Florida – Friday, February 10th 1-3:00 PM

Wildlife Student Paper Competition

Nonnative grasses affect habitat selection of grassland birds, decoupling density and nest success

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Oral Presentation

Habitat selection is the behavioral process that animals use to identify and settle areas that provide the resources and environmental conditions they need to survive and reproduce. Because animals often need to identify habitat before key seasonal resources are present, they rely on proximate cues that have been linked to habitat quality over evolutionary timescales. When plants provide these cues, nonnative species that are structurally similar to native species may decouple the link between proximate cues and future resources when they invade the plant community. Animals may not have the capacity to respond to these changes and may select areas where their fitness is low. This has important implications for conservation and management of grassland birds, a group that has declined more than any other group of birds in part due to the reduction in quantity and quality of habitat that accompanies invasions by nonnative plants.

To gain insight into how birds breeding in grasslands are affected by invasions of nonnative plants, we studied how territory establishment, density, and nest success varied with dominance of nonnative grasses. We focus on two species of obligate grassland birds that are abundant in arid grasslands of southern Arizona, Botteri's (*Peucaea botterii*) and grasshopper sparrow (*Ammodramus savannarum*).

To determine how plant invasions influence demography of these sparrows, we surveyed birds and vegetation from 2013 to 2015 on 140, 10-ha plots established at random across a gradient of invasion by nonnative grasses in southeastern Arizona. We surveyed each plot four times per year with distance-sampling methods and located and monitored 274 nests at 3-4 day intervals. We used hierarchical N-mixture models[1] and logistic-exposure models[2] to model density and nest survival, respectively, as a function of composition of nonnative grasses after accounting for other habitat features important to each species.

Areas where density of a species is high can indicate high quality habitat or locations where subordinate individuals have been relegated. Settlement patterns can help differentiate between these alternatives because migratory species that distribute themselves spatially with respect to habitat quality are expected to settle sites in sequence from highest to lowest quality[3]. To determine how invasions by nonnative grasses affect the process of territory establishment, we studied settlement patterns of sparrows as they arrived on breeding grounds. We established 40, 2.25-ha square plots systematically along gradients of invasion by two nonnative grasses in a 2-km^2 area of grassland in southeastern Arizona in 2016. Beginning before birds arrived on breeding territories, we surveyed plots twice weekly during the first 2.5 hours after sunrise and mapped locations of singing males during 10-min surveys. For each species of sparrow, we used multiple regression to evaluate whether grass composition changed as a function of week of territory establishment after accounting for other important habitat features.

If birds can perceive changes in habitat quality as a consequence of plant invasions, both density and nest success should move in parallel (i.e., both increase or decrease). For both sparrow species, however, density and nest success moved oppositely as dominance of nonnative grasses changed.

Specifically, density of Botteri's sparrows increased and nest success decreased as dominance of nonnative grasses increased (Figure 1). Conversely, density of grasshopper sparrows decreased and nest success increased as dominance of nonnative grasses increased (Figure 2).

The settlement patterns we observed indicate that high densities reflect behavioral decisions by sparrows rather than relegation of subordinate individuals to lower quality sites. This is evident because areas along the invasion gradient associated with high densities were settled earlier or at the same time as areas where density was low (Figure 3). Territories established by grasshopper sparrows early in the settlement period were dominated by native grasses, but as settlement progressed and native- dominated sites became unavailable, grasshopper sparrows colonized areas dominated by nonnative species at an increasing rate (average increase of 19% per week). Botteri's sparrows did not establish territories preferentially based on composition of grasses, but settled areas dominated by native and nonnative grass species at similar rates.

Typically, density and reproductive success are related positively in areas not disturbed by human activities [4], but invasions by nonnative grasses may represent a scenario where these two demographic parameters have become decoupled. When novel plant species invade a community, some animals will selectively avoid areas dominated by those species because the novel plants do not provide cues that indicate high habitat quality, even if those sites provide a level of resources that enhance reproductive success, as demonstrated by grasshopper sparrows. For other animals, such as Botteri's sparrows, areas dominated by nonnative plants may function as ecological traps by attracting breeders away from areas of high-quality habitat to areas where reproductive success is markedly lower. By decoupling settlement cues from resources associated with those cues over evolutionary timescales, nonnative plants can alter substantially the distribution and demography of grassland birds.

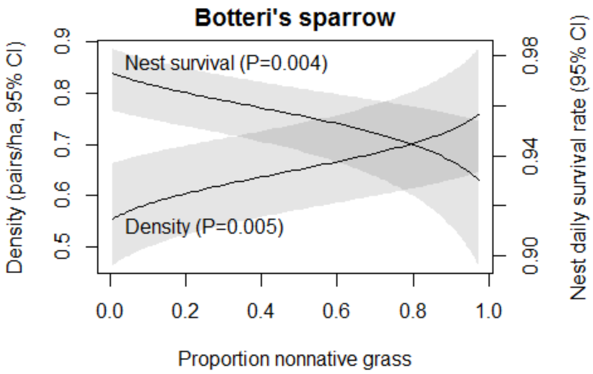

Figure 1. Density of Botteri's sparrows increased and nest success decreased as dominance of nonnative grasses increased.

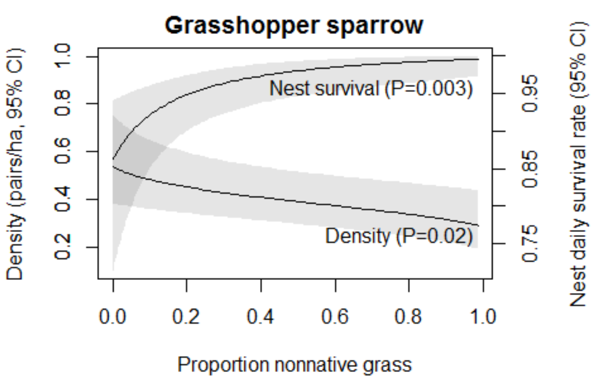

Figure 2. Density of grasshopper sparrows decreased and nest success increased as dominance of nonnative grasses increased

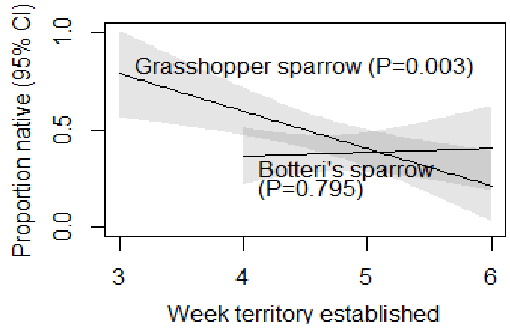

Figure 3. Grasshopper sparrows established territories in areas dominated increasingly by nonnative species as native sites became unavailable. Botteri's sparrows selected native- and nonnative-dominated sites at similar times.

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ITS2 good to be true: an optimal metabarcoding approach to determine diet of herbivores

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Oral Presentation

Metabarcoding is a genetic technique used to identify biological communities. This method, often used to characterize plant diet from the feces of herbivores, has the benefit of being fast, inexpensive, and sensitive, making it a convenient tool for large datasets. Metabarcoding uses DNA barcodes— short, informative fragments of DNA— to identify taxa present in environmental samples. Commonly used markers such as trnL, a chloroplast gene, is associated with low taxonomic resolution and analytical inflexibility (Fahner et al. 2016). This marker also requires a custom, publically inaccessible reference library. The nuclear ribosomal gene, ITS2, shows new promise as a metabarcoding tool that can use public reference libraries, making it an optimal approach for the study of herbivore diets (Chen et al. 2010).

We sought to study the diet of the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*), an endangered species obligate to riparian habitats in New Mexico, Arizona, and Colorado. The jumping mouse hibernates for 8 to 9 months per year, making it particularly difficult to study and requiring long hours in the field and intensive study methods. Wright and Frey (2014) observed jumping mice during a radio-telemetry study in the summers of 2009 and 2010 during which they were able to identify 8 diet items. However, the taxa at a single site is not representative of jumping mouse diet throughout its broader, disconnected range. Here we present ITS2 as a more flexibly applied, high resolution, plant metabarcode to determine diet of herbivores.

We first compared ITS2 to trnL based on their ability to taxonomically resolve (to genus) plants occurring in habitat used by jumping mice. Using known plants from the Northern Arizona University Ecological Restoration Institute herbarium, we sequenced both markers across 26 plant genera. Using the National Center for Biotechnology Information's *Basic Local Alignment Search Tool* (NCBI BLAST) we found that the taxonomic resolution of the 2 markers were very similar; 93% of the plants were identified correctly to genus level, while 7% were ambiguous or incorrect.

Next, we scaled both markers for Illumina short read sequencing, which can yield millions of reads reflecting complex taxonomic mixtures. We first modified both PCR primer sets (Coleman et al. 2015), which uses a custom indexing strategy to alleviate optical error, a form of cross contamination. To lessen the computational cost of aligning to genetic databases such as NCBI, sequences must be compared to a reference library consisting of target barcode sequences. Using the Barcode of Life Database (BOLD systems), we were able to easily assemble a reference library for ITS2 consisting of 50,890 publicly accessible barcode sequences. Although, BOLD is not a repository for trnL sequences, we were able to acquire a curated reference library of 274,979 sequences used in a previous study (Craine et al. 2016). While we are currently modifying the reference library for use with QIIME scripts, we have already completed dietary datasets for the jumping mouse using ITS2.

Although the trnL approach is widely used in dietary surveys, ITS2 demonstrated a more convenient and immediate metabarcoding tool for revealing dietary taxonomy. This is largely because of the ease of assembling a universal ITS2 reference library from BOLD. This, combined with its high taxonomic resolution allows for fast and flexible data acquisition as well as immediate application toward other herbivorous taxa, such as rodents (Order *Rodentia*) or elk (*Cervus elaphus*), in any region. While trnL may still show promise as a supplementary marker that could correct for potential priming biases in ITS2, we believe the ITS2 marker can provide results more quickly, especially important for threatened or endangered species.

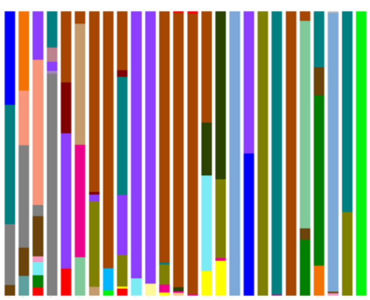

Figure 1. ITS2 taxonomic composition of 26 jumping mouse fecal samples (each bar represents 1 individual; colors within each bar represent plant genera) collected in 2015-2016 on 3 National Forests in Arizona and New Mexico.

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Predicting seasonal distribution and migratory pathways for neotropical nectar-feeding bats

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Oral Presentation

Introduction

Three species of Neotropical nectar-feeding bats reach their northernmost extent in the southwestern United States, two of which are federally endangered. These endangered long-distance migrants, lesser long-nosed bats (*Leptonycteris yerbabuenae*) and Mexican long-nosed bats (*Leptonycteris nivalis*) play important ecological roles as pollinators and seed dispersers of keystone desert plants (Horner et al., 1998). Though *L. yerbabuenae* has been studied extensively, important ecological relationships are not fully understood (Rojas-Martínez et al., 2012). Many inferences about *L. nivalis* are based on studies of *L. yerbabuenae* (Sánchez and Medellín, 2007). Neotropical populations of these species are said to migrate along a nectar corridor of columnar cacti and *Agave* species throughout the Chihuahuan and Sonoran Deserts (Fleming et al., 1993). Consequently, the distribution and seasonal movements of these species are largely dictated by the phenology of available food plants. However, the theory of general latitudinal migration is challenged (Rojas-Martínez et al., 1999) and has not been reinvestigated since major developments in distribution modeling tools. In this study, we generate seasonal distribution and species richness models of food resources for *L. nivalis* and *L. yerbabuenae*, quantify the contribution of each resource to the seasonal distribution of each nectarivore, and model potential migratory routes between spring and summer habitat.

Methods

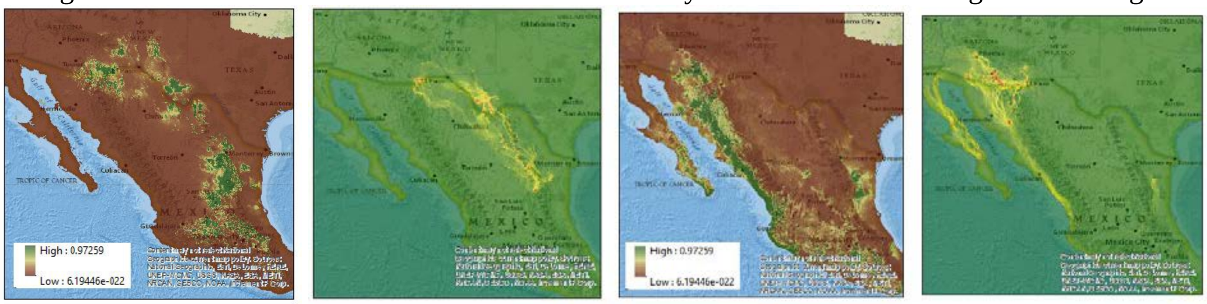
We used MaxEnt (Phillips et al., 2006) to generate distribution models of known food resources for nectarivorous bats throughout the southwestern United States and Mexico. We identified resources from previous studies and followed the methods of Warren et al. (2014) to select top models. The initial set of environmental variables for each model included all 19 BioClim variables from WorldClim (Hijmans et al., 2005), elevation, heat load, and land cover. A total of 53 resource models were generated. We then created a binary raster for each resource by maximizing the sum of the sensitivity and specificity (Liu et al., 2016) and utilized phenological information to generate species richness models of available food resources. Species richness, resource models, seasonal climatic variables, and distance to karst were then used as covariates to model the distribution of *L. nivalis* and *L. yerbabuenae.* All presence records were verified. To model potential spring migration routes, we averaged the spring and summer distribution models for *L. nivalis* and *L. yerbabuenae* to incorporate spring, summer, and transitional habitat in one model for each species. A random subset of spring and summer capture locations were selected and used as nodes and the inverse of the spring-summer distribution model was used as a resistance layer in circuitscape (McRae et al., 2008).

Results

According to the distribution models, the most important variables for *L. nivalis* in the spring include *A. inaequidens*, *A. lecheguilla*, *Crescentia cujete*, and species richness. The most important spring variables for *L. yerbabuenae* include *Pachycereus pectin-aboriginum*, species richness, *Stenocereus standleyi*, *A. schottii*, *Ceiba acuminata*, and *Cephalocereus purpusii*. The most important summer variables for *L. nivalis* include *A. havardiana*, *A. salmiana, A. marmorata*, distance to karst, *Pachycereus pringlei*, *A. neomexicana*, species richness, and *A. macroacantha.* The most important summer resources for *L. yerbabuenae* include *A. schottii*, species richness, *Stenocereus thurberi*, *Crescentia alata,* and *C. gigantea*. Our migration models for *L. nivalis* and *L. yerbabuenae* imply that the two species follow divergent migration routes that may converge in the southwestern corner of New Mexico. The models indicate potential presence of undocumented transitional roosts for *L. yerbabuenae* in the northern state of Sonora, and in the Davis, Guadalupe, Sacramento, and Gila Mountains of Texas and New Mexico, and throughout the northern state of Chihuahua for *L. nivalis*.

Discussion

We hope this study provides valuable information to effectively aid recovery efforts for migratory nectarivorous bats. While *L. yerbabuenae* and *L. nivalis* are currently listed as endangered in the United States, *L. yerbabuenae* is being considered for de-listing due to potential population recovery (USFWS, 2016). The results of this study highlight the importance of predictive modeling when studying wide ranging migratory nocturnal species. Based on this study, we add support to the theory of latitudinal migration following a corridor of spring-blooming columnar cacti throughout the Sonoran Desert for *L. yerbabuenae*. However, it appears as though *L. nivalis* follows a corridor of spring-blooming *Agave* spp. throughout the Chihuahuan Desert. The results of this study warrant further investigation on the ground.



Left to right: 1.) spring and summer habitat of *L. nivalis*; 2.) potential migratory corridors of *L. nivalis*; 3.) spring and summer habitat of *L. yerbabuenae*; 4.) and potential migratory corridor of *L. yerbabuenae*.

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Developing conservation guidelines for the Oscura Mountain Chipmunk using occupancy models

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Oral Presentation

The Oscura Mountain Colorado chipmunk, *Tamias quadrivittatus oscuraensis*, (hereafter OMC) is a rare subspecies of the Colorado chipmunk endemic to the Oscura Mountains in south-central New Mexico. These mountains act as a biogeographic island, providing an isolated patch of marginal montane habitat consisting mainly of piñon-juniper woodlands (Muldavin et al. 2000), and are entirely within the White Sands Missile Range (WSMR). OMC is listed as threatened by the state of New Mexico, primarily because it is a unique endemic subspecies with a small, isolated habitat and the potential for continuing habitat loss (NMDGF 2008). Most available information about the biology of the OMC is speculative, based on limited sampling or on the biology of related taxa. More information about OMC's distribution and ecology is needed to develop a monitoring plan for conservation of this threatened subspecies.

Surveying OMC using live-trapping is not feasible due the remote field site and the sporadic, unpredictable base closures associated with military activities, so non-invasive survey techniques are needed (Frey 2011). Given this, occupancy is an ideal state variable to measure. Occupancy modeling 0 estimates the likelihood that a species is present at a site while accounting for the fact that detection probability may not be 100% (MacKenzie et al. 2006). Camera trapping is particularly well-suited to the specific needs of developing an occupancy model for OMC. The species is easily distinguishable by its size and coloration, cameras are a quick and easy method of conducting repeat surveys at many sites simultaneously, and are non-invasive, which is ideal when working in a large area with access closures.

The overarching goal of this study was to develop a non-invasive monitoring technique for OMC that WSMR staff can utilize in the future to detect changes in occupancy and thus implement informed conservation decisions. This will require collecting baseline data about OMC's biology, distribution, and habitat to inform the implementation of, and allow for inferences from, the monitoring techniques.

We used 30 Reconyx PC800 HyperFire cameras with peanut butter as bait to detect OMC at 131 sites across the Oscura Mountains during summer 2016. We deployed cameras at a site for at least 7 days, and considered each day to be an independent repeat survey for the purposes of occupancy modeling. We collected ground cover and plant composition data at each camera site along 3 equally spaced 40 m transects radiating out from the camera. We used a Daubenmire plot to record ground cover every 2 m along the transects. Temperature data was recorded at each site using iButtons. Additional topographic data was calculated in ArcGIS using vegetation type and elevation layers provided by WSMR staff.

We developed a suite of a priori occupancy models using covariates on detection probability and occupancy based on our limited knowledge about the species' ecology and the ecology of other *Tamias* species. For both detection probability and occupancy, we performed a series of model selection iterations, which served as a variable reduction technique similar to stepwise logistic regression. We tested how occupancy or detection may be related to different categories of ecological to determine the best sub-model for each category. We then obtained a final model by comparing all possible combinations of each best sub-model. Model selection used AIC to determine which model best described the data (Burnham & Anderson 2002). We considered models with ΔAICc < 2 to be informative. We first determined the best detection model by running the competing detection models with a naïve occupancy estimate, and then used the final detection model variables in the a priori occupancy models.

The final model contained covariates on occupancy and detection probability (Table 1). The strongest effect was from elevation, with occupancy probability being larger at high elevations. Elevation had a strong positive correlation with the number of mature piñons at a site, so we interpret occupancy as increasing with increasing number of piñon trees at a site as well. Heat Load Index had a negative effect on occupancy, meaning that occupancy probability is highest at sites with northeast aspects that receive the least solar radiation. We detected chipmunks at 26 of the 131 sites surveyed; 21 of these presence sites were in Piñon Pine Woodlands, 4 in Montane Scrub, and 1 in Juniper Woodland. Detection probability was highest at sites with much herbaceous and litter cover near the camera, low overall forb cover, fewer mature pinyon trees, high solar radiation, and sites surveyed later in the season (Table 1).

Table 1. Final occupancy model for the Oscura Mountain Chipmunk.

Detection covariates	**Estimate**	**SE**	**Occupancy covariates**	**Estimate**	**SE**
Detection Intercept	-16.132	3.146	Occupancy Intercept	36.686	22.096
Herbaceous Cover near camera	5.617	1.350	Shrub Cover	-61.205	34.283
Litter Cover near camera	5.830	1.153	Slope	0.967	0.510
Julian Date	0.028	0.011	Elevation	185.982	97.702
# Mature Piñon	-0.086	0.032	Heat Load Index	-83.869	45.637
Heat Load Index	6.070	1.554	Rock Cover	75.965	39.820
Forb Cover	-0.419	3.609	Temperature Max	1.824	1.024
			Veg Type - Juniper Woodland	referent	
			Veg Type - Montane Scrub	16.187	10.267
			Veg Type - Piñon Pine	19.967	11.526
			Elevation*Heat Load Index	-171.007	89.866
			Elevation*Temperature Max	4.215	2.373

Camera trapping proved an effective method for studying OMC. Photos of over 1000 days of surveys were taken at remote field sites, a number that would be impossible with daily in-person visits. OMC occupancy was related to covariates from four different life history categories: food availability, nest site availability, heat stress, and vegetation type, suggesting that many different biological factors influence the species' distribution. Still, occupancy seems most closely tied to high elevation sites on cool aspects with lots of mature piñon, rock cover, and low shrub cover. This habitat is threatened by loss and disturbance from military testing and associated activities (Sullivan & Wilson 2000). Future climate change also will likely constrict mountaintop habitat by driving ecosystems to retreat to higher elevations to avoid warming temperatures or disrupt ecological associations entirely (US EPA 1998).

These results provide crucial baseline information on the ecology of OMC and the macro- and microhabitat factors that influence its distribution, both of which are vital for determining how to best conserve this threatened species. Based on our estimates of occupancy and detection probability from the final model, we will determine the ability of the occupancy modeling protocol to detect different levels of change in occupancy over time given parameters like the number of camera sites and number of surveys per site. We will run power analyses for a variety of potential monitoring protocols and acceptable power levels to give WSMR enough data to make an informed decision.

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Predicting spatial factors associated with cattle depredations by the Mexican wolf (*Canis lupus baileyi*) in Arizona and New Mexico

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Oral Presentation

Large carnivores can cause conflicts with humans by predating on livestock which causing both economic losses and negative attitudes toward carnivores by segments of the public (Woodroffe et al. 2008). A variety of non-lethal approaches to reduces human-carnivore conflicts are available, especially for endangered species. However, non-lethal control methods are often unsatisfactory because they are expensive, are effective for only short time periods, or require increased time and effort by livestock producers (Breck et al. 2012). An alternative approach is to prevent conflicts from occurring, which may be more efficient and less costly than trying to reduce conflict after it has occurred.

The Mexican wolf (*Canis lupus baileyi*) is an example of a rare carnivore that is being restored to its native range, but which also causes conflicts with humans. In 2015 revised regulations resulted in a dramatic increase in the area where Mexican wolves will be allowed to occupy, from the former Blue Range Wolf Recovery Area (BRWRA) to the Mexican Wolf Experimental Population Area (MWEPA), which includes all of Arizona and New Mexico south of I-40; this expansion could increase Mexican wolf-livestock conflicts (FWS 2015). Residents of Arizona and New Mexico that oppose Mexican wolf restoration, do so primarily because of concerns about livestock and human safety (Schoenecker & Shaw 1997). However, thus far there has been little research on factors associated with Mexican wolf depredation on livestock. Risk maps predict spatial distributions of the potential intersection of human and carnivore activities and provide an opportunity for early warning (Kaartinen et al. 2009). The overarching goal of this study was to develop models that explain spatial factors associated with Mexican wolf depredations on cattle. Specific objectives included 1) predicting livestock and natural prey abundances in Arizona and New Mexico with the aim of using these models as predictors in the risk model, 2) developing a risk model for the MWEPA to illustrate spatial arrangement of depredation conflict hotspots, and 3) make recommendations for future wolf recovery program and livestock management to reduce potential conflicts.

We used a presence-only maximum entropy modeling approach (Maxent; Phillips et al. 2006) to develop the risk model based on 120 confirmed depredation incidents that occurred on public lands within the former BRWRA and 4,000 random background points within a study area defined by the radius of a mean Mexican wolf home range around each depredation point. Predictor variables included abundance of livestock, abundance of natural prey (elk, mule deer, white-tailed deer), land cover, canopy cover, distance to and density of water resources, distance to developed areas, human population density, topographic ruggedness index (TRI), and elevation. We developed a model for abundance of livestock using regression analysis of Animal Unit Month (AUM) data from public grazing allotments in Arizona and New Mexico and then interpolated to the remainder of the study area. We developed models for abundance of natural prey (elk, mule deer, white-tailed deer) using Maxent as a proxy for the upper limit of their abundances. For all Maxent models, we identified the most important set of uncorrelated variables and regularization multiplier using corrected Akaike information criterion (Akaike 1974). The final risk model was projected to the entire MWEPA (i.e., AZ and NM south of I-40) using clamping method.

The final depredation model included eight variables. Those with a positive influence on cattle depredation were: elk abundance (19.8% contribution), canopy cover variety (18.5% contribution), montane grassland land cover (13.6% contribution), density of water (8.2% contribution), and dense herbaceous ground cover (3.8% contribution). Variables with negative influence on cattle depredation were density of roads (12.3% contribution) and density of humans (6.9% contribution). Predation risk had a nonlinear relationship with TRI (highest at mid values of TRI; 16.9% contribution). Projection of the model onto the MWEPA revealed ca 5% of the MWEPA has enhanced, moderate, or high risk of cattle depredations (Figure 1). Difference between predictions when clamping is used versus when it is not used shows that the accuracy of predictions increased with increasing distance from populated areas.

Areas with high elk abundance, more diverse canopy cover, rugged terrain, and located further from developed areas increase the risk of livestock depredation by Mexican wolves. The risk model can be used to inform future management of Mexican wolves by targeting non-lethal control methods in higher risk areas and suggesting locations for future establishment of wolves in areas with lower risk of depredation.

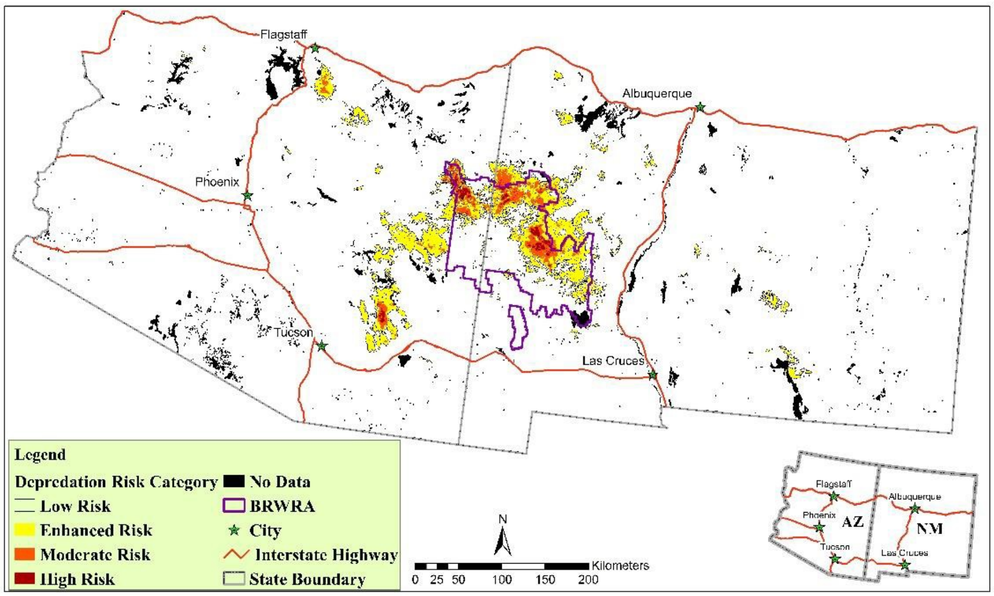

Figure1. Predicted areas at risk of depredation on livestock by Mexican wolf in the Mexican Wolf Experimental Population Area. Black areas had no predictions due to missing data.

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Animas – Friday, February 10th 1-3:00 PM

Surveillance plan for highly pathogenic avian influenza in wild migratory birds in the United States including Arizona

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Oral Presentation

The first report of H5N1 Highly Pathogenic Avian Influenza (HPAI) occurred in Asia in 1996. And now a diverse viral gene pool exists in the world due to co-circulation of many avian influenza viruses (AIV's) in domestic and wild birds. The 1996 Asian H5N1 HPAI is the predecessor of multiple viral reassortants, including H5N2, H5N5, and H5N8. In the fall of 2014, Eurasian HPAI H5N2 was identified in commercial poultry in the Fraser Valley region of southern British Columbia, Canada. Subsequent samples collected from wild birds in the United States, combined with mortality events associated with captive raptors, revealed a least three Eurasian H5 HPAIs in circulation. Between March and June of 2015, HPAI outbreaks in US domestic poultry operations resulted in the loss of nearly 50 million birds. In January of 2016, an HPAI event was identified in domestic turkeys in Indiana. Testing revealed a H7N8 virus of North American lineage and therefore different from the Eurasian HPAIs responsible for poultry outbreaks in 2014-2015. Surveillance associated with the 2015 Surveillance Plan for Highly Pathogenic Avian Influenza in Wild Migratory Birds in the United States had identified a LPAI H7N8 in a wild bird from a neighboring state prior to the domestic turkey outbreak. Federal and state agencies continue to collect wild bird samples to define the extent of HPAI infection in specific avian species groups. The Arizona Wildlife Services Program, Arizona Game and Fish Department, and the US Fish and Wildlife Service has been actively monitoring hunter harvested waterfowl for HPAI on the lower Colorado River.

Breeding habitat requirements of Bendire's thrasher (*Toxostoma bendirei*) throughout its New Mexico and Arizona range

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Oral Presentation

Bendire's Thrasher is an understudied and cryptic arid land obligate. Data from breeding bird surveys

indicates that this species is experiencing among the greatest declines of any species in North America. It is estimated that 28.7% of the global population of Bendire's Thrasher occurs in New Mexico, where breeding bird surveys indicate a 4.4% annual decline in populations over the last 10 years, and a more recent analysis estimates the population will decline by 30% in the next 15 years and 50% within 20 years. The lack of knowledge about the Bendire's Thrasher, and the apparent population declines have led to an interest in increasing conservation efforts and basic ecological knowledge for this species. This research aims to answer some basic questions about Bendire's Thrasher in New Mexico and Arizona while setting ground work for future conservation efforts. Our objectives were to determine the most effective way to survey for Bendire's Thrasher, and to improve the current understanding of Bendire's Thrasher breeding habitat requirements. Over the two-year study we found 69 Bendire's Thrasher territories. We found the use of recorded call playback to be the best method for detecting thrashers. We completed vegetation surveys on all Bendire's Thrasher territories to compare with 70 randomly placed vegetation surveys. In addition to on the ground surveys, we completed a landscape level analysis using aerial photography and ArcGIS to develop landscape variables for our models. Preliminary analysis of this data suggests Bendire's Thrashers select breeding habitat with more tall shrubs and bare ground than random locations. We will present our most supported models of Bendire's Thrasher habitat requirements developed from these two-years of data collection.

Occupancy, reproduction, and forest structure of burned Mexican spotted owl sites 14 years after the Rodeo-Chediski fire, Arizona

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Oral Presentation

Wildland fire is considered a potential factor affecting the Mexican spotted owl (*Strix occidentalis lucida*) in the United States but the influence of large, high-severity fire is highly contested in the literature. While patches of high-severity fire may provide foraging habitat for spotted owls, extensive areas burned at high-severity may leave little nesting and roosting habitat available for colonization. Our objective was to evaluate the effects of the 2002 Rodeo-Chediski fire (187,000 ha, 37% burned at high severity) on spotted owls. Our study area covered 18000 ha of burned area on the Apache-Sitgreaves and Tonto National Forests. Before the fire (1990-1998) an average of 10 owl pairs (maximum 14) occupied this area. We surveyed this area intensively during the 2014-2016 breeding seasons and observed an average of 5 pairs (maximum 6). We also observed a post-fire decline in average reproduction from 8 fledged young per year to 2 fledged young per year. Through the influence of fire, the area may have become a population sink for spotted owls. Our study supports previous suggestions that "megafires" present a serious risk to spotted owls.

Lesser prairie-chicken survival in an energy landscape

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Oral Presentation

Few studies have documented the relationship between anthropogenic disturbances and Lesser prairie-chicken (*Tympanuchus pallidicinctus*) ecology. In recent years, increased oil and natural gas extraction and associated infrastructure in western North America have exacerbated some of the factors impacting wildlife populations. The effects of anthropogenic structures on Lesser prairie-chicken survival, habitat selection, and nest success, especially as they relate to varying densities of development, are poorly understood. Our objectives were to provide a quantitative measure of the behavioral and demographic responses of Lesser Prairie-chickens to varying densities of oil and gas development in eastern New Mexico. Between 2013 and 2015, we captured 70 hens and 128 males and fitted them with VHF radio collars or PTTs. Locations and state (i.e., dead/alive/missing) were recorded to assess habitat selection and survival, respectively. We digitized features associated with oil and gas infrastructure (well pads, roads, utility poles, etc.) and incorporated them as covariates in a known fate analysis using the R package, *RMark*. We found that the density of utility poles within an individual's home range, age, and gender were among the variables that best explained survival. The density of utility poles within a home range was in each of the top three models of our model set. This covariate appeared to have the greatest effect on males, with subadult male survival decreasing the most as utility pole density increased. By understanding the effects of oil and gas development on Lesser prairie-chicken survival, we may better plan the distribution of such activities, thereby increasing the likelihood of population persistence.

Using biomarkers to evaluate use of food subsidies by greater sandhill cranes wintering in New Mexico

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Oral Presentation

Human activities have adversely transformed terrestrial ecosystems, degrading biological integrity and consequently encumbering many species to fragmented and confined areas. Under some circumstances, this can create the need for management programs to directly support wildlife. Often, such programs are established to provide food resources for population persistence or to mitigate socioeconomic conflicts with humans. Evaluating reliance on and efficacy of food subsidized to wildlife is important to justify these programs. Furthermore, determining when to make food resources available is equally important, as is the case for migratory species. Stable isotope values of food items and proteinaceous tissues of target species can be used to estimate diet composition but also the rate of isotopic incorporation of a new diet into tissues if a species has isotopically distinct diets that fluctuate spatially and/or temporally. For migratory species, this information can then be used to identify timing of diet switching and thus reveal timing of migration events. In the Middle Rio Grande Valley of New Mexico, corn subsidies are provided to wintering sandhill cranes to support their energetic needs and minimize crop depredation. We used stable isotopes to characterize the use of subsidized corn by sandhill cranes, developed the first field-based estimates of rate

of isotopic incorporation for different tissues of sandhill cranes, and used isotope incorporation estimates of tissues to estimate arrival dates of sandhill cranes on the wintering grounds. Our approach demonstrates a novel field application of biomarkers to validate and inform the success of food supplementation practices for wildlife.

Habitat suitability model for the dusky grouse in the American southwest

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Oral Presentation

The dusky grouse (*Dendragapus obscurus*) is a game bird that occurs in boreal forests from southern Canada and Alaska south to isolated mountaintops in Arizona and New Mexico. This species has been ill-studied in the American Southwest where it is a protected game species. Our study aims to develop a habitat suitability map of dusky grouse in New Mexico and Arizona using Maximum Entropy Modeling (MaxEnt). We collected occurrence records of dusky grouse from museum collections, eBird, iNaturalist, professional observations, and the New Mexico Ornithological Society database. We assigned observations error based on the observer's knowledge and location precision. We constructed models, based on 8 biophysical variables (elevation, heat load index, terrain ruggedness index, GAP landcover, slope, aspect, Normalized Difference Vegetation Index, distance to water) and 19 standard bioclimatic variables. We optimized the background extent, variables and beta parameter. The final model included maximum temperature of the warmest month (72.1%), elevation (22.9%), and precipitation of the warmest quarter (4.9%). The largest and most suitable areas of grouse habitat were the northern mountains of New Mexico with significant areas of suitable habitat also found on the Kaibab Plateau. Suitable habitat in the southern part of both states was small and fragmented. Grouse could be affected by recent land cover changes and the effects of climate change. Future research will need to be undertaken in order to better understand this species and its current status in the American Southwest.

Florida – Friday, February 10th 3:20-5:20 PM

Behavioral character displacement and territoriality of an isolated endangered species under invasion

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Oral Presentation

Behavioral character displacement leads to niche separation and coexistence of ecologically similar species. However, anthropogenic syntopy resulting from introductions may occur too rapidly for characters to diverge, and instead lead to competitive exclusion. Red squirrels (*Tamiasciurus hudsonicus*) and Abert's squirrels (*Sciurus aberti*) co-occur naturally in Arizona, but endangered Mount Graham red squirrels (MGRS; *T. h. grahamensis*) were isolated from other tree squirrels until Abert's squirrel introductions in the 1940s. Now syntopic with MGRS, Abert's squirrels compete for food and space, and relaxed character displacement may place MGRS at a disadvantage. Red squirrels defend a single larder-hoard (midden) at the center of a territory. Abert's squirrels are non-territorial scatter-hoarders. We tested hypotheses on the role of behavioral character displacement for these species in natural and anthropogenic syntopy. From fall 2015 - spring 2016, we simulated territorial intrusions by Abert's squirrels at red squirrel middens in 3 Arizona mountain ranges. We used repeated measures to quantify territorial responses under 4 conditions at 5 middens per site. Compared with sites of natural syntopy, MGRS exhibited greater territoriality in all significant behaviors. There were no consistent responses to experimental conditions, suggesting relaxed behavioral character displacement does not lead to additional invader effects. The uniformly higher intensity of territorial behaviors by endangered MGRS may impose behavioral costs in increased energy expense and heightened predation risk. Such mismatches between behavior and benefit could affect similarly imperiled species under invasion.

MOM knows best: Mouse Occupancy Modeling reveals habitat of an endangered rodent

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Oral Presentation

The New Mexico meadow jumping mouse (*Zapus hudsonious luteus*) is considered a riparian obligate that uses tall, dense herbaceous vegetation along perennial flowing water such as streams and wet meadows. Vegetation dominated by sedges (*Carex* spp.) and forbs provides high quality cover and food sources for the jumping mouse. We tested this habitat description using occupancy modeling, an analytical technique that allows for a rapid assessment of multiple sites and yields probabilities of occupancy. We used a Geographic Information System to select locations across the Apache-Sitgreaves National Forests based on our criteria for elevation (<2740 m), perennial streams, and riparian vegetation. We randomly selected 75 of these sites and stratified them based on grazing and recreational use. At each site, we used 80 Sherman live traps or track plates over 3 nights. We detected jumping mice at 21 sites; 12 with livestock grazing. We detected jumping mice at 4 sites outside designated critical habitat. Sites varied in their plant communities but overall had high species richness. Our model found that jumping mice used wide, low-gradient streams with high soil moisture, tall vegetation, and alder, forb, and sedge cover. Less important predictors indicated higher occupancy of jumping mice when plant species richness was higher, distance to roads and recreational sites was lower and lower occupancy at sites grazed by livestock and with higher grass cover. Our results support previous findings and highlight the potential importance of stream characteristics for jumping mouse habitat.

Varied herbaceous diet of the New Mexico meadow jumping mouse revealed by DNA metabarcoding

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Oral Presentation

The New Mexico meadow jumping mouse (*Zapus hudsonious luteus*) is an endangered subspecies that occupies riparian zones in the southwestern United States. This subspecies forages for seeds and achenes atop tall herbaceous canopies during three months of activity, then enters a 9-month hibernation period. Diet across their fragmented range (Arizona, New Mexico, Colorado) is undescribed. It is also unclear whether jumping mice favor grasses (*Poa*), rushes (*Juncus*) or sedges (*Carex*), since it is presumed these plants form habitat structure. During summer 2015 and 2016, we collected feces of 40 jumping mice from animals captured on three National Forests and used DNA metabarcoding to identify dietary plant taxa to genus. We detected 42 genera with, on average, each mouse consuming ~4 genera (range 1 to 8). We identified the genera of avens (*Geum*), willowherbs (*Epilobium*), violets (*Viola*), and grasses in 20 to 40% of jumping mice but rushes and sedges were detected in low frequencies. We conclude jumping mice have an overall varied plant diet. Our future goals are to assess which plant groups offer the most caloric reward and whether diet changes (1) by sex during periods of reproduction (given increased energy demands for females) and (2) for all animals in the period leading to hibernation (given increases in masses of 20% in the month prior to hibernation).

Use of remote cameras to detect the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) at Bosque del Apache National Wildlife Refuge

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Oral Presentation

The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is a riparian obligate that is federally listed as endangered. Although formerly widespread along the Rio Grande, the only currently known population occurring along this river is located at Bosque del Apache National Wildlife Refuge, Socorro Co. The species is difficult to trap and trapping poses risks to small populations. Consequently, we developed a non-invasive method for detecting jumping mice using remote cameras. We utilized information on the species' natural history to design a camera trap set that targets jumping mice while reducing captures of non-target species. Initially, we deployed pairs of cameras that differed in night imaging capabilities (Reconyx 800 black/white photos; Reconyx 850 color photos). We discontinued use of the Reconyx 800 cameras because no jumping mice were detected and the lack of color and pixelated night images made identifications of mice difficult. We deployed camera traps at 28 locations within 11 management units and along an irrigation canal. We detected jumping mice on 87 photographs representing 27 events at 7 locations. By comparison, conventional Sherman trapping surveys over 3,888 trap-nights conducted within the same study area resulted in just three captures of jumping mice (0.08 % capture rate). Remote cameras offer an important new tool for surveying for jumping mice that offers advantages over other methods including low risk to animals, relatively long-term passive monitoring of locations, and

verifiable evidence that can be archived as per voucher specimens in museum collections.

Identification, distribution and ecology of the New Mexico meadow jumping mouse in the zone of sympatry with the western jumping mouse

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Oral Presentation

In southern Colorado and northern New Mexico the endangered New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is sympatric with the western jumping mouse (*Zapus princeps*). I evaluated characters for identifying these taxa, identified historical specimens in the zone of sympatry, conducted surveys to find persisting populations, and evaluated habitat of the two species. Using reference specimens verified by DNA, morphological analyses revealed that *Z. h. luteus* can be distinguished from *Z. p. princeps* on basis of pelage, external morphology, cranial characters, and dentition. I examined > 750 specimens of *Zapus* to determine historical distributions and conducted surveys at >100 sites in the zone of sympatry to determine current distribution. In the zone of sympatry, *Z. h. luteus* historically occurred in the San Juan River watershed, headwaters of the Chama River (San Juan Mountains), headwaters of the Rio Grande (Sangre de Cristo Mountains), and headwaters of the Cimarron and Canadian rivers (Las Vegas-Raton Plateau). Records indicate potential syntopy. Current populations occur in the San Juan, Cimarron, and Canadian watersheds. Elevation was the best variable discriminating *Z. h. luteus* and *Z. princeps* habitat. In the zone of sympatry, *Z. h. luteus* is a herbaceous riparian specialist mostly restricted to elevations < 7,600 ft. In contrast, *Z. princeps* becomes more common at increasing elevations (although it also can occur at low elevations) and is more of a habitat generalist, sometimes occurring far from riparian zones. However, *Z. princeps* also can occur in the same habitat type used by *Z. h. luteus*.

Population dynamics in fragmented habitats: is the pika population in Bodie State Historic Park a true metapopulation?

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Oral Presentation

The metapopulation concept has become an important theoretical construct guiding management of many wildlife and fish populations. However, as classically defined, true metapopulations appear to be rare. A population of American pikas (*Ochotona princeps*) inhabiting an anthropogenic landscape in the ghost mining town of Bodie, CA have historically been interpreted as a true metapopulation. This landscape comprises discrete habitable talus (ore dumps) surrounded by Great Basin sage scrub. Although a 20-year dataset shows that the ore dumps experience repeated cycles of extinction and recolonization, the interpretation as metapopulation dynamics has been challenged by two competing alternatives. One suggests that large ore dumps act as mainlands, making the landscape a classical MacArthur-Wilson island-mainland system. The second alternative, due to Clinchy in 2002, proposes an "extinction disk" model, in which patch occupancy dynamics are driven by spatially correlated extinctions. Here we test the extinction disk model by comparing the 20-year Bodie dataset to results generated by a computational model of the extinction disk process. We find that measures applied in the past may be unable to distinguish the two hypotheses, and propose new measures based on well-established spatial statistical procedures. Our models and statistics can be adjusted and parameterized to fit other fragmented populations to identify or exclude

metapopulation dynamics. With habitat fragmentation increasing globally, robust models of the type we study here can help biologists and managers predict population-level responses to increasing isolation caused by fragmentation.

Animas – Friday, February 10th 3:20-5:00 PM

Surveys and microhabitat use of northern Mexican gartersnakes at lower Tonto Creek

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Oral Presentation

Northern Mexican Gartersnakes (*Thamnophis eques megalops*) are federally-listed as Threatened with proposed designation of critical habitat under the Endangered Species Act. Monitoring and understanding microhabitat use of *T. e. megalops* is imperative for developing recovery plan for this species. Our group has been conducting surveys and radio telemetry for *T. e. megalops* at Lower Tonto Creek, near the confluence with Roosevelt Lake since fall 2015. To survey for this species, we conducted intensive minnow trapping and visual encounter surveys at three sites along the creek. In total, we detected 41 *T. e. megalops* at our site, 24 juveniles and 17 adults, i.e., > 40 cm snout vent length. Our catch per unit effort for visual encounter surveys was 0.07 snakes per person-hour and catch per unit effort for minnow trapping was 0.0003 snakes per person-hour. Our preliminary results through radio-telemetry revealed that this species selects sites with high vegetative cover (74 – 95%) and were typically found close to water (an average distance to water was 56.89 m ± 19.24). The four most common macrohabitats used were riparian woodland (22%), meadow (22%), aquatic edge (17%), and dry edge (15%). We recommend investing in intensive search efforts during any presence/absence surveys for this cryptic species.

Snakes move in mysterious ways: daily activity patterns and movements of northern Mexican gartersnakes

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Oral Presentation

Knowledge of daily activity periods and movement patterns are important components of species conservation and study design. The northern Mexican gartersnake (*Thamnophis eques megalops*) was listed as threatened under the Endangered Species Act in 2014. This species can be difficult to locate and monitor due to its cryptic behavior and selection of complex habitats. Our objectives were to document daily activity and movement patterns of this species and to determine influence of monitoring frequency on daily movement estimates and habitat selection. We located transmittered snakes every three hours during 24-hour periods and recorded location, distance moved, and macrohabitat type. From June 2015 – July 2016, 20 individuals were monitored during 49 sampling sessions. Snakes were more active and moved longer distances from 9:00–15:00, although some nocturnal activity was observed. Snakes also moved longer distances during the active season (March–October), but short-distance movements were common during the inactive season (November–February). Estimates of daily distance traveled decreased with less-frequent monitoring; a sampling interval of once every 24-hours yielded only 53–62% of known daily distances moved during the active season. These results can help inform management activities and research design.

Researchers should carefully assess timing and frequency of monitoring in order to meet project objectives.

Phylogeography of the smooth greensnake: divergent lineages and introgression discovered through comparative genomics

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Oral Presentation

The smooth greensnake (*Opheodrys vernalis*) is a wide ranging yet poorly-studied colubrid snake. Some authors support putative morphologically-based subspecies but no large scale molecular works have been done for this species. We used a comparative approach of mitochondrial (mtDNA) sequencing on 119 smooth greensnakes and nuclear (nDNA) double-digest restriction-site associated DNA sequencing (ddRADseq) on a subset of 45 smooth greensnakes to generate the first molecular phylogeography for *O. vernalis*. This yielded over 3,000 informative variant sites (SNPs) across the genome that identified population structure, differentiation, and demographics. Both datasets were congruent in discovering a distinct geographic split between two lineages, and ddRADseq identified an introgression zone of secondary contact which occurred in the Great Lakes region after the last glacial maximum. Populations are well differentiated (mean FST = 0.301) and isolation ($\varphi PT = 52\%$, $p < 0.001$) appears to impede gene flow, especially in contracting relict populations in the southwestern *O. vernalis* range. Finally, both datasets are in discordance with prior morphological systematics and do not support those conclusions. Due to population differentiation, isolation, and limited gene flow, conservation managers should focus on local populations rather than wide scale efforts.

Snake communities on the urban fringe in the Sonoran Desert: influences on species richness and abundance

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Oral Presentation

Sonoran Desert habitat in southern Arizona is increasingly altered by urban development near metropolitan areas. Understanding how reptiles respond in these impacted habitats is critical to conservation efforts to retain intact biotic communities, especially those with a high diversity of reptile species. We surveyed snakes at one impacted site on the northern edge of the Phoenix metropolitan area in desert/urban interface, and at another site in a desert/rural interface near Florence, Arizona. The site near Phoenix was lower in species richness (15 spp.), and evenness: two snake species accounted for 75% of all snakes encountered (total = 420). The site near Florence was higher in species richness (19 spp.), and a more even community: no species accounted for more than 20% of snakes encountered (total = 594). Sampling methodology had a strong influence on species richness and abundance of snakes at the respective sites: road riding, coverboards, and traps each provided evidence of unique species missed by other methods. These results were compared with inventories at three other sites in the central Sonoran Desert of Arizona, and are consistent with the view that the impacted site near Phoenix is uneven, potentially as a result of a single species reacting to shifts in prey availability.

Comparisons of reptile community assemblages in two subdivisions of the Sonoran Desertscrub biotic community

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Oral Presentation

Anthropogenic disturbances can have negative effects on species community assemblages and diversity. This study was established to form baseline data on reptile assemblages and environmental structure within a planned energy corridor in Pinal County, Arizona prior to construction. We emphasized evaluating the differences in reptile assemblages and diversity in two subdivisions of the Sonoran Desertscrub, the Lower Colorado River Valley (LCV) and Arizona Upland (AZU). Surveys were conducted on 50 sites (LCV = 15; AZU = 35) along the proposed 67.1-km long energy corridor. Environmental structure and reptile assemblages were examined along the energy corridor through environmental surveys and 50 drift-fence trapping arrays with 400 box funnel traps. Vegetation height, number of burrows and percent rock, ground cover, and coarse woody debris were significantly higher in the AZU than LCV. Eighteen reptile species (n = 995) were detected on the energy corridor, including eight lizard species (n = 952) and 10 snake species (n = 43). Neither species richness nor capture rates were significantly different between the LCV and AZU. Yet, species diversity was significantly higher in the LCV. Reptile abundance (LCV = 281, AZU = 714) differed in the two subdivisions and rank-abundance curves revealed that evenness was higher in the LCV than in AZU. Post hoc examination revealed the geographic separation of sites within the LCV may have contributed to our results. We conclude that both subdivisions are equally important to the maintenance of local biotic diversity and recommend that any future land set-asides consider both subdivisions.

Florida – Saturday, February 11th 8:20-10:00 AM

The remarkable endemism of moths in White Sands National Monument, New Mexico

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Oral Presentation

White Sands National Monument protects 297.85 km2 (40%) of the world's largest snow-white gypsum dune formation. The adaptations of Squamata, Rodentia, and Orthoptera prompts the National Park Service to call White Sands the Galapagos of North America. These animals are now rivaled by moths as showing the greatest amount of speciation. The National Park Service invited Metzler to undertake a study of moths at White Sands NM. Along a transect 2.4 km long by 300 m wide through the dunes, 550 species of moths were recorded during 2007-2016 including. at least 40 previously unknown species of moths in seven families. The rate of endemism is about 7%. To date thirteen of the new species are named. Species of normally dark-colored moths have white phenotypes in the dunes. Many plants in the dunes have haplotypes, chemical signatures, and associated microbes that are different from the same plant species outside the dunes. Larvae within the dunes are ingesting a different diet than larvae eating the same species of plants outside the dunes, thus they inhabit an ideal place for evolution.

Seasonal movements and habitat use of Chiricahua leopard frogs in the Santa Rita Mountains of Arizona

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Oral Presentation

The Arizona Game and Fish Ranid Frogs Project radio-tracked federally threatened Chiricahua leopard frogs (CLFs; *Lithobates chiricahuensis*) to study their movement and habitat use. We tracked 46 adult frogs at four sites in the Santa Rita Mountains during winter of 2014-2015 and summer of 2015. During winter, the longest recorded straight-line movement in a single week was 135.07 m, while the longest cumulative movement, over ten weeks, was 240.04 m. We observed minimal shelter use, mostly within root masses in cut banks and beneath bunchgrasses. When in a terrestrial habitat, frogs were most often basking. We observed almost complete mortality from the fungal pathogen *Batrachochytrium dendrobatidis* (Bd) during the winter season. Anecdotally, CLFs are known to disperse one mile overland, three miles along an intermittent drainage, and five miles along a perennial drainage. We aimed to test this by tracking frogs during the summer monsoon season, when streams are flowing and dispersal potential is greatest. We observed dispersal of four frogs from one site. During the monsoon, the longest movement in a single week was 858.03 m, while the longest cumulative movement was 1510.40 m. The longest movements coincided with week of highest rainfall. For non-dispersing frogs, the max home range size was 569.5 m^2. We found no significant difference in home range sizes between males and females or between sites. The results of this study will inform recovery decisions and help direct efforts regarding habitat construction and maintenance and enrollment of non-federal landowners in the Safe Harbor Agreement for the Chiricahua Leopard Frog in Arizona.

Conservation genetics of the Chiricahua leopard frog (*Lithobates chiricahuensis*).

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Oral Presentation

Chiricahua leopard frog populations have declined precipitously throughout Arizona and New Mexico since the species was listed as threatened in 2002. The species was known historically from over 400 localities, but is now considered likely extant at only 36-59 sites in Arizona and 30-35 in New Mexico.. The study objectives were to develop species-specific microsatellite markers for the Chiricahua leopard frog, use these markers to examine genetic relationships among Chiricahua leopard frog populations in Arizona, New Mexico and Mexico, and to examine if more than one species in present across this study area. A total of 431 frog tissue samples were obtained for this study, from across their range. Novel microsatellites were developed for the Chiricahua leopard frog and 16 of these were PCR amplified in the frog tissues along with four mtDNA loci and analyzed for a variety of population genetic data algorithms and models. Results from mtDNA haplotypes and microsatellite alleles indicate that frog populations in this study area have relatively high genetic diversity with haplotype diversity ranging from 0.362 to 1; but also high levels of inbreeding,

F_{IS} varies between 0.204 and 0.853; with extensive population fragmentation and little evidence of gene flow among populations, G'_{ST} values between 0.372 to 0.868. The extent of subdivision of populations was determined to be anywhere from 14 to 23 populations, using Bayesian analyses implemented in STRUCTURE and GENELAND. A conservation implication of this study is to define management units for Chiricahua leopard frogs that will aid translocation efforts aimed at re-establishing extirpated populations.

Citizens and barking frogs

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Oral Presentation

Researchers from the University of New Mexico conducted a status assessment of the eastern barking frog, *Craugastor augusti*, for the state in 2016, and recommended that future monitoring be done via local volunteers, or Citizen Science. The New Mexico Department of Game and Fish will be designing a program for such monitoring, to be implemented by the spring of 2017. The species will be discussed and why citizen science is the best option for monitoring the barking frog, as well as the program itself. A model of when citizen science is and is not appropriate for monitoring of amphibians and reptiles will be presented, including a discussion of future species to be monitored in such a way for the state.

Baseline inventory of small mammals, amphibians, and reptiles on the Barry M. Goldwater Range–west, southwestern Arizona

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Oral Presentation

The Barry M. Goldwater Range-West (BMGR-W) is a military training area that includes 283,280 ha of Sonoran Desert near Yuma, Arizona. The Integrated Natural Resources Management Plan (INRMP) for the BMGR-W requires that baseline conditions for small mammals, reptiles, and amphibians be established so that natural resource managers may determine how best to protect natural resources. Little is known about the small mammals, reptiles, and amphibians of BMGR-W. What is currently known about these animals comes from either short term surveys at small locations or species-specific monitoring range-wide. Our objectives are to: 1) to establish a repeatable baseline monitoring methodology that will capture the diversity found in small mammals, reptiles, and amphibians on the BMGR, 2) develop potential distribution maps for small mammals, reptiles, and amphibians captured on the BMGR, and 3) provide recommendations to monitoring efforts and natural resource stewardship to assist the military mission on the BMGR. We surveyed for amphibians, reptiles, and small mammals by conducting 5,641 km of visual encounter surveys in all five general habitat types present on the range. Additionally, we sampled for small mammals by setting trapping grids of Sherman traps (5,292 trap-nights) and Tomahawk traps (540 trap-nights). Here we document 18 species of small mammals and 35 species of amphibians and reptiles from the range, including several unexpected or special concern species. We conclude with plans and priorities for future work to improve the completeness of this inventory.

Animas – Saturday, February 11th 8:20-10:00 AM

Sportsmen's value mapping – mapping hunting and fishing voice in Arizona

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Oral Presentation

The effort to guarantee every Arizonan a quality place to hunt and fish is shared by the Arizona Game and Fish Department (AZGFD), the Theodore Roosevelt Conservation Partnership (TRCP), and many Arizona sportsmen groups. Collectively, AZGFD, TRCP and sportsmen organizations sought to quantify the location of the public's most-valued fish and game lands in the state of Arizona. This information would be used in efforts to provide continued access to and better conservation of these highly valued lands. On September 15, 2015, a unique public survey was launched that that gave 7500 sportsmen and sportswomen an opportunity to physically draw their most-valued hunting and fishing locations on an interactive web-map. Over 1100 responded, providing results to the first-ever, online mapping survey of public opinion for over 15 game and fish species in Arizona. These results are effectively providing a voice to hunters and anglers in Arizona by providing these data as a supplement to the traditional distribution and habitat data that are the basis for land use decisions in Arizona. The survey results are available online at http://arcg.is/2aWV1z2. This interactive map series provides the most-valued locations for hunting and fishing of over 15 game and fish species in Arizona, and provides a fascinating glimpse into the motivations why the public values these areas so strongly. This presentation outlines the methods used to create and distribute the survey as well as an overview of the resulting maps, their utility, and interpretation.

Mapping and quantifying terrestrial vertebrate biodiversity at a national scale

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Oral Presentation

The ability to assess, report, map, and forecast functions of ecosystems is critical to our capacity to make informed decisions to maintain the sustainable nature of our environment. Because of the variability among living organisms and levels of organization (e.g. genetic, species, ecosystem), biodiversity has always been difficult to measure precisely, especially within a systematic manner and over multiple scales. In answer to this challenge, the U.S. Environmental Protection Agency has created a partnership with other Federal agencies, academic institutions, and Non-Governmental Organizations to develop the *EnviroAtlas* (https://www.epa.gov/enviroatlas), an online national Decision Support Tool that allows users to view and analyze the geographical description of the supply and demand for ecosystem services, as well as the drivers of change. As part of the EnviroAtlas, an approach has been developed that uses deductive habitat models

for all terrestrial vertebrates of the conterminous United States and clusters them into biodiversity metrics that relate to ecosystem service-relevant categories. Metrics, such as species and taxon richness, have been developed and integrated with other measures of biodiversity. Collectively, these metrics provide a consistent scalable process from which to make geographic comparisons, provide thematic assessments, and to monitor status and trends in biodiversity. The national biodiversity component operates across approximately 89,000 12-digit HUCs and includes over 1700 terrestrial vertebrate species. As an example of this incremental approach, we provide selected results for the contiguous United States along with sub-national areas of interest to demonstrate the multi-scale utility of the system.

Analysis of reptile biodiversity and ecosystem services within the protected areas at a national scale

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Oral Presentation

A focus for resource management, conservation planning, and environmental decision analysis has been mapping and quantifying biodiversity and ecosystem services. The challenge has been to integrate ecology with economics to better understand the effects of human policies and actions and their subsequent impacts on human well-being and ecosystem function. Biodiversity is valued by humans in varied ways, and thus is an important input to include in assessing the benefits of ecosystems to humans. Some biodiversity metrics more clearly reflect ecosystem services (e.g., game species, threatened and endangered species), whereas others may indicate indirect and difficult to quantify relationships to services (e.g., taxa richness and cultural value). In the present study, we identify and map reptile biodiversity and ecosystem services metrics. The importance of reptiles to biodiversity and ecosystems services is not often described. We used species distribution models for reptiles in the conterminous United States from the U.S. Geological Survey's Gap Analysis Program. We focus on species richness metrics including all reptile species richness, taxa groupings of lizards, snakes and turtles, NatureServe conservation status (G1, G2, G3) species, IUCN listed reptiles, threatened and endangered species, Partners in Amphibian and Reptile Conservation listed reptiles, and rare species. These metrics were analyzed with the Protected Areas Database of the United States to provide insight into current conservation lands and reptile biodiversity and ecosystem services. We present results of these biodiversity and ecosystem services metrics focusing on current distributions and overlap with conservation lands.

Predicting habitat use by bats to protect bats and inform wind energy development

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Oral Presentation

Although wind turbines are a clean source of energy, they incidentally kill many bats and birds. Migratory species have the highest mortality; in 2012, ~600,000 bats died from encounters with turbines in the U.S. alone. Arizona has both high species richness of bats and a high proportion of migratory species that creates a high risk of mortality from interactions at wind energy facilities. Our objectives are to determine the species composition, bat use, and topographic features that might influence bat movement. Our study area encompasses open grassland and shrubland in northern Arizona in areas that are similar to where wind energy sites have been considered or proposed for development. We deploy 34 acoustic detectors (SM3BAT) to sample for bat activity at randomly-selected points that represent a range of measures for each habitat covariate. We survey points during spring, summer, and fall of 2015, 2016, and 2017. We use SonoBat 3 software to identify bat calls to species or species groups. In preliminary analysis of 2015 data, we fit linear regression models to evaluate the effects of landscape covariates. The highest bat activity occurred in valleys, lower slopes, and evergreen forests. Since most wind energy development in northern Arizona has occurred on flat slopes, shrubland, and grassland, this might indicate that the best sites for wind energy might not overlap with the best sites for bat use. We will create a map that predicts bat use in areas of northern Arizona that may also be suitable for wind energy development.

Effects of urbanization on bat habitat use in Phoenix, Arizona: a multi-scale landscape analysis

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Oral Presentation

Urbanization can have negative effects on bat habitat use through the loss and isolation of habitat. Yet, how bats respond to the changing landscape pattern of urban environments remains poorly understood. We examined how landscape pattern affects bat activity, foraging activity, and species richness (response variables), and the distinct habitats that they use. We used a multi-scale landscape approach and acoustic monitoring data to create predictive models that identified key predictor variables across three scales. We found the extent and extensiveness of water (i.e., small water bodies and large watercourses) were the most important predictor variables across all response variables. Species richness was predicted to be high in golf courses, which included the detection of the uncommon pocketed free-tailed bat (*Nyctinomops femorosaccus*), and low in commercial areas. Bat activity was predicted to be high in native vegetation remnants, and low in outlying native desert habitat. Foraging activity was predicted to be high in areas of fine-scale land cover heterogeneity. Bat habitat use was affected by urban landscape pattern primarily at the landscape and site scales. Our results suggested in hot, arid urban landscapes water is a limiting factor for bats, even in urban landscapes where the availability of water may be greater than in outlying native desert habitat. Also golf courses may serve as important stop-overs or refuges for rare or elusive bats. Golf courses and urban waterways are novel urban cover types that can serve as compliments to urban preserves, and other green spaces for bat conservation.

Florida – Saturday, February 11th 10:20 AM-11 AM

Evaluation of desert bighorn sheep overpasses and fencing along US Highway 93 in Arizona

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Oral Presentation

Wildlife crossing structures with exclusionary fencing are applied to reduce collisions and maintain habitat connectivity. Species specific design requirements are largely unknown. Desert bighorn sheep (DBS) show reluctance to use underpasses. The expansion of U.S. Highway 93 (US93) brought concerns for the local DBS population. Vehicle-collisions with DBS were estimated at 11/year. The widening would also inhibit DBS access to essential resources. To address these concerns, three overpasses were constructed at sites prescribed by a DBS movement study. These and other structures were linked together with fencing to and guide DBS to the crossings and prevent access to US93. From March 2011-March 2015 Arizona Game and Fish Department (AGFD) evaluated the mitigation components using video and still camera surveillance, Global Positioning System-collared DBS, and vehicle collision monitoring. DBS used the overpasses more (5862 crossings) than bridges (474 crossings) and culverts (195 crossings). Overpass passage rates (crossings/approaches) increased 210% by year four. DBS used escape ramps to access the roadway until modification to prevent the reverse-use. By year four, collared DBS crossings increased 100% and the crossing distribution shifted to align with the structures. Collar passage rates for the same period increased by 1367%. DBS-vehicle-collisions initially declined by 68%. Identification and treatment of fence breach points reduced collisions further (86% overall). These findings indicate that overpasses connected with appropriate ungulate-proof fencing and escape ramps can reduce DBS-vehicle collisions and promote connectivity. An adaptive-management approach to post-construction monitoring can efficiently identify shortfalls to ensure long-term success of mitigation measures.

New insight into utilizing bone marrow to assess ungulate health

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Oral Presentation

Bone marrow fat content has commonly been utilized as a metric to assess ungulate body condition. Evaluating body condition of individuals provides important insight to wildlife managers that allows them to better understand local population dynamics and sustainably manage herds. Studies have compared different methods of measuring bone marrow fat content as well as identified which bones are most representative of an individual's health. However, no previous research has examined how the amount of time from death to sample collection affects bone marrow fat measurements of ungulates in natural conditions. It is not always feasible to collect marrow samples from an individual at the time of mortality, which could potentially bias fat estimates from bone marrow samples. We examined how bone marrow fat content is affected by time post mortem and other factors by collecting multiple bones from individual elk and deer at different time intervals. We found that marrow fat content can change significantly over time. Our top model that explained this change included time between samples, initial fat content and sex of the species. Future research efforts that utilize bone marrow fat content should attempt to retrieve bone samples immediately after death. Failure to do so can lead to false conclusions regarding the nutritional state of individual animals.

Animas – Saturday, February 11th 10:20 AM- 11 AM

Spatial ecology of gray foxes: informing rabies management in the southwest

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Oral Presentation

Space use is a fundamental ecological characteristic of a species, that informs habitat selection, movement dynamics, and inter- and intraspecific interactions including disease etiology. Gray foxes (*Urocyon cinereoargenteus*) are thought to be a substantial reservoir for rabies in the southwestern US; however, their spatial ecology is poorly known. Knowledge of gray fox spatial ecology and movement dynamics across an expansive geographic area can better inform disease management plans in areas. Understanding how foxes as vectors use the landscape is important to control the spread of rabies. We utilized data acquired from GPS satellite collars on gray foxes in the White Mountains and Pinaleño Mountains of Arizona to compare habitat selection, movement patterns, and home range requirements between a well-connected landscape and an isolated sky island. In addition, we employed remote wildlife camera traps to assess density and sympatry with other carnivores. We used occupancy modeling and kernel density estimates to compare habitat selection between continuous and isolated forests. Preliminary results indicate that gray foxes select for areas of upper evergreen forest mix and Ponderosa Pine (*Pinus ponderosa*) forest mix. In addition to providing valuable information for wildlife disease managers, our results regarding the spatial ecology of gray foxes also address regional public health challenges.

Factors determining the long-term success of the Mexican wolf reintroduction project

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Oral Presentation

The reintroduction of the Mexican wolf (*Canis lupus baileyi*) has resulted in a small wolf population residing in New Mexico and Arizona. Many factors, including genetics, illegal killing, fragmented habitat, politics, regulations, and management, have delayed meeting the recovery goal. A long-term self-sustaining population with minimal management will require a meta-population with at least three subpopulations of wolves within a larger area of habitat. Monitoring via genetic and disease surveillance, as well as population assessments must continue to assure Mexican wolf viability. Educational and cooperative efforts with livestock owners and hunters will be necessary for cattle, people, and livestock to cohabit on the same landscape. Perhaps the most unpredictable factor that will affect Mexican wolf survival is climate change, where both the wolf and its prey will have to adapt to an ever-changing environment.

La Plata – Saturday, February 11th 10:20 AM-11 AM

Feral swine: history of an expanding North American threat and current eradication efforts in Arizona

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Oral Presentation:

In recent history, the negative impacts of feral swine expansion throughout North America have reached epidemic proportions. Responsible for over $1.5 billion every year in damage and control efforts, this invasive species poses an ongoing and increasing threat to agriculture, natural resources and human health. Having a population of over 5 million individuals throughout 40 states, efforts to manage and eradicate feral swine vary based on local conditions. With a limited distribution and abundance of feral swine in Arizona, the US Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (WS), National Feral Swine Damage Management Program works in conjunction with WS – Arizona Program and other partners including additional government agencies, as well as private landowners to eliminate this destructive invasive statewide. Through the use of various direct control methods, thorough surveillance and disease sampling, we are able to monitor damage and disease threats posed by feral swine while working toward elimination. A main area of concern regarding feral swine is present along the Colorado River at Havasu National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service (USFWS). In recent years, Special Use Permits (SUP's) have allowed us to work cooperatively with the USFWS toward eradication of feral swine on the wildlife refuge in order to preserve natural resources. While feral swine continue to increase in population and range, strategic efforts and preventative measures on a national and local scale allow WS, USFWS, and our other partners to manage damage caused by one of North America's most prevalent and destructive invasive species.

Monitoring and surveillance for common vampire bats in Arizona

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Oral Presentation:

Common vampire bats (*Desmodus rotundus*) occur throughout much of South America, Central America and into northern México. The diet of vampire bats consists of the blood of mammals. Vampire bat bites are known to: weaken livestock and wildlife due to loss of blood; lead to secondary infections; reduce milk production; and lead to death if the animals contracts paralytic rabies which can cause impacts to agricultural economies and native wildlife. The common vampire bat is currently found in Mexico as far north as the states of Sonora and Tamaulipas. To date, common vampire bats have not been documented in the United States but have recently been documented within 50 km of the state of Texas. However, there is some evidence that future range expansion may extend into south Texas and Arizona over the coming decades as the climate in the southwest warms. Due to this potential risk to livestock and wildlife, USDA APHIS Wildlife Services have partnered with SAGARPA to train personnel in identifying signs of vampire bat feeding. Trained personnel have initiated surveillance at various livestock auctions and feedlots to monitor for evidence of vampire bat feeding due to their potential northward shift outside of their current range.