicensis*	2007	1	6	14		2				23	1	47
		2008	1	32	22		13		4	6	34	2	114
		2009		13	10	14	10	9	8	7	18	4	93
Ferruginous Hawk	*Buteo regalis*	2007			1					1	1		3
		2008		2	7					12			21
		2009		6	3			1		25	2	1	38

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Buteo sp.	*Buteo sp.*	2008		2	1		1			1	1		6
		2009				2		1	1	1			5
Golden Eagle	*Aquila chrysaetos*	2008			2				2				4
		2009			1			2		3	3		9
Unidentified Hawk	*Accipitrinae*	2007			2								2
		2008			2				1				3
		2009			1		3		1				5
Crested Caracara	*Caracara cheriway*	2009								3			3
American Kestrel	*Falco sparverius*	2007		8	16		5			2	15		46
		2008	2	37	23		10		3	17	16	10	118
		2009	1	46	15	17	33	17	6	18	15	28	196
Merlin	*Falco columbarius*	2007		6	4						2		12
		2008		5							1		6
		2009		4			2				1		7
Aplomado Falcon	*Falco femoralis*	2008									3		3
		2009									2		2
Peregrine Falcon	*Falco peregrinus*	2009	1			2			1				4
Prairie Falcon	*Falco mexicanus*	2007		1	1						2		4
		2008		2	3		3				3		11
		2009		1		7		1			1		10
American Coot	*Fulica americana*	2008		4									4
		2009		15									15
Sandhill Crane	*Grus canadensis*	2007		163	3		186						352
		2008	431		416		1						848
		2009	69		306		13						388
Killdeer	*Charadrius vociferus*	2007			1								1
		2008		10	2				2				14
		2009	1	18	2			2	1				24
Mountain Plover	*Charadrius montanus*	2007								8			8
		2008			23					33	6		62
		2009								9			9
American Avocet	*Recurvirostra americana*	2007									10		10
Spotted Sandpiper	*Actitis macularius*	2008		12									12
Greater Yellowlegs	*Tringa melanoleuca*	2008	5	7									12
		2009							1				1
Long-billed Curlew	*Numenius americanus*	2007			12		24			2	1		39
		2008		21	57		13			5			96
		2009	7		147	2	1	4					161

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Western Sandpiper	*Calidris mauri*	2009							17				17
Least Sandpiper	*Calidris minutilla*	2009		13					33				46
Stilt Sandpiper	*Calidris himantopus*	2007									1		1
Eurasian Collared-Dove	*Streptopelia decaocto*	2007			7								7
		2008			9								9
		2009		2	8								10
White-winged Dove	*Zenaida asiatica*	2007		10							1	1	12
		2008		33			1						34
		2009		57		2				1	19		79
Mourning Dove	*Zenaida macroura*	2007	5	68	797		62			7	774	1	1,714
		2008		561	391		34		1	72	48	10	1,117
		2009		452	294	693	219	61	58	14	279	43	2,113
Inca Dove	*Columbina inca*	2008		15									15
Greater Roadrunner	*Geococcyx californianus*	2007			10		1				3		14
		2008		4	3		1		3	1	6		18
		2009	1	3	9						1	1	15
Barn Owl	*Tyto alba*	2007					1						1
		2008			2								2
Great-horned Owl	*Bubo virginianus*	2008			2								2
		2009			2								2
Burrowing Owl	*Athene cunicularia*	2007			12		4			6	1		23
		2008			31		2			2	9		44
		2009			6	2	3	3		5	2		21
Long-eared Owl	*Asio otus*	2007			1								1
Short-eared Owl	*Asio flammeus*	2007			5		2				6		13
		2008			5		2				6	1	14
		2009			2		6				5		13
Acorn Woodpecker	*Melanerpes formicivorus*	2007		1	1								2
		2008		1									1
		2009		1					2				3
Gila Woodpecker	*Melanerpes uropygialis*	2008							3				3
		2009							2				2
Golden-fronted Woodpecker	*Melanerpes aurifrons*	2008		2									2
Williamson's Sapsucker	*Sphyrapicus thyroideus*	2009		2									2
Yellow-bellied Sapsucker	*Sphyrapicus varius*	2007		1									1

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Ladder-backed Woodpecker	*Picoides scalaris*	2007	1		10						1		12
		2008		7	7				4		3		21
		2009	1	7	14				2	6	2	5	37
Northern Flicker	*Colaptes auratus*	2007			17								17
		2008		3	25		2		8	3	1		42
		2009		2	4				5	4		2	17
Unidentified Woodpecker	*Picidae*	2008			2								2
Gray Flycatcher	*Empidonax wrightii*	2009		12									12
Empidonax sp.	*Empidonax sp.*	2007		3									3
		2008		2									2
		2009								1			1
Black Phoebe	*Sayornis nigricans*	2008		3					2				5
		2009							5				5
Eastern Phoebe	*Sayornis phoebe*	2007										1	1
		2008		3									3
		2009									2		2
Say's Phoebe	*Sayornis saya*	2007	2	3	8		20			3	19	2	57
		2008	2	59	8		28		6	17	17	4	141
		2009	1	68	4	81	109	8	10	25	12	4	322
Vermilion Flycatcher	*Pyrocephalus rubinus*	2007			1								1
		2008	1	11									12
		2009		9	1				3	1	1		15
Cassin's Kingbird	*Tyrannus vociferans*	2007		1									1
		2008		2									2
		2009		1							1		2
Western Kingbird	*Tyrannus verticalis*	2007									1		1
Unidentified Kingbird	*Tyrannus sp.*	2008								1			1
		2009								1			1
Loggerhead Shrike	*Lanius ludovicianus*	2007	3	8	32		10			3	16		72
		2008	7	79	51		63		2	14	23	12	251
		2009	9	74	46	47	48	20	12	24	49	37	366
Western Scrub-Jay	*Aphelocoma californica*	2009						1					1
Mexican Jay	*Aphelocoma ultramarina*	2007		1	13								14
		2008		10	7								17
		2009		6									6
Chihuahuan Raven	*Corvus cryptoleucus*	2007	5	9	38					6	27	1	86
		2008	6	55	19		8		3	11	7	15	124
		2009	37	36	73	25	10	48		18	34	4	285

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Common Raven	*Corvus corax*	2007		2	18		2			1	5		28
		2008		16	59		5		29	1	10		120
		2009	2		46	9	5	6	30	8	13		119
Unidentified Raven	*Corvus sp.*	2007			14								14
		2008	1		53		1		2	7			64
		2009	1		25	1	3		7	7		23	67
Horned Lark	*Eremophila alpestris*	2007	7		199					138	126		470
		2008	127	158	1,069		99		35	922	1,194	41	3,645
		2009	91	6	485	165	35	108	131	2,187	398	24	3,630
Tree Swallow	*Tachycineta bicolor*	2007			1								1
		2008		31			1						32
		2009		16	6		14		5		92		133
Violet-green Swallow	*Tachycineta thalassina*	2009									2		2
Bridled Titmouse	*Baeolophus wollweberi*	2007		4	2								6
		2008		7									7
		2009		4	14								18
Verdin	*Auriparus flaviceps*	2007		3	3								6
		2008		2			5			1			8
		2009			1	1							2
Bushtit	*Psaltriparus minimus*	2007		5	5								10
		2008		10									10
		2009		6	2				6	19			33
Cactus Wren	*Campylorhynchus brunneicapillus*	2007	1	15	45		1			4	4		70
		2008	3	78	55		18		3	3	5	5	170
		2009	1	66	80	10	4	12	2	13	12	9	209
Rock Wren	*Salpinctes obsoletus*	2007		1	4								5
		2008		5	1					1			7
		2009		4	3	1							8
Canyon Wren	*Catherpes mexicanus*	2007		2	2								4
		2008		5									5
		2009		2									2
Bewick's Wren	*Thryomanes bewickii*	2007			11							2	13
		2008			5				1				6
		2009			6							7	13
House Wren	*Troglodytes aedon*	2007		1									1
Unidentified Wren	*Troglodytidae*	2008			1								1
Marsh Wren	*Cistothorus palustris*	2009	1										1
Ruby-	*Regulus*	2007		14	2								16

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
crowned Kinglet	*calendula*	2008		7	2								9
		2009		2	1				3				6
Blue-gray Gnatcatcher	*Polioptila caerulea*	2007		3							1		4
		2008					1						1
		2009		6		3	1			1		2	13
Black-tailed Gnatcatcher	*Polioptila melanura*	2007		1	2		3						6
		2008		1	1		37				4		43
		2009				8	12	2			3		25
Eastern Bluebird	*Sialia sialis*	2007		2									2
		2009			2								2
Western Bluebird	*Sialia mexicana*	2007		2									2
		2008		9	7					27			43
		2009		12						11			23
Mountain Bluebird	*Sialia currucoides*	2007	19	21	21		95			1	8	14	179
		2009		42	3	1	10	15		34		6	111
Unidentified Bluebird	*Sialia sp.*	2007			3								3
American Robin	*Turdus migratorius*	2007		1									1
		2008		1	1								2
Northern Mockingbird	*Mimus polyglottos*	2007	3	3			5			1		1	13
		2008	9	22			2			9		1	43
		2009	5	16		7	14		1	3		3	49
Sage Thrasher	*Oreoscoptes montanus*	2007	1		1		4						6
		2009			1	3	7	2				1	14
Curve-billed Thrasher	*Toxostoma curvirostre*	2007		8	35		2			3	1		49
		2008	1	30	20		21		6	8	5	4	95
		2009	3	35	47	4	13	6	1	16	3	9	137
Crissal Thrasher	*Toxostoma crissale*	2007			1						1		2
		2008			2								2
		2009			2				1				3
European Starling	*Sturnus vulgaris*	2007			1								1
		2008			6								6
		2009			3								3
American Pipit	*Anthus rubescens*	2007	2				1			435			438
		2008			1					56	1		58
		2009	51					5		428			484
Sprague's Pipit	*Anthus spragueii*	2007	2		11					7	7		27
		2008	1	32	10					17	26	3	89
		2009		36	12	2	5	2	12	28	3	18	118
Unidentified	*Anthus sp.*	2007					3			13			16

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Pipit		2008									14		14
		2009		4									4
Cedar Waxing	*Bombycilla cedrorum*	2008					1						1
Phainopepla	*Phainopepla nitens*	2007	56	3							3		62
		2008		1	6		2						9
		2009		5	2								7
Orange-crowned Warbler	*Vermivora celata*	2008		1									1
		2009	1	1									2
Yellow-rumped Warbler	*Dendroica coronata*	2007	14										14
		2008	12	5									17
		2009	6	2									8
Green-tailed Towhee	*Pipilo chlorurus*	2007		4	23								27
		2008		1	6		8				1		16
		2009		4	10	3	4	1			9		31
Spotted Towhee	*Pipilo maculatus*	2007			3								3
		2008			1		2						3
Canyon Towhee	*Pipilo fuscus*	2007		12	8					4		1	25
		2008		76	8				5	4	12		105
		2009		49	13	28	2	12	4	12	4		124
Cassin's Sparrow	*Aimophila cassinii*	2007		4	8						5		17
		2008		2	5					1	1		9
		2009		7	3	1	2	25	1		2	20	61
Botteri's Sparrow	*Aimophila botterii*	2007		8									8
		2008								1			1
		2009		1									1
Rufous-crowned Sparrow	*Aimophila ruficeps*	2007		4	1							1	6
		2008		15	1		4					1	21
		2009		7	13				1			22	43
Aimophila sp.	*Aimophila sp.*	2008		4							1	3	8
		2009								2		1	3
Chipping Sparrow	*Spizella passerina*	2007		157	192		17				43		409
		2008		1,392	22		29		75	59	51		1,628
		2009		1,871	193	386	12	224	32	35	59	67	2,879
Clay-colored Sparrow	*Spizella pallida*	2007		237	127		259			7	55	1	686
		2008		212	26		178				34		450
		2009		148		1,300	230	156			125	3	1,962
Brewer's Sparrow	*Spizella breweri*	2007		40	184		34			1	130		389
		2008		1,135	237		636		16		98		2,122
		2009		692	320	49	1,319	54	3		322	31	2,790

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Worthen's Sparrow	*Spizella wortheni*	2008								7			7
		2009								5			5
Black-chinned Sparrow	*Spizella atrogularis*	2007		6									6
Spizella sp.	*Spizella sp.*	2007		1	440		2				8		451
		2008		56	135		293		27				511
		2009		33	51	84	35	13			9	2	227
Vesper Sparrow	*Pooecetes gramineus*	2007	1	28	780		107			7	776	31	1,730
		2008		925	252		217		246	15	297	148	2,100
		2009		1,607	441	947	916	253	142	8	836	965	6,115
Lark Sparrow	*Chondestes grammacus*	2007		66	1		1				8		76
		2008		17			9			6			32
		2009		326	1	5	1	1					334
Black-throated Sparrow	*Amphispiza bilineata*	2007		70	143		53			1	30		297
		2008	1	215	53		437		22	8	32	20	788
		2009	1	119	103	151	229	157	14	9	130	14	927
Sage Sparrow	*Amphispiza belli*	2008		10							2		12
		2009						27			3		30
Lark Bunting	*Calamospiza melanocorys*	2007			2,556		230				127		2,913
		2008	64	238	242		827		53		118	27	1,569
		2009		3	248	1,019	6,035	120		271	33	53	7,782
Savannah Sparrow	*Passerculus sandwichensis*	2007		30	516		91			25	366	4	1,032
		2008		135	46		4		27	45	33	102	392
		2009	1	417	425	48	117	213	137	22	162	1,042	2,584
Grasshopper Sparrow	*Ammodramus savannarum*	2007		44	86		45				19	2	196
		2008		58	5		7		3	2	16	1	92
		2009		80	21	202	98	49	13	8	71	117	659
Baird's Sparrow	*Ammodramus bairdii*	2007		3	1						4	1	9
		2008		38	3		4						45
		2009		49	6	12		1	5		30	4	107
Ammodramus sp.	*Ammodramus sp.*	2007		1	31						55	6	93
		2008		14	6				1	3	1	4	29
		2009		54	46	19	10	1	50	1	63	21	265
*Ammodramus sp.*or Savannah Sparrow	*Ammodramus sp.*or *P. sandwichensis*	2008		27	33		2			1	1	3	67
		2009		86	6	3	19		8	1	28	19	170
Song Sparrow	*Melospiza melodia*	2007					4						4
		2008					1		1				2
Lincoln's Sparrow	*Melospiza lincolnii*	2007		5	10						2		17
		2009		9	5		5				1	7	27

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Melospiza sp.	*Melospiza sp.*	2008			1								1
White-throated Sparrow	*Zonotrichia albicollis*	2008		10									10
		2009						2					4
White-crowned Sparrow	*Zonotrichia leucophrys*	2007			42		2				18		62
		2008	1	22	76		4		11		71	20	205
		2009		2	25	2		6	5		19	77	134
Dark-eyed Junco	*Junco hyemalis*	2007		1	24								25
		2008			5								5
		2009			2								2
Unidentified Sparrow	*Emberizidae*	2007		31	701					2	27		761
		2008		151	92				25		2		270
		2009		91	365	49	75		26		14	15	635
McCown's Longspur	*Calcarius mccownii*	2007			7						16		23
		2008			169		3						172
		2009			60			1	2				63
Chestnut-collared Longspur	*Calcarius ornatus*	2007			1,403		23				1,111	12	2,549
		2008		1,523	1,661		6		19	3	517		3,729
		2009		936	1,262	5,578	564	1,707	291		4,749	159	15,246
Unidentified Longspur	*Calcarius sp.*	2007			501		172						673
		2008							15				15
		2009						1	4			1	6
Northern Cardinal	*Cardinalis cardinalis*	2009		2									2
Pyrrhuloxia	*Cardinalis sinuatus*	2007		2	3		2						7
		2008	1	14	12		1						28
		2009		4	1	13	4	7			1		30
Eastern Meadowlark	*Sturnella magna*	2007		9	72						21		102
		2008		204	115		1		27	2	51	8	408
		2009	17	149	184	2	95	9	89	26	79	49	699
Western Meadowlark	*Sturnella neglecta*	2007	1	11	12		55				11	2	92
		2008		24	18		15			22			79
		2009		22	8	173	32	272	1	22	8	42	580
Unidentified Meadowlark	*Sturnella sp.*	2007			144					10	46		200
		2008	13	75	148		16		2	102	63	30	449
		2009		60	60	2	25		68	29	34	43	321
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	2009							2				2
Brewer's Blackbird	*Euphagus cyanocephalus*	2008	272						17				289
		2009	464		13						8	24	509
Great-tailed	*Quiscalus*	2007								1			1

Common Name	Scientific Name	Year	Cuatro Ciénegas	Cuchillas de la Zarca	Janos	Lagunas del Este	Mapimí	Marfa	Sonoita	El Tokio	Valles Centrales	Valle Colombia	Total
Grackle	*mexicanus*	2009			1		361		1				363
Unidentified Blackbird	*Icteridae*	2008			1								1
		2009			5								5
Brown-headed Cowbird	*Molothrus ater*	2007		62			20						82
		2008		19									19
		2009		42	1				39				82
Unidentified Cowbird	*Molothrus sp.*	2008		72									72
House Finch	*Carpodacus mexicanus*	2007			45					75			120
		2008	6		3		7		1	31			48
		2009		11	7				8	2	7	4	39
Pine Siskin	*Carduelis pinus*	2008							3				3
Lesser Goldfinch	*Carduelis psaltria*	2007		49									49
		2008		6									6
		2009		3	1								4
House Sparrow	*Passer domesticus*	2007			6								6
		2009			3				10				13
Unidentified Bird species		2007			4								4
		2008	4		28		77		6				115
		2009			26				5		1		32
All species		All years	1,870	28,626	21,519	11,282	15,815	3,732	2,476	5,745	15,599	3,623	110,287

APPENDIX B. DENSITY ESTIMATES FOR GRASSLAND-ASSOCIATED SPECIES BY YEAR AND GPCA.

Density estimates (D) for years 2007 -2009 expressed as number of individuals / km^2, with associated % coefficient of variation (%CV), lower and upper confidence limits at 95% (LCL and UCL), post-truncation sample size (n) used in estimating D, and proportion of transects on which we detected the species. GPCAs *we did not survey* in a particular year are indicated by "NS".

		2007				2008				2009			
Species	**GPCA**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**
	All	9.1	49	3.6	23.0	26.8	20	18.2	39.5	9.8	23	6.3	15.2
	LAGU	NS				NS				9.7	61	3.0	30.9
Scaled Quail	CUAT	0.0				0.0				0.0			
Callipepla squamata	CUZA	15.2	101	2.7	86.1	34.1	36	17.1	68.0	23.2	39	10.9	49.3
n = 96	JANO	12.7	75	3.3	48.3	14.1	55	5.1	39.0	7.9	68	2.2	28.2
Proportion of Transects	MAPI	6.9	121	0.9	52.4	10.3	59	3.5	30.8	10.5	55	3.6	30.3
2007 = 0.05	MARF	NS				NS				9.5	75	2.5	36.0
2008 = 0.09	SONO	NS				3.0	100	0.5	18.8	7.0	100	1.3	38.2
2009 = 0.05	TOKI	0.0				1.5	100	0.3	8.0	0.3	100	0.1	1.5
	VACE	7.8	92	1.4	45.1	63.9	23	40.6	100.7	8.7	46	3.6	20.9
	VACO	0.0				0.0				4.5	84	1.0	20.2
	All	0.1	57	0.0	0.2	0.1	30	0.1	0.2	0.0	39	0.0	0.1
	LAGU	NS				NS				0.1	63	0.0	0.4
White-tailed Kite	CUAT	0.0				0.0				0.0			
Elanus leucurus	CUZA	0.2	101	0.0	1.1	0.0				0.0			
n = 31	JANO	0.1	101	0.0	0.4	0.3	43	0.1	0.7	0.0			
Proportion of Transects	MAPI	0.0				0.2	41	0.1	0.5	0.1	50	0.1	0.3
2007 = 0.02	MARF	NS				NS				0.0			
2008 = 0.03	SONO	NS				0.0				0.0			
2009 = 0.01	TOKI	0.0				0.0				0.0			
	VACE	0.1	78	0.0	0.5	0.0	71	0.0	0.1	0.0	101	0.0	0.1
	VACO	0.0				0.0				0.0			
	All	1.4	14	1.0	1.8	1.4	12	1.1	1.8	1.2	10	1.0	1.5
	LAGU	NS				NS				1.3	24	0.8	2.0
Northern Harrier	CUAT	0.0				0.2	100	0.0	1.4	0.0			
Circus cyaneus	CUZA	0.5	56	0.2	1.4	0.5	28	0.3	0.9	0.7	28	0.4	1.3
n = 404	JANO	1.8	20	1.2	2.7	3.1	26	1.9	5.1	1.5	27	0.9	2.5
Proportion of Transects	MAPI	1.4	35	0.7	2.9	1.1	30	0.6	1.9	1.8	20	1.2	2.6
2007 = 0.30	MARF	NS				NS				1.2	26	0.7	2.0
2008 = 0.25	SONO	NS				4.1	26	2.4	7.1	1.4	27	0.8	2.4
2009 = 0.26	TOKI	0.0				0.4	44	0.2	0.8	0.5	42	0.2	1.1
	VACE	1.9	19	1.3	2.8	2.0	14	1.5	2.6	1.3	17	0.9	1.8
	VACO	0.0				0.1	100	0.0	0.6	2.0	28	1.1	3.5

Species	GPCA	2007 D	2007 %CV	2007 LCL	2007 UCL	2008 D	2008 %CV	2008 LCL	2008 UCL	2009 D	2009 %CV	2009 LCL	2009 UCL
Red-tailed Hawk *Buteo jamaicensis* n = 194 Proportion of Transects 2007 = 0.17 2008 = 0.19 2009 = 0.13	All	0.4	22	0.3	0.7	0.7	14	0.6	1.0	0.4	15	0.3	0.5
	LAGU	NS				NS				0.2	45	0.1	0.6
	CUAT	0.2	100	0.0	1.2	0.2	100	0.0	1.2	0.0			
	CUZA	0.7	51	0.3	1.9	1.1	22	0.7	1.6	0.5	30	0.3	0.9
	JANO	0.4	36	0.2	0.8	0.9	26	0.5	1.4	0.2	45	0.1	0.6
	MAPI	0.3	70	0.1	1.2	0.5	34	0.3	1.0	0.5	31	0.3	0.9
	MARF	NS				NS				0.3	48	0.1	0.8
	SONO	NS				0.9	53	0.3	2.8	0.8	38	0.4	1.7
	TOKI	0.0				0.4	47	0.2	0.9	0.4	47	0.1	0.9
	VACE	0.6	34	0.3	1.2	1.0	22	0.6	1.5	0.5	24	0.3	0.8
	VACO	0.0				0.2	70	0.1	0.7	0.2	70	0.1	0.7
Ferruginous Hawk *Buteo regalis* n = 59 Proportion of Transects 2007 = 0.01 2008 = 0.04 2009 = 0.05	All	0.0	58	0.0	0.1	0.1	23	0.0	0.1	0.1	21	0.1	0.1
	LAGU	NS				NS				0.0			
	CUAT	0.0				0.0				0.0			
	CUZA	0.0				0.0	71	0.0	0.1	0.1	48	0.0	0.3
	JANO	0.0	100	0.0	0.1	0.2	37	0.1	0.3	0.1	58	0.0	0.2
	MAPI	0.0				0.0				0.0			
	MARF	NS				NS				0.0	100	0.0	0.1
	SONO	NS				0.0				0.0			
	TOKI	0.2	100	0.0	1.3	0.3	27	0.2	0.6	0.6	24	0.4	1.0
	VACE	0.0	100	0.0	0.2	0.0				0.0	71	0.0	0.1
	VACO	0.0				0.0				0.0	100	0.0	0.3
American Kestrel *Falco sparverius* n = 311 Proportion of Transects 2007 = 0.18 2008 = 0.21 2009 = 0.22	All	0.9	18	0.6	1.3	1.0	11	0.8	1.3	1.3	10	1.0	1.5
	LAGU	NS				NS				0.6	30	0.4	1.1
	CUAT	0.0				0.5	69	0.1	2.0	0.3	100	0.0	1.6
	CUZA	1.5	42	0.7	3.4	1.7	20	1.1	2.5	2.3	16	1.7	3.1
	JANO	1.0	28	0.6	1.7	0.9	27	0.5	1.5	0.8	32	0.4	1.5
	MAPI	0.4	70	0.1	1.5	0.7	30	0.4	1.2	2.1	21	1.4	3.2
	MARF	NS				NS				0.8	26	0.5	1.3
	SONO	NS				1.2	75	0.3	5.4	0.8	45	0.3	1.9
	TOKI	1.1	67	0.3	4.3	1.2	25	0.7	2.0	1.2	29	0.7	2.1
	VACE	1.0	31	0.5	1.9	0.6	24	0.4	1.0	0.5	32	0.3	1.0
	VACO	0.0				1.3	28	0.8	2.3	3.6	25	2.2	5.9

		2007				2008				2009			
Species	**GPCA**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**
Long-billed Curlew *Numenius americanus* n= 35 Proportion of Transects 2007 = 0.03 2008 = 0.03 2009 = 0.02	All	0.4	60	0.1	1.2	0.5	51	0.2	1.3	0.6	63	0.2	1.8
	LAGU	NS				NS				0.0	100	0.0	0.2
	CUAT	0.0				0.0				1.0	101	0.2	6.1
	CUZA	0.0				0.6	92	0.1	4.1	0.0			
	JANO	0.1	63	0.0	0.5	1.9	76	0.5	7.8	4.4	79	1.1	18.1
	MAPI	2.7	104	0.5	16.0	0.1	83	0.0	0.3	0.0	101	0.0	0.2
	MARF	NS				NS				0.1	101	0.0	0.7
	SONO	NS				0.0				0.0			
	TOKI	0.6	101	0.1	4.1	0.2	101	0.0	1.2	0.0			
	VACE	0.0	101	0.0	0.2	0.0				0.0			
	VACO	0.0				0.0				0.0			
Mourning Dove *Zenaida macroura* n = 815 Proportion of Transects 2007 = 0.44 2008 = 0.20 2009 = 0.26	All	84.8	20	57.2	126.0	31.2	18	22.1	44.2	40.4	20	27.5	59.3
	LAGU	NS				NS				117.2	47	48.8	281.2
	CUAT	4.1	71	1.1	15.7	0.0				0.0			
	CUZA	37.1	31	20.3	67.9	61.0	20	41.5	89.6	67.8	21	45.4	101.3
	JANO	134.3	28	77.6	232.5	65.5	39	31.1	137.7	34.7	39	16.4	73.8
	MAPI	11.9	51	4.4	32.2	6.2	54	2.2	17.5	40.5	31	22.4	73.4
	MARF	NS				NS				10.3	54	3.8	28.0
	SONO	NS				1.2	100	0.2	7.7	22.4	77	5.5	92.1
	TOKI	11.4	100	1.7	77.4	6.9	80	1.7	28.4	1.7	101	0.3	8.9
	VACE	59.1	30	33.0	106.1	5.6	52	2.0	15.2	32.5	78	7.9	133.8
	VACO	2.9	100	0.3	29.6	4.1	49	1.6	10.4	13.1	40	6.0	28.5
Burrowing Owl *Athene cunicularia* n = 36 Proportion of Transects 2007 = 0.08 2008 = 0.03 2009 = 0.03	All	1.7	35	0.9	3.3	0.7	44	0.3	1.7	0.5	33	0.3	1.0
	LAGU	NS				NS				0.4	101	0.1	2.1
	CUAT	0.0				0.0				0.0			
	CUZA	0.0				0.0				0.0			
	JANO	2.9	48	1.2	7.1	2.7	73	0.7	10.7	2.3	47	0.9	5.7
	MAPI	1.3	101	0.2	7.2	0.4	101	0.1	2.2	1.2	58	0.4	3.5
	MARF	NS				NS				0.8	71	0.2	2.8
	SONO	NS				0.0				0.0			
	TOKI	10.0	51	3.3	29.9	0.0				0.0			
	VACE	0.5	101	0.1	2.8	0.7	53	0.3	1.8	0.0			
	VACO	0.0				0.0				0.0			

		2007				2008				2009			
Species	**GPCA**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**
	All	1.0	54	0.4	2.7	0.8	38	0.4	1.7	0.5	37	0.3	1.1
	LAGU	NS				NS				0.0			
Short-eared Owl	CUAT	0.0				0.0				0.0			
Asio flammeus	CUZA	0.0				0.0				0.0			
n = 28	JANO	1.3	60	0.4	4.0	1.7	63	0.5	5.5	0.9	73	0.2	3.2
Proportion of Transects	MAPI	0.0				0.9	102	0.2	5.1	2.2	56	0.8	6.3
2007 = 0.04	MARF	NS				NS				0.0			
2008 = 0.02	SONO	NS				0.0				0.0			
2009 = 0.02	TOKI	0.0				0.0				0.0			
	VACE	2.3	81	0.6	9.6	1.3	48	0.5	3.2	1.1	53	0.4	2.8
	VACO	0.0				0.9	102	0.2	5.1	0.0			
	All	1.9	19	1.3	2.7	2.1	12	1.6	2.6	3.4	11	2.8	4.2
	LAGU	NS				NS				6.3	20	4.3	9.3
Say's Phoebe	CUAT	0.9	69	0.2	3.4	0.0				0.5	100	0.1	2.7
Sayornis saya	CUZA	0.6	70	0.2	2.3	5.0	16	3.7	6.7	5.6	15	4.1	7.5
n = 436	JANO	0.7	57	0.2	2.0	0.6	40	0.3	1.4	0.3	57	0.1	0.9
Proportion of Transects	MAPI	5.7	30	3.1	10.3	2.5	24	1.6	4.1	11.8	12	9.2	15.1
2007 = 0.19	MARF	NS				NS				0.6	41	0.3	1.4
2008 = 0.23	SONO	NS				2.1	53	0.7	6.1	2.3	32	1.2	4.3
2009 = 0.27	TOKI	2.7	71	0.6	12.0	2.1	25	1.3	3.4	2.0	29	1.1	3.6
	VACE	2.4	27	1.4	4.2	1.1	28	0.6	1.9	0.6	40	0.3	1.3
	VACO	3.3	62	0.7	15.8	0.7	56	0.2	2.0	0.9	60	0.3	2.8
	All	1.9	14	1.5	2.5	3.1	8	2.6	3.7	3.0	8	2.6	3.5
Loggerhead Shrike	LAGU	NS				NS				2.8	18	2.0	4.1
Lanius ludovicianus	CUAT	1.1	54	0.4	3.3	1.1	54	0.4	3.2	2.2	42	1.0	5.3
	CUZA	2.1	40	0.9	4.6	5.2	13	4.0	6.8	4.7	14	3.6	6.2
n = 557	JANO	2.2	21	1.5	3.4	3.6	18	2.5	5.1	3.2	20	2.1	4.8
Proportion of Transects	MAPI	2.6	37	1.3	5.4	5.7	14	4.3	7.5	4.1	15	3.1	5.5
	MARF	NS				NS				1.1	35	0.6	2.2
2007 = 0.26	SONO	NS				1.1	68	0.3	4.3	1.9	34	1.0	3.7
2008 = 0.34	TOKI	2.2	50	0.8	6.6	1.3	29	0.8	2.4	1.5	28	0.9	2.7
2009 = 0.36	VACE	1.5	27	0.9	2.6	1.2	21	0.8	1.8	2.5	17	1.7	3.5
	VACO	0.0				2.2	29	1.2	4.0	6.4	31	3.5	11.6

		2007				2008				2009			
Species	GPCA	D	%CV	LCL	UCL	D	%CV	LCL	UCL	D	%CV	LCL	UCL
Chihuahuan Raven *Corvus cryptoleucus* n = 213 Proportion of Transect 2007 = 0.21 2008 = 0.13 2009 = 0.15	All	1.1	20	0.7	1.6	0.8	16	0.6	1.2	1.4	17	1.0	1.9
	LAGU	NS				NS				1.4	50	0.5	3.6
	CUAT	1.3	62	0.4	4.2	1.5	59	0.5	4.8	8.2	28	4.6	14.4
	CUZA	1.2	58	0.4	3.7	1.9	23	1.2	3.0	1.7	27	1.0	2.9
	JANO	1.6	29	0.9	2.8	0.8	34	0.4	1.6	3.1	52	1.1	8.3
	MAPI	0.0				0.4	55	0.1	1.1	0.6	53	0.2	1.6
	MARF	NS				NS				0.3	61	0.1	0.9
	SONO	NS				0.8	68	0.2	3.0	0.0			
	TOKI	2.5	54	0.8	7.9	0.8	51	0.3	2.0	0.9	41	0.4	1.9
	VACE	0.6	42	0.3	1.4	0.2	54	0.1	0.5	1.2	24	0.8	2.0
	VACO	0.9	100	0.1	9.3	0.8	84	0.2	3.3	0.5	62	0.2	1.6
Horned Lark *Eremophila alpestris* n = 1680 Proportion of Transects 2007 = 0.23 2008 = 0.37 2009 = 0.35	All	17.0	23	10.9	26.7	60.9	11	48.8	76.0	40.5	12	32.2	51.0
	LAGU	NS				NS				18.6	82	4.5	77.6
	CUAT	3.3	82	0.7	15.0	36.2	69	10.0	131.4	39.4	30	21.1	73.5
	CUZA	0.0				11.6	61	3.4	39.1	0.5	78	0.1	2.2
	JANO	23.5	31	13.0	42.5	115.7	18	81.8	163.6	46.5	23	29.6	72.9
	MAPI	0.0				10.9	70	3.1	38.6	3.8	45	1.6	8.8
	MARF	NS				NS				10.2	33	5.4	19.5
	SONO	NS				25.1	33	12.8	48.9	31.0	23	19.8	48.7
	TOKI	123.4	38	54.3	280.7	123.3	17	88.8	171.2	258.6	15	191.4	349.4
	VACE	11.3	35	5.7	22.2	82.4	16	60.8	111.6	23.8	15	17.8	31.9
	VACO	0.0				9.7	138	0.6	159.1	5.7	73	1.5	21.6
Mountain Bluebird *Sialia currucoides* n = 76 Proportion of Transects 2007 = 0.04 2008 = 0.00 2009 = 0.03	All	4.2	37	2.1	8.6	0.0				1.0	33	0.5	1.9
	LAGU	NS				NS				0.1	101	0.0	0.5
	CUAT	6.9	98	1.1	41.8	0.0				0.0			
	CUZA	5.2	93	0.7	41.1	0.0				2.8	51	1.1	7.3
	JANO	1.5	67	0.4	5.2	0.0				0.3	106	0.0	1.4
	MAPI	15.9	65	4.7	54.1	0.0				0.9	57	0.3	2.5
	MARF	NS				NS				1.3	128	0.1	10.7
	SONO	NS				0.0				0.0			
	TOKI	0.7	100	0.1	4.9	0.0				3.3	54	1.2	9.0
	VACE	0.9	82	0.2	3.8	0.0				0.0			
	VACO	18.4	121	1.8	187.3	0.0				1.1	100	0.2	5.9

Species	GPCA	2007 D	2007 %CV	2007 LCL	2007 UCL	2008 D	2008 %CV	2008 LCL	2008 UCL	2009 D	2009 %CV	2009 LCL	2009 UCL
Sprague's Pipit *Anthus spragueii* n = 172 Proportion of Transects 2007 = 0.11 2008 = 0.12 2009 = 0.11	All	2.8	25	1.8	4.6	3.6	16	2.7	5.0	4.0	15	3.0	5.4
	LAGU	NS				NS				0.7	100	0.1	3.8
	CUAT	3.0	69	0.8	11.3	0.0				0.0			
	CUZA	0.0				6.5	29	3.7	11.4	10.1	26	6.0	16.8
	JANO	3.8	39	1.8	7.9	2.8	46	1.2	6.8	3.5	30	2.0	6.3
	MAPI	0.0				0.0				1.4	49	0.6	3.6
	MARF	NS				NS				0.4	100	0.1	1.8
	SONO	NS				0.0				9.1	39	4.3	19.4
	TOKI	9.1	71	2.1	39.4	4.1	40	1.9	8.8	8.0	27	4.7	13.6
	VACE	3.3	36	1.6	6.7	5.6	22	3.6	8.7	0.6	57	0.2	1.9
	VACO	0.0				1.5	70	0.4	5.4	11.4	38	5.4	23.9
Cassin's Sparrow *Aimophila cassinii* n = 53 Proportion of Transects 2007 = 0.06 2008 = 0.01 2009 = 0.05	All	3.9	37	1.9	7.8	1.1	44	0.5	2.6	3.4	27	2.0	5.8
	LAGU	NS				NS				0.0			
	CUAT	0.0				0.0				0.0			
	CUZA	9.7	86	1.7	54.9	1.3	71	0.4	4.6	2.9	42	1.3	6.4
	JANO	6.1	43	2.7	13.7	4.1	66	1.2	13.5	1.6	71	0.5	5.8
	MAPI	0.0				0.0				0.8	100	0.2	4.4
	MARF	NS				NS				7.3	45	3.1	17.1
	SONO	NS				0.0				1.8	100	0.3	9.6
	TOKI	0.0				1.1	100	0.2	5.6	0.0			
	VACE	2.2	71	0.6	7.8	0.5	100	0.1	2.6	0.5	100	0.1	2.6
	VACO	0.0				0.0				28.1	46	11.7	67.7
Chipping Sparrow *Spizella passerina* n = 439 Proportion of Transects 2007 = 0.14 2008 = 0.15 2009 = 0.18	All	32.7	33	17.4	61.5	58.9	19	40.7	85.3	77.9	15	58.0	104.8
	LAGU	NS				NS				39.5	63	12.3	126.5
	CUAT	0.0				0.0				0.0			
	CUZA	136.4	49	53.2	349.5	220.1	20	148.6	326.2	432.7	15	321.9	581.6
	JANO	39.8	47	16.1	98.8	2.4	61	0.7	7.6	22.0	47	9.0	54.0
	MAPI	13.8	74	3.6	53.5	9.1	116	1.4	60.7	0.9	57	0.3	2.7
	MARF	NS				NS				35.0	67	10.3	119.1
	SONO	NS				144.6	50	53.5	391.0	20.6	79	4.1	103.6
	TOKI	0.0				21.6	113	2.9	160.4	10.8	88	2.3	52.1
	VACE	2.8	82	0.6	13.4	9.3	76	2.0	42.2	8.6	61	2.8	26.1
	VACO	0.0				0.0				25.7	56	8.9	74.4

		2007				2008				2009			
Species	**GPCA**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**
Clay-colored Sparrow *Spizella pallida* n = 501 Proportion of Transects 2007 = 0.25 2008 = 0.08 2009 = 0.17	All	34.6	24	21.7	55.3	14.3	25	8.8	23.0	47.4	17	34.1	65.8
	LAGU	NS				NS				273.4	22	178.7	418.1
	CUAT	0.0				0.0				0.0			
	CUZA	70.8	39	33.4	150.2	39.8	38	19.1	82.8	20.0	66	5.7	70.5
	JANO	32.3	38	15.7	66.6	6.2	56	2.2	17.3	0.0			
	MAPI	152.2	54	55.0	420.8	31.1	39	14.8	65.3	56.1	29	32.2	97.5
	MARF	NS				NS				28.4	35	14.5	55.5
	SONO	NS				0.0				0.0			
	TOKI	12.2	105	1.7	86.5	0.0				0.0			
	VACE	16.9	50	6.5	44.2	4.9	38	2.4	10.4	14.4	40	6.7	30.9
	VACO	0.0				0.0				1.5	77	0.4	6.5
Brewer's Sparrow *Spizella breweri* n = 968 Proportion of Transects 2007 = 0.22 2008 = 0.29 2009 = 0.26	All	22.8	26	13.7	37.9	81.3	14	62.1	106.5	81.4	12	64.9	102.0
	LAGU	NS				NS				6.1	54	2.3	16.5
	CUAT	0.0				0.0				0.0			
	CUZA	11.7	69	3.2	43.2	199.3	17	142.3	279.2	141.4	19	96.6	207.0
	JANO	34.1	34	17.4	66.6	51.0	31	27.8	93.5	64.7	32	34.8	120.3
	MAPI	9.1	76	2.3	36.7	162.5	32	88.1	299.9	353.5	13	274.4	455.4
	MARF	NS				NS				10.1	54	3.6	28.2
	SONO	NS				17.8	26	10.3	30.7	1.8	77	0.4	7.5
	TOKI	2.4	100	0.3	16.1	0.0				0.0			
	VACE	33.9	44	14.6	78.9	16.5	29	9.4	29.0	37.1	33	19.7	69.9
	VACO	0.0				0.0				11.7	72	3.0	46.2
Spizella spp. n =2085 Proportion of Transects 2007 = 0.46 2008 = 0.38 2009 = 0.44	All	132.4	15	97.9	179.1	173.4	12	137.2	219.2	208.5	9	176.0	247.0
	LAGU	NS				NS				296.3	21	195.8	448.4
	CUAT	0.0				0.0				0.0			
	CUZA	222.1	31	120.8	408.4	472.7	13	367.7	607.7	513.7	13	400.4	658.9
	JANO	210.3	20	142.7	310.0	87.3	28	50.7	150.1	112.4	25	68.8	183.7
	MAPI	190.1	46	79.4	455.4	262.1	29	149.5	459.4	418.2	12	331.5	527.6
	MARF	NS				NS				80.2	30	44.9	143.2
	SONO	NS				189.8	37	91.6	393.5	15.9	91	2.1	120.3
	TOKI	15.7	107	2.2	111.0	19.0	113	2.6	140.9	9.5	87	2.0	45.7
	VACE	65.6	36	32.6	131.9	29.3	28	17.1	50.2	62.1	26	37.5	102.8
	VACO	0.0				0.0				32.3	39	15.1	68.9

Species	GPCA	2007 D	2007 %CV	2007 LCL	2007 UCL	2008 D	2008 %CV	2008 LCL	2008 UCL	2009 D	2009 %CV	2009 LCL	2009 UCL
	All	169.3	9	141.6	202.4	86.5	8	74.1	101.0	181.0	6	160.7	203.9
	LAGU	NS				NS				229.3	15	170.3	308.9
Vesper Sparrow	CUAT	1.3	100	0.2	7.7	0.0				0.0			
Pooecetes gramineus	CUZA	13.1	34	6.7	25.6	195.3	10	160.4	237.9	307.6	9	256.7	368.7
n = 3808	JANO	252.1	14	191.1	332.6	74.1	21	49.1	111.7	116.2	17	83.1	162.3
Proportion of Transects	MAPI	58.1	27	33.7	100.4	51.8	33	27.1	99.0	251.8	11	201.7	314.3
2007 = 0.70	MARF	NS				NS				64.1	24	39.8	103.2
2008 = 0.56	SONO	NS				480.5	27	276.0	836.7	94.8	19	65.3	137.6
2009 = 0.61	TOKI	15.9	100	2.3	108.6	5.2	45	2.2	12.3	3.1	57	1.1	9.0
	VACE	274.2	10	222.7	337.5	49.1	9	41.4	58.1	129.7	16	95.6	175.8
	VACO	149.6	74	28.9	775.7	94.3	36	47.2	188.3	476.8	16	348.2	652.8
	All	6.6	52	2.5	17.4	1.3	67	0.4	4.2	8.0	37	4.0	16.1
	LAGU	NS				NS				1.6	78	0.4	6.2
Lark Sparrow	CUAT	0.0				0.0				0.0			
Chondestes grammacus	CUZA	45.4	62	14.1	145.9	4.2	77	1.0	17.3	63.3	37	31.4	127.6
n = 61	JANO	0.3	101	0.1	1.8	0.0				0.3	101	0.1	1.6
Proportion of Transects	MAPI	0.0				3.0	103	0.6	16.5	0.3	101	0.1	1.7
2007 = 0.04	MARF	NS				NS				0.3	101	0.1	1.6
2008 = 0.01	SONO	NS				0.0				0.0			
2009 = 0.03	TOKI	0.0				0.0				0.0			
	VACE	3.3	87	0.7	15.9	0.0				0.0			
	VACO	0.0				0.0				0.0			
	All	75.7	42	34.2	167.5	22.9	29	13.1	39.8	72.3	18	51.0	102.4
	LAGU	NS				NS				121.4	35	61.4	239.8
Lark Bunting	CUAT	0.0				36.9	100	6.4	213.6	0.0			
Calamospiza melanocorys	CUZA	0.0				25.9	46	10.8	62.0	0.3	78	0.1	1.3
n = 413	JANO	241.9	53	90.0	650.1	17.6	67	4.9	63.0	8.5	80	1.9	38.2
Proportion of Transects	MAPI	32.0	61	10.1	100.8	70.8	55	25.4	197.5	480.2	18	336.5	685.2
2007 = 0.15	MARF	NS				NS				16.0	69	4.6	55.9
2008 = 0.09	SONO	NS				8.6	82	1.5	47.7	0.0			
2009 = 0.15	TOKI	0.0				0.0				0.0			
	VACE	6.2	59	2.0	18.8	9.7	45	4.1	22.9	2.7	137	0.2	41.8
	VACO	0.0				10.1	79	2.5	41.3	15.3	107	0.9	249.1

		2007				2008				2009			
Species	**GPCA**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**
Savannah Sparrow *Passerculus sandwichensis* n = 1401 Proportion of Transects 2007 = 0.46 2008 = 0.17 2009 = 0.30	All	101.2	17	72.7	140.9	14.6	16	10.7	19.8	67.0	12	53.2	84.4
	LAGU	NS				NS				10.5	51	4.1	27.1
	CUAT	0.0				0.0				1.3	100	0.2	7.6
	CUZA	21.5	25	12.9	35.8	25.7	20	17.5	37.6	82.3	22	53.6	126.2
	JANO	157.0	25	95.6	257.8	13.0	48	5.3	32.2	94.9	23	60.0	150.0
	MAPI	43.2	54	15.4	121.3	1.3	62	0.4	4.2	30.5	24	18.9	49.1
	MARF	NS				NS				44.3	31	24.1	81.7
	SONO	NS				53.0	97	9.5	296.9	87.1	35	43.7	173.4
	TOKI	65.1	100	8.7	484.4	15.3	66	4.6	50.5	8.4	45	3.5	19.8
	VACE	109.1	23	69.9	170.3	6.1	41	2.8	13.6	23.9	27	14.0	40.6
	VACO	14.2	41	4.8	41.9	52.1	42	23.2	116.7	450.0	19	307.6	658.1
Grasshopper Sparrow *Ammodramus savannarum* n = 600 Proportion of Transects 2007 = 0.32 2008 = 0.09 2009 = 0.34	All	72.0	17	51.3	100.9	13.4	24	8.4	21.4	76.4	11	62.2	93.9
	LAGU	NS				NS				207.6	21	137.3	313.8
	CUAT	0.0				0.0				0.0			
	CUZA	98.8	41	44.0	221.6	43.3	32	23.1	81.1	89.4	19	61.2	130.6
	JANO	105.1	25	64.3	171.6	4.3	57	1.5	12.5	18.7	31	10.4	33.9
	MAPI	167.6	26	98.8	284.5	9.4	73	2.6	34.7	106.6	18	75.4	150.7
	MARF	NS				NS				57.5	34	29.9	110.5
	SONO	NS				28.1	72	6.8	116.2	37.4	30	20.7	67.7
	TOKI	0.0				3.7	70	1.1	13.3	10.9	62	3.5	33.8
	VACE	15.5	34	8.1	29.9	6.2	37	3.0	12.7	45.8	22	29.6	70.9
	VACO	45.1	61	9.5	214.1	3.1	100	0.6	16.8	209.0	22	134.7	324.3
Baird's Sparrow *Ammodramus bairdii* n = 119 Proportion of Transects 2007 = 0.03 2008 = 0.05 2009 = 0.10	All	5.1	52	1.9	13.3	10.1	31	5.6	18.3	18.7	17	13.5	25.8
	LAGU	NS				NS				22.2	43	9.8	50.1
	CUAT	0.0				0.0				0.0			
	CUZA	17.7	101	3.1	99.6	50.0	30	27.8	90.1	73.8	21	48.7	112.0
	JANO	2.1	101	0.4	11.2	0.0				5.9	57	2.0	17.2
	MAPI	0.0				2.1	100	0.4	11.3	0.0			
	MARF	NS				NS				2.0	100	0.4	10.4
	SONO	NS				0.0				4.3	100	0.8	23.2
	TOKI	0.0				0.0				0.0			
	VACE	8.0	57	2.8	23.1	0.0				21.9	26	13.3	36.2
	VACO	0.0				0.0				8.6	70	2.4	30.8

		2007				2008				2009			
Species	**GPCA**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**
Ammodramus spp. n = 1121 Proportion of Transects 2007 = 0.43 2008 = 0.15 2009 = 0.48	All	108.7	13	83.9	140.7	24.1	17	17.2	33.6	115.0	9	97.2	136.1
	LAGU	NS				NS				231.7	19	160.9	333.7
	CUAT	0.0				0.0				0.0			
	CUZA	110.8	42	48.5	253.2	83.2	21	54.6	126.5	176.5	14	135.3	230.3
	JANO	140.4	21	93.5	210.8	14.6	32	7.8	27.1	77.7	15	58.2	103.6
	MAPI	153.2	25	91.9	255.2	9.2	62	3.0	28.8	115.9	17	82.6	162.7
	MARF	NS				NS				60.5	31	33.2	110.3
	SONO	NS				31.5	57	9.9	100.4	128.6	35	65.4	252.6
	TOKI	0.0				7.9	52	3.0	21.0	10.7	54	3.9	29.2
	VACE	104.6	20	70.8	154.5	6.7	33	3.6	12.6	100.3	16	73.2	137.4
	VACO	170.7	62	35.5	821.8	13.0	51	4.9	34.8	252.0	22	162.5	390.9
Ammodramus spp. & Savannah Sparrow (*Passerculus sandwichensis)* n = 2051 Proportion of Transects 2007 = 0.64 2008 = 0.25 2009 = 0.59	All	181.2	12	142.0	231.3	41.1	12	32.3	52.3	151.1	8	129.7	176.0
	LAGU	NS				NS				139.4	17	99.2	195.9
	CUAT	0.0				0.0				3.1	100	0.5	18.2
	CUZA	104.1	31	55.9	193.8	98.6	17	71.1	136.8	234.8	13	180.4	305.7
	JANO	376.6	22	245.1	578.8	58.9	33	31.2	111.4	199.4	26	119.6	332.4
	MAPI	108.2	23	67.6	173.2	11.9	39	5.6	25.2	119.1	16	87.0	163.0
	MARF	NS				NS				102.3	25	62.5	167.3
	SONO	NS				103.8	80	22.7	475.1	182.5	31	100.4	331.8
	TOKI	150.2	120	15.5	1457.8	28.3	65	8.7	92.3	11.9	49	4.7	30.0
	VACE	162.7	23	104.3	253.7	21.4	30	11.9	38.4	75.9	16	55.6	103.7
	VACO	68.2	49	19.1	243.5	63.2	37	30.9	129.2	683.1	16	500.1	933.1
Chestnut-collared Longspur *Calcarius ornatus* n = 954 Proportion of Transects 2007 = 0.27 2008 = 0.14 2009 = 0.23	All	112.7	22	73.0	173.8	87.2	24	54.3	140.0	175.2	17	126.9	241.9
	LAGU	NS				NS				259.9	33	138.3	488.2
	CUAT	0.0				0.0				0.0			
	CUZA	0.0				186.1	46	77.7	445.6	62.0	93	11.7	328.4
	JANO	219.3	25	133.9	359.1	241.3	34	125.9	462.5	103.7	34	53.5	201.3
	MAPI	11.9	106	2.0	70.9	0.7	61	0.2	2.1	12.5	55	4.5	34.9
	MARF	NS				NS				153.5	37	74.8	315.0
	SONO	NS				19.2	79	4.3	85.8	97.9	44	41.3	231.6
	TOKI	0.0				0.6	100	0.1	3.2	0.0			
	VACE	126.8	37	62.3	258.1	38.6	30	21.6	68.9	411.6	21	275.8	614.3
	VACO	29.2	105	3.0	279.6	0.0				10.8	91	2.2	53.3

		2007				2008				2009			
Species	**GPCA**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**	**D**	**%CV**	**LCL**	**UCL**
Eastern Meadowlark *Sturnella magna* n = 531 Proportion of Transects 2007 = 0.17 2008 = 0.21 2009 = 0.30	All	5.3	31	2.9	9.6	10.8	25	6.6	17.6	10.5	11	8.4	13.1
	LAGU	NS				NS				0.4	100	0.1	2.0
	CUAT	0.0				0.0				10.3	45	4.2	25.3
	CUZA	3.8	54	1.3	10.9	29.1	36	14.6	58.1	18.1	18	12.7	26.0
	JANO	10.4	40	4.9	22.3	17.8	62	5.7	55.6	16.0	25	9.9	26.0
	MAPI	0.0				0.2	100	0.0	1.1	17.9	43	7.9	40.6
	MARF	NS				NS				1.5	39	0.7	3.1
	SONO	NS				23.8	63	6.6	85.8	32.1	23	20.6	50.0
	TOKI	0.0				0.0				3.2	46	1.4	7.7
	VACE	4.7	55	1.7	13.1	5.7	26	3.4	9.6	7.9	20	5.3	11.8
	VACO	0.0				3.2	47	1.3	7.8	13.9	34	7.1	27.0
Western Meadowlark *Sturnella neglecta* n = 356 Proportion of Transects 2007 = 0.13 2008 = 0.04 2009 = 0.20	All	3.1	32	1.7	5.8	1.2	33	0.6	2.3	5.9	18	4.2	8.3
	LAGU	NS				NS				15.2	37	7.6	30.7
	CUAT	0.4	100	0.1	2.5	0.0				0.0			
	CUZA	1.2	60	0.4	3.8	1.9	51	0.7	5.0	1.8	36	0.9	3.5
	JANO	1.3	54	0.5	3.6	1.7	50	0.7	4.4	0.6	47	0.2	1.5
	MAPI	18.3	53	6.6	50.7	1.6	89	0.3	8.9	3.3	68	0.9	12.1
	MARF	NS				NS				24.2	19	16.7	35.0
	SONO	NS				0.0				0.2	100	0.0	1.2
	TOKI	0.0				2.9	72	0.8	10.6	2.3	47	0.9	5.6
	VACE	1.5	41	0.7	3.3	0.0				0.5	50	0.2	1.3
	VACO	3.1	100	0.3	31.3	0.0				8.9	36	4.5	17.7
Meadowlark spp. *Sturnella spp.* n = 1176 Proportion of Transects 2007 = 0.37 2008 = 0.37 2009 = 0.50	All	17.9	22	11.8	27.3	17.4	15	12.9	23.4	18.8	7	16.3	21.6
	LAGU	NS				NS				13.1	24	8.3	20.8
	CUAT	0.6	100	0.1	3.5	7.9	71	2.1	29.7	8.5	44	3.5	20.5
	CUZA	4.6	38	2.1	9.9	33.3	27	19.9	55.8	25.4	16	18.6	34.7
	JANO	30.2	33	15.9	57.4	23.5	38	11.4	48.5	29.6	20	19.9	44.0
	MAPI	23.4	59	7.6	71.9	3.7	52	1.3	10.1	22.0	32	11.9	40.8
	MARF	NS				NS				29.5	17	21.1	41.1
	SONO	NS				18.3	63	5.1	65.7	46.3	32	24.7	86.8
	TOKI	9.7	107	1.4	67.9	21.9	47	9.0	53.4	11.0	54	4.0	30.1
	VACE	14.2	27	8.5	23.9	9.8	23	6.2	15.4	9.8	17	7.0	13.5
	VACO	4.4	100	0.4	44.3	11.5	21	7.6	17.4	36.9	31	20.4	66.8

APPENDIX C. ANNUAL CHANGES IN GLOBAL DENSITY AS MEASURED BY EFFECT SIZE.

Effect size reflects change in mean density (individuals/km^2) between years as determined using the delta method (Powell 2009). Abbreviations SE, LCL and UCL denote standard error, and lower and upper confidence limits at the 95% level, respectively. Determination of statistical significance is at the 95% level.

Species	Year	Effect size	SE	LCL	UCL	Significant?
Scaled Quail *Callipepla squamata*	2007-2008	17.71	6.98	4.03	31.40	Yes
	2008-2009	-17.03	5.79	-28.37	-5.69	Yes
	2007-2009	0.68	5.00	-9.12	10.49	No
White-tailed Kite *Elanus leucurus*	2007-2008	0.01	0.05	-0.10	0.11	No
	2008-2009	-0.06	0.03	-0.12	0.00	No
	2007-2009	-0.05	0.05	-0.14	0.05	No
Northern Harrier *Circus cyaneus*	2007-2008	0.05	0.26	-0.45	0.56	No
	2008-2009	-0.18	0.21	-0.60	0.23	No
	2007-2009	-0.13	0.23	-0.57	0.31	No
Red-tailed Hawk *Buteo jamaicensis*	2007-2008	0.30	0.15	0.02	0.59	Yes
	2008-2009	-0.35	0.12	-0.59	-0.11	Yes
	2007-2009	-0.05	0.12	-0.27	0.18	No
Ferruginous Hawk *Buteo regalis*	2007-2008	0.05	0.02	0.01	0.09	Yes
	2008-2009	0.02	0.03	-0.03	0.07	No
	2007-2009	0.07	0.02	0.02	0.11	Yes
American Kestrel *Falco sparverius*	2007-2008	0.11	0.20	-0.27	0.50	No
	2008-2009	0.26	0.17	-0.09	0.60	No
	2007-2009	0.37	0.21	-0.04	0.78	No
Long-billed Curlew *Numenius americanus*	2007-2008	0.12	0.35	-0.57	0.80	No
	2008-2009	0.04	0.43	-0.80	0.89	No
	2007-2009	0.16	0.42	-0.66	0.98	No
Mourning Dove *Zenaida macroura*	2007-2008	-53.63	18.10	-89.11	-18.15	Yes
	2008-2009	9.18	9.74	-9.90	28.26	No
	2007-2009	-44.45	18.99	-81.67	-7.24	Yes
Burrowing Owl *Athene cunicularia*	2007-2008	-0.98	0.67	-2.29	0.33	No
	2008-2009	-0.19	0.36	-0.90	0.52	No
	2007-2009	-1.17	0.61	-2.38	0.03	No
Short-eared Owl *Asio flammeus*	2007-2008	-0.17	0.61	-1.37	1.04	No
	2008-2009	-0.27	0.37	-0.99	0.46	No
	2007-2009	-0.43	0.57	-1.55	0.68	No
Say's Phoebe *Sayornis saya*	2007-2008	0.19	0.43	-0.66	1.04	No
	2008-2009	1.35	0.44	0.48	2.21	Yes
	2007-2009	1.54	0.50	0.55	2.52	Yes
Loggerhead Shrike *Lanius ludovicianus*	2007-2008	1.21	0.37	0.49	1.94	Yes
	2008-2009	-0.08	0.36	-0.77	0.62	No
	2007-2009	1.14	0.35	0.45	1.83	Yes
Chihuahuan Raven	2007-2008	-0.26	0.26	-0.78	0.25	No

Species	Year	Effect size	SE	LCL	UCL	Significant?
Corvus cryptoleucus	2008-2009	0.55	0.27	0.03	1.08	Yes
	2007-2009	0.29	0.32	-0.34	0.92	No
Horned Lark *Eremophila alpestris*	2007-2008	43.86	7.95	28.27	59.45	Yes
	2008-2009	-20.37	8.41	-36.85	-3.89	Yes
	2007-2009	23.49	6.20	11.34	35.64	Yes
Mountain Bluebird *Sialia currucoides*	2007-2008	-4.22	1.57	-7.30	-1.14	Yes
	2008-2009	1.03	0.34	0.37	1.70	Yes
	2007-2009	-3.19	1.61	-6.34	-0.03	Yes
Sprague's Pipit *Anthus spragueii*	2007-2008	0.80	0.91	-0.98	2.57	No
	2008-2009	0.40	0.83	-1.22	2.02	No
	2007-2009	1.20	0.91	-0.59	2.99	No
Cassin's Sparrow *Aimophila cassinii*	2007-2008	-2.74	1.51	-5.70	0.22	No
	2008-2009	2.28	1.05	0.22	4.35	Yes
	2007-2009	-0.46	1.70	-3.79	2.88	No
Chipping Sparrow *Spizella passerina*	2007-2008	26.18	15.50	-4.21	56.57	No
	2008-2009	19.03	16.27	-12.86	50.92	No
	2007-2009	45.21	15.96	13.92	76.50	Yes
Clay-colored Sparrow *Spizella pallida*	2007-2008	-20.39	9.05	-38.14	-2.65	Yes
	2008-2009	33.12	8.74	16.00	50.25	Yes
	2007-2009	12.73	11.55	-9.90	35.36	No
Brewer's Sparrow *Spizella breweri*	2007-2008	58.47	12.72	33.53	83.40	Yes
	2008-2009	0.11	14.65	-28.60	28.83	No
	2007-2009	58.58	11.14	36.75	80.41	Yes
Spizella spp.	2007-2008	40.97	29.17	-16.20	98.14	No
	2008-2009	35.08	27.53	-18.89	89.05	No
	2007-2009	76.05	27.29	22.57	129.53	Yes
Vesper Sparrow *Pooecetes gramineus*	2007-2008	-82.84	16.84	-115.84	-49.83	Yes
	2008-2009	94.55	12.92	69.22	119.88	Yes
	2007-2009	11.71	18.90	-25.33	48.75	No
Lark Sparrow *Chondestes grammacus*	2007-2008	-5.36	3.54	-12.30	1.57	No
	2008-2009	6.74	3.06	0.74	12.75	Yes
	2007-2009	1.38	4.52	-7.49	10.25	No
Lark Bunting *Calamospiza melanocorys*	2007-2008	-52.86	32.39	-116.35	10.63	No
	2008-2009	49.38	14.51	20.95	77.81	Yes
	2007-2009	-3.48	34.26	-70.62	63.66	No
Savannah Sparrow *Passerculus sandwichensis*	2007-2008	-86.64	17.31	-120.55	-52.72	Yes
	2008-2009	52.48	8.23	36.35	68.61	Yes
	2007-2009	-34.16	18.89	-71.18	2.86	No

Species	Year	Effect size	SE	LCL	UCL	Significant?
Grasshopper Sparrow *Ammodramus savannarum*	2007-2008	-58.53	12.88	-83.77	-33.29	Yes
	2008-2009	62.99	8.68	45.98	80.00	Yes
	2007-2009	4.46	14.84	-24.63	33.55	No
Baird's Sparrow *Ammodramus bairdii*	2007-2008	5.05	4.07	-2.93	13.03	No
	2008-2009	8.54	4.39	-0.06	17.14	No
	2007-2009	13.59	4.06	5.63	21.55	Yes
Ammodramus spp.	2007-2008	-84.58	14.92	-113.84	-55.33	Yes
	2008-2009	90.94	10.72	69.94	111.95	Yes
	2007-2009	6.36	17.42	-27.79	40.51	No
Ammodramus spp. & Savannah Sparrow *Passerculus sandwichensis*	2007-2008	-140.09	23.11	-185.38	-94.80	Yes
	2008-2009	109.96	12.81	84.84	135.08	Yes
	2007-2009	-30.13	25.43	-79.98	19.72	No
Chestnut-collared Longspur *Calcarius ornatus*	2007-2008	-25.46	32.95	-90.05	39.12	No
	2008-2009	87.97	35.99	17.44	158.51	Yes
	2007-2009	62.51	38.39	-12.74	137.76	No
Eastern Meadowlark *Sturnella magna*	2007-2008	5.45	3.19	-0.81	11.70	No
	2008-2009	-0.28	2.99	-6.14	5.57	No
	2007-2009	5.17	2.02	1.20	9.13	Yes
Western Meadowlark *Sturnella neglecta*	2007-2008	-1.91	1.07	-4.02	0.19	No
	2008-2009	4.71	1.11	2.52	6.89	Yes
	2007-2009	2.79	1.44	-0.03	5.61	No
Meadowlark spp. *Sturnella spp.*	2007-2008	-0.57	4.69	-9.77	8.63	No
	2008-2009	1.41	2.96	-4.39	7.22	No
	2007-2009	0.84	4.11	-7.22	8.91	No

APPENDIX D. BIRD-HABITAT RELATIONSHIP MODEL SELECTION RESULTS

Model selection with corresponding variable combinations (variable), number of parameters (# param.), log likelihood (log Lik), Akaike's information criterion values with small sample size adjustment (AICc), delta AIC values with small sample size adjustment (ΔAICc), and AICc model weights (Wi AICc).

Species	Variable	# param	log Lik	AICc	ΔAICc	Wi AICc
Scaled Quail	grass+shrub	4	-103.45	215.01	0.00	0.28
Callipepla squamata	grass+other+shrub	5	-103.03	216.22	1.22	0.15
	shrub	3	-105.16	216.39	1.38	0.14
	grass^2+shrub	5	-103.21	216.58	1.58	0.13
	grass^2+other+shrub	6	-102.49	217.20	2.20	0.09
	other+shrub	4	-104.95	218.01	3.00	0.06
	grass+other^2+shrub	6	-102.94	218.12	3.12	0.06
	grass^2+other^2+shrub	7	-102.25	218.82	3.81	0.04
Northern Harrier	grass^2+other^2	6	-239.23	490.70	0.00	0.35
Circus cyaneus	grass+other^2	5	-240.75	491.66	0.96	0.22
	grass^2+other^2+shrub	7	-239.13	492.56	1.86	0.14
	grass^2+other	5	-241.45	493.07	2.37	0.11
	grass+other^2+shrub	6	-240.61	493.44	2.74	0.09
American Kestrel	grass+shrub	3	-228.52	463.11	0.00	0.33
Falco sparverius	grass+other+shrub	4	-228.06	464.24	1.13	0.19
	grass^2+shrub	4	-228.52	465.15	2.04	0.12
	grass^2+other+shrub	5	-227.96	466.08	2.98	0.07
	grass+other^2+shrub	5	-228.01	466.19	3.08	0.07
	grass	2	-231.41	466.85	3.75	0.05
Say's Phoebe	grass+other	4	-269.50	547.10	0.00	0.20
Sayornis saya	grass+other+shrub	5	-268.64	547.45	0.35	0.17
	grass^2+other	5	-269.48	549.12	2.01	0.07
	grass+other^2	5	-269.50	549.16	2.05	0.07
	grass^2+other+shrub	6	-268.62	549.47	2.36	0.06
	grass	3	-271.72	549.50	2.39	0.06
	grass+other^2+shrub	6	-268.64	549.52	2.41	0.06
	grass+shrub	4	-270.77	549.66	2.55	0.06
	other	3	-272.13	550.33	3.22	0.04
	grass^2	4	-271.26	550.62	3.52	0.04
	grass^2+shrub	5	-270.34	550.83	3.73	0.03
	other+shrub	4	-271.45	551.01	3.90	0.03

Species	Variable	# param	log Lik	AICc	ΔAICc	Wi AICc
Loggerhead Shrike	other	3	-376.13	758.33	0.00	0.15
Lanius ludovicianus	$grass^2$+other	5	-374.39	758.95	0.61	0.11
	grass+other	4	-375.53	759.18	0.84	0.10
	shrub+other	4	-375.56	759.22	0.89	0.09
	$other^2$	4	-375.59	759.30	0.96	0.09
	$grass^2$+other+shrub	6	-373.69	759.62	1.29	0.08
	grass+other+shrub	5	-374.88	759.92	1.58	0.07
	$other^2$+shrub	5	-375.01	760.18	1.85	0.06
	$grass^2$	4	-376.25	760.62	2.28	0.05
	$grass^2$+$other^2$	6	-374.19	760.62	2.28	0.05
	grass+$other^2$	5	-375.24	760.65	2.31	0.05
	$grass^2$+shrub	5	-375.46	761.08	2.74	0.04
	$grass^2$+$other^2$+shrub	7	-373.50	761.31	2.98	0.03
	grass+$other^2$+shrub	6	-374.58	761.40	3.07	0.03
Horned Lark	grass+$other^2$+shrub	6	-465.73	943.69	0.00	0.66
Eremophila alpestris	$grass^2$+$other^2$+shrub	7	-465.37	945.05	1.36	0.34
Sprague's Pipit	Shrub	3	-144.99	296.04	0.00	0.20
Anthus spragueii	$other^2$+shrub	5	-143.05	296.27	0.23	0.18
	grass+shrub	4	-144.10	296.31	0.27	0.17
	other+shrub	4	-144.54	297.20	1.16	0.11
	grass+other+shrub	5	-143.65	297.46	1.42	0.10
	grass+$other^2$+shrub	6	-142.67	297.57	1.53	0.09
	$grass^2$+shrub	5	-144.10	298.36	2.32	0.06
	$grass^2$+$other^2$+shrub	7	-142.41	299.12	3.08	0.04
	$grass^2$+other+shrub	6	-143.50	299.24	3.20	0.04
Clay-colored Sparrow	grass+other+shrub	5	-131.99	274.15	0.00	0.20
Spizella pallida	grass+$other^2$+shrub	6	-131.04	274.32	0.17	0.18
	$other^2$+shrub	5	-132.14	274.44	0.29	0.17
	$grass^2$+$other^2$+shrub	7	-130.35	275.02	0.87	0.13
	$grass^2$+other+shrub	6	-131.56	275.36	1.21	0.11
	grass+shrub	4	-133.94	275.99	1.85	0.08
	other+shrub	4	-134.33	276.78	2.63	0.05
	Shrub	3	-135.84	277.75	3.60	0.03
	$grass^2$+shrub	5	-133.93	278.03	3.88	0.03
Brewer's Sparrow	grass+$other^2$+shrub	6	-416.05	844.34	0.00	0.67
Spizella breweri	$grass^2$+$other^2$+shrub	7	-416.05	846.41	2.07	0.24
Vesper Sparrow	$grass^2$+other	5	-607.00	1224.16	0.00	0.51
Pooecetes gramineus	$grass^2$+$other^2$	6	-606.80	1225.84	1.67	0.22
	$grass^2$+other+shrub	6	-607.00	1226.23	2.06	0.18
	$grass^2$+$other^2$+shrub	7	-606.80	1227.91	3.75	0.08

Species	Variable	# param	log Lik	AICc	ΔAICc	Wi AICc
Lark Bunting	Shrub	3	-156.50	319.06	0.00	0.26
Calamospiza melanocorys	$grass^2$+shrub	5	-155.24	320.64	1.57	0.12
	grass+shrub	4	-156.38	320.88	1.82	0.11
	other+shrub	4	-156.49	321.09	2.03	0.10
	Grass	3	-158.00	322.07	3.00	0.06
	$grass^2$+other+shrub	6	-155.01	322.25	3.19	0.05
	$grass^2$	4	-157.14	322.39	3.33	0.05
	Other	3	-158.35	322.77	3.71	0.04
	$other^2$+shrub	5	-156.34	322.85	3.79	0.04
	grass+other+shrub	5	-156.38	322.92	3.86	0.04
Savannah Sparrow	$grass^2$+shrub	5	-263.87	537.90	0.00	0.62
Passerculus sandwichensis	$grass^2$+other+shrub	6	-263.85	539.93	2.03	0.23
	$grass^2$+$other^2$+shrub	7	-263.76	541.84	3.94	0.09
Grasshopper Sparrow	grass+shrub	4	-127.84	263.78	0.00	0.14
Ammodramus savannarum	Grass	3	-128.94	263.95	0.17	0.12
	grass+other+shrub	5	-126.91	263.98	0.20	0.12
	$grass^2$+shrub	5	-127.04	264.24	0.46	0.11
	grass+other	4	-128.11	264.34	0.56	0.10
	$grass^2$	4	-128.29	264.69	0.91	0.09
	grass+$other^2$+shrub	6	-126.37	264.96	1.18	0.08
	grass+$other^2$	5	-127.44	265.04	1.26	0.07
	$grass^2$+other+shrub	6	-126.54	265.31	1.53	0.06
	$grass^2$+other	5	-127.81	265.78	2.00	0.05
	$grass^2$+$other^2$+shrub	7	-126.20	266.71	2.93	0.03
	$grass^2$+$other^2$	6	-127.33	266.90	3.12	0.03
Baird's Sparrow	$grass^2$+other	5	-97.42	205.01	0.00	0.42
Ammodramus bairdii	$grass^2$+other+shrub	6	-97.12	206.47	1.46	0.20
	$grass^2$+$other^2$	6	-97.30	206.83	1.82	0.17
	$grass^2$+$other^2$+shrub	7	-97.00	208.30	3.29	0.08
	grass+$other^2$	5	-99.29	208.75	3.74	0.06
Chestnut-collared Longspur	grass+$other^2$+shrub	6	-199.97	412.17	0.00	0.60
Calcarius ornatus	$grass^2$+$other^2$+shrub	7	-199.83	413.97	1.80	0.24
	grass+$other^2$	5	-202.70	415.56	3.38	0.11
Eastern Meadowlark	$grass^2$+other	5	-242.52	495.21	0.00	0.51
Sturnella magna	$grass^2$+$other^2$	6	-242.50	497.23	2.02	0.19
	$grass^2$+other+shrub	6	-242.51	497.25	2.04	0.19

APPENDIX E. SPECIES ACCOUNTS

Each species account contains a comparison of densities by GPCA, a map displaying relative density estimates across the GPCAs, and predictive habitat relationship models if we were able to model them for that particular species.

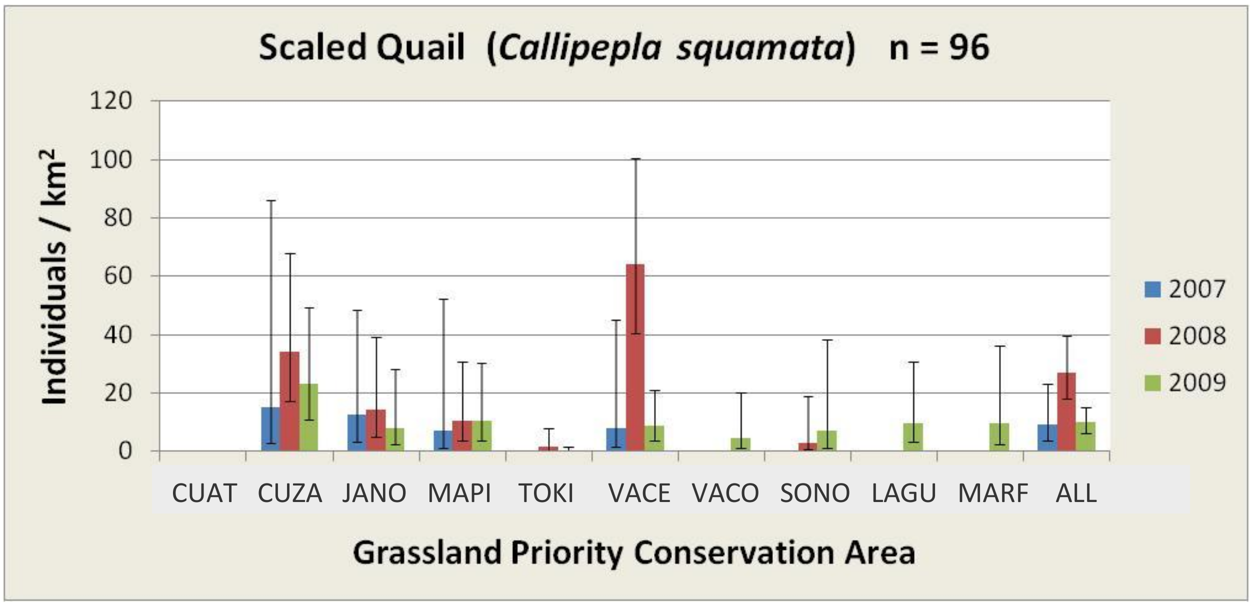
The density bar graphs contain densities estimates by GPCA and a global estimate for each year with associated 95% confidence limits represented as *y*-error bars. The number of detections used to estimate density (post-truncation) appears in graph title, represented by *n*. Density estimates are in individuals per km^2. Refer to Table 1 for interpretation of GPCA acronyms.

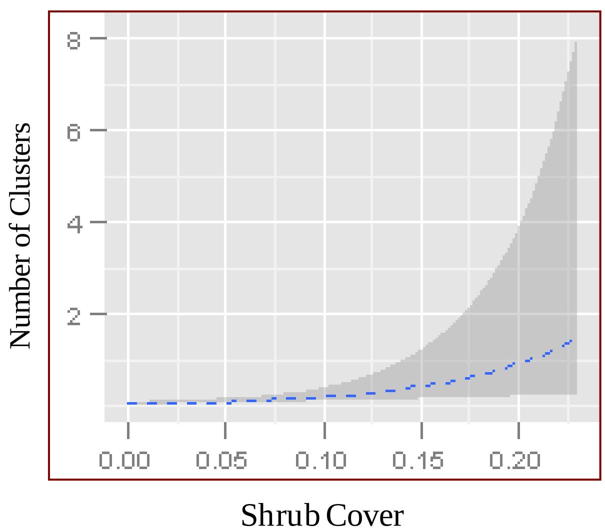
The species account maps show the same density estimates as the bar graph. Although the bar graphs lack a scale, they provide a picture of relative abundance across the geographic distribution of the species. The reader should refer to the bar graphs and Appendix B for measures of error associated with each estimate.

Figures representing habitat relationships appear if habitat relationships were modeled for that species and if the analysis identified any strongly influential parameters among grass cover, shrub cover and/or other cover. In order to maintain independence in our response variable, the number of independent observations (i.e. clusters) per transect was our response variable (rather than the number of individuals counted) and is represented on the Y axis. Average cluster size varies by species and ranged from 1.0 for American Kestrel to 23.8 for Lark Bunting and Chestnut-collared Longspur. Average cluster sizes are only given for species with modeled habitation relationships as an aid to interpreting the response variable.

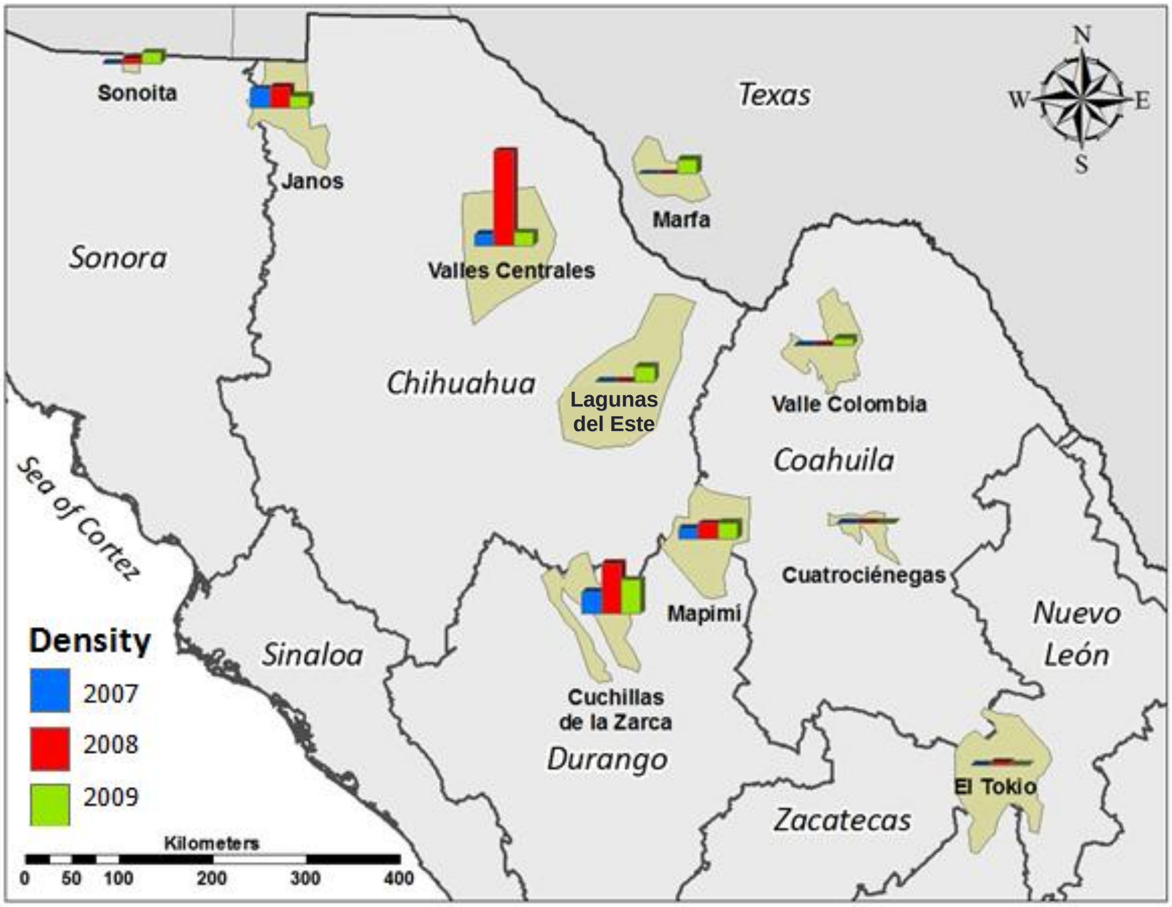
Scaled Quail (*Callipepla squamata*)

Scaled Quail was most common in the northern and western GPCAs. Average density of Scaled Quail increased significantly and the proportion of all transects on which we detected the species nearly doubled between 2007 and 2008, before declining again to 2007 levels in 2009. These changes in global density appear to have been driven mainly by a large population increase, and subsequent decrease, in Valles Centrales. Shrub cover had a positive influence on Scaled Quail abundance. Grass cover was also retained in the top model and appears to have a positive effect.



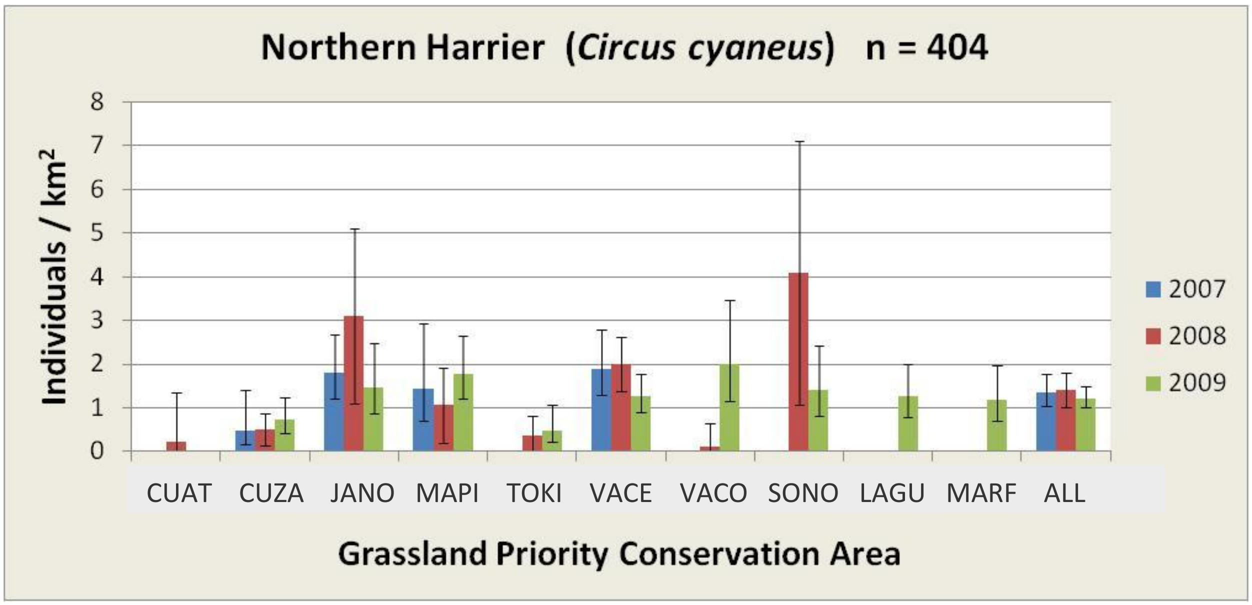


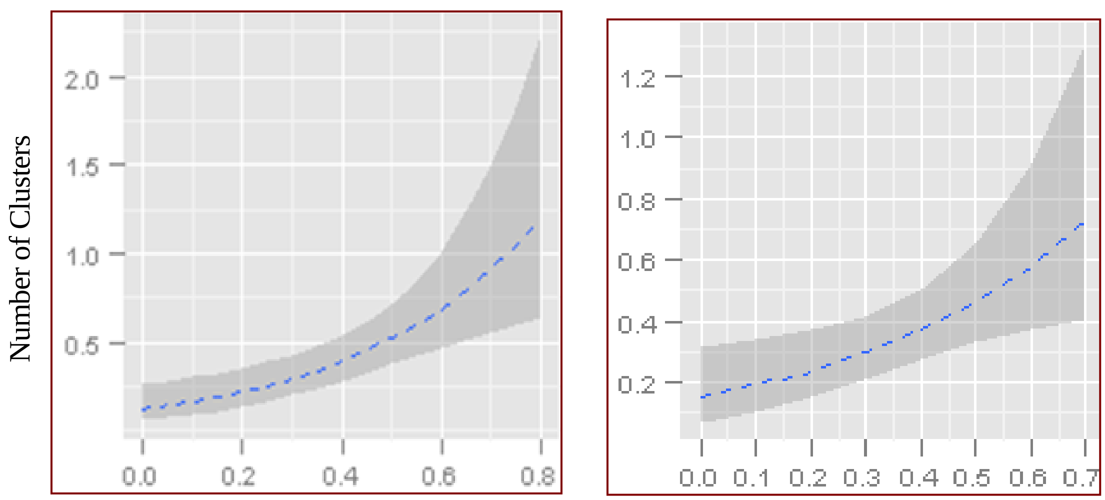
Scaled Quail (*Callipepla squamata*)



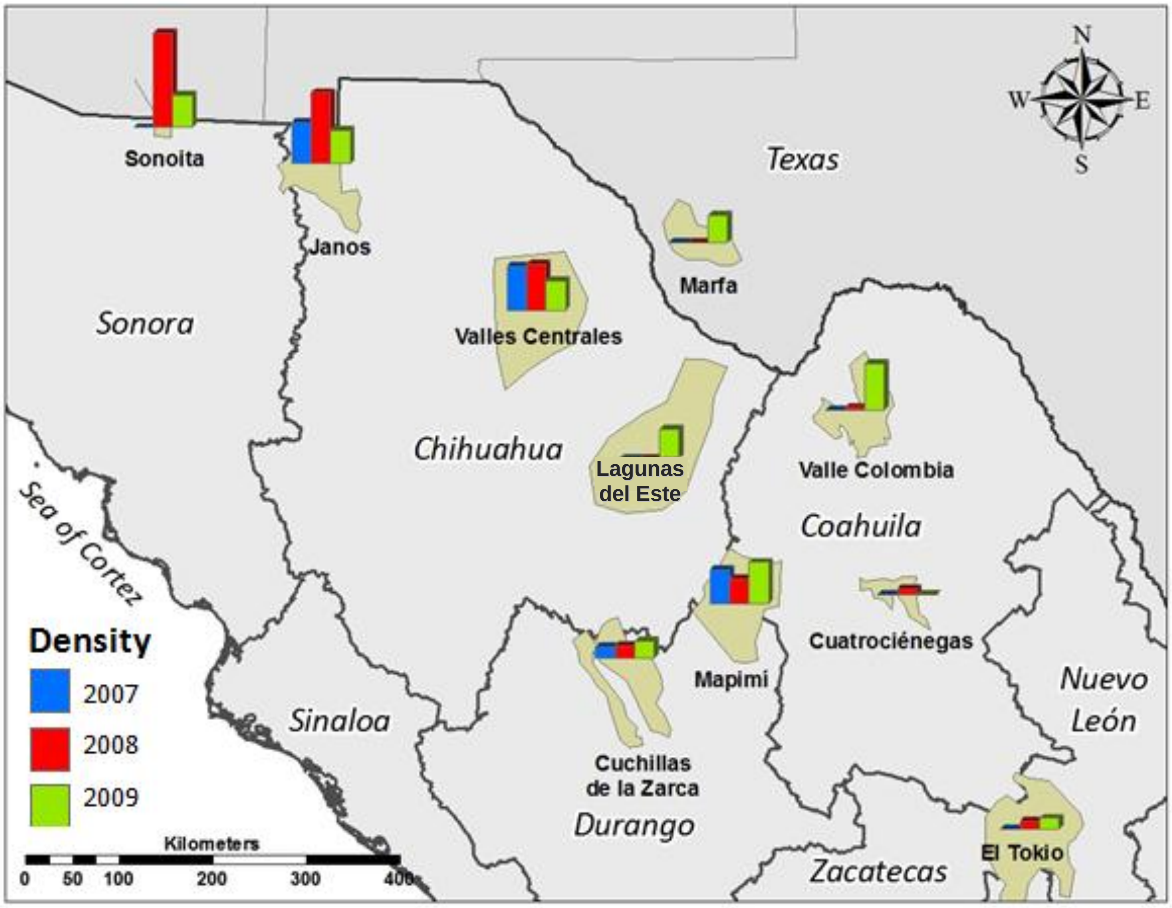
Northern Harrier (*Circus cyaneus*)

Northern Harrier is the most common raptor wintering in Chihuahuan Desert grasslands and was found on 25-30% of transects each year. Density was similar in most GPCAs, although Northern Harriers appear to be less abundant in Cuatro Ciénegas, Cuchillas de la Zarca, and El Tokio. Densities were also similar in most GPCAs across the three years, with the exception of Valle Colombia where density increased significantly between 2008 and 2009. Northern Harrier abundance was positively influenced by grass and 'other' ground cover.



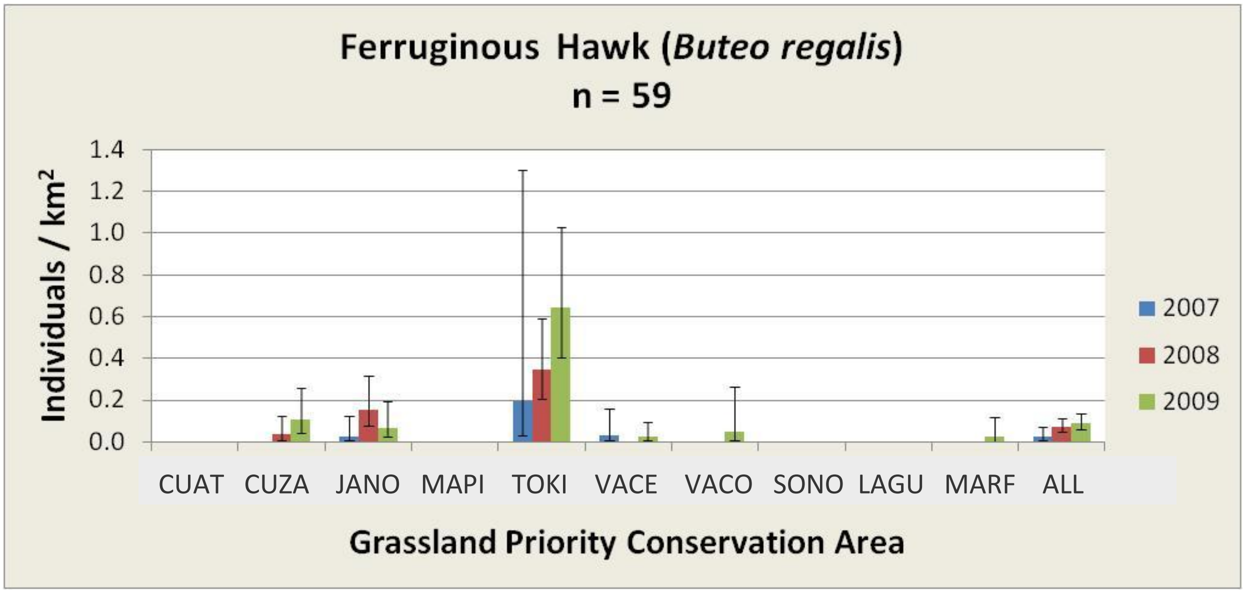


Northern Harrier (Circus cyaneus)

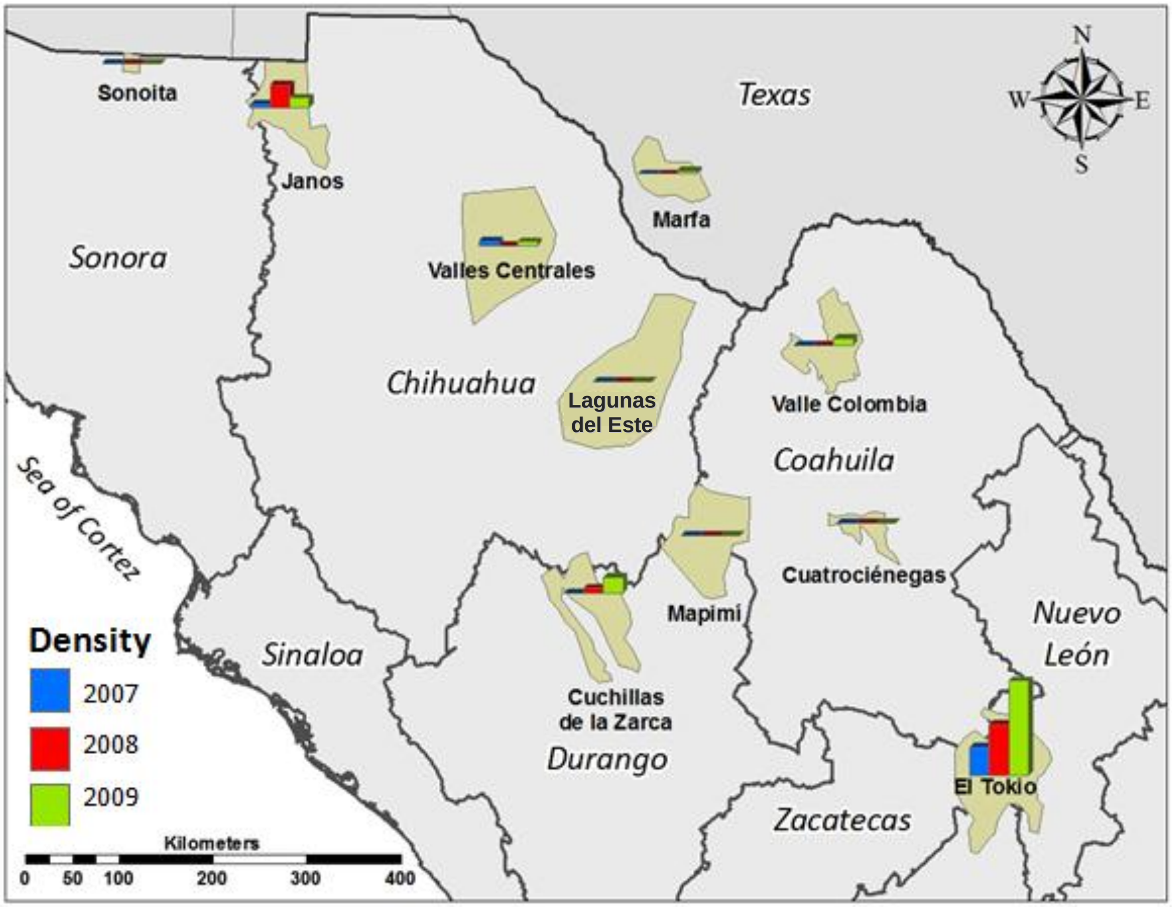


Ferruginous Hawk (*Buteo regalis*)

Ferruginous Hawk is a local winter resident in Chihuahuan Desert grasslands, although it can be locally fairly common in areas with prairie dogs (*Cynomys mexicanus and C. ludovicianus*) and other fossorial rodents. El Tokio appears to be especially important, as is Janos and Cuchillas de la Zarca. Densities were low in all years, but increased significantly from 2007 to 2009. Too few were detected in 2008 to analyze relationships with vegetation cover; regardless, the presence of fossorial rodents is likely a more important factor.

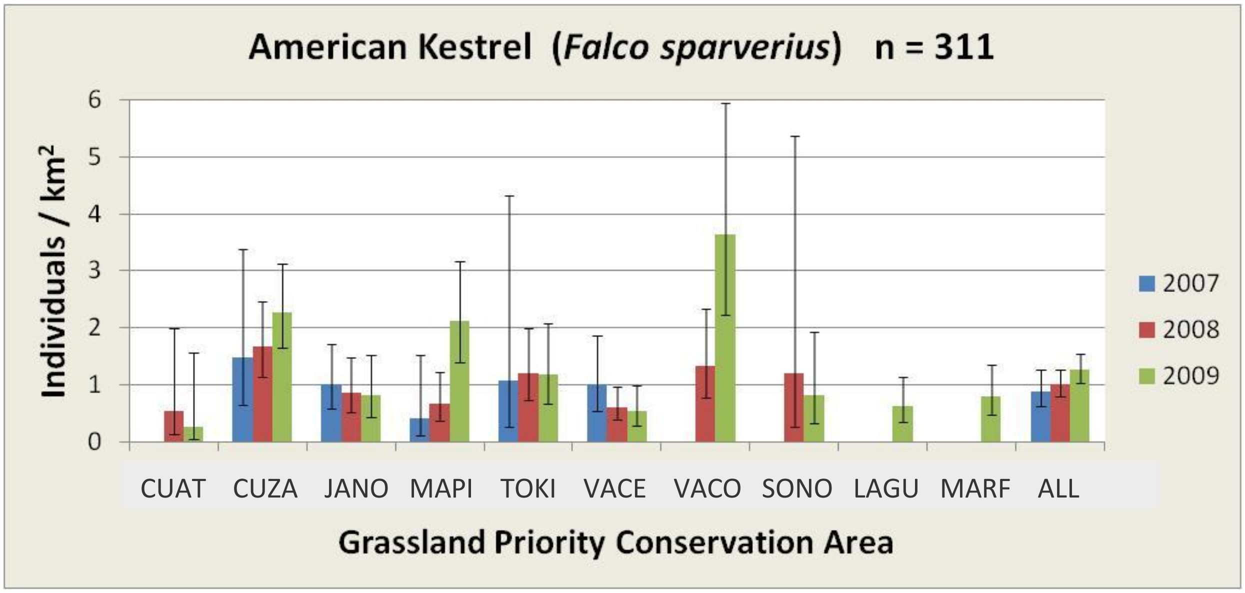


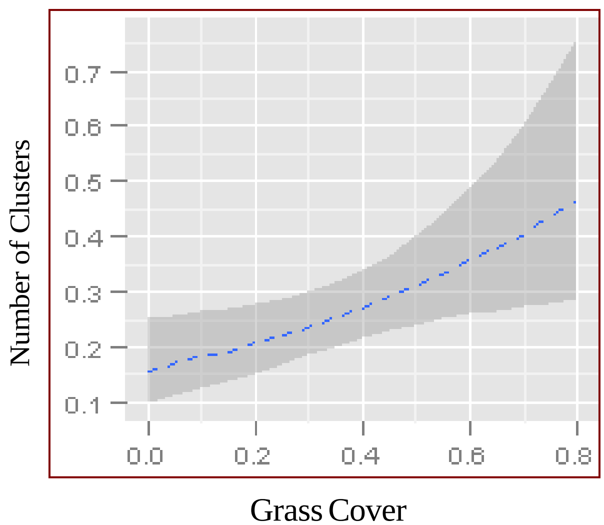
Ferruginous Hawk (*Buteo regalis*)



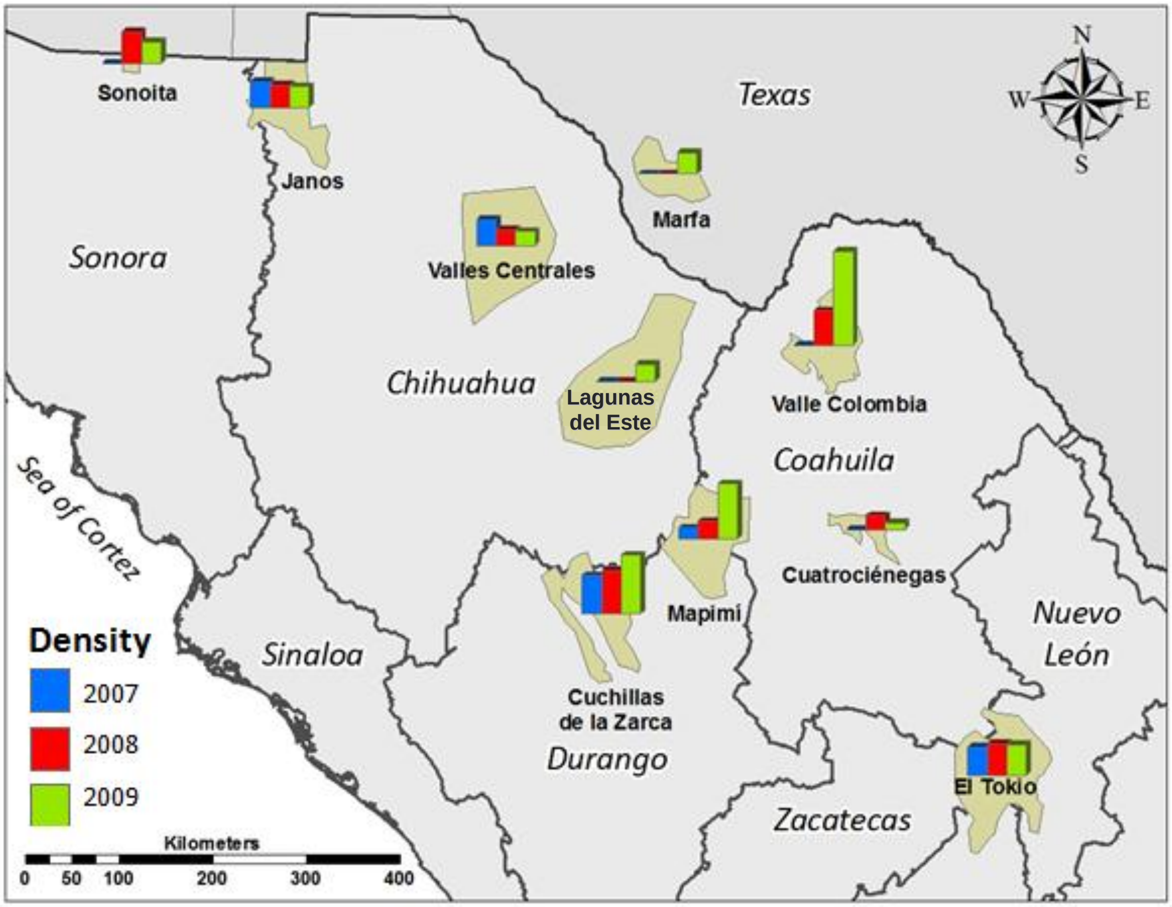
American Kestrel (Falco sparverius)

American Kestrel is a widespread winter resident in Chihuahuan Desert grasslands and was encountered on roughly 20% of transects in all years. Local and global densities did not change significantly between years, with the exception of significant increases in Mapimí and Valle Colombia in 2009. Grass cover had a positive effect on American Kestrel abundance. Shrub cover appears to have had an even stronger negative effect on abundance, although the CV exceeded 40%.



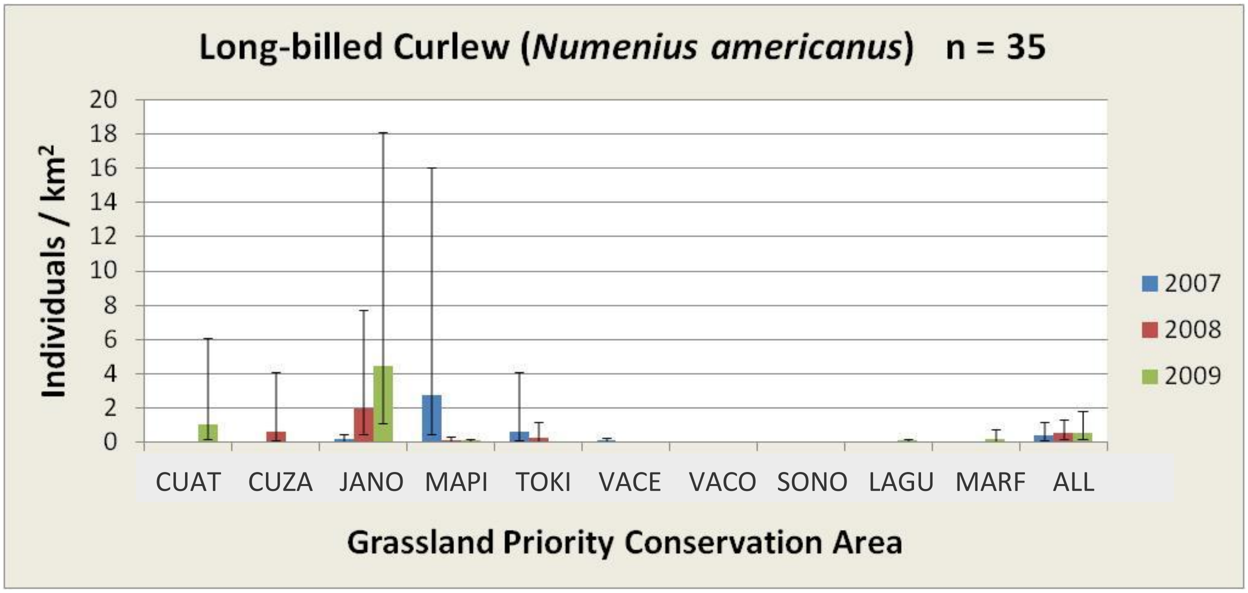


American Kestrel (*Falco sparverius*)

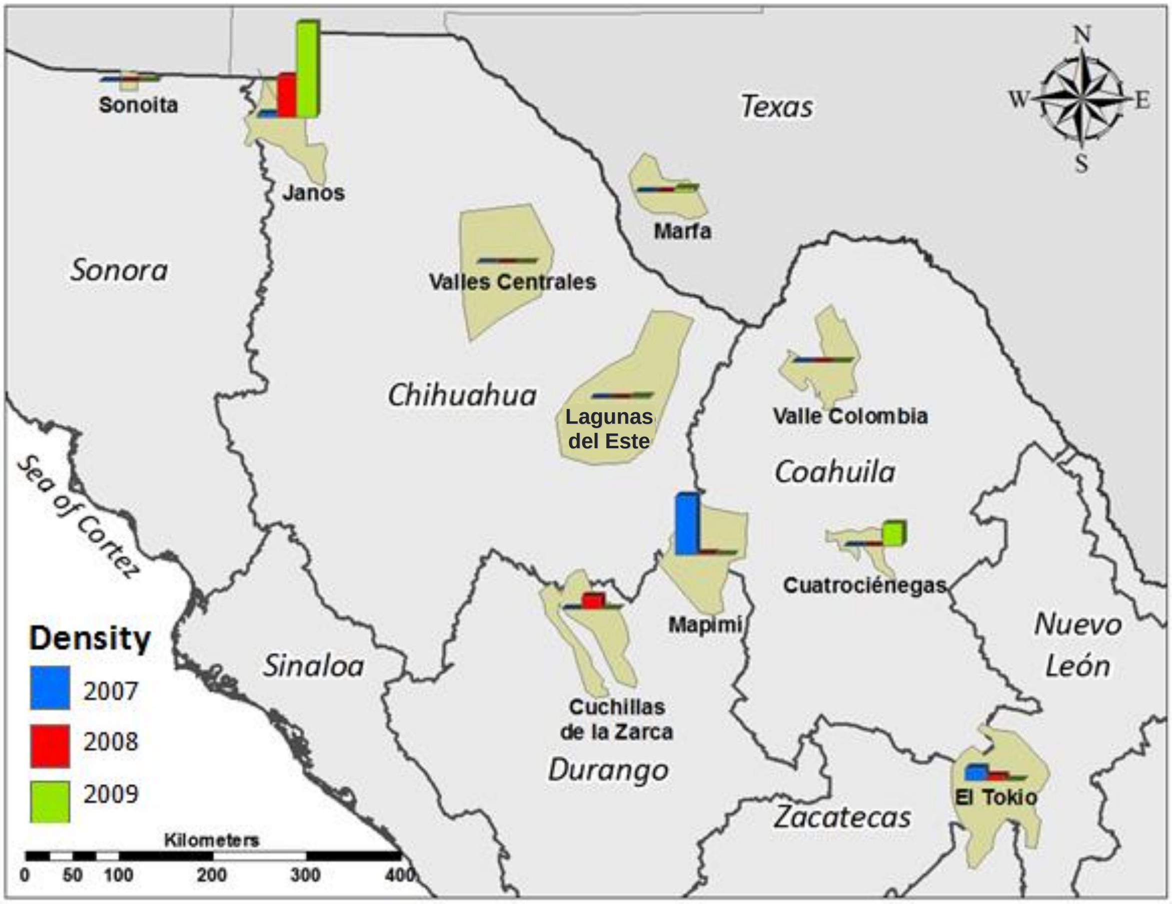


Long-billed Curlew (*Numenius americanus*)

Long-billed Curlews are a relatively rare winter resident in Chihuahuan Desert grasslands. We detected Long-billed Curlew on 3% of transects in 2007 and 2008, and only on 1.5% of transects in 2009. Anecdotal observations suggest this species may instead prefer agricultural areas and water bodies. Thus inferences to its abundance and distribution from our data are limited since we only surveyed grasslands. Long-billed Curlews have been recorded in eight of the ten GPCAs, although Janos, Mapimí, and El Tokio appear to support larger and more regularly-occurring populations.

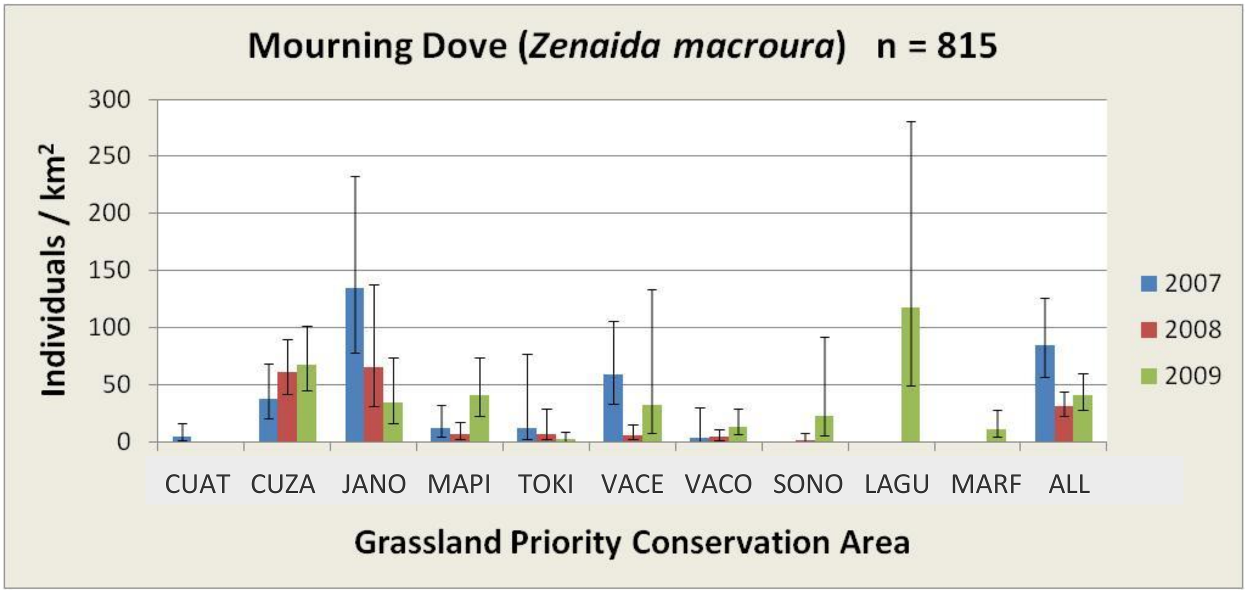


Long-billed Curlew (*Numenius americanus*)

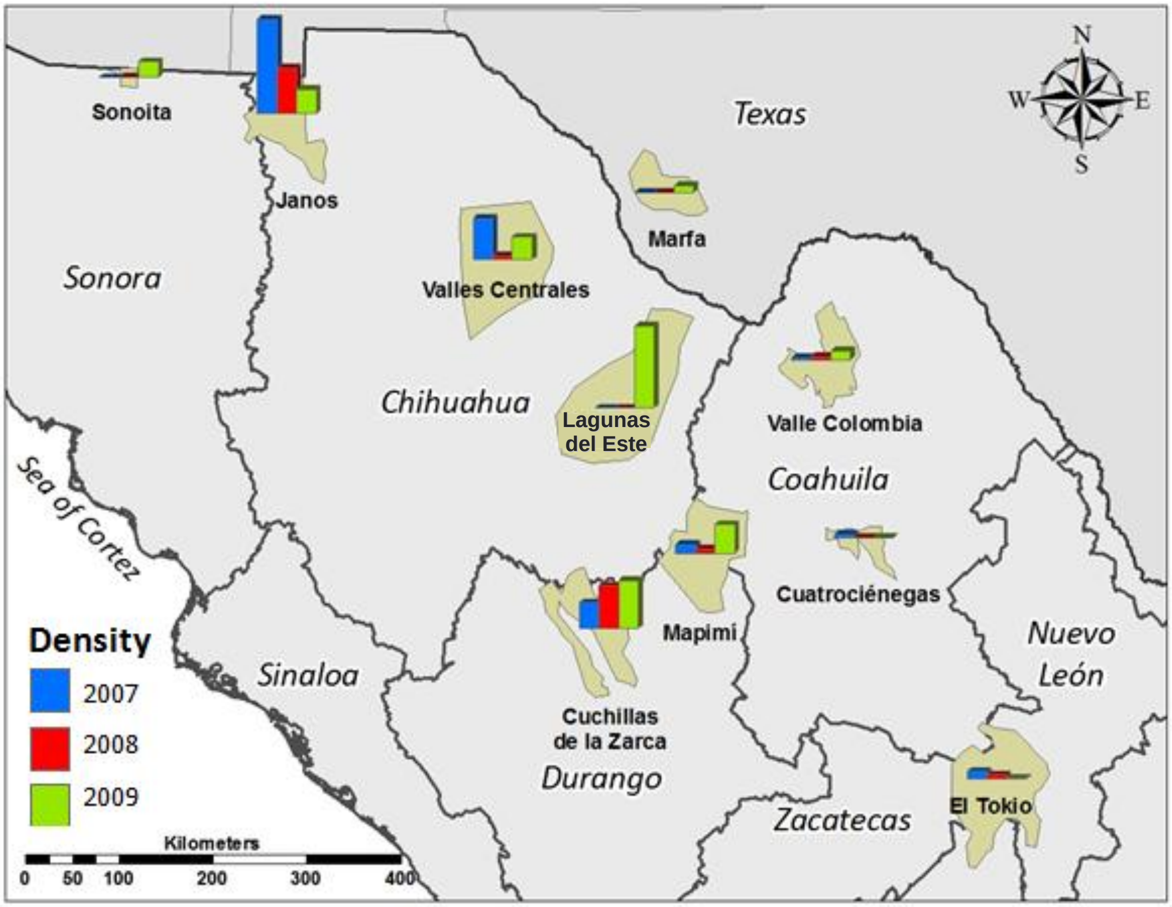


Mourning Dove (*Zenaida macroura*)

Mourning Dove is widely distributed across the Chihuahuan Desert grasslands in winter. Global density decreased significantly from 2007 to 2008 and remained lower in 2009. Similarly, the percentage of transects on which we detected it dropped from 44% in 2007 to 20% and 26% in 2008 and 2009, respectively. High model uncertainty in our analyses of habitat relationships suggests Mourning Doves occupy a broad range of grassland conditions, although grass cover and a moderate level of 'other' cover appear to be most important in influencing abundance.

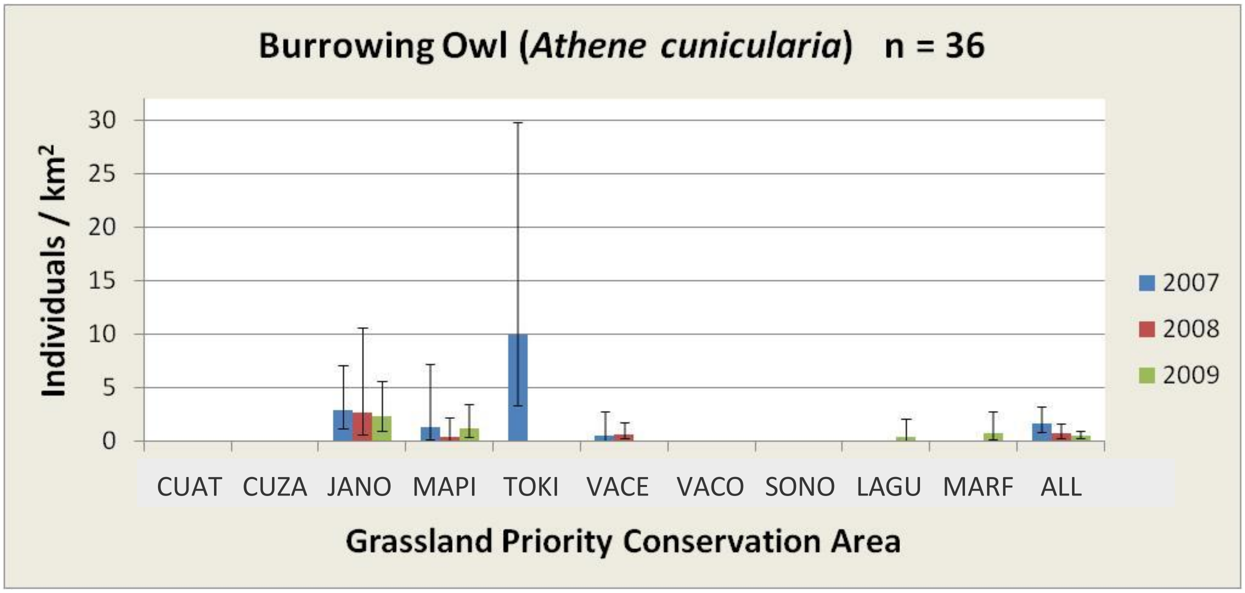


Mourning Dove (*Zenaida macroura*)

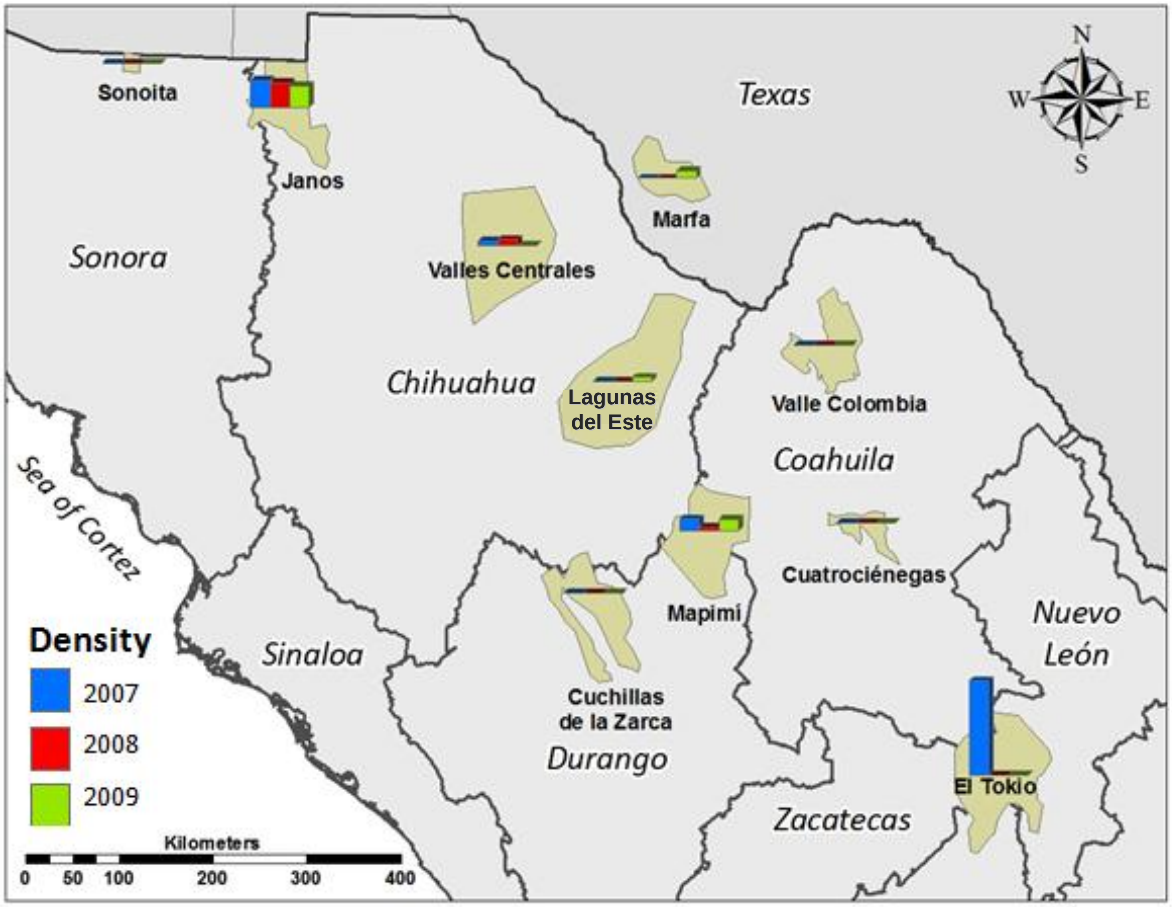


Burrowing Owl (*Athene cunicularia*)

We have found Burrowing Owls in six of the GPCAs, including Janos, Mapimí, El Tokio, Valles Centrales, Lagunas del Este and Marfa. We found Burrowing Owl on 8% of transects in 2007 and on 3% of transects in both 2008 and 2009. While there appears to be a decreasing trend region-wide, there are no statistically significant differences in density between years. The absence of Burrowing Owls in El Tokio in 2008 and 2009 is noteworthy. This GPCA has a far higher percentage of transects (89%) with prairie dogs (*Cynomys mexicanus*) than any other GPCA and Burrowing Owls have remained fairly common in the surrounding agricultural areas where prairie dogs persist.

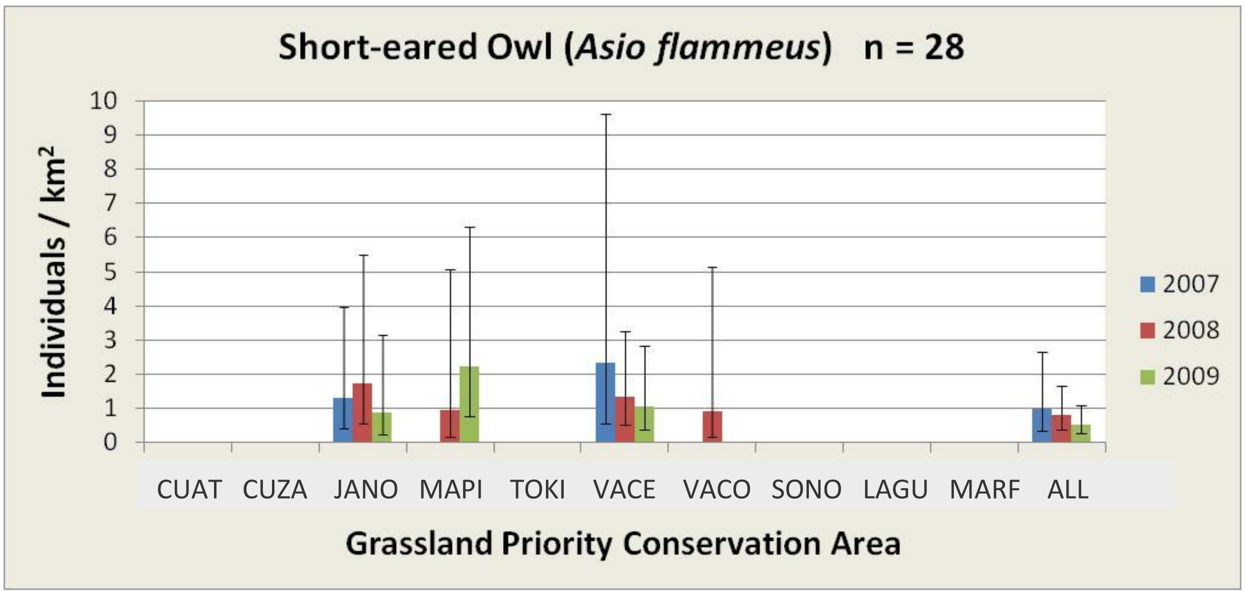


Burrowing Owl (*Athene cunicularia*)

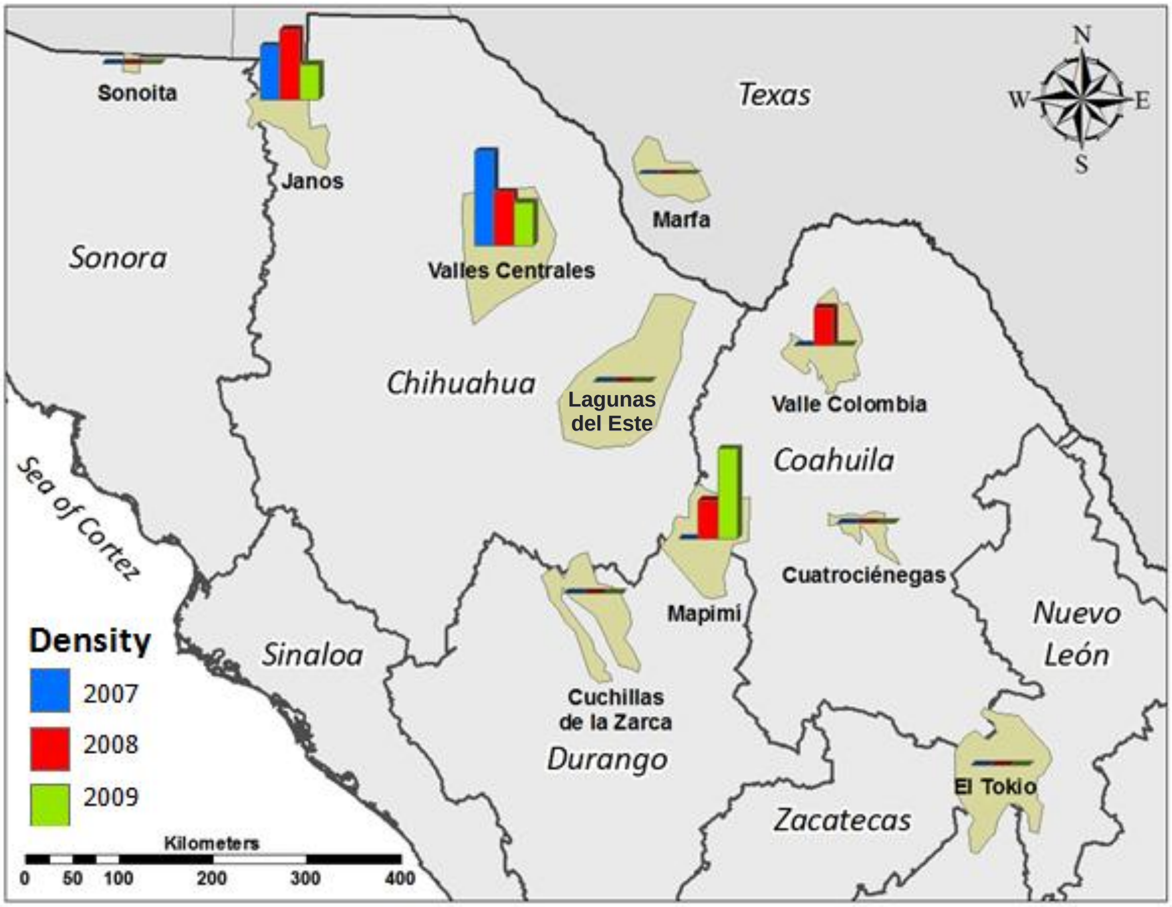


Short-eared Owl (*Asio flammeus*)

We found Short-eared Owls in Janos, Valles Centrales, Mapimí, and Valle Colombia, where they can be locally fairly common. Short-eared Owls appear to prefer areas with tall grass for roosting on the ground during the day. Compared to most other raptors, detection probability is low, due their crepuscular hunting habitats and tendency to roost on the ground amongst tall grass during the day, often not flushing until an observer is nearly upon them. Our sample size is insufficient for meaningful interpretation of trends, although there appears to be a slight, non-significant downward trend.

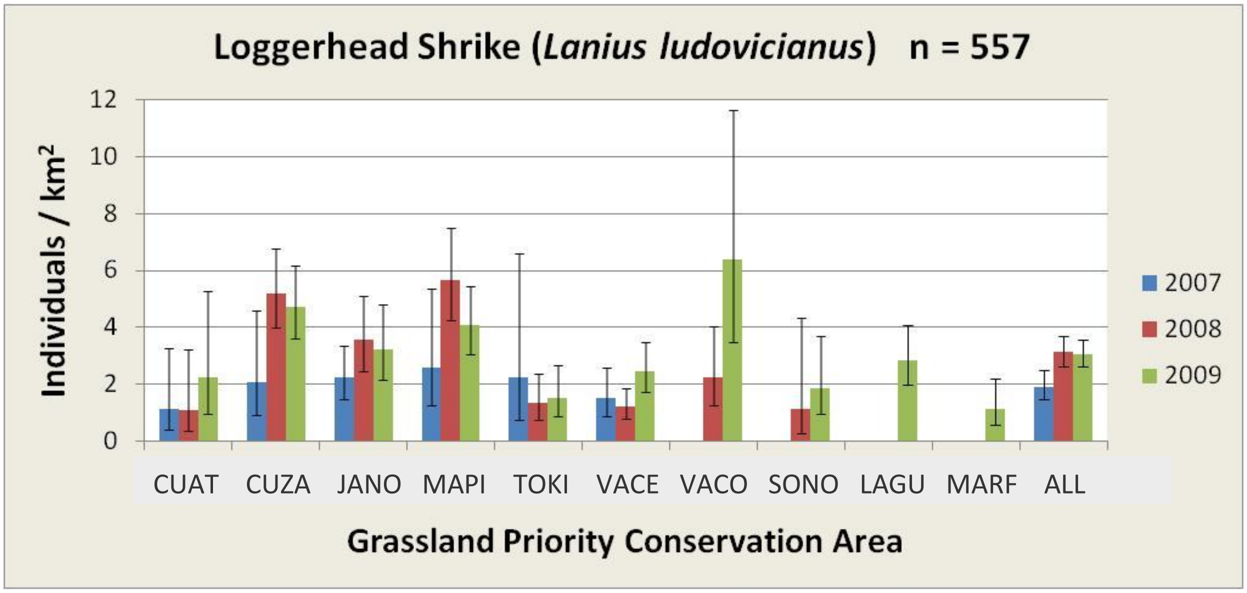


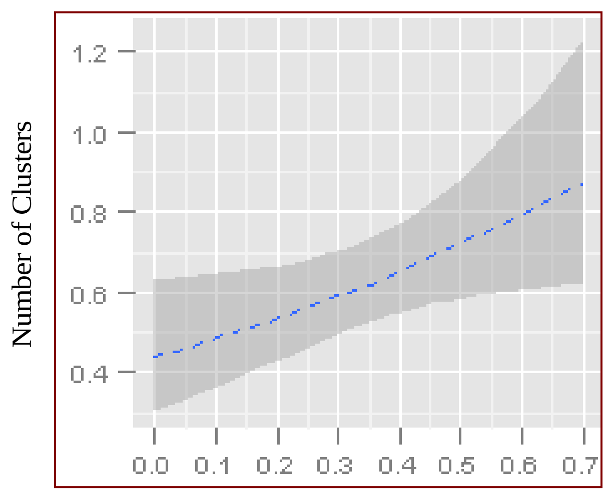
Short-eared Owl *(Asio flammeus)*



Loggerhead Shrike (*Lanius ludovicianus*)

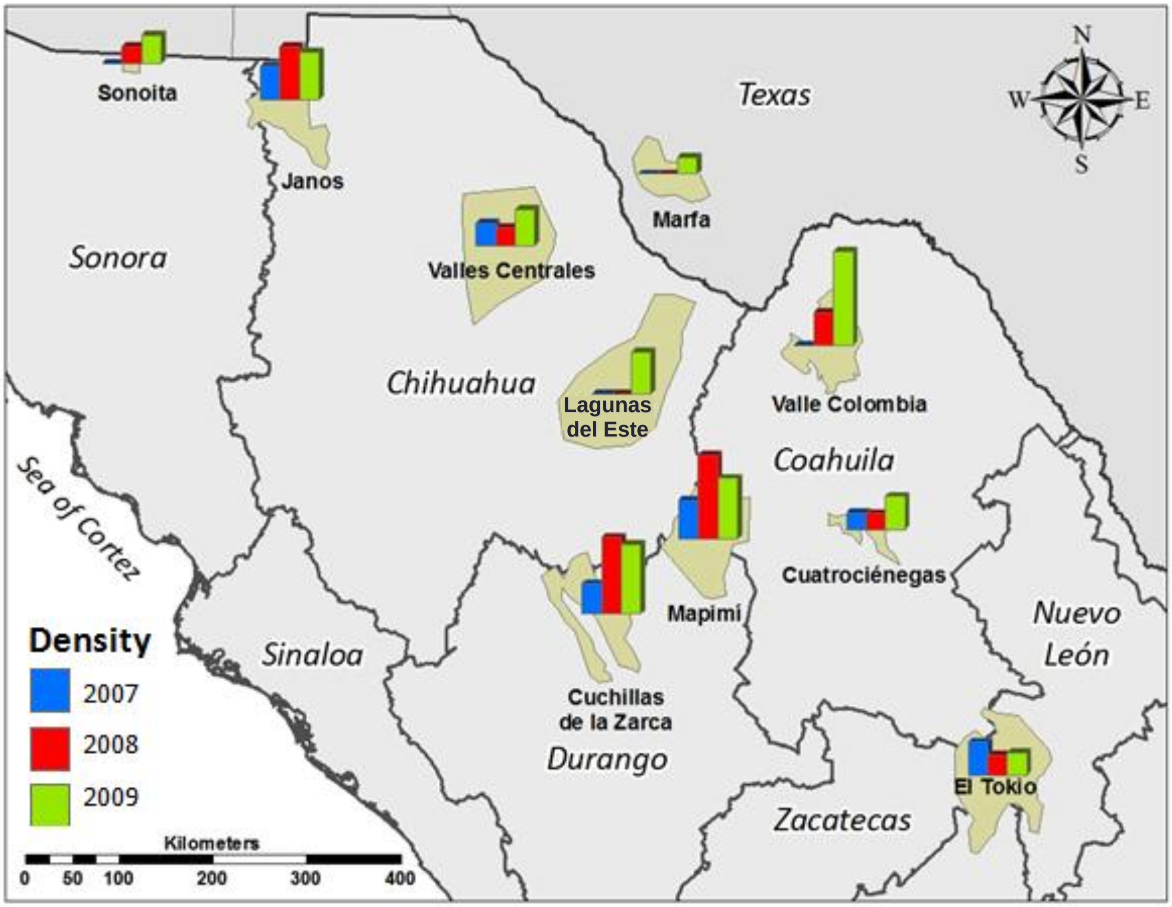
Loggerhead Shrike is widespread across the Chihuahuan Desert grasslands. Global density appeared to increase from 2007 to 2008, and remain stable from 2008 to 2009. The proportion of transects on which we found it followed a similar pattern. High model uncertainty and low AICc weights suggest Loggerhead Shrike accepts a broad range of grassland conditions, although 'other' cover appears to have the most important positive effect on abundance. Grass cover may also have a marginal positive effect.





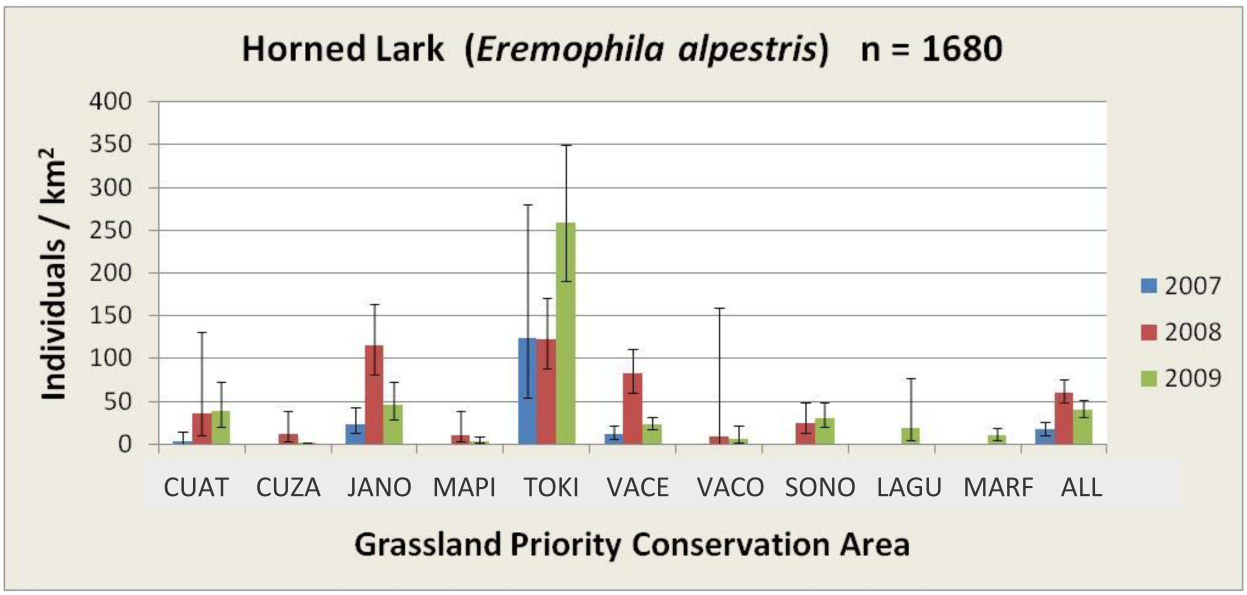
Other Cover

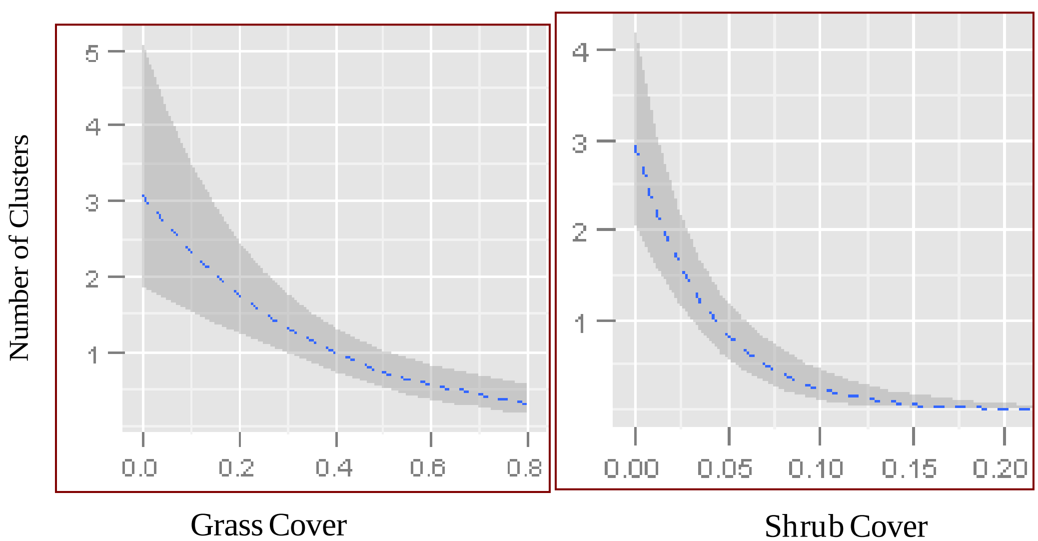
Loggerhead Shrike (*Lanius ludovicianus*)



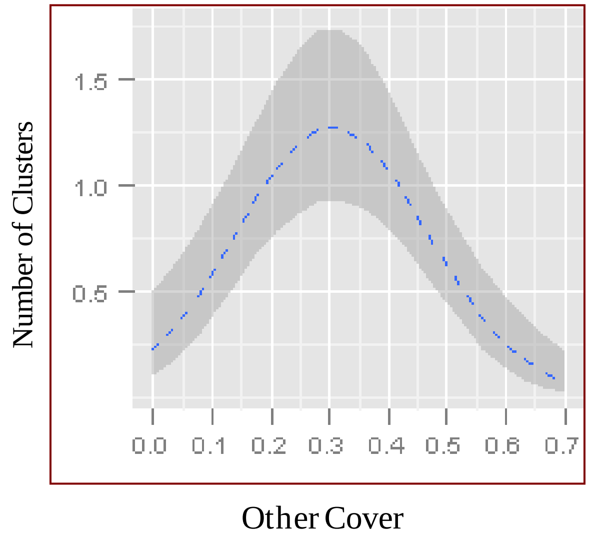
Horned Lark (*Eremophila alpestris*)

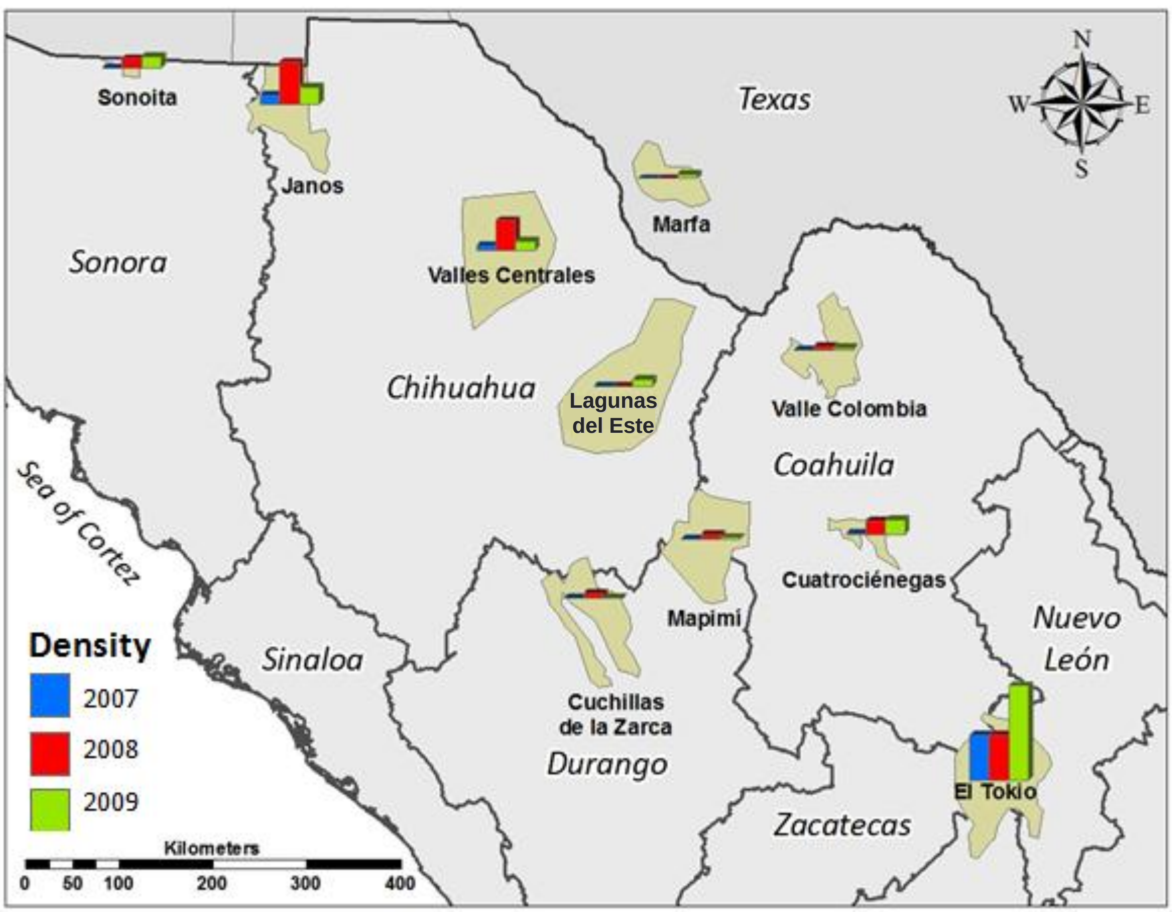
Horned Lark was widely distributed across all GPCAs although highest densities occurred in Cuatro Ciénegas, Janos, Valles Centrales, and El Tokio. Density was highest in 2007 and 2009 in the gypsophytic grasslands of El Tokio. Global densities were significantly higher in 2008 and 2009 than in 2007, despite a significant decrease from 2008 to 2009. We found Horned Lark on 23% of transects in 2007, 37% in 2008 and 35% in 2009. Densities appeared to increase in Janos and Valles Centrales in 2008, before returning to near-2007 levels in 2009. Shrub and grass cover both had a strong negative effect on Horned Lark abundance, whereas 'other' cover appeared to have a quadratic effect. Horned Larks were detected in clusters averaging 5.4 individuals, indicating a propensity for flocking.





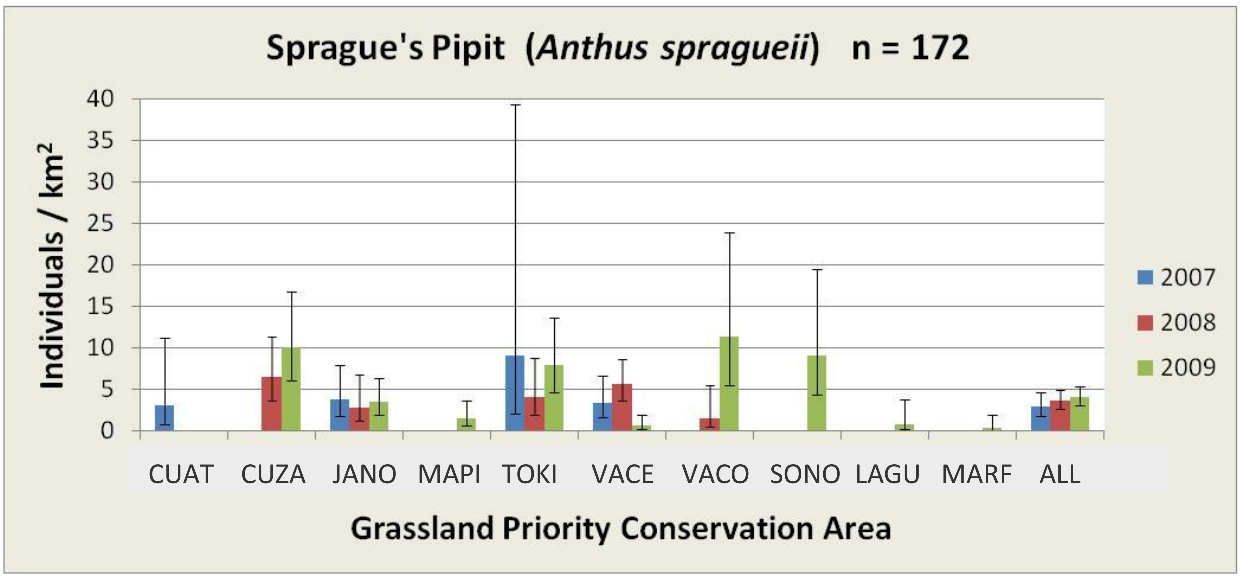
Horned Lark (*Eremophila alpestris*)

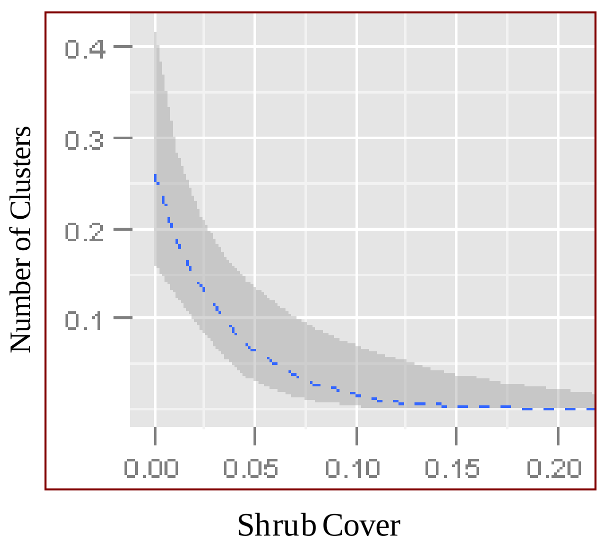




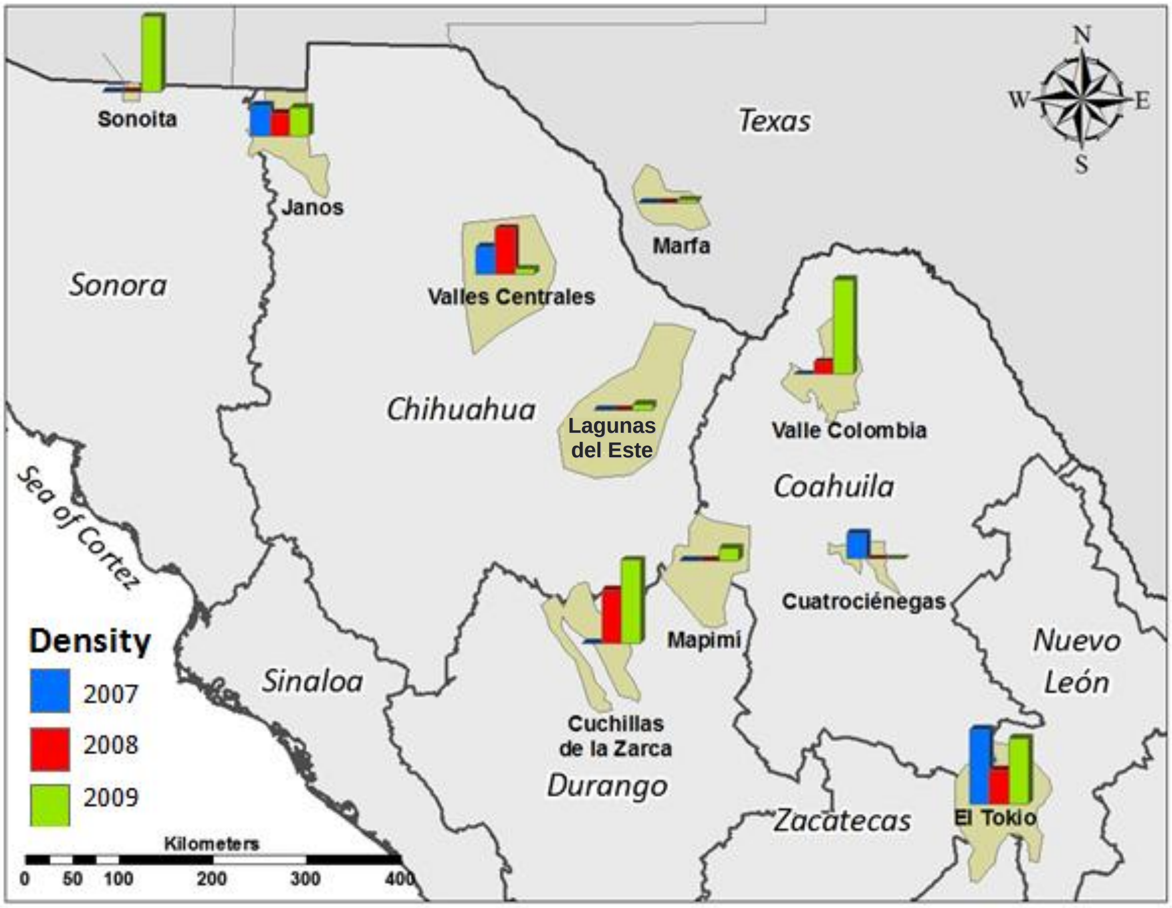
Sprague's Pipit (*Anthus spragueii*)

Sprague's Pipit is a widespread winter resident in Chihuahuan Desert grasslands, having been recorded in all GPCAs since 2007. Densities appear to be greatest in Cuchillas de la Zarca, Janos, El Tokio, Valles Centrales, Valle Colombia and Sonoita, although some annual variation exists. Estimates of global density were similar across years, as were the proportion of transects on which we detected the species (~11%). Shrub cover had a strong negative influence on Sprague's Pipit abundance. Grass cover and the quadratic of 'other' cover were retained in the top two competing models, suggesting these variables may also have been important. Sprague's Pipits are usually solitary in winter but occasionally occur in loose flocks of 2-4 individuals; average cluster size was 1.3 birds.



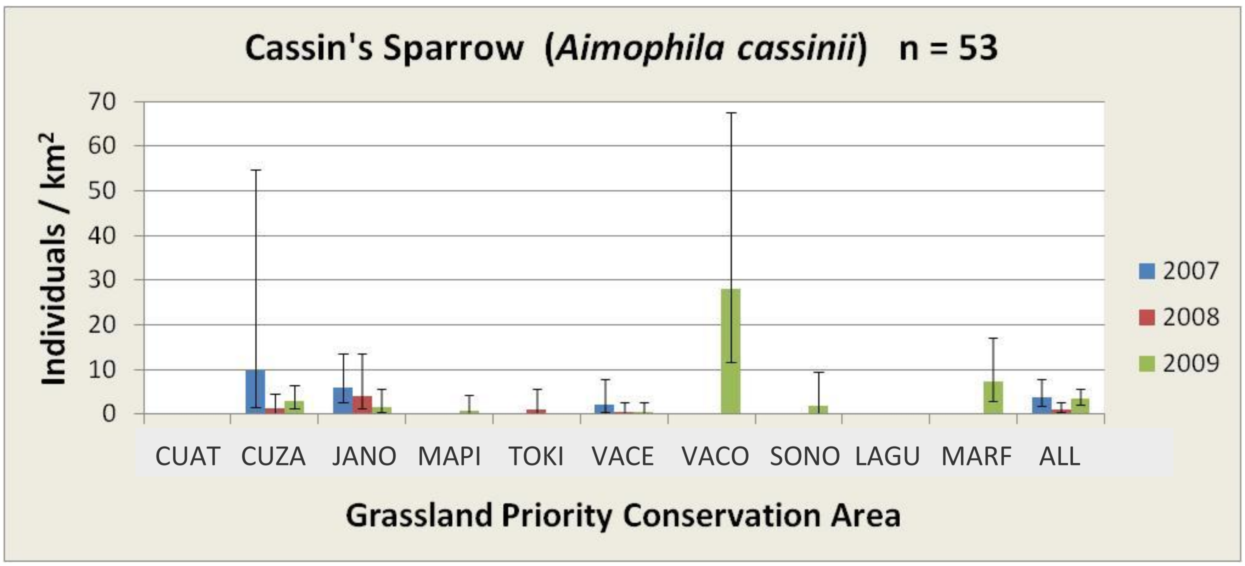


Sprague's Pipit (*Anthus spragueii*)

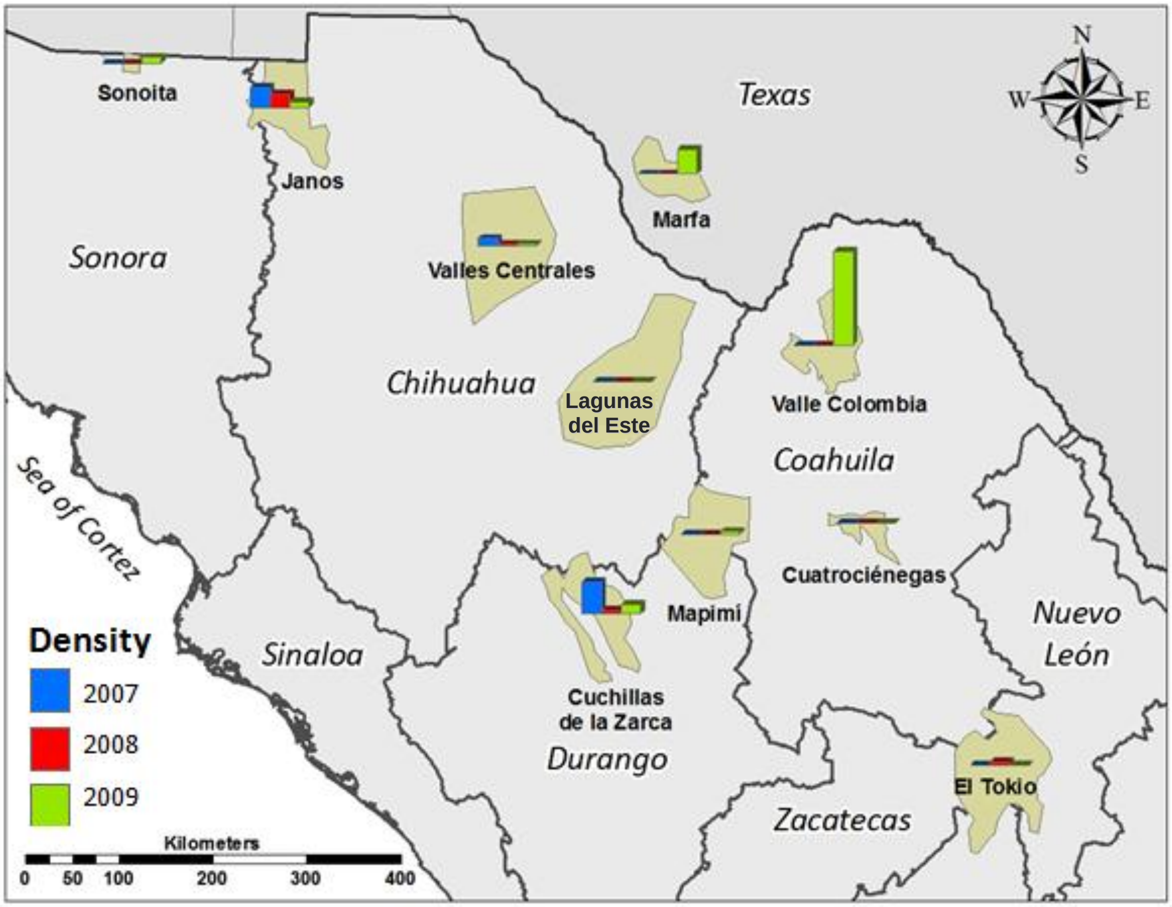


Cassin's Sparrow (*Aimophila cassinii*)

Despite being one of the most common and conspicuous breeding birds in Chihuahuan Desert grasslands, Cassin's Sparrow are rarely encountered in winter. This low detection rate is likely a result, in part, of their secretive non-breeding behavior, an apparent preference for shrubby grasslands and identification challenges. As a result, Cassin's Sparrow is poorly represented in our samples, and inferences to its abundance and distribution should be made with extreme caution. Still, the paucity of observations is surprising. Cassin's Sparrow has been recorded in eight of the ten GPCAs, although in very small numbers. The apparent high density in Valle Colombia in 2009 should be viewed with caution because of the low sample size. We found this species on 6% of transects in 2007, only 1% of transects in 2008, and 5% of transects in 2009.

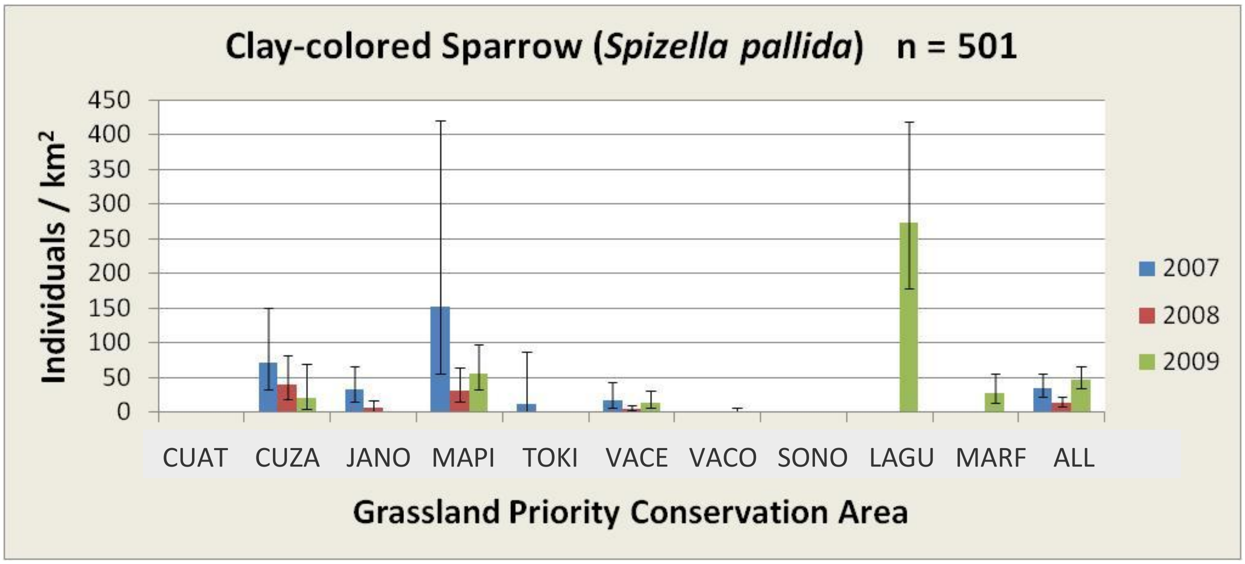


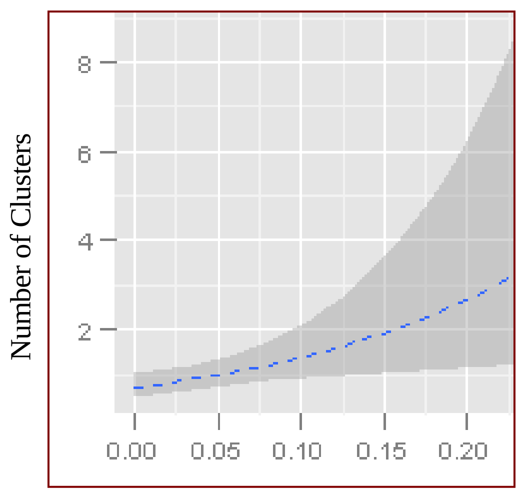
Cassin's Sparrow (*Aimophila cassinii*)



Clay-colored Sparrow (*Spizella pallida*)

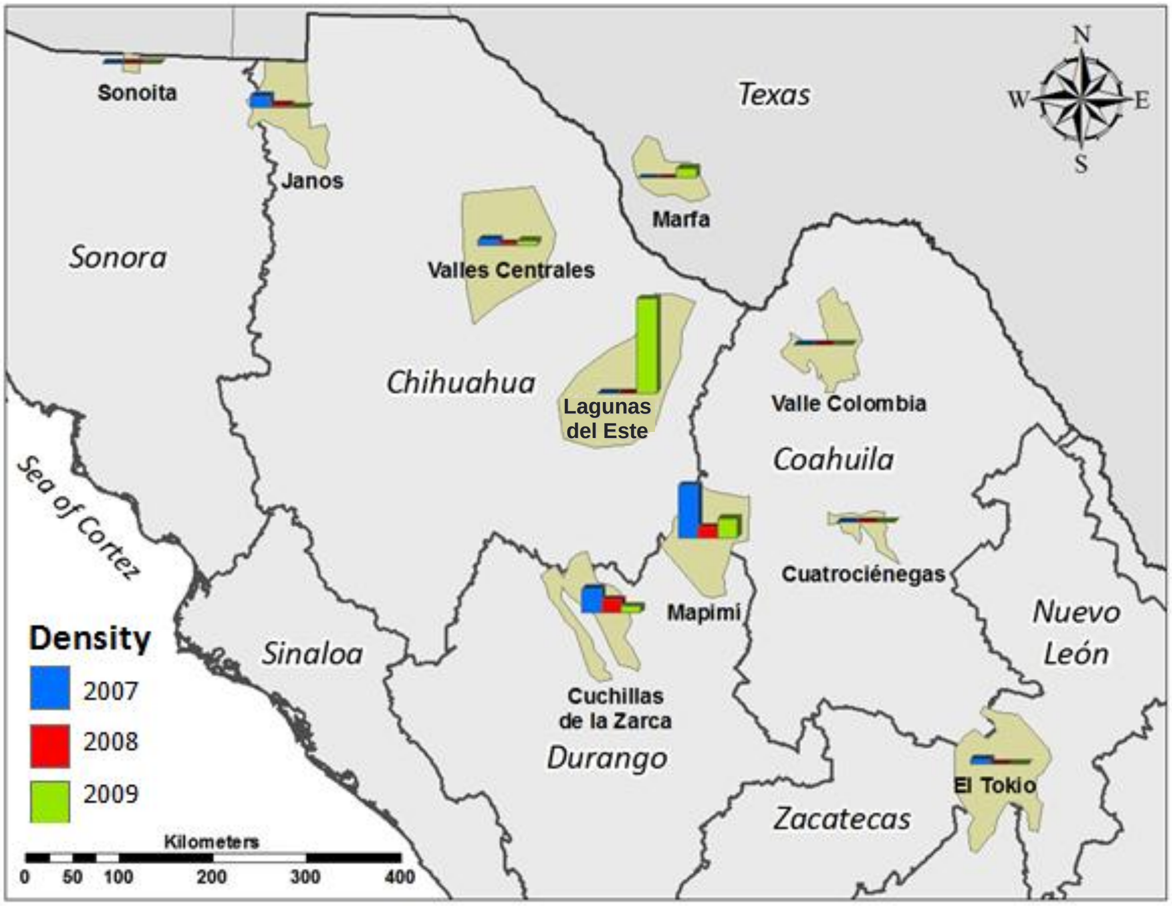
Clay-colored Sparrow appears to be concentrated in the central and southern portions of the Chihuahuan Desert, with highest densities in Cuchillas de la Zarca and Mapimí, and in 2009, Lagunas del Este. Between 2007 and 2008 there was a 68% decrease in the number of transects on which we detected it as well as a significant decrease in global density. Global density in 2009 increased significantly, likely due in part to the addition of Lagunas del Este to the sampling frame, where the species was very common. Clay-colored Sparrow abundance was positively influenced by shrub cover. Grass cover and 'other' cover also appeared to have a positive effect. Average cluster size was 7.2 birds, reflecting a strong propensity for flocking.





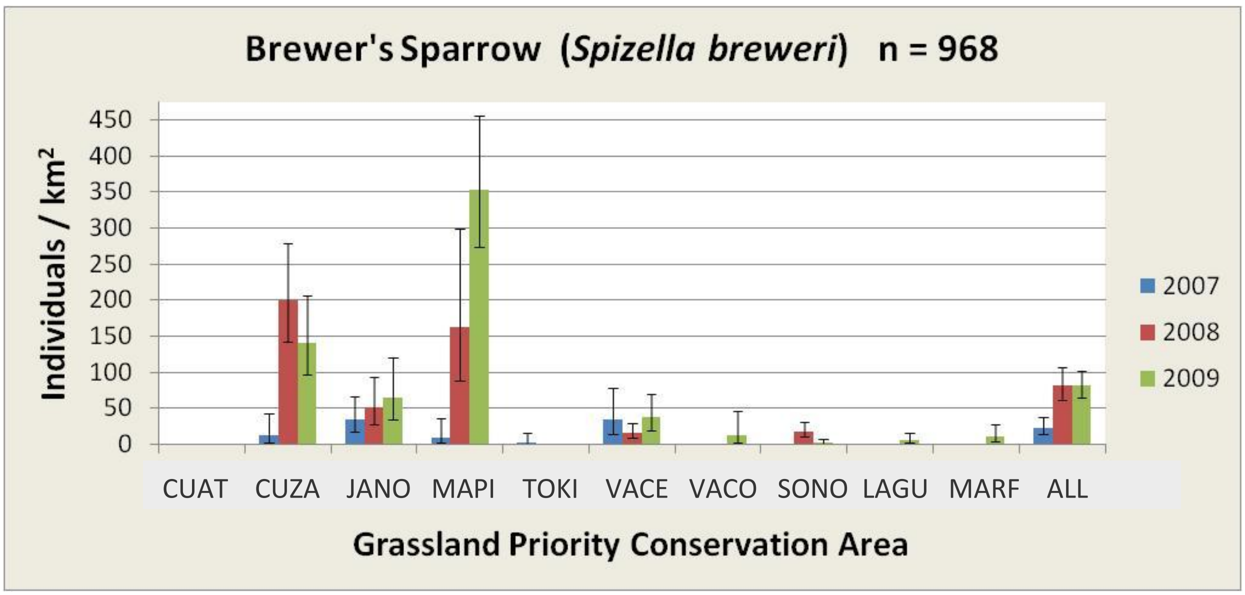
Shrub Cover

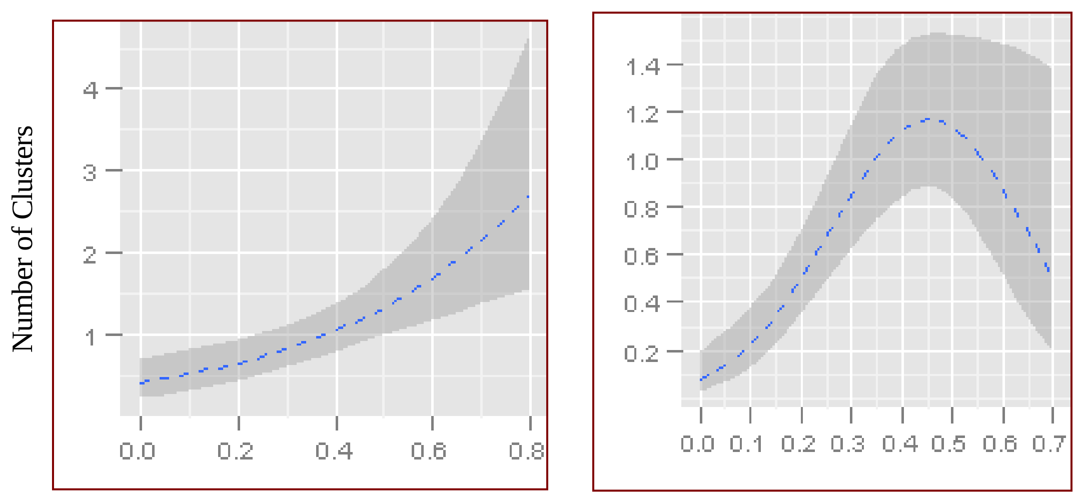
Clay-colored Sparrow (*Spizella pallida*)



Brewer's Sparrow (*Spizella breweri*)

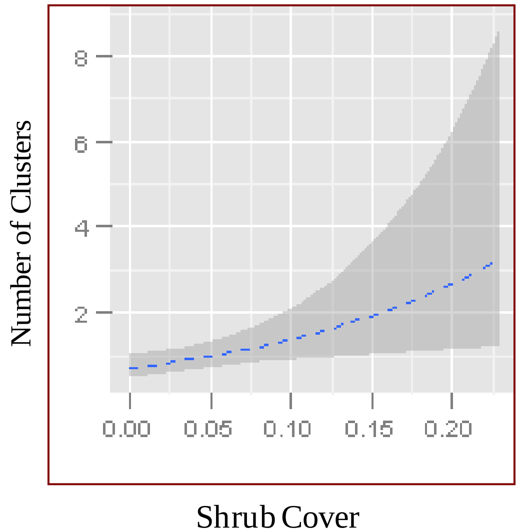
Brewer's Sparrow, while fairly widespread across the Chihuahuan Desert, appears to occur most regularly, and in highest density, in the southwestern-most GPCAs. We detected Brewer's Sparrow on 22% - 29% of transects each year. Wintering densities increased significantly in Cuchillas de la Zarca and Mapimí from 2007 to 2008, and remained high or increased further in 2009. Wintering densities in Janos and Valles Centrales appeared to be more stable, but lower. Global densities have roughly mirror the trends in Cuchillas de la Zarca and Mapimí, with significantly higher densities in 2008 and 2009 than in 2007. Brewer's Sparrow abundance was strongly and positively influenced by both shrub and grass cover, as well as the quadratic of 'other' cover. Average cluster size was 6.5 individuals, reflecting its propensity for flocking.

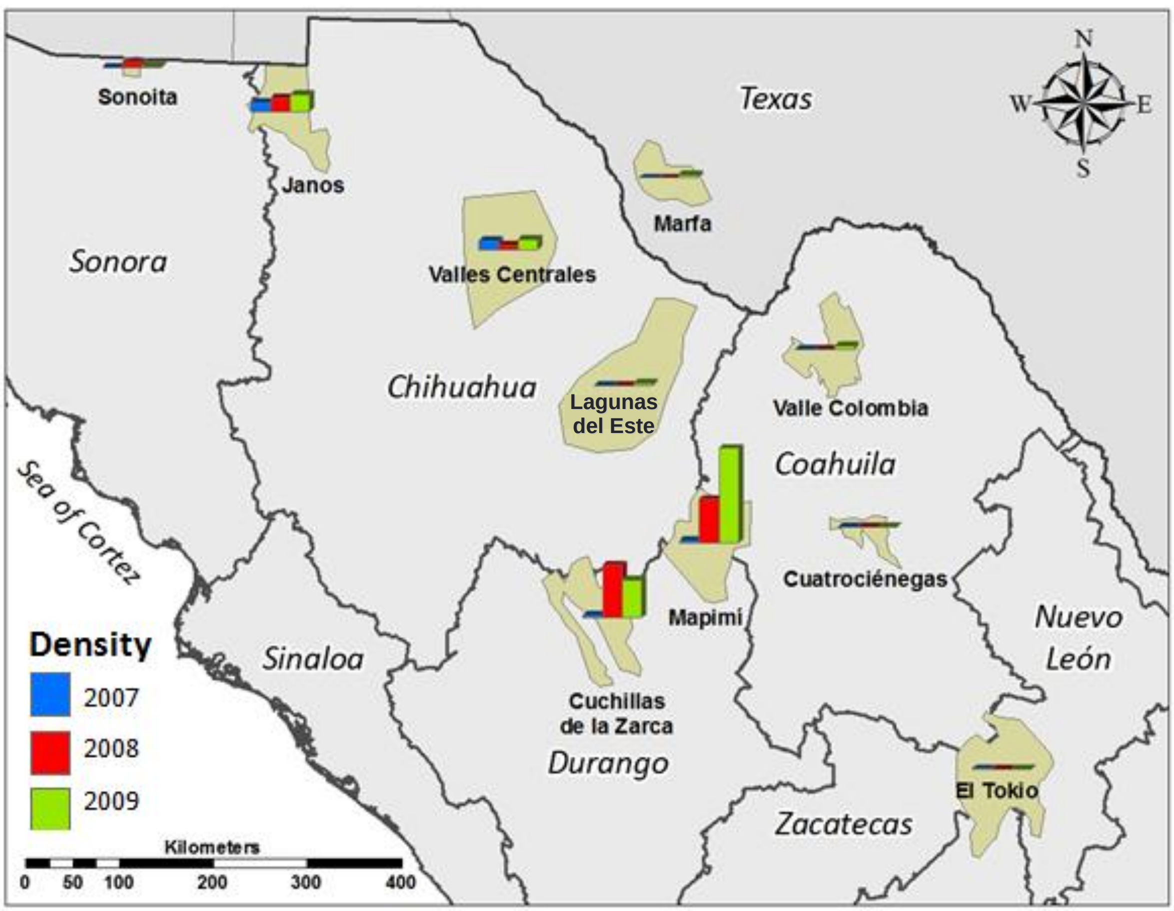




Grass Cover Other Cover

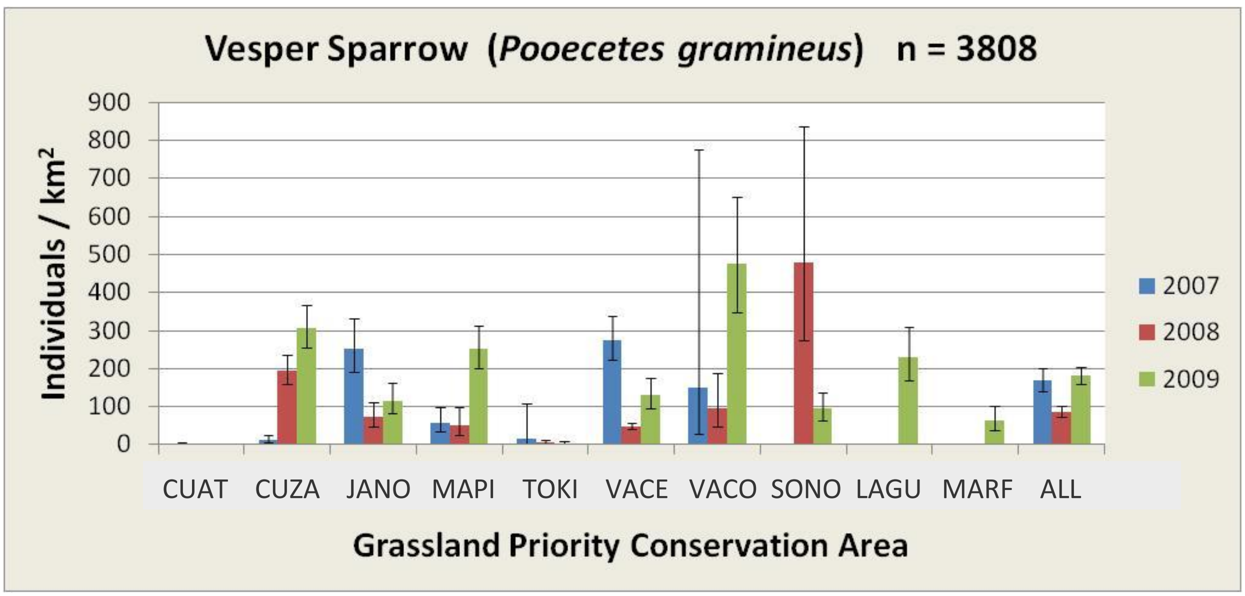
Brewer's Sparrow (*Spizella breweri*)



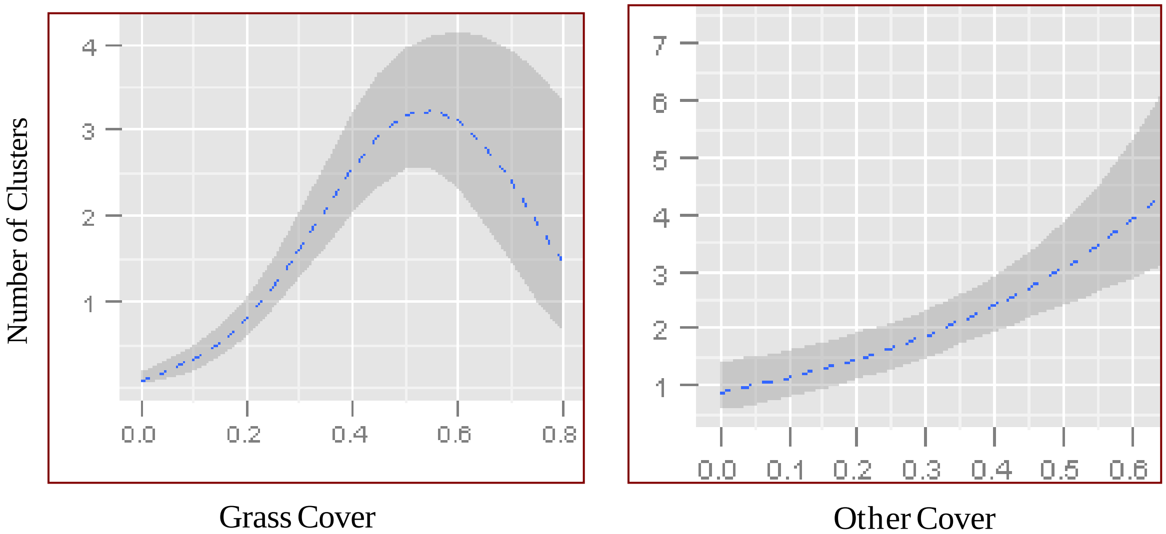


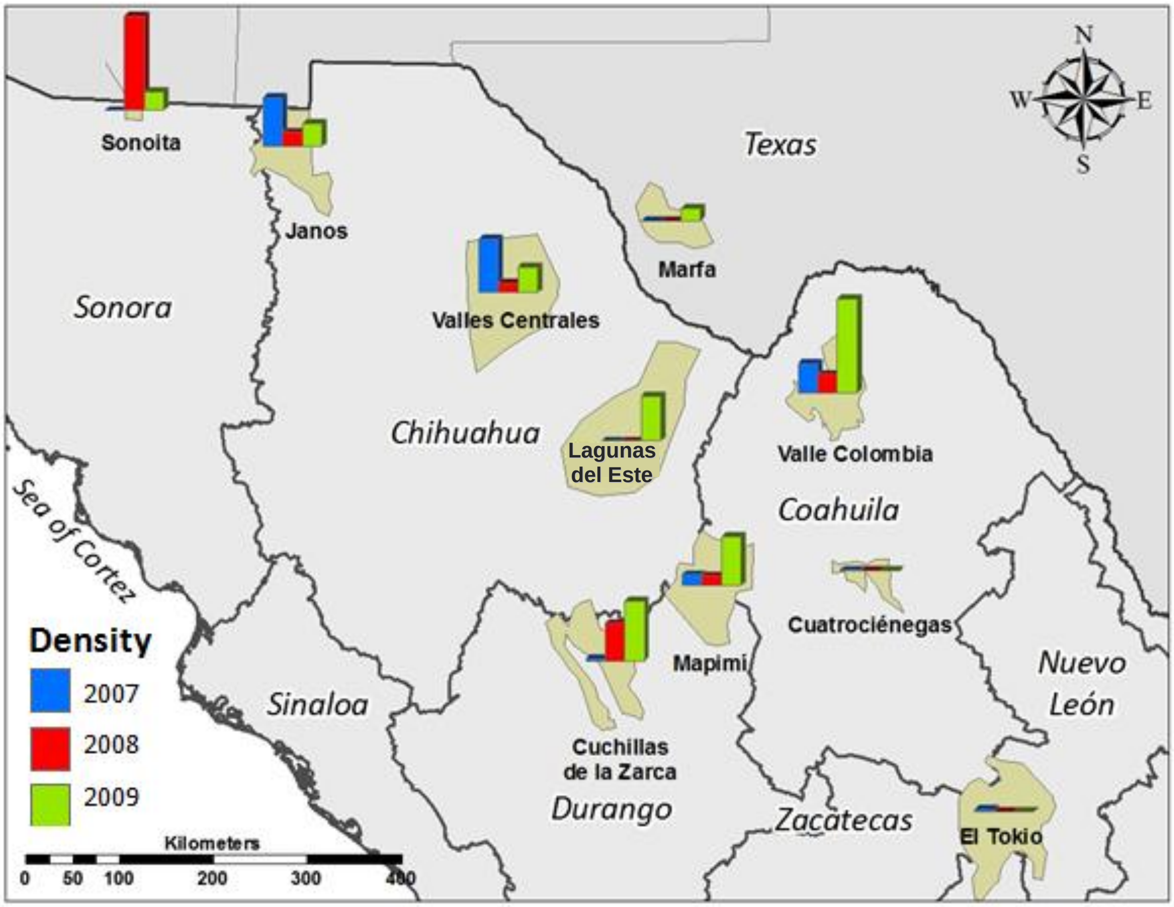
Vesper Sparrow (*Pooecetes gramineus*)

Vesper Sparrow is one of the most abundant and widely distributed wintering bird species in Chihuahuan Desert grasslands, except perhaps in El Tokio, where it is significantly less abundant, and in Cuatro Ciénegas, where it is essentially absent. We detected Vesper Sparrow on 70% of transects in 2007, 56% in 2008 and 61% in 2009. Population density appears to vary both locally and across the Chihuahuan Desert between years; there was a significant decrease in density from 2007 to 2008 and a significant, and nearly equal, increase from 2008 to 2009. While density decreased from 2007 to 2008 in Janos and Valles Centrales, density increased in Cuchillas de la Zarca, suggesting a southward shift in distribution between these years. Likewise density was very high in Sonoita in 2008, perhaps indicating a shift into these grasslands as well, although comparable estimates from 2007 are not available. There was a clear increase in density from 2008 to 2009 in Cuchillas de la Zarca, Mapimí, Valles Centrales, and Valle Colombia, while density decreased in Sonoita. Vesper Sparrow abundance was strongly influenced by grass cover up to about 55%, after which abundance declined with additional grass cover. Vesper sparrow abundance was also strongly positively influenced by 'other' cover. Average cluster size was 2.6 birds, suggesting a moderate propensity for forming loose flocks.



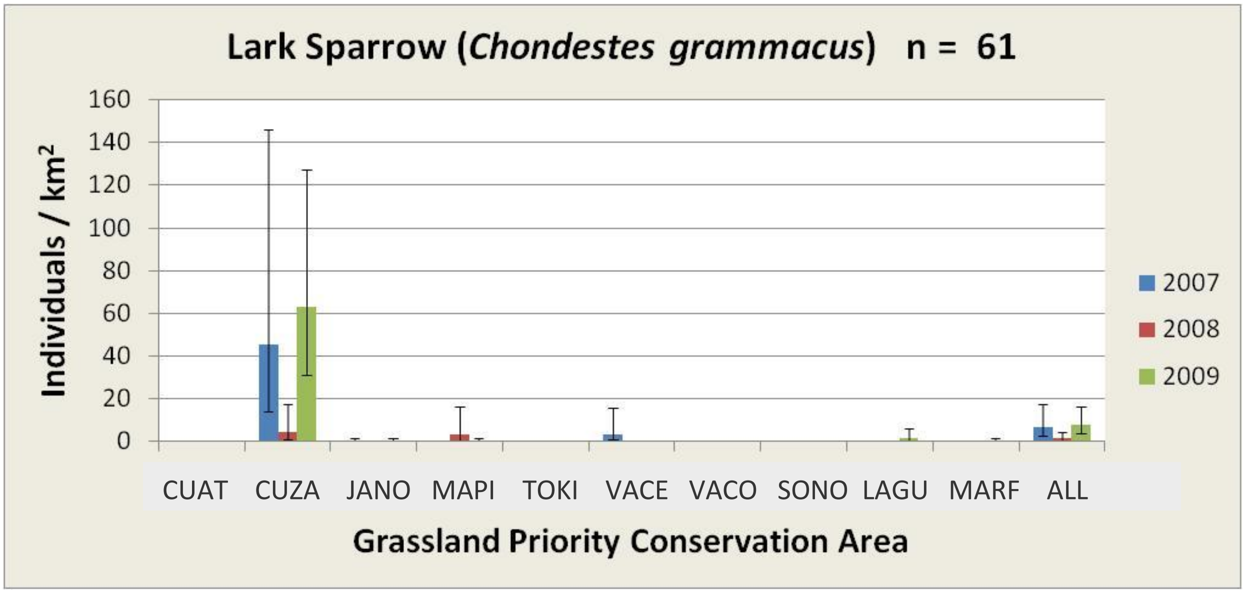
Vesper Sparrow (*Pooecetes gramineus*)



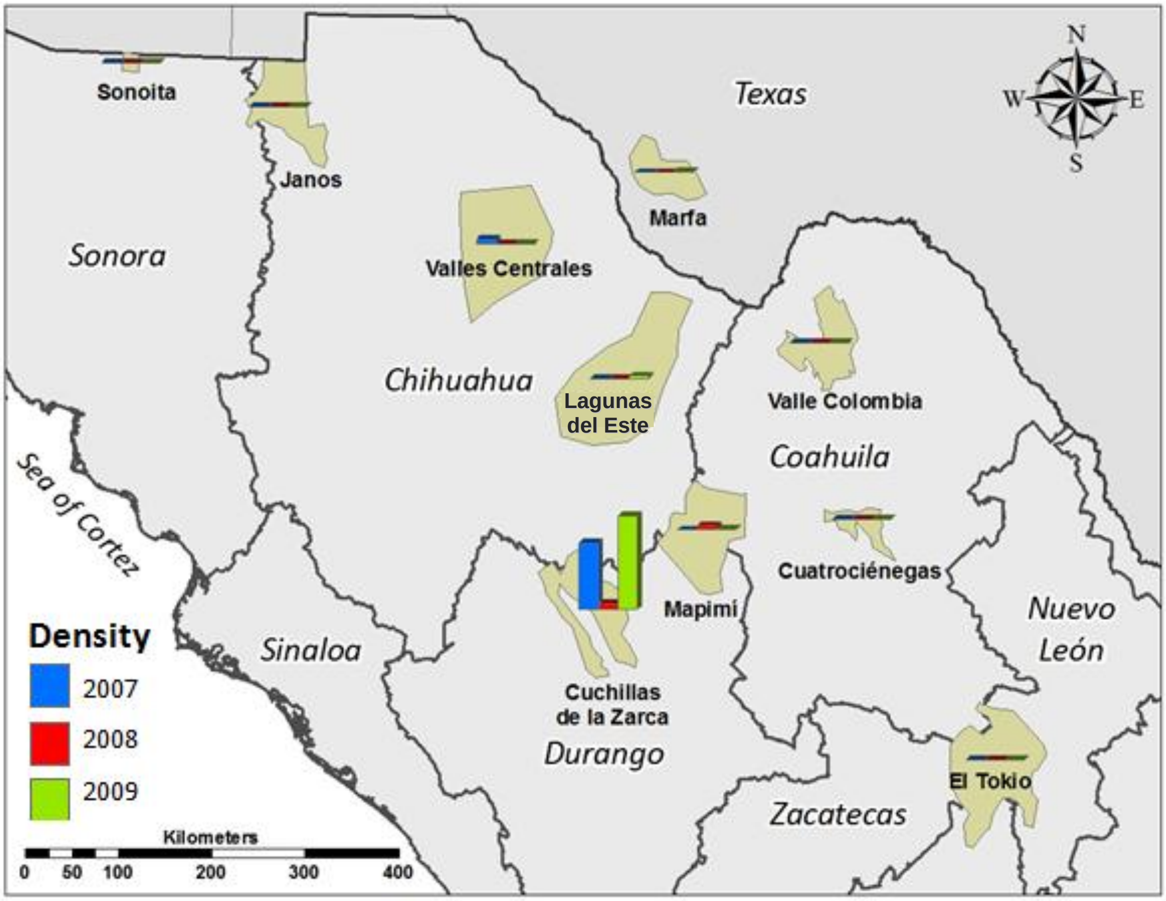

Sonoita
Janos
Texas
Marfa
Valles Centrales
Sonora
Chihuahua
Lagunas
del Este
Valle Colombia
Coahuila
Sea of Cortez
Mapimí
Cuatrociénegas
Density
2007
2008
2009
Sinaloa
Cuchillas
de la Zarca
Nuevo
León
Durango
Zacatecas
El Tokio
Kilometers
0 50 100 200 300 400
N
W
E
S

Lark Sparrow (*Chondestes grammacus*)

Lark Sparrow was rarely recorded in our study area in all years (<5% of transects). Cuchillas de la Zarca is the only GPCA where it was commonly detected, although in 2008 its density there was very low. There were scant observations in Janos, Mapimí, Lagunas del Este, and Marfa in 2009. The increase in global density from 2008 to 2009 is significant. It is likely that this species winters mainly outside of the Chihuahuan Desert region, or perhaps in shrubland, forested or disturbed habitats.

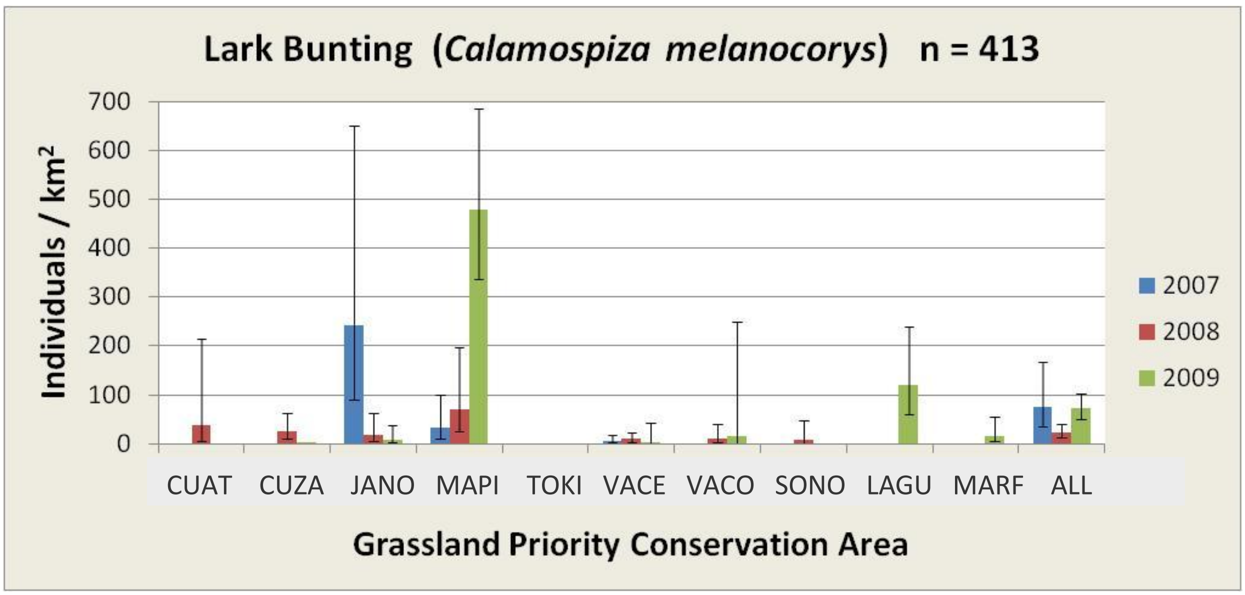


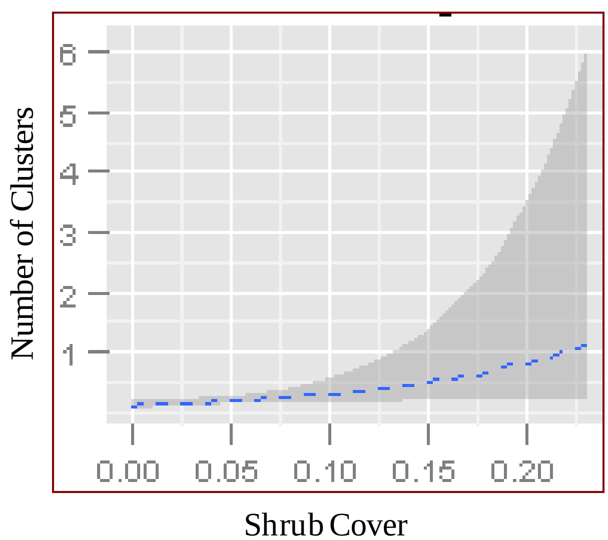
Lark Sparrow (*Chondestes grammacus*)



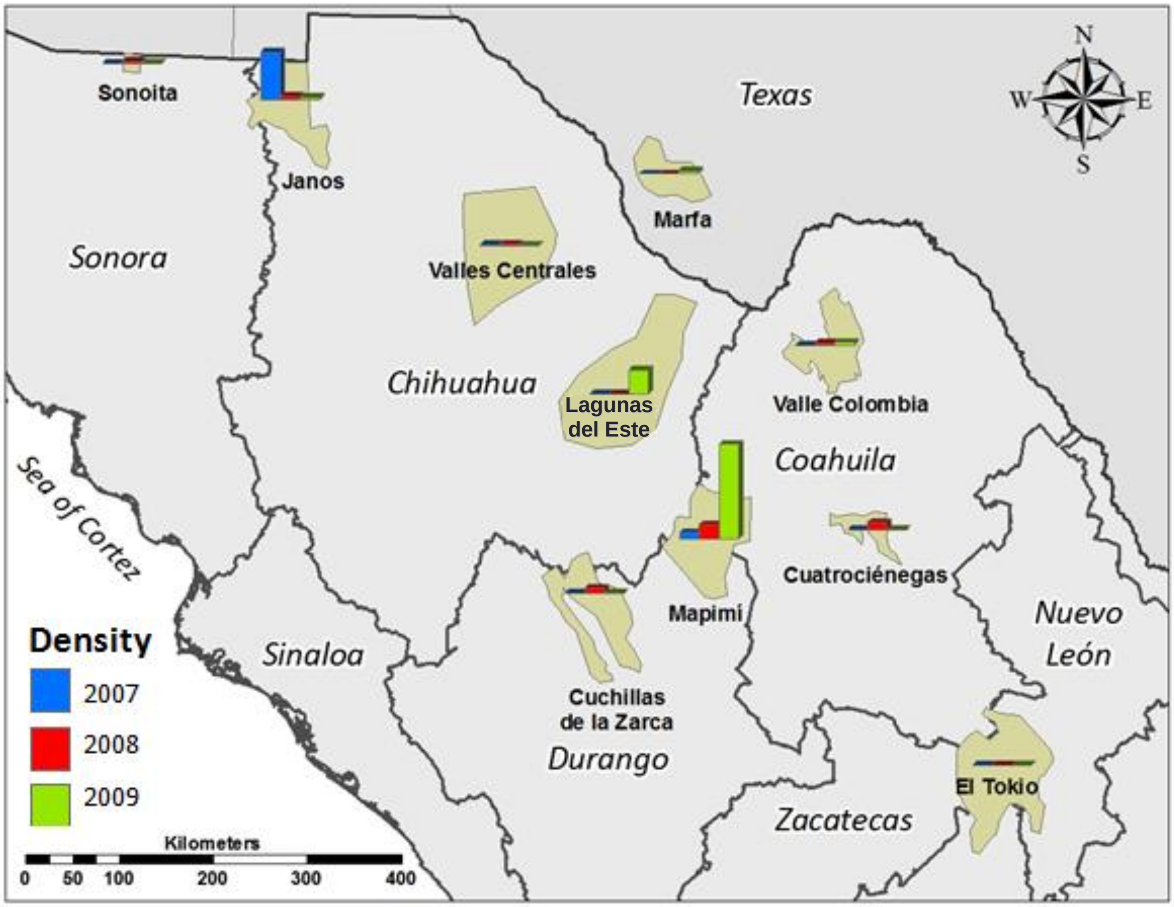
Lark Bunting (*Calamospiza melanocorys*)

Lark Bunting is a widespread winter resident and has been found in nine of the ten GPCAs since 2007. However, population densities appear to vary greatly both temporally and spatially. Across all study sites, there was a significant decrease from 2007 to 2008, followed by a nearly equal increase in 2009. However, the addition of Lagunas del Este as a new study area in 2009 contributed in part toward the observed increase. The proportion of transects on which it was detected also increased from 9% in 2008 to 15% in 2009. The high estimates in Janos in 2007 and Mapimí and Lagunas del Este in 2009 illustrate the wandering nature of this species, and the highly variable numbers observed. Average cluster size was 23.8 birds, reflecting a propensity for forming large flocks. Lark Bunting abundance was positively influenced by shrub cover.



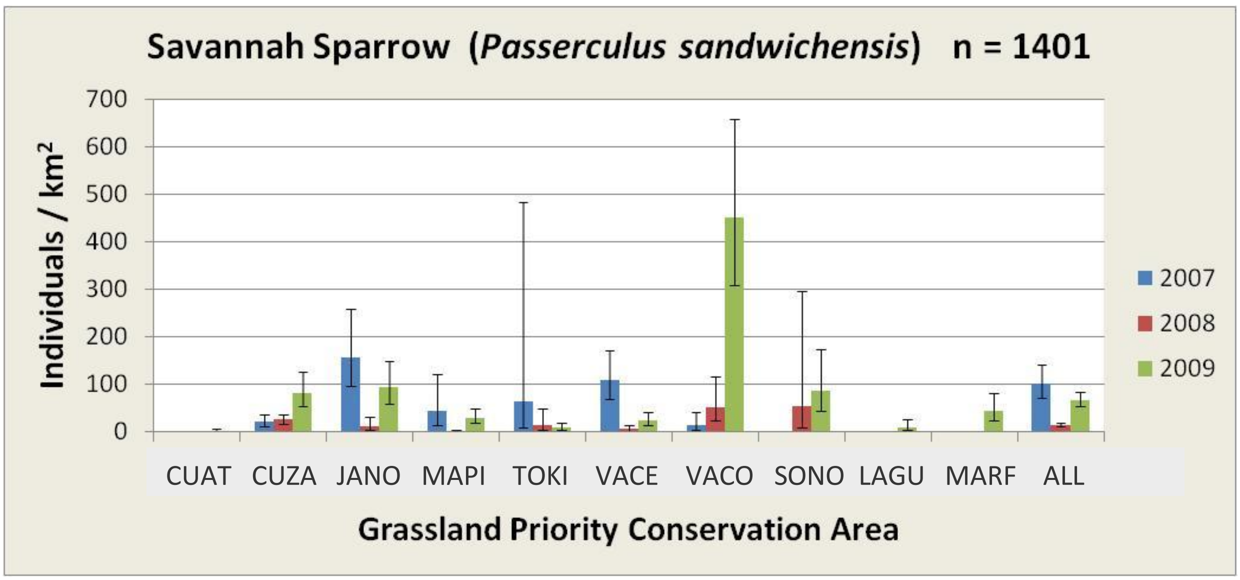


Lark Bunting (*Calamospiza melanocorys*)

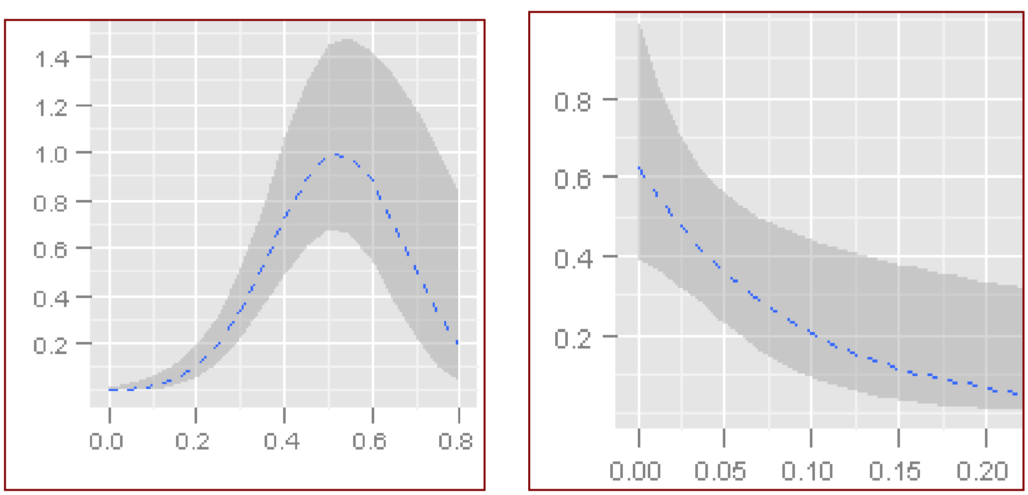


Savannah Sparrow (*Passerculus sandwichensis*)

Like many grassland birds in winter, Savannah Sparrow shows large swings in population density and distribution across the Chihuahuan Desert. We have found Savannah Sparrow in all GPCAs since 2007, although annual densities have varied greatly, both within and across GPCAs. Density across all GPCAs was highest in 2007, and dropped by roughly 85% in 2008, before increasing again in 2009. The percent of transects on which the species was observed also mirrored this pattern. Density was higher in Valle Colombia in 2009 than in any other GPCA in any year, and densities in all GPCAs were highly variable each year. Savannah Sparrow had a positive quadratic relationship with grass cover and was negatively influenced by shrub cover, demonstrating its preference for open grasslands with moderate levels of grass cover. Average cluster size was 2.1 birds, reflecting its propensity for forming loose flocks.



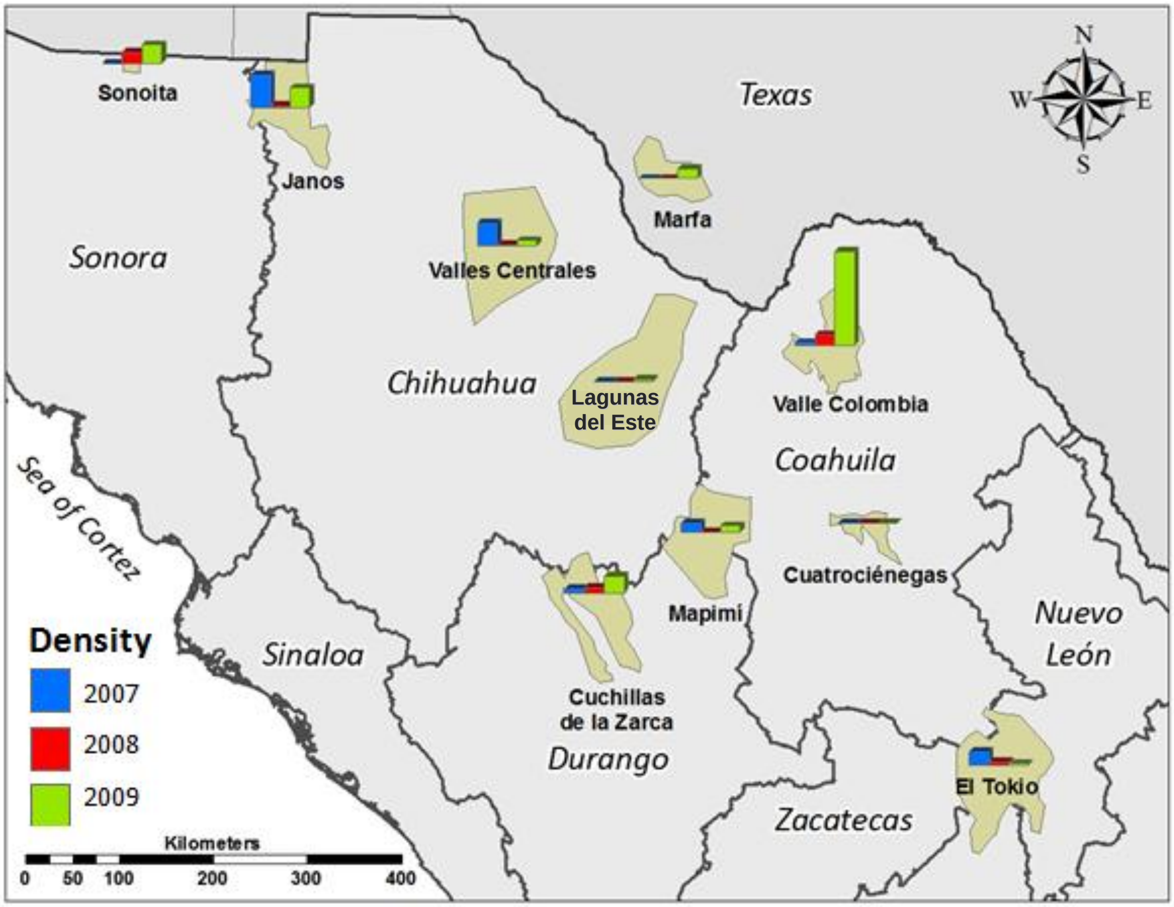
Number of Clusters



Grass Cover

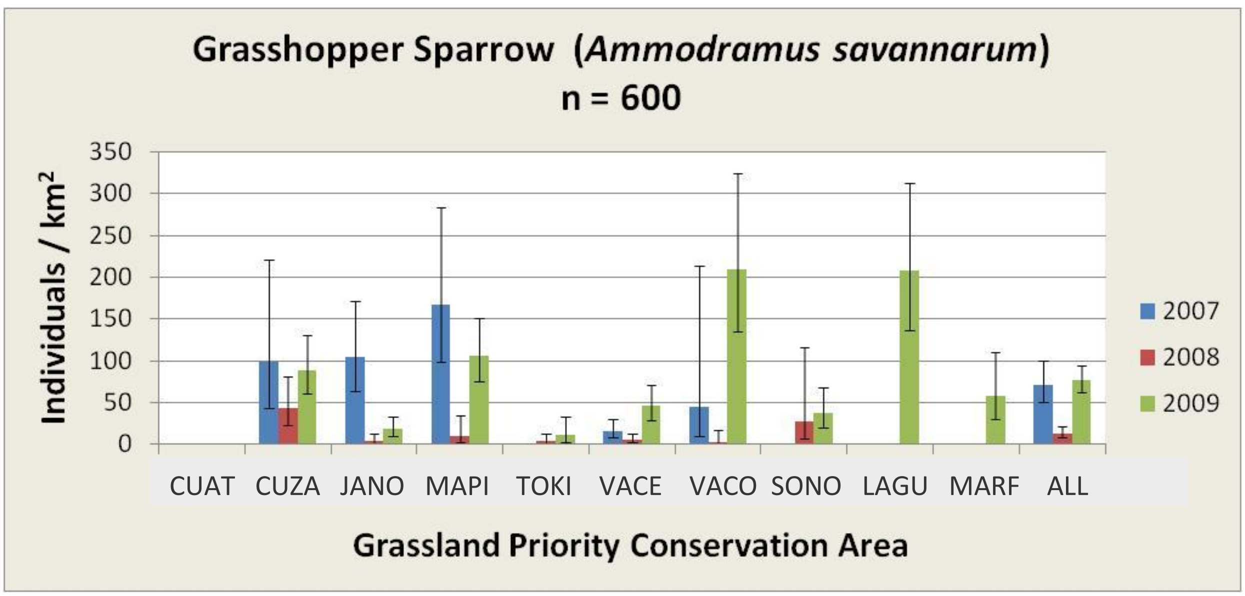
Shrub Cover

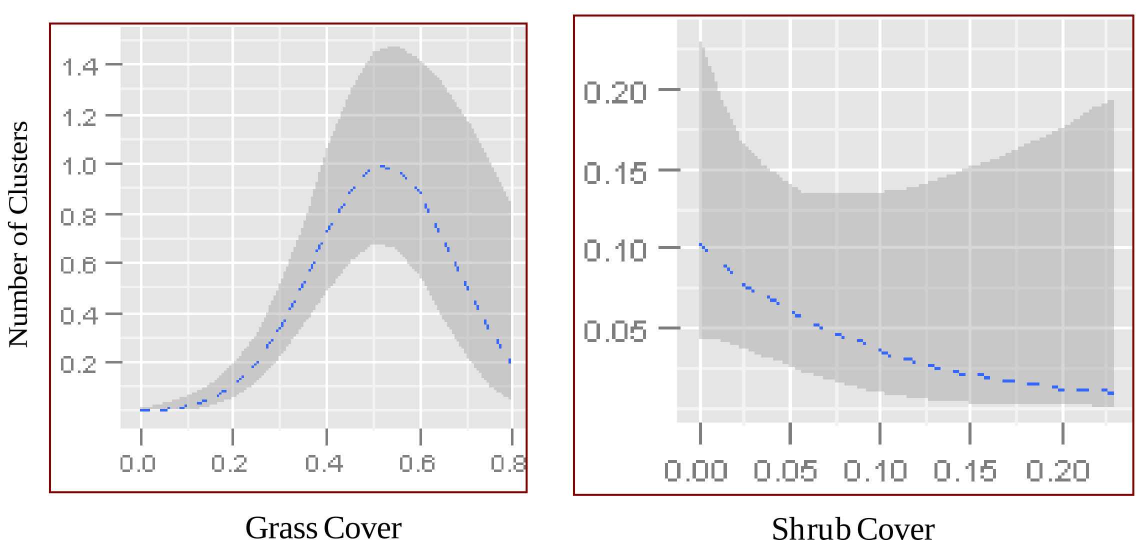
Savannah Sparrow (*Passerculus sandwichensis*)



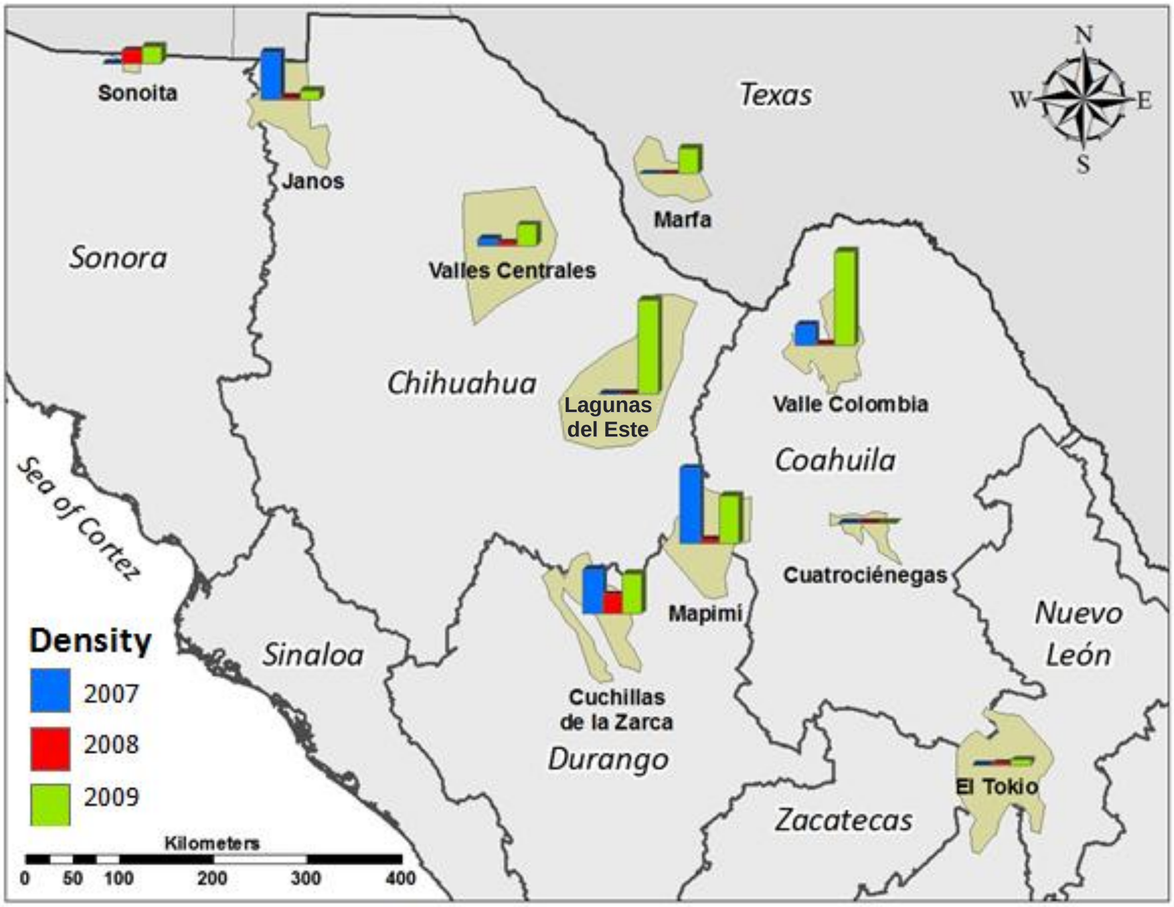
Grasshopper Sparrow (*Ammodramus savannarum*)

Grasshopper Sparrow is widespread and locally common in winter throughout the Chihuahuan Desert grasslands. We found Grasshopper Sparrow in nearly all GPCAs in all years except for Cuatro Ciénegas. However, local and global densities varied greatly among years. Global density dropped dramatically from 2007 to 2008, before rebounding to a similar level in 2009. These changes in density were reflected in most GPCAs as well. The percentage of transects on which we detected Grasshopper Sparrow also declined steeply from 2007 to 2008 (a 72% decrease), and similarly, rebounded in 2009. Densities were highest in Cuchillas de la Zarca, Janos, Mapimí, Valle Colombia and Lagunas del Este, although actual densities were likely higher still, given that many Grasshopper Sparrows detected are not identified to species, and instead are lumped with either *Ammodramus* spp. or *Ammodramus*/Savannah Sparrow (see accounts below for these groups). Grasshopper Sparrow had a strong quadratic relationship with grass cover and a weak negative relationship with shrub cover. Average cluster size was 1.2 birds, indicating its solitary nature.



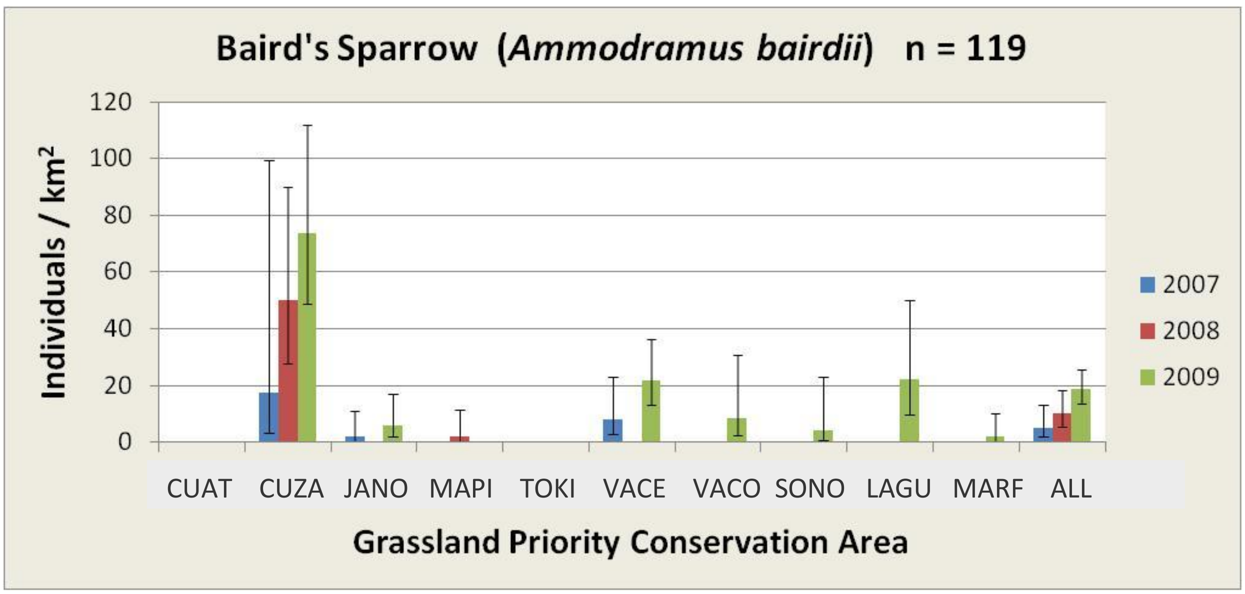


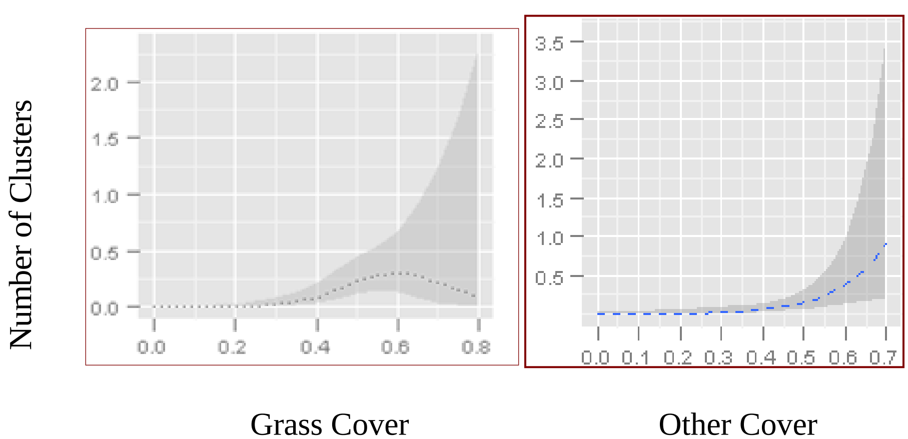
Grasshopper Sparrow (*Ammodramus savannarum*)



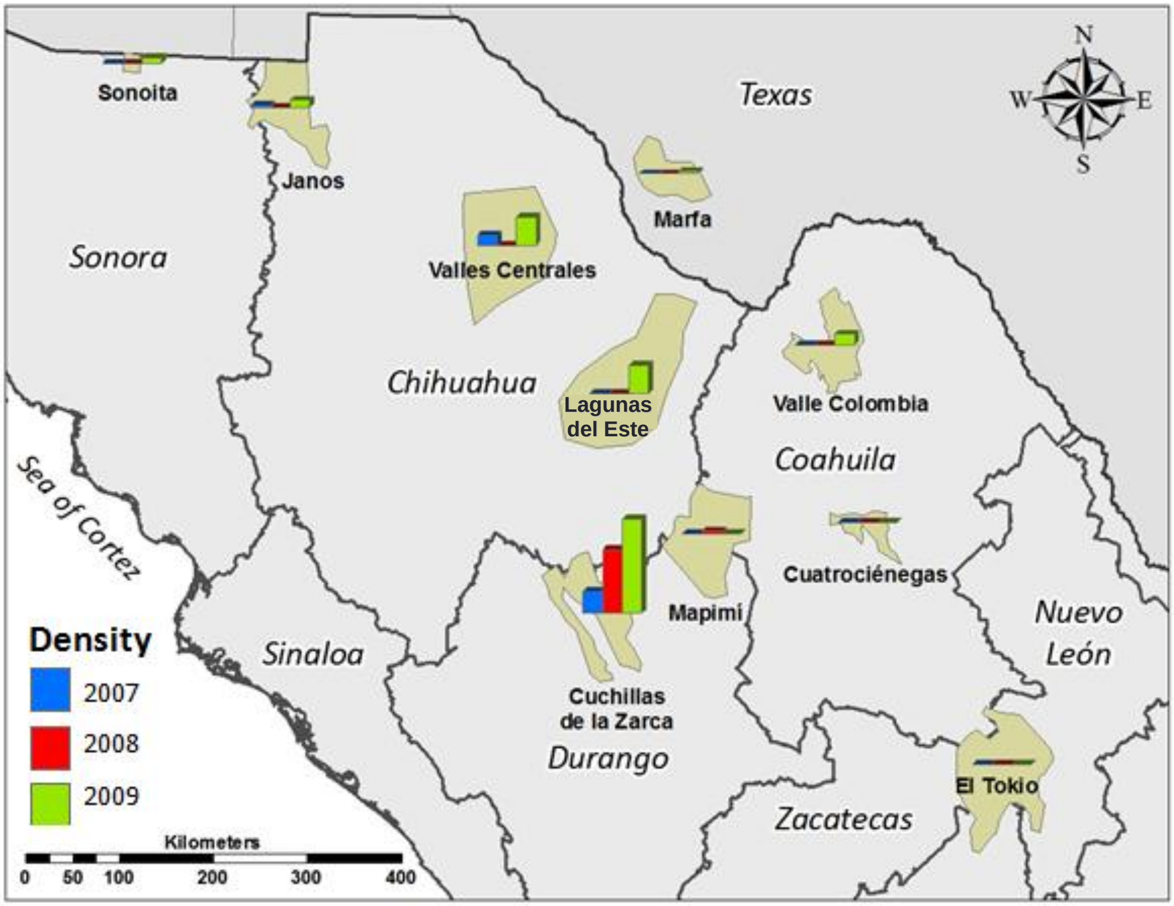
Baird's Sparrow (*Ammodramus bairdii*)

Baird's Sparrow has been found in most of the GPCAs, with the exception of El Tokio and Cuatro Ciénegas. However, densities in Cuchillas de la Zarca demonstrate the importance of the grasslands along the Sierra Madre foothills relative to the lower desert GPCAs. Our data suggest that Valles Centrales and Lagunas del Este are also of major importance to this species in some years. Baird's Sparrow density appeared to increase over time, both globally and in Cuchillas de la Zarca, but this may reflect in part an improvement in observer's identification abilities, as well as an expansion of sampling effort in the core of their wintering range in 2008. Baird's Sparrow abundance was strongly influenced by grass cover and 'other' cover and appears to require a significant amount of each. The parameter estimate for shrub cover was strongly negative, but since the confidence interval included zero, a clear relationship with shrubs could not be discerned. This lack of a significant relationship may be an artifact of low sample size in 2008; analysis of 2009 and 2010 data is needed. Baird's Sparrows were generally observed alone, as reflected by their average cluster size of 1.1 birds/observation.





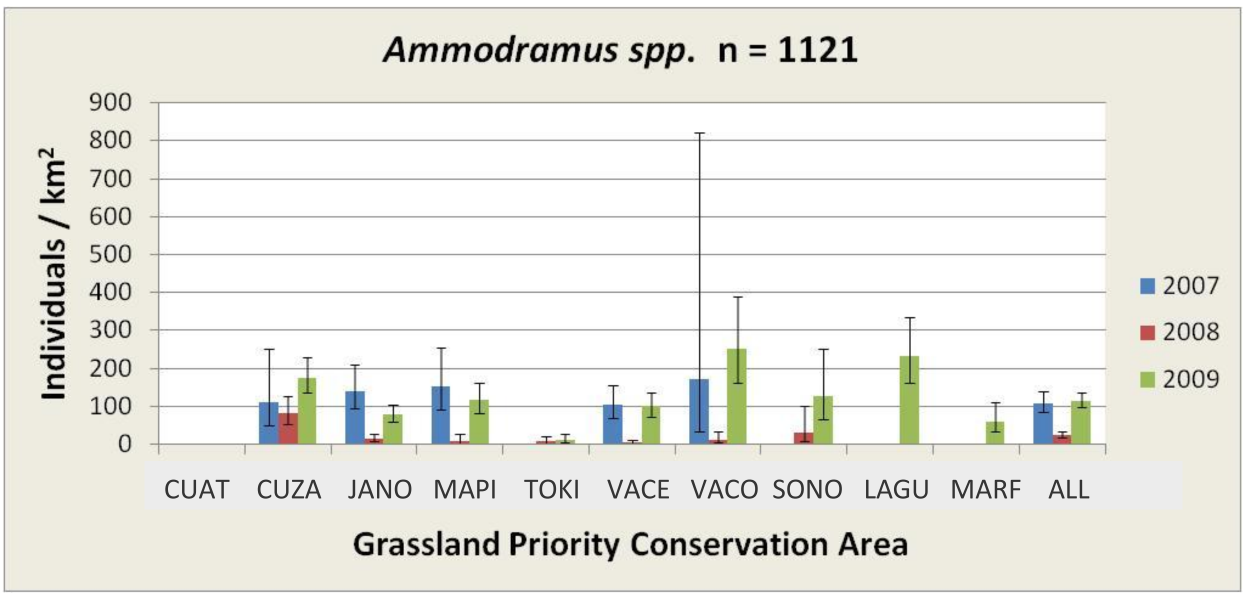
Baird's Sparrow (*Ammodramus bairdii*)



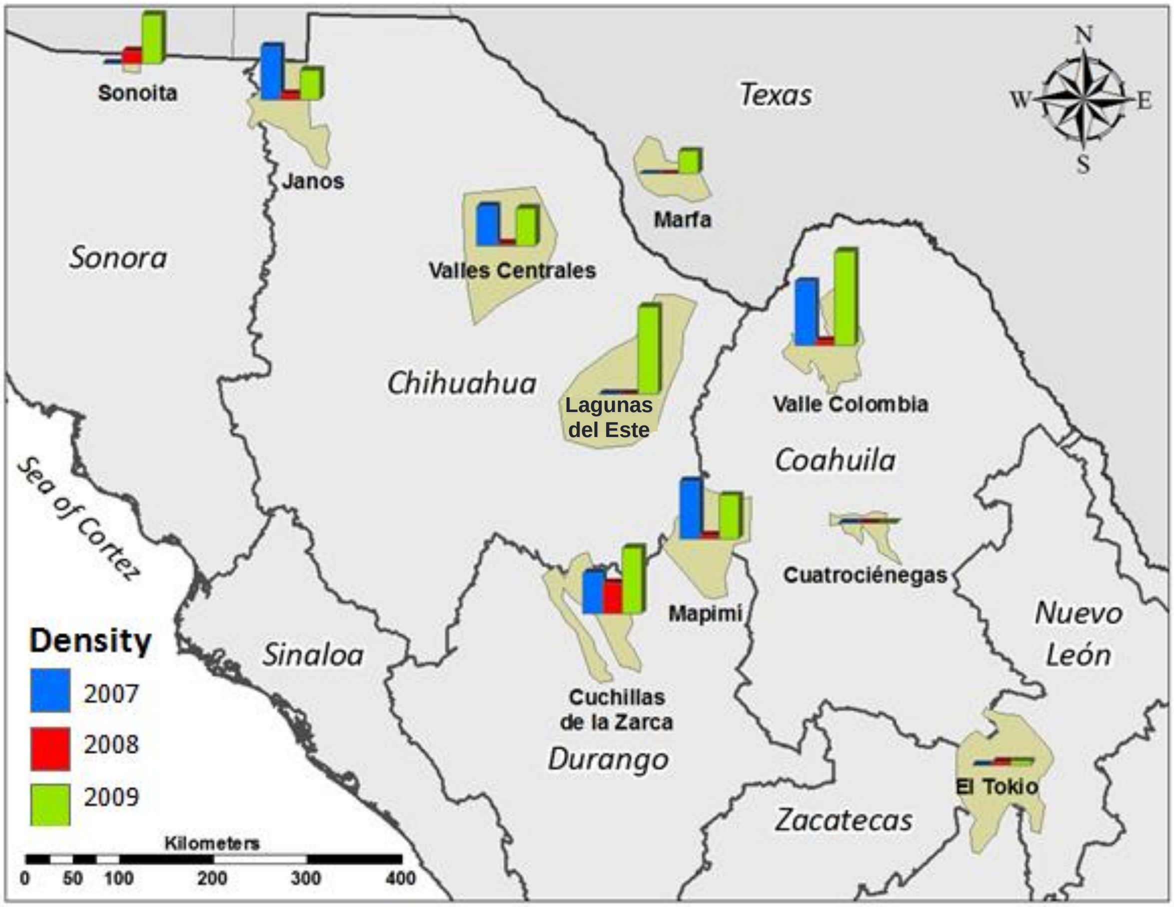
Ammodramus spp.

Ammodramus spp. is the aggregate of Grasshopper Sparrow, Baird's Sparrow, and unidentified sparrows of the genus *Ammodramus*. In addition to Baird's and Grasshopper Sparrows, 402 unidentified *Ammodramus* sparrows were recorded on transects since 2007. This genus was widely distributed throughout our study area with the exception of Cuatro Ciénegas. Similar to Baird's and Grasshopper Sparrows, there was a 65% decrease in the number of transects on which we detected *Ammodramus* spp. from 2007 to 2008. There was a significant global decrease (78%) in density between 2007 and 2008 and between 2008 and 2009 there was a significant increase in density, returning to the 2007 level. Between 2008 and 2009 there were also significant increases in Cuchillas de la Zarca, Janos, Mapimí, Valles Centrales, and Valle Colombia.

Note: The use of the '*Ammodramus spp*. or Savannah Sparrow' category was adopted in 2008 and may confound the interpretation of *Ammodramus spp.* densities when comparing 2008 and 2009 estimates to 2007 estimates, since the addition of the new broader category potentially reduced the use of *Ammodramus spp*. category in 2008 and beyond.

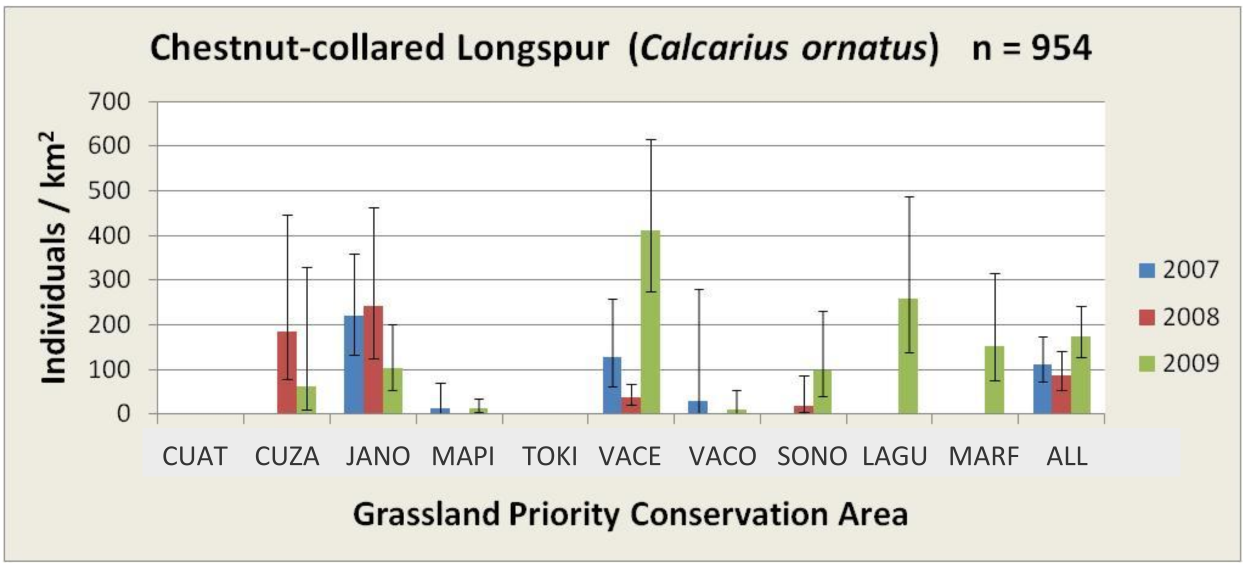


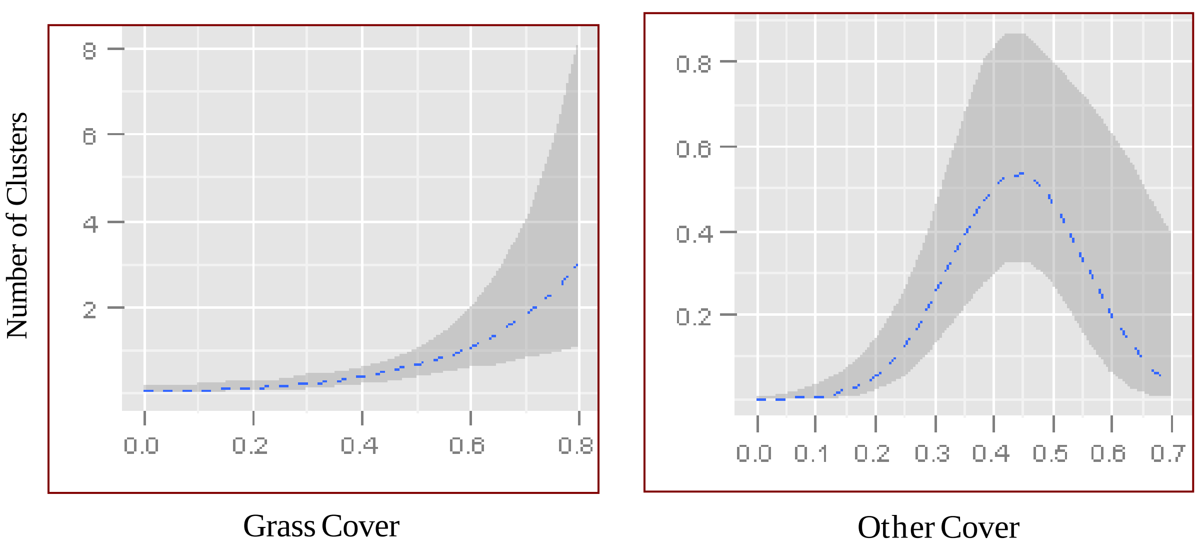
Ammodramus spp.



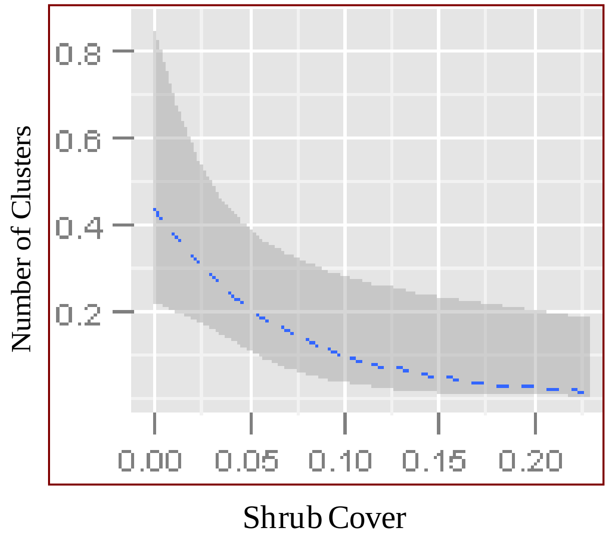
Chestnut-collared Longspur *(Calcarius ornatus)*

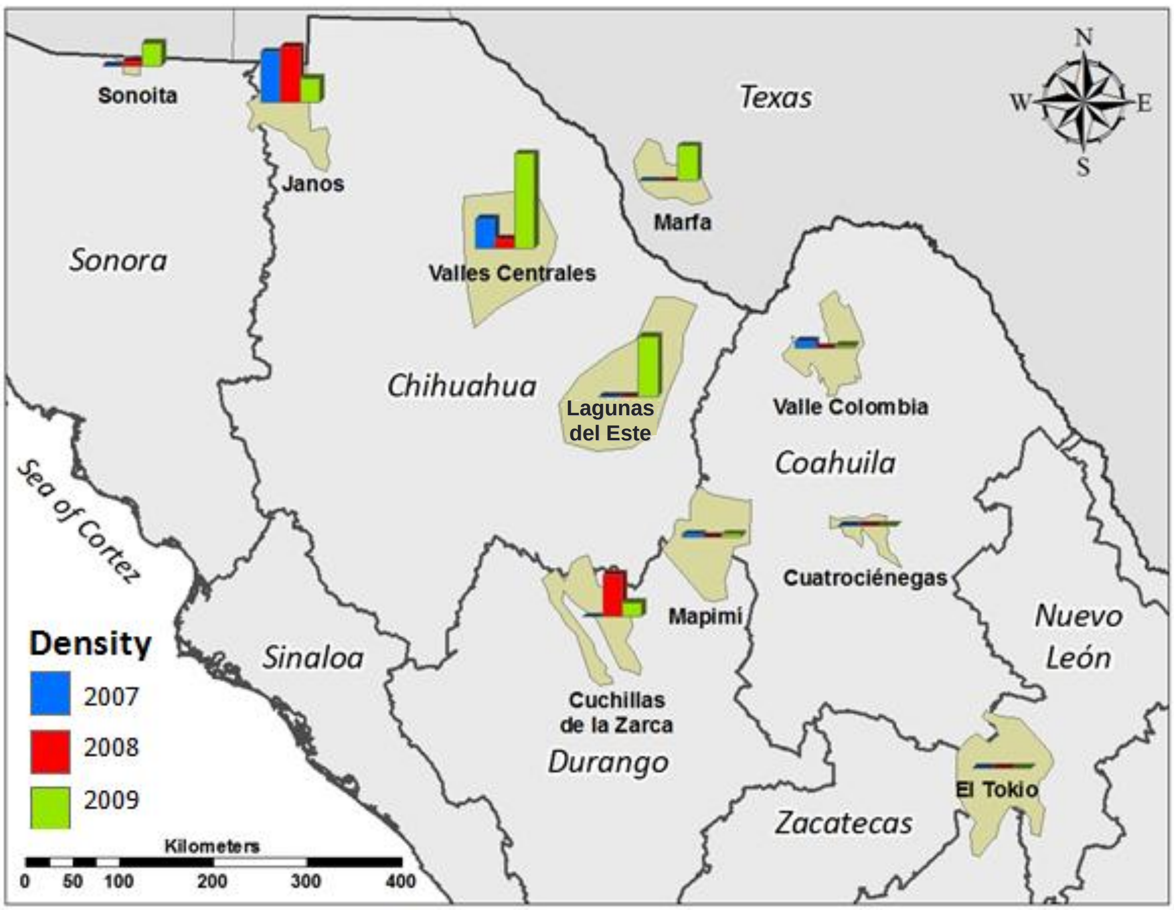
Chestnut-collared Longspur is distributed primarily in the northern and western Chihuahuan Desert grasslands, where it can be very common. It was the most numerous species recorded in both 2008 and 2009. The percentage of transects on which we detected it decreased from 27% in 2007 to 14% in 2008 although there was no significant decrease in global density between those years, perhaps due in part to an apparent population shift into the Cuchillas de la Zarca GPCA. Between 2008 and 2009 there was a significant increase in global density, due in part to the addition of the two new study areas in the northern Chihuahuan Desert, although there was also a notable increase in Valles Centrales. Based on our habitat use analyses, Chestnut-collared Longspur are most likely to be found in grasslands with extensive grass cover, few shrubs, and moderate amounts of other ground cover. Average cluster size was 23.8 birds, reflecting its propensity for forming large flocks.





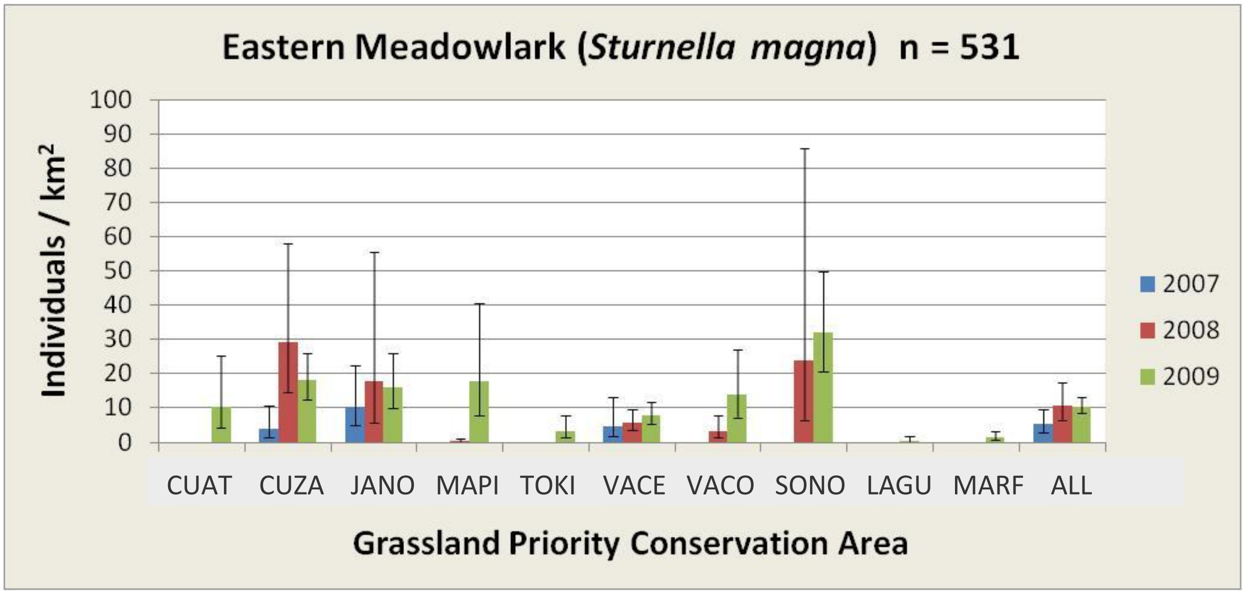
Chestnut-collared Longspur (*Calcarius ornatus*)

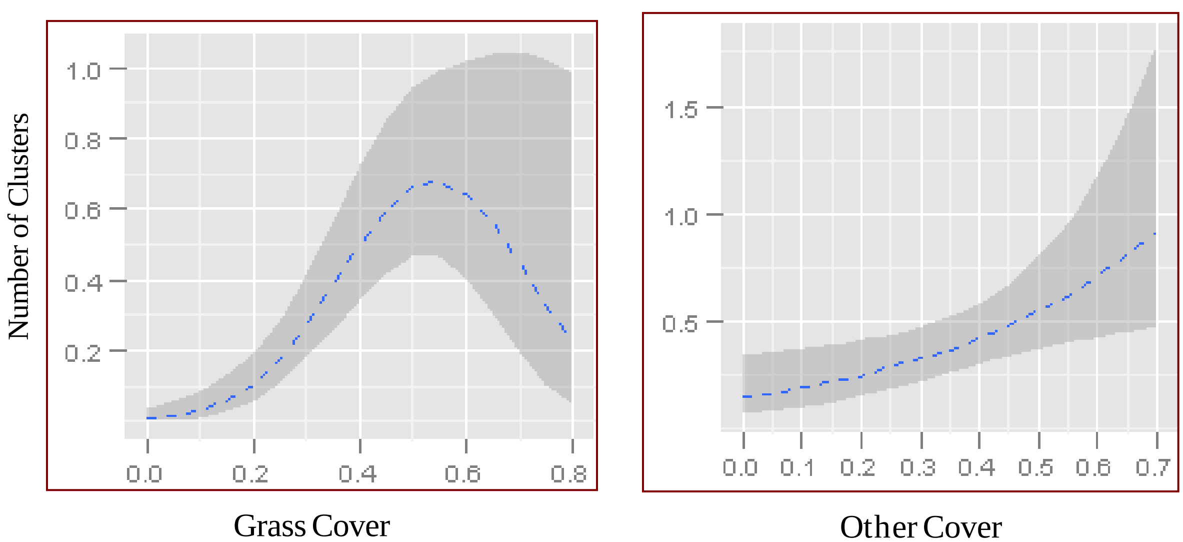




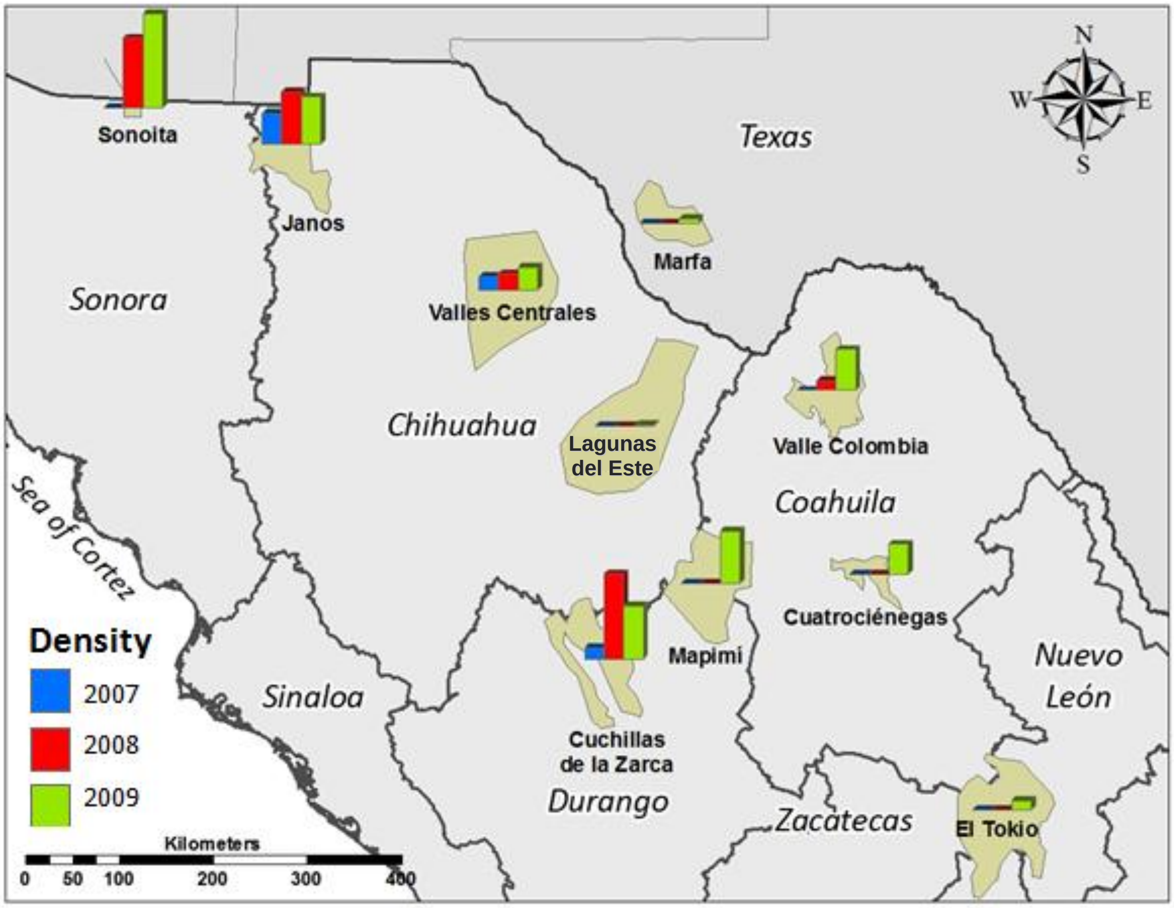
Eastern Meadowlark (*Sturnella magna*)

Eastern Meadowlark (ssp. *lilianae*) is the dominant meadowlark species in most of the Chihuahuan Desert, with the exception of the northeastern GPCAs of Lagunas del Este, Valle Colombia and Marfa, where Western Meadowlarks far outnumber Eastern Meadowlarks. We found Eastern Meadowlark in every GPCA in 2009. The percentage of transects on which we have detected it increased from 2007 (17%) to 2009 (30%), as did global density, perhaps due in part to better identification abilities of observers from improved training and more experience. There was also a significant increase in density from 2008 to 2009 in Mapimí and Valle Colombia. Eastern Meadowlark abundance increased linearly with ‘other cover’ and with grass cover up to about 55%, after which abundance declined with increased grass cover. Average cluster size was 2.8 birds, suggesting a strong propensity for forming small to medium-sized flocks.



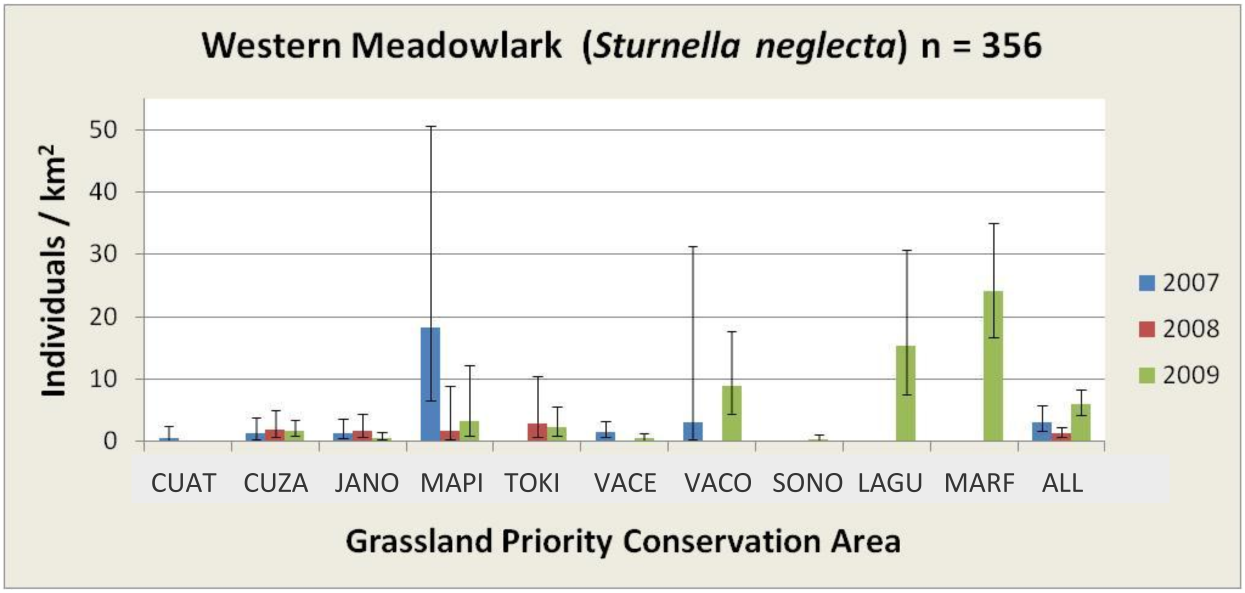


Eastern Meadowlark (*Sturnella magna*)

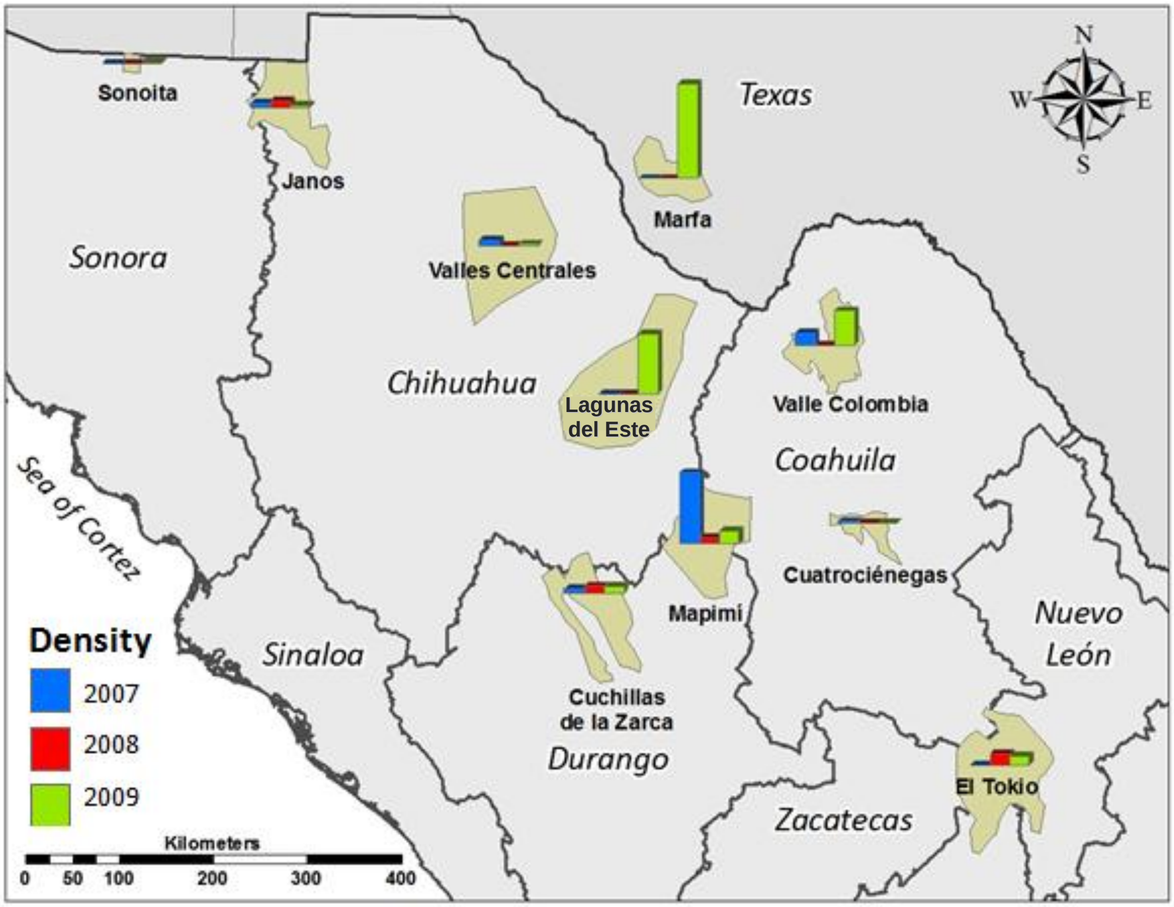


Western Meadowlark (*Sturnella neglecta*)

Despite being significantly less abundant than Eastern Meadowlark in most places, we found Western Meadowlark in every GPCA. Western Meadowlark becomes dominant in the northeastern GPCAs over Eastern Meadowlarks, and the addition of Lagunas del Este and Marfa in 2009 is likely responsible in large part for the observed increase in global density from 2008 to 2009. The percentage of transects on which we detected Western Meadowlark paralleled the trend seen in our density estimates (13% in 2007, 4% in 2008, and 20% in 2009). There were insufficient observations in 2008 to include this species in our habitat relationship modeling.

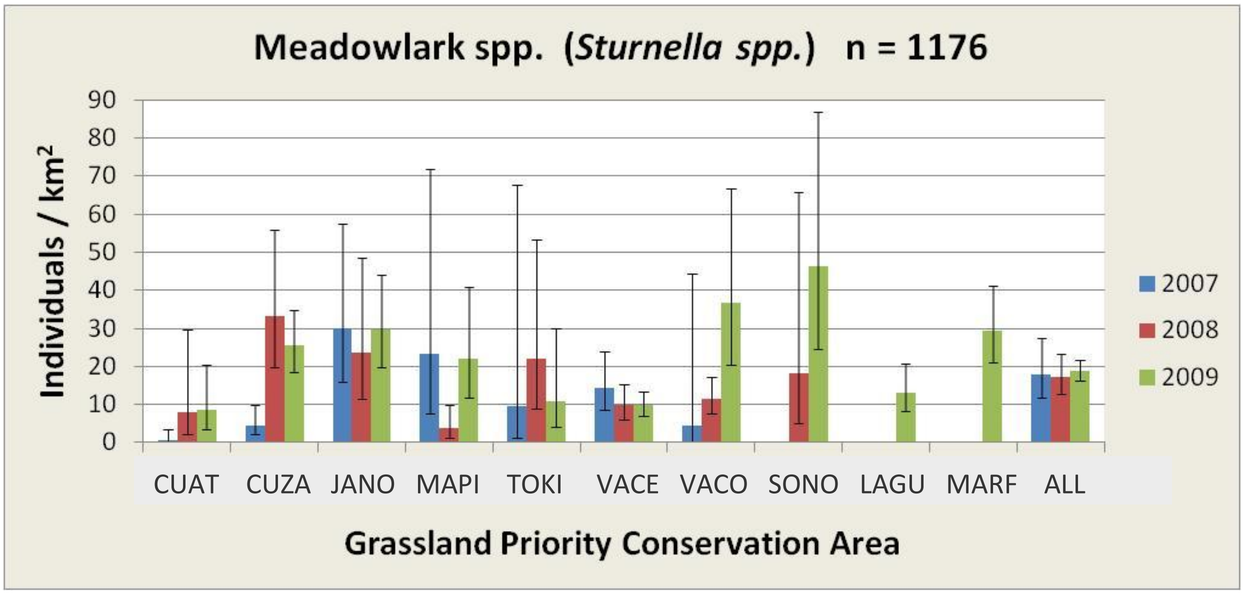


Western Meadowlark (*Sturnella neglecta*)

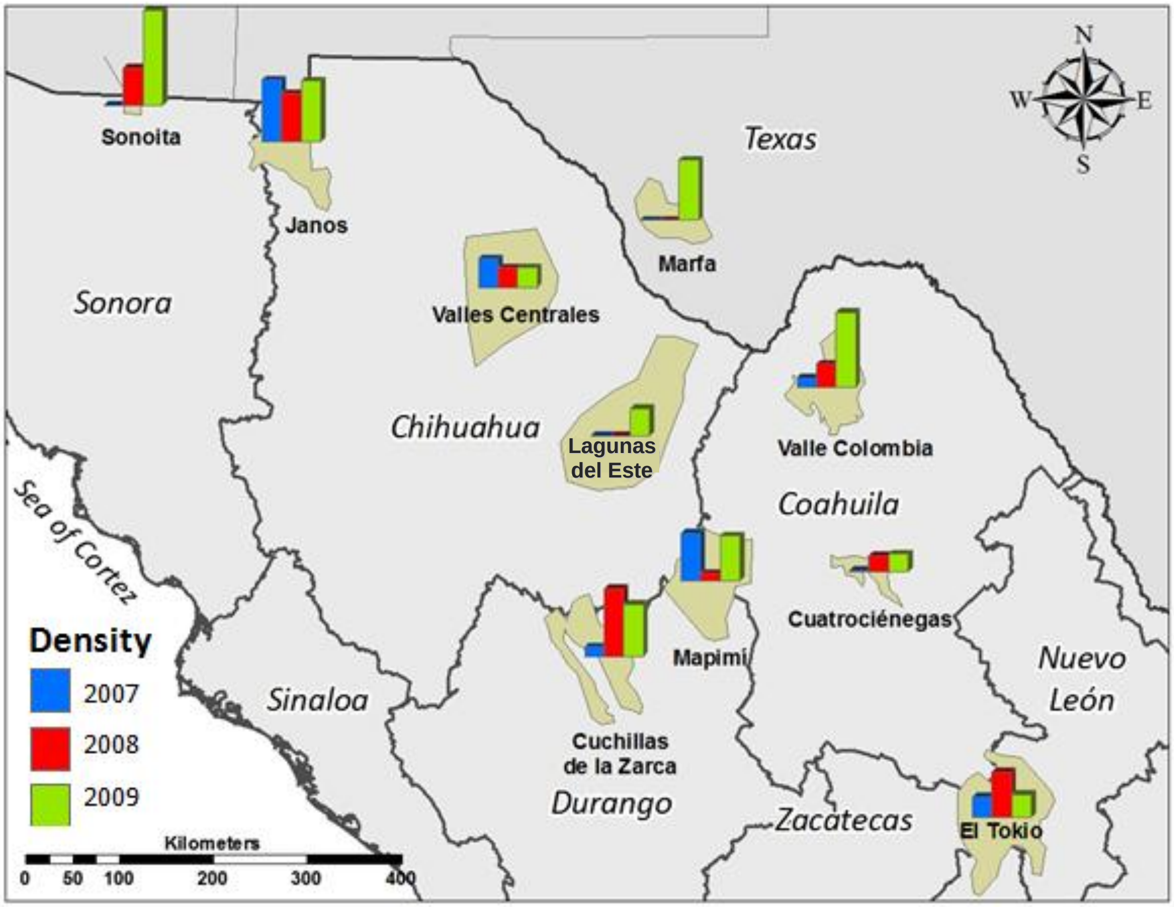


Meadowlark spp. (*Sturnella spp*.)

Meadowlark spp. is the aggregation of Eastern Meadowlark, Western Meadowlark, and unidentified meadowlarks (*Sturnella sp.*). Species from this genus are difficult to identify without decent views or audible calls and therefore a significant proportion of *Sturnella* observation are not identified to species. This genus was widely distributed throughout the entire study area. The global density across the three years has remained constant with no significant changes between any years, although confidence limits around the point estimates have narrowed each year. Within GPCAs there were only two significant changes between 2008 and 2009, in Mapimí and Valle Colombia, and both were positive.

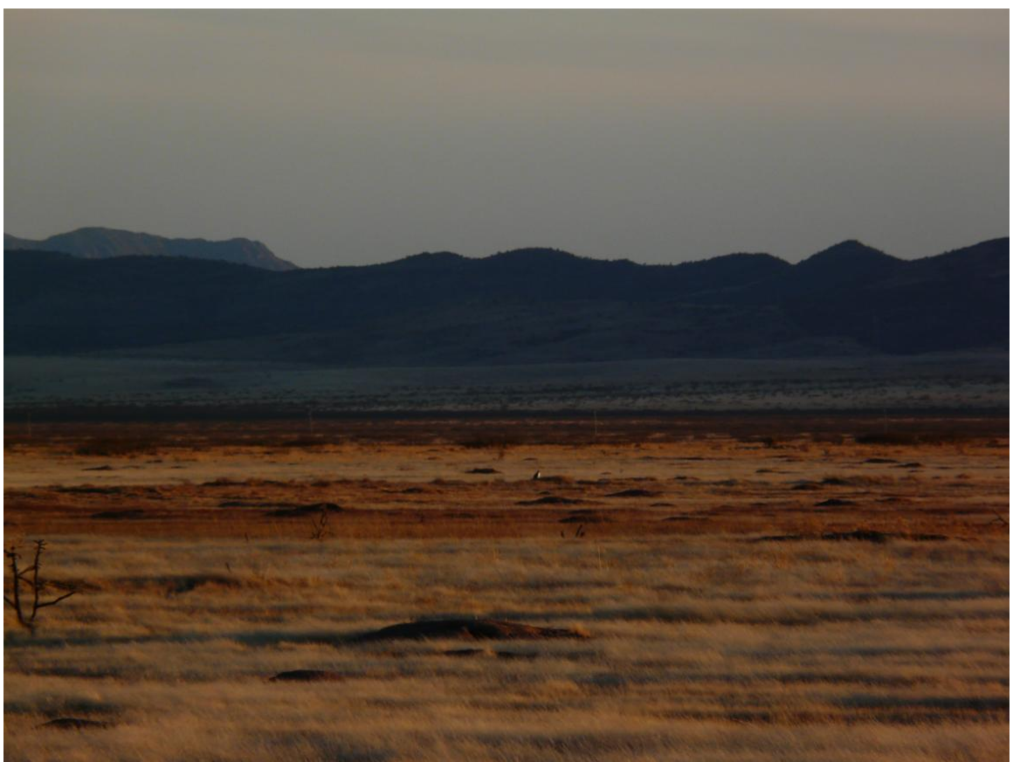


Meadowlark spp. (*Sturnella spp*.)



APPENDIX F. PHOTOS FROM THE FIELD.

Baird's Sparrow at El Uno Ecological Reserve, Janos, Chihuahua (Photo: Arvind Panjabi)



Ferruginous Hawk on prairie dog colony at El Uno Ecological Reserve (Photo: Arvind Panjabi)

Training at The Nature Conservancy's Reserva Ecológica 'El Uno'. Janos, Chihuahua. January 2010. (Photo: Greg Levandoski)

Poor grazing management on communally-owned lands near Janos, Chihuahua. (Photo: Greg Levandoski)

Ferruginous Hawk in a prairie dog colony with encroaching agriculture in Janos, Chihuahua. Winter 2009. (Photo: Greg Levandoski)

Center pivot irrigation system for cattle grazing with shrub invaded grasslands in the background. Janos, Chihuahua. Winter 2009. (Photo: Greg Levandoski)

Grassland destruction in the Valles Centrales of Chihuahua, 2010. (Photo: Alberto Macias-Duarte)

Inter-seeding restoration efforts on Rancho El Berrendo, Janos Chihuahua. February 2007. (Photo by Lucas Foerester.)

Two years post-interseeding on Rancho El Berrendo, Janos Chihuahua. Winter 2009. (Photo: Greg Levandoski)

Grassland fragments in the Temosachic Valley, Chihuahua, March 2008. (Photo: Greg Levandoski)

Near complete invasion by mesquite. Janos, Chihuahua. Winter 2007. (Photo: Greg Levandoski)

Rancho Las Palmas, near the U.S. border. Janos, Chihuahua. February 2007. (Photo: Greg Levandoski)

Rancho Las Carretas in the Sierra Madre foothills. Janos, Chihuahua. February 2008. (Photo: Greg Levandoski)

Gypsophytic grasslands in El Tokio. January 2010. (Photo by: UANL)