Wildlife Abstracts

Oral Presentation

Listed Alphabetically by Presenter

Lagomorph Herbivory Prevents Grass Establishment in a Semi-Arid Shrubland

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Shrub encroachment into arid grasslands over the last two centuries has negatively impacted range production, soil conservation, and grassland biodiversity. The primary driver of initial shrub encroachment has been altered fire regimes caused by overgrazing and the concomitant reduction of fine fuels. Following initial encroachment, shrublands have persisted despite cessation of livestock grazing and restoration efforts. We hypothesize that biotic feedbacks, such as native mammalian herbivory, is responsible for the persistence of shrublands. We established an herbivore exclosure experiment at the Walnut Gulch Experimental Watershed, near Tombstone, Arizona, at a site where cattle grazing ceased 60 years ago, yet the site remains dominated by shrubs and has almost no herbaceous vegetation. We created five treatment levels ranging from complete access to complete herbivore exclosure, and at each of our 50 exclosures, we introduced uniform divisions of lawn sod to measure herbivory, and set up motion-activated trail cameras to detect herbivore visitations. We found that prior to the monsoon rains, exclosures accessible to native lagomorphs had significantly more forage consumption compared to treatments that were inaccessible to lagomorphs. Camera observations detected desert cottontail (*Sylvilagus audubonii*) visitations far more frequently than any other herbivore. Following the onset of monsoon rains, differences in forage removal between exclosures disappeared, and desert cottontail visitations dropped significantly. Native mammalian herbivores, especially lagomorphs, may be contributing to shrubland persistence by preventing the establishment of grasses in shrub dominated landscapes. Land managers may consider mitigating lagomorph herbivory pressure by maintaining habitat for their natural predators.

Long-term Passive and Active Management, Data Collection and Trends, of a High Desert Riparian and Upland Preserve in Northwestern Mohave County, Arizona

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The Willow Creek Riparian Preserve (Preserve) is a 30-acre site located 30 miles east of Kingman, Arizona. The Preserve was formally established in 2007 with the purchase of 10-acres and agreement with the eastern adjoining private landowner to add approximately 20-acres upstream. The Preserve location was unfenced and wholly accessible by livestock, off-road vehicle use, and hunting. In October of 2008 the Preserve was fenced with volunteer efforts from the local Rotary Club and Boy Scout Troop 66. Additional financial assistance came through a large discount in the cost of fencing materials from Kingman Ace Hardware. A total of 0.5-linear mile of new fencing was installed along the south and west sides and connected to existing Arizona State Lands cattle allotment fencing. Baseline and on-going studies and data collection have occurred since 2004. These have included small mammal live trapping; chiropteran surveys with the use of Anabat; migratory, breeding, and winter avian surveys; amphibian and reptile surveys; deployment of game cameras; animal track and sign identification and movement patterns; vegetation and plant surveys; and a wetland delineation. Results and trends over a 10-year period have demonstrated not only an increase in wildlife and plant diversity, but an increase in overall abundance and use as well as additional habitat use beyond the Preserve boundaries. Habitat changes have resulted in some species no longer being present but subsequently replaced with a suite of other species dependent upon an increase of cover, structure, forage availability, nesting or burrowing opportunities, water availability, and other factors. Opportunities for additional on-going or new studies and data collection exist and volunteers are always welcome.

Road Mortality Mitigation: The Effectiveness of Animex Fence versus Mesh Fence.

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Fencing is one of the most effective mitigation measures used to reduce road kill however, little research is known about what materials work best to exclude herpetofauna from roads and there are a lot of concerns surrounding the safety and effectiveness of mesh fencing. This research attempts to fill this gap of knowledge and evaluates the effectiveness of mesh and Animex fencing by investigating their suitability to be used as solutions to protect wildlife near roads.
This behavioral study explored the reactions of various herpetofauna when placed in an enclosure comprising two sides of steel mesh fencing (1/4 inch), and two sides of Animex. The activity that was recorded and compared during the observations included:
1) Time spent within each fence zone
2) Physical interactions with the fencing
3) Climbing or escape attempts
The results showed that the animal groups spent a greater proportion of time along the mesh fencing and all the animal groups attempted to escape the mesh fencing during more than twice as many trials as the Animex. All species except Midland Painted Turtles successfully escaped

the mesh fencing; however, none escaped the Animex. Based on behaviors exhibited by animals during the trials, mesh fencing could result in injury to herpetofauna.
As the goal of exclusion fencing is not only to keep animals off the road but also to funnel animals safely to wildlife crossing structures, this study recommends plastic solid barrier fencing such as Animex is the most appropriate material to be used as exclusion or drift fencing for the species studied. This study shows that mesh fencing will hinder the funneling of animals towards wildlife crossings or into adjacent habitat due to additional risk of injury, delay or escape created by the type material.

What are climate-wise corridors?

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Improving connectivity is the most-frequently recommended strategy for helping biodiversity cope with climate change. Climate-wise corridors must allow species to shift their range. But how do we prioritize land to do this? I describe 5 strategies, arrayed along a spectrum from simple (little information needed) to convoluted (requiring detailed information and linked, complex models). Most simply, (1) we can prioritize riparian corridors. Because riparian areas are natural travel routes for many plants and animals, will remain the wettest parts of the landscape in any climate, often follow climate gradients, and (if wide enough) incorporate diverse climates and abiotic settings, they should be part of any climate-connectivity plan. Another simple strategy is (2) "naturalness corridors" of the least human-impacted land. In the middle of the spectrum, (3) land facet corridors aim to preserve connectivity of abiotic conditions (e.g., warm valley bottom corridors or sunny ridgeline corridors), and (4) climate gradient corridors aim to connect warm spots to cool spots along the gentlest gradient. Approaches 3 & 4 make few assumptions, and require data freely available for the globe at 30-m resolution (land facet corridors) or 1-km resolution (climate gradient corridors). At the sophisticated end of the spectrum, (5) climate envelope models attempt to map the shift climate space of individual species. In these models, guesses of future CO2 emissions drive global air-ocean circulation models, the outputs of which are downscaled to 100x100-km cells; then these downscaled climate projections are matched with the estimated physiological tolerances and dispersal capabilities of each species to map the potential paths of the species' shifting range. Finally the paths for all species are combined into climate envelope corridors – a glamorous but risky product. For all 5 approaches, a crucial unresolved issue is the minimum width of a corridor.

Zoo-based Adaptive Management for Repatriation of Threatened Species

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Zoo-based ex situ conservation breeding programs are invaluable resources to conserve at-risk wildlife species. Zoos can function as genetic repositories, raise community awareness for conservation support, and facilitate species reintroduction or population augmentation. Moreover, adaptive management strategies developed ex situ can inform reintroduction strategies. The narrow-headed gartersnake (THRU; *Thamnophis rufipunctatus*) is a small, semi-aquatic snake endemic to the sub-Mogollon Rim region of Arizona and New Mexico. Nonnative species, habitat loss, and wildfires have exacerbated THRU declines, resulting in federally threatened status in 2014. In collaboration with wildlife managers, the Arizona Center for Nature Conservation — Phoenix Zoo began a propagation for reintroduction program for THRU in 2007. Initially, our husbandry protocols included controlled winter brumation, access to live fish to encourage natural foraging, and genetic management of breeding pairs. For several seasons we observed copulation events, but no births resulted. From 2012-2013, we constructed a large enclosure that included refugia, an aerated pond with live prey, and a climate-controlled hibernaculum. This design allowed multiple THRU to forage, thermoregulate, and socialize. After spring emergence in 2014, we observed copulation and an increase in mass for one female. On 2 July 2014, the female gave birth to 18 healthy neonates. Most offspring have been designated for reintroduction back into their native range, whereas others remain in ex situ care for future breeding and management purposes. We will discuss how ex situ adaptive management is an applicable and vital tool for species reintroduction efforts.

Examining the Ecological Interactions of Feral Horses on Montane Riparian Systems

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Understanding the ecological interactions of feral horse populations is of increasing importance on Federal lands where management options are often case specific and complex. In the White Mountains, Arizona, USA, feral horse habitat overlaps heavily with cattle and other species of native ungulates including elk, mule deer and pronghorn. The addition of a novel large bodied grazing mammal within an ecosystem may have implications for both interspecies competition as well as for the soils and vegetative communities on which they graze. We established a network of time lapse cameras and grazing exclosures to examine interspecies interactions as well as to measure the intensity of grazing by species on two adjacent riparian study areas from May-October 2017. Photographic time series were used to examine both the fine scale spatial and behavioral relationship between grazers when they co-occurred as well as to explore the potential

for more coarse scale temporal distributional strategies between species. Grazing frequency and species detection rates were compared with available forage using a simple linear model. To estimate forage utilization we established six 1m2 grazing exclosures at each site (N=12). We compared stubble height, species composition and dry yield to six randomly selected grazed plots within both study areas. Our study establishes base line information that can be used to inform feral horse management and design future hypothesis driven research to better understand the potential impacts of feral horses on rangelands. Preliminary results of this research are pending and will be presented at the time of the conference.

On the Move: Terrestrial Ecology of the Endangered Sonoran Tiger Salamander

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Knowledge of ecological and behavioral processes are essential for the conservation of species at risk of extinction. Approximately one third of all amphibian species are threatened or endangered, and those with limited distribution or population size are particularly vulnerable. To develop effective conservation strategies for at-risk amphibians, managers need to understAand their ecological requirements. The Sonoran tiger salamander (STS; *Ambystoma mavortium stebbinsi*) is a federally endangered subspecies found only in the San Rafael Valley of southeastern Arizona and northern Sonora, Mexico. The STS was listed as endangered in 1997 due to highly restricted distribution, dependence on human-constructed environments, invasive species, genetic swamping by non-native salamanders, and disease. Cattle tanks created by ranchers to hold water have replaced natural springs, and are now primary breeding sites for STS. The terrestrial life stage is the only means of responding to pond drying or die-offs and thus is critical to the maintenance of metapopulation dynamics. However, the ecology of metamorphosed salamanders outside of breeding tanks is virtually unknown. We are using radio-telemetry to assess STS terrestrial movement patterns, habitat preferences, and life history traits. Preliminary radio-telemetry data will be presented. Spatial information is important for wildlife managers to develop effective management strategies to conserve the Sonoran tiger salamander and other isolated amphibians.

Counting Bats in Absentia

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Resource managers must often know the size of a bat colony to appropriately manage the resource. This is critical with white-nose syndrome killing bats as it moves westward. However, entering a bat roost to determine colony size is highly disturbing to the bats and can cause abandonment of a significant site. We have been monitoring bat roosts across Arizona and New Mexico since 1986 and have developed techniques which provide the greatest information with minor disturbance to the bats. Using an infrared (IR) camera and supplemental IR lights offers a

low disturbance method to monitor bat roosts. For large colonies, these video recordings can be slowed to less than ½ speed to obtain a more accurate colony size. However, this method can be labor-intensive. To determine colony sizes throughout a season, passive IR bat counters offer a nightly relative estimate of bats with surprising accuracy. Bats fly through an infrared (IR) beam, which records the event with a date and time stamp. The passage size is important for accuracy: the smaller the cross section, the more accurate the bat count. To determine the accuracy of the IR bat counter, a correlation is plotted between the nightly IR counts and less frequent human counts. We have found that IR bat counters can estimate within 82% the number of bats using the site, while also showing seasonal changes in colony behaviors. We offer examples from different sites where emergence counts were conducted and IR bat counters were used.

Genetic Origins of United States Feral Swine Populations

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Feral swine (*Sus scrofa*) are a long-established invasive species in the United States with populations established in the 1200s in Hawaii and mid-1500s on the mainland. Despite their long history, feral swine remained restricted to the southeast, California, and Hawaii until the 1980s but have since expanded dramatically with populations now established in >40 states. We used molecular tools to gain a greater understanding of the origins of both historic and newly emerging populations and elucidate the processes driving range expansion. Specifically, we used principal component analysis to compare high density single nucleotide polymorphism genotypes (29,383 loci) of 3436 feral swine sampled across the invaded US range to a comprehensive reference set of 2968 domestic pigs and wild boar, representing 152 distinct genetic groups sampled throughout the world. Historic populations were genetically intermediate to US/European pigs and European wild boar, consistent with the documented history in which feral populations were established through the release of domestic pigs and subsequently augmented with wild boar to improve hunting appeal. Newly emerging populations in Michigan, Colorado, and Indiana had a far higher wild boar genetic composition than historic populations, suggesting swine collected from novel sources were used in the establishment of these populations. Populations across the Hawaiian Islands and Guam represented a mix of Asian and US/European ancestry, reflective of establishment with Polynesian colonization and interbreeding with US/European pigs from the time of first European contact in 1778 onward. This work has demonstrated that natural range expansion, translocation from historic populations, and releases from novel genetic sources have contributed to the expansion of this ecologically destructive and economically costly invasive species.

Future work with genetic clustering algorithms will allow us to increase the precision in which we can quantify genetic composition and will improve our ability to identify the sources of new populations.

Livestock Depredation by Mexican Wolves and Non-lethal Mitigation Techniques

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Mexican wolves were extirpated from the Southwest by the middle of the last century. Mexican wolf extirpation was deemed necessary by the public and by agricultural and wildlife agencies due to perceived and real conflicts with humans and human enterprises, such as the agriculture industry (livestock depredation) and sport hunting (impacts on big game). Concerns about human safety contributed to the comprehensive effort to eliminate the wolf from the landscape. Eradication was carried out primarily by government agencies, with assistance from ranchers, hunters and bounty hunters. Since 1998, more than a 100 captive-born wolves have been released to the wild in Arizona, New Mexico, and Mexico. The Mexican Wolf Reintroduction Project is managed by the U.S. Fish and Wildlife Service in collaboration with the Arizona Game and Fish Department, Forest Service, USDA-APHIS Wildlife Services, and the White Mountain Apache Tribe. To understand and manage the Mexican wolf on the ground, Wildlife Services participates as a member of an Interagency Field Team. Wildlife Services participates with the Interagency Field Team as the lead agency for depredation investigations and to lead research on Mexican wolf depredations and to evaluate alternatives to mitigate Mexican wolf damage. The first reported depredation occurred on May 5, 1998, shortly after the return of the Mexican wolf to the Blue Range. Since 1998, over 800 incidents of reported Mexican wolf depredations have been investigated in Arizona and New Mexico including tribal lands. To mitigate the depredations, a variety of funding mechanisms have been set up to pay for compensation, pay for presence, to provide nonlethal alternatives to management. Nonlethal alternatives have included range riders, moving livestock, and fladry. As the Mexican wolf population continues to increase on the ground, the need to address depredations and public's desire for nonlethal alternatives will continue to grow.

Species From Feces (SFF) goes Diet

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Are you what you eat? Determining diet of an animal can be difficult, time consuming, and biased. Common approaches included observations of animals, utilization trials, gavage, salvage of gut contents, stable isotope analysis, and visual identification of animal or plant tissue found in feces. With Species From Feces, we paired high-throughput genetic and bioinformatics approaches to identify bat species from hundreds of fecal pellets simultaneously, for increased utility and decreased costs. We now apply similar methods to determine the diet of mammalian herbivores and insectivores from their feces. We used an amplicon-based sequencing approach of the COI gene to identify arthropod diet items. For plants, we used DNA metabarcoding targeting the ITS2 gene to determine plants in feces. We identified diet items to taxonomic order, family, genus, and even species. For example, the common vampire bat (*Desmodus rotundus*) in Belize fed solely on cows (*Bos taurus*). Compared to traditional methods, next generation sequencing approaches allow for fast and inexpensive data acquisition leading to expedited understanding of diet. We used these techniques to describe diet of pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), bats including temperate and tropical species, and rodents including the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*). In the case of the spotted bat (*Euderma maculatum*), analysis of 1 individual revealed diet beyond Lepidoptera, thought to be primary prey of this bat species. Genetic approaches broaden our knowledge of individual species and feces provide a rich source of information to understand ecology.

Accounting for Imperfect Detection of Groups and Individuals when Estimating Abundance

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When an abundance estimate is desired for grouped animals, the standard approach is to account for imperfect detection of groups, while assuming that individuals within detected groups are all detected. If the assumption holds, unbiased estimators include double-observer models, distance sampling models, and combined double-observer and distance sampling models (known as mark-recapture-distance-sampling models; MRDS). In some surveys, however, some individuals may go undetected. Here, we introduce an abundance estimator for grouped animals when detection of groups is imperfect and group size may be under-counted. The estimator combines an MRDS model with an N-mixture model to account for imperfect detection of individuals. The new MRDS-Nmix model relies on the same data as an MRDS model (two detection histories, an estimate of the distance to transect, and an estimate of group size), plus a second estimate of group size provided by the second observer. We simulated 12 datasets and used Bayesian methods to compare the performance of the new MRDS-Nmix model to an MRDS model. Abundance estimates generated by the MRDS-Nmix model exhibited minimal bias and nominal coverage levels. In contrast, MRDS abundance estimates were biased low and exhibited poor coverage. Many species of conservation interest reside in groups and could benefit from methods

to account for imperfect detection of individuals. We believe the proposed estimator is feasible because the only additional field data required is a second estimate of group size.

Genome-wide Analyses of SNPs is Consistent with no Domestic Dog Ancestry in the Endangered Mexican Wolf (*Canis lupus baileyi*)

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The Mexican gray wolf (*Canis lupus baileyi*) was historically distributed throughout the southwestern United States and northern Mexico. Predator removal campaigns in the early 1900s resulted in its extirpation by the mid-1980s. By this time, the Mexican wolf existed in three separate captive lineages descended from three, two, and two founders, respectively (McBride, Ghost Ranch, and Aragón). These lineages were eventually merged to increase genetic variation in captive wolves, and Mexican wolves were reintroduced into Arizona and New Mexico in 1998. It has been suggested that a proportion of the Mexican wolf ancestry, since being brought into captivity, may be derived from hybridization with domestic dogs. In this study, we genotyped 87 Mexican wolves, including individuals from all three captive lineages and individuals from cross-lineage wolves, for more than 172,000 single nucleotide polymorphisms (SNPs). We identified levels of genetic variation consistent with the known pedigree and the effects of genetic rescue. To identify the potential of this dataset to detect hybridization with domestic dogs, we compared our Mexican wolf genotypes with those from already published data from domestic dogs and other gray wolves. The proportion of Mexican wolf ancestry assigned to domestic dogs was only between 0.06% (SD 0.23%) and 4.2% (SD 1.0%) for global and local ancestry estimates, respectively; and is consistent with incomplete lineage sorting (evidence of historical ancestry between gray wolf and domestic dog). Overall, our results suggested that Mexican wolves lack biologically significant ancestry with domestic dogs and have useful implications for the conservation and management of this endangered wolf subspecies.

Abandoned Mine Protection as Bat Habitat

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Arizona has an estimated 50,000 open abandoned hard rock mines, 22,000 of these occur on BLM managed lands. Nearly 70 percent of the abandoned mines in the western United States show signs of bat use. To eliminate the hazards open abandoned mines present to the public these mines are being closed at an accelerating rate. With increasing concerns about the status of

bat populations in Arizona and the limited information regarding the utilization of mines, research with a focus on this taxa is imperative. The importance of abandoned mines for bats lies in their potential to provide a variety of roosting sites including maternity, hibernacula, day, night, and interim roosts. Thus, accurate surveys of bat activity are essential in identifying and preserving bat roosts. Since 2009 AZGFD has inventoried and provided bat habitat assessment and closure recommendations for approximately 4,000 abandoned mines. We used these closure recommendations to prioritize bat gate and fence installations on a statewide basis. To date AZGFD has installed 51 bat gates and fenced 224 mines. These gates and fences have the potential to aid bat habitat management for the long-term and protect the public from dangerous abandoned mine features.

Tracking Escherichia Coli Infections of the Endangered New Mexico Meadow Jumping Mouse (*Zapus hudsonius luteus*)

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The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is a riparian-obligate species in New Mexico, Arizona, and Colorado. When listed under the Endangered Species Act as Endangered in 2014, the most significant threats to existing populations were habitat loss due to livestock grazing, human recreation, and wildfire. In 2015, we identified a potential new threat: Escherichia coli infections. E. coli, found in the gut of 5 of 12 jumping mice tested, belonged to a pathogenic clade known to cause disease in humans. However, the source and risk of disease in jumping mice is unclear. To investigate the source of E. coli in the jumping mouse we genetically typed bacterial samples of jumping mice, other wildlife, and livestock from 7 sites in Arizona and New Mexico. We identified 5 E. coli lineages. Two lineages found in jumping mice were also found in wildlife and livestock. Determining the presence of 11 toxin-producing genes of E. coli helps characterize each lineage and indicates the potential for disease in jumping mice.

Balancing Highway Construction with Preservation of Extreme Biodiversity in the Kingdom of Bhutan

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The Himalayan Kingdom of Bhutan lies within one of the world's 36 biodiversity "hotspots." Bhutan's constitution protects its forests, much within 10 protected areas encompassing half its land area. A new southern highway corridor has been a priority and several segments are now

complete. Remaining segments will pass through biodiversity-rich protected areas subject to strict environmental safeguards. One proposed segment crosses through the 269 km2 Phipsoo Wildlife Sanctuary. Three alignments (40-60 km in length) were evaluated under a 2014-2015 biodiversity assessment, with one each in separate stratified sampling zones with different terrain, elevation, and vegetation. Our assessment was charged with determining if the road could be built and if so, to compare alignment impacts and develop strategies to minimize such impacts, as well as serve as a "model" for environmentally sensitive road and conservation projects elsewhere.
We inventoried forest/vegetation, avian, mammal, and fish species and special habitats, and quantified illegal tree harvest and poaching. We confirmed the presence of 27 species afforded IUCN threatened and endangered status; mammals accounted for the majority (74%). Camera trapping (5 months) yielded 4,300 individual mammals and 28 species; 15 were IUCN listed. We found a significant difference in mammalian biodiversity metrics among assessment zones. We identified a viable alignment passing through previously modified and degraded habitats with lower biodiversity than other alignments. Along with design features (e.g., underpasses) and conservation offsets, the road could be managed as a resource protection asset to protect wildlife and help achieve a net positive benefit to biodiversity.

Review of the Distribution, Habitat, and Conservation Status of the Peñasco Least Chipmunk

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The Peñasco least chipmunk (PLC, *Neotamias minimus atristriatus*) is endemic to the Sacramento Mountains in southcentral New Mexico. Based on declines in distribution and habitat, it is currently considered a Candidate for listing under the Endangered Species Act with a high magnitude of threats. In this presentation, I summarize historical information and recent research on the ecology and status of this taxon. The PLC can be distinguished from the sympatric grey-footed chipmunk (*Neotamias canipes*) on basis of pelage, cranial, and external characteristics. The Sacramento Mountains subpopulation of PLC has not been detected since 1966. Discovery of a large series of museum specimens collected in 1931-1932 during the Huber Expedition to the Sacramento Mountains provided insight into the historical distribution and habitat of the PLC relative to *N. canipes*. The Sacramento subpopulation was closely associated with herbaceous habitat within the ponderosa pine zone, an ecosystem that has been widely altered in the mountain range. In contrast, *N. canipes* is a classical "forest chipmunk" and uses a broader range of habitat associations. The White Mountains subpopulation of PLC was detected in 2016, confirming persistence of the taxon. Anecdotal evidence suggests this subpopulation is associated with subalpine Thurber fescue meadows above tree line. This ecosystem has declined in distribution due to encroachment of trees and is threatened by climate change and potentially recreation and other factors. Habitat changes may benefit *N. canipes*, which could outcompete the PLC based on its larger body size and broader habitat associations.

Distribution of the Gila Monster (*Heloderma suspectum*) in Southwestern New Mexico

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The Gila Monster is the iconic venomous lizard of the U.S. southwest yet little is known about its distribution in New Mexico. While widespread and relatively common elsewhere, the species is known from only a few scattered and disjunct areas in southwestern New Mexico and is categorized as endangered by the New Mexico Department of Game and Fish. Gila Monsters are threatened by multiple factors, including illegal collection for commercial and private trade, habitat fragmentation, changes in land use, and increased temperatures and drought condition from climate change. In the spring and summer of 2017 we conducted surveys throughout four target areas in southwestern New Mexico, identified from previous records and a preliminary model of distribution. While we detected Gila Monsters at all of the four areas, detection probability varied significantly among them; furthermore, these lizards were most prevalent near the Gila River. To evaluate the vulnerability of the populations at a landscape scale, we built suitability models for current and future landscape based on data gathered from various sources. While the potential extent of Gila Monsters occurrences in New Mexico is larger than previously known, our models suggest that occupied areas are likely small and their delineation is complicated by varying detection probabilities thus further sampling is needed to improve model estimates. This will be necessary in designing a comprehensive Gila Monster conservation strategy in New Mexico, where this charismatic lizards future is complicated by the increased pressures from changing climate and the effects of pet-trade harvesting.

The Value of Undergraduate Researchers: a Long-term Study of Gray Vireos in Central New Mexico.

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The Sevilleta National Wildlife Refuge, located in central New Mexico, contains about 25,000 acres of Juniper woodland and savanna. Much of this woodland provides breeding habitat for the Gray Vireo (*Vireo vicinior*), a little-known southwestern songbird listed as threatened within the state of New Mexico. For the last six of seven years, I have investigated various aspects of their breeding biology, cowbird parasitism and habitat characteristics. I have conducted the field work using undergraduate students from the UNM Research Experience for Undergraduates program. Each summer I had two different undergraduates conducting the research. They conducted point surveys using a playback protocol, searched for nests, monitored nest success, collected nest site and area habitat measurements, and characterized defended territories in three locations within Los Piños Mountains on the eastern portion of the refuge. One year included a prescribed fire in a portion of one of the study areas, and I compared pre-fire and post fire vireo numbers and territory locations. Over the 6 years, we located a total of 68 nests, 21 of which fledged at least one young (31%), and 11 of which were parasitized by Brown-headed Cowbirds (*Molothrus*

ater) and failed (16%). This presentation summarizes the habitat used on the refuge, characterizes nest trees, and reports on the size of defended territories. It also examines cowbird parasitism in relation to distance from cattle grazing, and discusses pinyon-juniper management in the range of the Gray Vireo. I include discussion on the pros and cons of using undergraduate researchers to conduct the research.

Preliminary Survey Results of Southwestern Speckled Rattlesnakes with a Unique Color Pattern in the Tinajas Altas Mountains, Yuma County, Arizona from 2015 to 2017.

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The Arizona Game and Fish Department is responsible for managing the wildlife resources in the State of Arizona. Limitations on the take of certain species are set by the department based on the best available information. We proposed to evaluate the status of Southwestern Speckled Rattlesnakes (*Crotalus mitchellii pyrrhus*) in the Tinajas Altas Mountains of Yuma County, Arizona to enhance the department's understanding of this species in order to add to information needed to re-evaluate take limits. The Speckled Rattlesnakes in the Tinajas Altas have a unique color pattern not found anywhere else in the species distribution. Because of this pattern, this species is especially sought after by collectors, leading to concern regarding take limits and regulation. We began a monitoring project to gain an understanding about populations of this species by surveying three canyons expected to provide easy access to collectors, including the Tinajas Altas Pass, "South Canyon", and "North Canyon". Surveys occurred in the springtime of 2015, 2016, and 2017 by searching for snakes in slope, bajada, and wash habitats in each canyon. Habitat characteristics were recorded for each capture location and snakes were measured (snout vent length and tail length), weighed, sexed, and injected with Passive Integrated Transponder (PIT) tags. Across the three years of surveys (770 search hrs.), we had 70 snake captures (41 individuals). Future surveys, including a current telemetry project, will provide more information for the re-evaluation of take limits for this species.

Restoring and Conserving Wildlife Corridors Through Land use Partnerships in Northern Arizona

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Maintaining wildlife movement corridors in the face of existing and ongoing habitat fragmentation is one of the largest challenges facing wildlife professionals today. In the last 10 years, the Arizona Game and Fish Department (AGFD) and partners have mapped many of these wildlife movement corridors across Arizona. The challenge now is to remove existing barriers within these corridors, and ensure that they remain unobstructed in the future. The AGFD actively engages in these efforts across northern Arizona, but relies almost entirely on the willing cooperation of partners for implementation. Our partners include Coconino County, City of Flagstaff, large ranches, ADOT, USFS, DOD, and the State Land Department. We strive to remain engaged at multiple scales with all partners by recommending wildlife-friendly policies and projects in broad land planning processes as well as site-specific projects. We will discuss where our efforts have been the most successful so far, and where our greatest challenges lie.

First Year Monitoring for Lymphoproliferative Disease Virus (LPDV) in Wild Arizona Turkeys

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Lymphoproliferative disease virus (LPDV) is an infectious retrovirus of gallinaceous birds that is known to infect wild and domestic turkeys. While most infected birds appear to be asymptomatic, lymphoplasmacytic neoplasia expressed as hard, scabby tumors around the head and feet occurs in a small percentage of cases. The first cases of LPDV in wild turkeys within the United States were diagnosed in 20 in Arkansas, and subsequent surveillance revealed the virus to be widespread in populations in 24 eastern states. While research is ongoing to determine whether LPDV is negatively impacting these populations, little to no surveillance has been conducted in the Western United States. Due to previous turkey Arizona translocation efforts from LPDV-positive states, we had reason to believe that the disease may be present in Arizona's turkey populations. Our objective for this study was to determine whether LPDV is present in Arizona's wild turkey populations. During the spring of 2017, samples of whole blood were collected from 20 live turkeys, and samples of whole blood and bone marrow were collected from 28 hunter-harvested turkeys postmortem (n=48). Lymphoproliferative disease virus genetic sequences were detected via polymerase chain reaction in 54% (n=26) of samples tested. Furthermore, four strains of the virus were sequenced and found to be novel compared to those that have been identified in eastern populations. Further studies will determine prevalence within the state as well as whether the virus is present in Gould's turkey (*Meleagris gallopavo mexicana*), a previously untested species.

Gunnison's Prairie Dogs (*Cynomys gunnisoni*) Maintain Body Condition, Not Population Size, Under Extended Drought Conditions

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Gunnison's prairie dog (*Cynomys gunnisoni*) inhabits temperate grasslands experiencing marked seasonal and interannual variability in primarily productivity, and utilizes internal energy stores to survive periods of negative energetic balance. We investigated relationships of energetic resource use and storage to population demographics in two populations of *C. gunnisoni*. Both the arid lower-elevation (prairie) and more mesic higher-elevation (montane) populations experienced extended drought conditions that began following study initiation. We found no overall differences in body mass or condition between the two *C. gunnisoni* populations, but patterns of seasonal body mass changes differed between sites. Female *C. gunnisoni* at the montane site reached their lowest body mass following energetically-demanding periods of parturition and lactation, while males and prairie females increased in mass each season following emergence from hibernation. Despite similar body condition and initial densities, montane *C. gunnisoni* populations reached densities up to 15x those from the prairie site, and increased each year following recruitment. Our results suggest that consumers may be forced to choose between reproductive and somatic investment during extended droughts, and that maintenance of body mass and long-term energy stores may be independent of conditions necessary to support population growth.

The Rise and Fall of an Endangered Species: Methods for Improving Black-footed Ferret Management

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Re-establishment of the black-footed ferret began in Arizona in 1996 at the Aubrey Valley and was the first release of ferrets in a Gunnison's prairie dog colony. In 2007, an additional ferret release occurred on the Espee Ranch but due to reoccurring disease issues, this site has never established itself. After years of trial and error in the Aubrey Valley, the population grew and became one of the U.S. Fish and Wildlife Service's "successful sites". But success within the Aubrey Valley only lasted so long and the colony has declined but still persists. This decline pushed the Department to reexamine the program and make decisions about how to maintain the population of ferrets as a whole. The entire program depended on one population of ferrets and it was obvious that a variety of sites were needed across a wide range. In 2017, the Department released the first nation-wide State Management Plan for Black-footed Ferrets. In this plan, the Department has identified goals for expanding ferret release sites, included monitoring methods for ferrets, prairie dogs, and disease, and integrated new tools such sylvatic plague vaccine into disease management protocols. We hope this Management Plan will lead to recovery of black-footed ferrets in Arizona and contribute to the nation-wide effort to save one of the most critically endangered species.

An Analysis of Factors Influencing Mortality and Habitat Selection in Two Desert Bighorn Sheep (*Ovis canadensis mexicana*)

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Mountain lions (*Puma concolor*) and bighorn sheep (*Ovis canadensis*) are native species sharing a long history in the Southwest and, in current times, are commonly the focus of management and research efforts. Numerous previous studies have reported on bighorn sheep, mountain lions, and their interspecific relationships, including the influence of predation on bighorn sheep populations and bighorn sheep habitat selection strategies. However, questions still remain regarding which factors influence risk of predation for bighorn sheep and how they select habitat to reduce this risk. Currently, the Research Branch of the Arizona Game and Fish Department is conducting a 4-year study with the purpose of a) understanding factors that influence bighorn sheep risk of lion predation and b) documenting bighorn sheep habitat selection in relation to presumed predator avoidance strategies. We are tracking 104 GPS-collared bighorn sheep in two Arizona populations, including one recently reintroduced population, and recording data on bighorn sheep group size/composition and cause-specific mortality. Additionally, we are recording measurements on environmental factors including topographic features, vegetation, and horizontal visibility. We will use a proportional-hazards analysis framework to examine which factors put bighorn sheep at increased risk of mortality. We will use a habitat selection framework to a) document if and how selection changes with time after translocation/reintroduction, and b) to examine whether bighorn sheep select habitat consistent with presumed predator avoidance strategies. We anticipate this research will inform the Department's ongoing bighorn sheep and mountain lion management actions, including decisions related to fire, recreation, predators, and translocation strategies.

A Primer on the Endangered Mt. Graham Red Squirrel: Current Status and Threats

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The Mt. Graham red squirrel (*Tamiasciurus fremonti grahamensis*) was federally listed as endangered in 1987 and this montane endemic has remained among the most critically endangered species in North America. Population numbers have fluctuated over 31 years of surveys but in recent years numbers had stabilized between 200 and 300 animals. However, the Frye Fire in summer 2017 affected nearly 20,000 ha and the population declined to 35 animals. Mt. Graham red squirrels traverse large home ranges that suggest issues related to habitat quality including response to fire, insect damage, roads, and introduced Abert's squirrels. Mortality is high with few animals living to reproduce more than once in their short lifetime. Litter size is reduced compared to non-endangered populations of red squirrels. The demographic challenges faced by Mt. Graham red squirrels are likely exacerbated by a paucity of genetic variation.

Ultimately, the persistence of the USA's most endangered breeding mammal will depend on multi-agency, NGO, and academic collaboration on in situ and ex situ conservation efforts.

A Comparison of Territory- and Grid-based Models of Mexican Spotted Owl Site Occupancy on a Burned Landscape

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The Rodeo-Chediski fire of 2002 appears to have driven a substantial decline of a local population of Mexican spotted owls on the Apache-Sitgreaves and Tonto National Forests in east-central Arizona. Fifteen years later, is the population stable, declining, or trending up? We used two different approaches to occupancy modeling to answer this question. One was based upon sampling known pre-fire owl territories, analogous to a commonly used approach for California spotted owls. The other used a grid system to model occupancy over our entire 18,800 ha study area, including areas rarely-sampled in past surveys. Both models were based upon detection histories generated from owl surveys during the 2014-2016 breeding seasons. Territory- and grid-based sampling schemes produce similar results but with some discrepancies that may be important to consider in designing surveys for Mexican spotted owls, especially in a post-fire landscape.

A scale-optimized model of Mexican spotted owl habitat after the Rodeo-Chediski fire, Arizona

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Large, severe wildfires present a potential threat to the Mexican spotted owl by altering the structure and arrangement of a landscape that was historically fragmented and patchy at multiple scales. Single-scale models of habitat may not precisely reflect how fire has affected habitat selection by Mexican spotted owls. Our objectives were twofold: to determine if large, severe fires drive Mexican spotted owls to select for different habitat features or for the same features at different spatial scales, and to determine how the owl's relationship with fire is mediated by spatial scale. Our study area was a 18,800 ha region of the Rodeo-Chediski fire, which burned 187,000 ha in east-central Arizona in 2002. We used location data from the 2014-2016 breeding seasons to construct a scale-optimized post-fire habitat model for the Mexican spotted owl. We then compared the results to a model that used owl location data from 1990-1993. Preliminary results indicate that areas with steep topography and higher canopy cover continue to be

important components of habitat selected by Mexican spotted owls in this study area, but selection of habitat with high canopy cover may be occurring at finer spatial scales.

The Costs of Being Cool: Panting Thresholds, Thermal Limits, and Evaporative Cooling in Southwestern Lizard Communities

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In the American Southwest, operative environmental temperatures (Te) often exceed what is physiologically tenable for many reptilian species. When faced with extreme environmental temperatures, lizards must either retreat to thermal refugia or attempt to maintain or lower body temperature (Tb) through evaporative processes such as open-mouth panting. Currently, the capacities for evaporative heat dissipation are largely unknown as are the relative efficiencies of evaporative cooling for various species. To better understand the role of panting in body temperature defense against extreme environmental temperatures, we measured thermoregulatory performance for a variety of lizard species native to the southwest. We used flow-through respirometry to gather data on standard metabolic rate (SMR) and evaporative water loss (EWL) at air temperatures (Ta) that ranged from 35°C to 50°C. Concurrently, we used a live-streaming camera to monitor lizard activity, and panting initiation, and Tb in real-time using thermocouples that were inserted into the lizard's cloaca. We found SMR and EWL, increased steeply following the onset of panting, with the ability to maintain a gradient between Ta and Tb strongly associated with EWL rate. Species inhabiting hot desert environments had higher panting thresholds, were much more efficient at dissipating heat, and tolerated higher Ta's and Tb's for longer periods than species adapted to more mesic environments. Identifying the onset of panting, the capacity for heat defense and its relationship to critical thermal limits should provide valuable insight into how climate warming may impact lizard activity and hence water and energy budgets under future climates.

On Geographic Song Variation in Willow Flycatchers

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In birds, song is used to select mates and defend territories, and therefore can act as a behavioral barrier to gene flow. Innate songs that are genetically determined may be an especially important evolutionary driver, because song is not learned and can be relatively stereotyped within closely related species. Despite the potential role of innate song in driving speciation, most studies investigate song variation in species with learned song, but understanding how innate song varies and affect speciation would provide insight into the evolutionary relationships between closely related species. In the US, a common widespread bird is the willow flycatcher (*Empidonax traillii*, WIFL). The US Fish and Wildlife Service currently recognizes four subspecies. Previous work has shown that WIFL subspecies differ by genetics and plumage. Song is innate in WIFLs, and has

been shown to geographically vary in two subspecies. Whether or not other WIFL subspecies' songs vary or if WIFLs recognize these differences remains unknown, but is critical to understand the taxonomy, if any, within the WIFL species complex. From a principle components analysis, we found that WIFL songs grouped into eastern, western and southwestern groups. We also conducted playback experiments, to determine if birds recognized these subspecific song differences. When we played a WIFL's own subspecies song, birds responded faster, spent more time close to the speaker and approached the speaker closer. Our results suggest song may be acting as a behavioral barrier to gene flow among these subspecies potentially driving speciation within the WIFL species complex.

Linking Perennial Surface Water and Aquatic Food Subsidies to Terrestrial Lizards in Arid Environments

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Severe drought driven by climate change and water use by humans is causing formerly perennial streams to flow intermittently, presenting an unprecedented level of disturbance. The loss of aquatic prey could negatively impact riparian and terrestrial species, including lizards. Because lizards play important roles in riparian food webs (e.g. predators, nutrient cycling), it is crucial to understand the cascading effects of stream drying on lizard communities. We hypothesized that perennial streams provide aquatic subsidies to terrestrial species, which reduces competition and opens niches for riparian lizards. We predicted that (P1) lizard communities near perennial water will be more diverse than communities that do not have access to water, (P2) individuals within a species will grow larger and faster with access to perennial water than those without. We surveyed three paired 100-meter perennial and ephemeral reaches with similar microhabitat but differing water availability. We measured individual growth rate during a 2-month mark-recapture study of three species [Yarrow's spiny lizard (*Sceloporus jarrovii*), striped plateau lizard (*Sceloporus virgatus*), and ornate tree lizard (*Urosaurus ornatus*)]. We used emergence traps to quantify the availability of aquatic prey. Preliminary data analysis suggests that lizards were scarce across ephemeral sites, but common at perennial sites. Analysis of mark-recapture data and insect prey data are ongoing, but I expect the data will reflect my predictions of increased growth rates and prey availability along perennial streams. This research will be relevant for predicting what may happen to riparian communities when streams dry in response to drought and water withdrawals.

Burn Severity is an Important Predictor of Space Use, Settlement, and Landscape Connectivity for an Endangered Small Mammal

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Altered fire regimes and drought are important drivers of disturbance events in forests throughout the western United States. Understanding how disturbance events such as fire influence space use, dispersal, and settlement of threatened and endangered species and whether populations are able to persist following disturbance is key. We modeled probability of landscape use by the endangered Mt. Graham red squirrel (*Tamiasciurus fremonti grahamensis*) in the Pinaleño Mountains, Arizona, USA as a function of topography, forest structure, and burn severity from three increasingly catastrophic fires in 1996 (2,600 ha), 2004 (12,029 ha), and 2017 (19,604 ha). Burn severity of past fires in 1996 and 2004 was among the most important variables to explain space use and settlement by dispersing animals; individuals rarely used locations where burn severity was moderate or high (only 2.8% of 10,805 locations). We applied circuit theory to assess landscape connectivity and identify potential dispersal corridors within a landscape fragmented by past fires. In 2017, the Frye Fire impacted the majority of remaining red squirrel habitat with higher burn severity; 15% moderate - high severity. We developed new probability of landscape use and connectivity models following the 2017 Frye Fire to predict areas that may support red squirrel persistence and assess how recent fire has further impacted connectivity. We estimated immediate post-fire survival of marked animals and use mountain-wide post-fire censuses for model validation. These efforts support and inform continued conservation efforts for one of North America's most endangered mammals.

Evaluating the Performance of Environmental Diversity as a Surrogate in Site Prioritization for Biodiversity Conservation at a Fine Resolution

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Maintaining species diversity is of upmost importance in preserving the integrity of ecosystems and their services. One of the most effective strategies for protecting biodiversity is to design protected land areas specifically for high species diversity representation. However, this can be challenging to implement without knowing where most species are found. Previous research has shown that environmental diversity (mainly climate variables) can sufficiently act as a surrogate to identify important sites for species diversity representation at a coarse resolution (100 km2 to 125 km2; Beier and Albuquerque 2015). However, it has not been determined how well environmental diversity can work as a surrogate for species diversity at a smaller scale (<1 km2) and with just geophysical variables (i.e. topographic and edaphic variables). This study assesses how well selecting sites based on environmental diversity captures species diversity representation at a fine resolution (<1 km2). Twelve datasets that represent species inventories of birds, arthropods, and plants from around the global, including Arizona, are used. Environmental diversity will be defined using an ordination strategy (e.g. Non-metric multidimensional scaling

or NMDS) to combine 72 soil and topographic properties. Methods include selecting a target number of sites based on biological diversity, environmental diversity, and random chance. Then comparing the number of species represented with each selection procedure using Species Accumulation Curves. The outcome of this study is a thorough assessment of how well environmental diversity, specifically geophysical characteristics, can work as a tool for protected area selection.

Creating Bat Assemblage and Temporal Activity Baselines in Arizona: Evaluating the Utilization of Stationary Acoustic Detectors

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We used the conservation management needs of land managers in Arizona as a basis for a long-term bat monitoring project. The recent decline in bat populations in the Eastern U.S. associated with white nosed-syndrome (WNS) indicates that bat species assemblages and the temporal distribution of bat activity may be the first indications of the disease on a landscape scale. In order to detect these changes in bat species assemblages and the temporal distribution of activity a comparison of bat activity across time is needed. We designed a study to establish a baseline index of bat activity that can be compared statistically across time using a mixed modeling approach. The combination of three ongoing studies within Grand Canyon National Park (GCNP), Barry Goldwater Bombing Range (BMGRE) and the Bureau of Reclamation (USBR) allowed us to create a landscape scale sampling scheme. All three of these projects utilize elevated stationary acoustic bat detectors that are deployed year long. We used the data collected from these 30 stations to create a baseline bat assemblage and temporal activity pattern at each station. These baselines can then be compared across year to detect changes in bat assemblages and temporal use patterns. These methods have the potential to allow for the early detection of changes in bat species diversity and temporal use patterns that may indicate population declines.

Impact of Frye Fire (Mt Graham) on Small Mammals

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Climate change exacerbates the magnitude of extreme environmental events. Annual frequency of large-scale wildfire events are predicted to increase in the Western United States. Wildfire effects on small mammals include death or injury, and environmental change (resource availability, predator pressures, availability of nesting sites). Frye Fire was ignited On June 7, 2017, lightning ignited the Frye Fire on Mt. Graham (Pinaleño Mountains, Arizona) and was contained on July 30, 2017. The wildfire scorched 19,704 ha (48,443 Acres). We address the direct impact of fire on wildlife, with specific focus on small mammals. Camera traps provided information about animal behavior during wildfire. White tail deer and different small mammals seem to remain in the area during the fire event. Preliminary data obtain from trapping sections,

show different composition before and after fire, but only in area totally burned. In specific Peromyscus maniculatus is found also in severe burned area, while Neotoma mexicana, Microtus longicadus and Tamias dorsalis are found only in low severe burned area. The federally endangered species, Mt Graham Red Squirrel declined precipitously, but animals that survived adjusted their behavior to the new condition. In specific, they are using big hole in the ground left from fire to cash cones. Information about impact of fire on wildlife would provide valuable insight for post fire habitat restoration.

Grasshopper Mice Exhibit Sex Differences in Behavioral Responses to Sound Playbacks

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Many animals produce sound in a variety of social contexts, including mate attraction, territory defense, and alarm signaling. Understanding the function of acoustic signals requires quantification of receiver responses, which can be challenging in field settings and/or for inconspicuous animals. We designed a large indoor arena to measure phonotaxis (movement in response to sound) in northern grasshopper mice (*Onychomys leucogaster*), a species in which both males and females produce loud, long-distance vocalizations. Captive-bred animals were given two days to acclimate, followed by presentation of one of three stimuli (silence, white noise control, or conspecific call) throughout the night over three consecutive nights in random order. We quantified phonotaxis and vocal responses using automated tracking and recording equipment. Our preliminary results (n=10) indicate that males approach and spend more time near speakers broadcasting both conspecific calls and white noise, suggesting indiscriminate attraction. In contrast, females increased their overall activity but did not approach nor retreat from either stimulus compared to silent nights. The data suggests that males use vocalizations to actively locate potential mates and/or competitors, whereas females perform behaviors that increase the likelihood of being located. Our findings are consistent with anecdotal observations of mice in the field and highlight the utility of semi-natural environments in understanding animal communication.

Effects of Catastrophic Wildfires on Threatened Narrow-headed Gartersnakes

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Extensive, severe wildfires have become increasingly common in the southwestern United States, destroying or damaging large areas of terrestrial and aquatic habitats. The federally threatened Narrow-headed Gartersnake (*Thamnophis rufipunctatus*) has its entire range within the Mogollon Rim, White and Blue Mountains, and Gila National Forest, where the Slide,

Wallow, Whitewater-Baldy, and other large wildfires have occurred over the last decade. We studied the effects of these fires on stream habitats at four locations during 2014 and 2015, and assessed effects on Narrow-headed Gartersnakes, including comparison to unburned sites. Fire effects varied among burned sites, ranging from severe, resulting in the local extirpation of fish and Narrow-headed Gartersnakes (Whitewater Creek, NM), to mild, with no evident effects attributable to fire (Oak Creek, AZ). At two sites (Black River, AZ and Middle Fork of the Gila River, NM), Narrow-headed Gartersnake populations appeared depressed and their body condition was lower compared to pre-fire periods. Body condition was highest at the unburned site, likely as a result of dense prey populations. Large wildfires in this region will continue to be a substantial threat, and additional research and management planning are needed to protect the isolated and much-reduced populations of the Narrow-headed Gartersnake.

Amphibians and Reptiles of Camp Navajo, Coconino Co., Arizona.

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Camp Navajo is an Army National Guard installation near Flagstaff, Arizona that has not had a comprehensive study of the amphibians and reptiles within its boundaries. We conducted planning-level surveys for amphibians and reptiles using visual encounter surveys, cover boards, drift fence trapping arrays, and remote audio recording devices over the course of six one-week sampling sessions between 2016 and 2017. We also conducted a search of existing records from the Arizona Game and Fish Department's Heritage Data Management System, 171 museum specimen collections, and a citizen science project. We document ten species of amphibians and reptiles from Camp Navajo, and discuss eleven additional species that might be present on the installation.

Chiricahua Leopard Frog Recovery in Arizona: Current Status and Future Directions

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The Chiricahua leopard frog (CLF), federally listed as threatened in 2002, had declined by as much as 80% range-wide at the time of listing due mainly to predation by nonnatives, the fungal disease chytridiomycosis (Bd), and habitat loss/degradation. The 2007 Recovery Plan outlined a multi-pronged recovery approach that includes habitat restoration, invasive species control, safe harbor agreements, and captive propagation, all of which have helped reestablish AZ CLF populations. We have reached significant benchmarks in our progress in CLF conservation since 2007, including a more than 300% increase in occupied sites, the presence of functioning

metapopulations in several recovery units, and the control of bullfrogs in some key areas. However, CLF recovery in AZ will still require intensive monitoring and management. For example, Bd continues to be a challenge to reintroduction efforts, and individuals, and sometimes populations, still succumb to the disease; applied research could help us improve overwinter survival of CLF and survival of Bd naïve captive-reared frogs following release. Additionally, continual nonnative species management is required, which consumes considerable time and money. We also need assurance of water supply at CLF occupied sites, particularly given predicted climate trajectories for the southwest. Finally, successful recovery will require a monitoring plan that would allow an assessment of the species' range-wide status, and a genetic management plan that will prevent further genetic drift in small, isolated populations.

The First Known Occurrence of EDHV-6 in Arizona Mule Deer

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Hemorrhagic Disease is a viral disease that has been known to affect North American deer, elk, bighorn sheep, and pronghorn. The disease is transmitted through bites of small flies in the genus Culicoides. Since its first discovery in Arizona in 1993, two viruses, Epizootic Hemorrhagic Disease Virus (EHDV) and Bluetongue virus (BT-V) have been found to cause the disease. Up until 2017, only EHDV type 2 and BTV types 10, 11, and 17 had been isolated in the southern half of the state in low occurrences. This past year, Arizona Game and Fish investigated 6 mule deer mortalities from northwestern areas in the state that were found to be linked to hemorrhagic disease using an RT-PCR test. Using viral serotyping, the viral RNA detected in the sample was identified as EHDV type 6 based on VP2 gene sequence. This is the first known occurrence of this particular EHDV serotype in the state, and was found further north than EHDV has been found in the past. EHDV-6 was first detected in the U.S. in 2006 and has been detected every year since, primarily in the northern Midwest. So far in 2017, there has been a spread of the serotype into new states including Arizona, Alabama, Connecticut, Pennsylvania, and West Virginia. Due to the disease being transmitted by Culicoides bites, and no transmission from deer to deer, the disease is usually found on a seasonal basis. Further investigation will be conducted to understand the potential factors that could be influencing the spread of the virus to new areas.

Available Forage and Vegetative Structure in the Northern Sacramento Mountains, and the Potential Impact on Neonatal Pronghorn Survival

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Fawn survival often limits population growth and persistence for native and translocated pronghorn (*Antilocapra americana*) populations. However, pronghorn fawn survival can be highly variable due to predation, habitat quality (potential forage) issues, and weather stochasticity during the fawning period. To estimate effects of available forage and vegetative structure on pronghorn fawn survival in the Fort Stanton Snowy River Cave National Conservation Area, New Mexico, we compared habitat data from pronghorn fawn capture or bed site locations and randomly located plots in 2016 and 2017. Also, using plant production and composition data from 24 and 20 exclosures in 2016 and 2017, respectively, we estimated biomass production of different vegetative communities across the study area. During May and early June (2016 and 2017), we captured 101 pronghorn fawns aged ≤ 5 days, and marked them with ear tag radio transmitters to monitor survival. Naïve estimates of summer fawn survival for 2016 and 2017 were 23% (13/56 survived) and 20% (9/45) respectively, which is greater than previously estimated 0% and 19% survival in 2014 and 2015. Preliminary analyses indicate that average vegetation height within exclosures was greater than average vegetation height of random locations near exclosures, but clear patterns of bed site and capture site selection have not emerged during initial analyses. Fawn survival is likely most strongly influenced by predation pressures in the area, but further analyses will inform potential management strategies to improve fawn cover and habitat structure for long-term persistence.

Resource Use and Disease Patterns of an Urban Coyote Population in the Mojave Desert
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While numerous studies have examined the ecology of urban coyotes (*Canis latrans*), few have investigated the impact of disease and parasite loads on these populations. High density populations typically experience higher transmission rates and infected individuals may have altered behavioral patterns, particularly regarding use of anthropogenic resources. The National Training Center (NTC) Fort Irwin, CA has a large permanently occupied garrison that has become home to a number of urban coyotes that also use the surrounding Mojave Desert. Our objectives were to assess the mechanisms maintaining an epizootic of sarcoptic mange within this urban population and determine how mange influences space use and resource selection. Home range size was estimated using 95% minimum convex polygons and 99% dynamic Brownian bridge movement models. Resource selection functions were developed using mixed-effects logistic regression to assess resource selection among six land-cover types utilizing a suite of covariates selected a priori. We monitored radio-collared coyotes (n = 41) from May 2015 to April 2017 and detected apparent signs of mange on 26 (63%) individuals. Estimates of MCP home range sizes (n = 21) varied from 7.3 to 2,130.6 km2, with smaller mean (± SE) home ranges for residents (35.0 ± 8.7 km2) compared with transients (562.6 ± 213.5 km2; t19 = -6.10, P < 0.001). The percentage of relocations within available habitats was highest in urban land-cover types and urban use appeared to vary slightly between the dry season (56 ± 9%) and wet season (35 ± 7%; t14 = -1.84, P = 0.087). At the landscape level (2nd order selection) anthropogenic subsidies appeared to be an important predictor of coyote resource use. Preliminary results appear to contrast with similar studies, with a higher prevalence of mange

and a higher relative use of urban land-cover types over natural types in this heavily diseased population. Understanding the environmental drivers facilitating urban use by both infected and uninfected coyotes may assist wildlife managers in developing strategies to control future mange epizootics and mitigate human-coyote conflicts in urban environments.

The Salad Within: Herbivorous Diet of the New Mexico Meadow Jumping Mouse

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The New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is an endangered subspecies restricted to high elevation riparian zones in the southwestern United States. Jumping mice are threatened by habitat loss and knowledge of their diet could help guide habitat recovery. They forage for seeds and fruits of tall herbaceous plants mid-spring to early autumn, accumulating fat to survive hibernation; however, the taxonomic breadth of the plants they select remains undescribed. During the summer of 2016, we collected feces from 43 live-captured jumping mice on 3 National Forests in Arizona and New Mexico. We used DNA metabarcoding to identify dietary plant taxa. We detected 44 genera (mean ± SE per individual jumping mouse: 4.3 ± 2.6); forbs and grasses were most frequently consumed and the dietary richness of forbs significantly increased before the hibernation window. Some of the most common taxa in the diet were avens (*Geum macrophyllum*), sunflowers (*Helianthus* spp.), willowherb (*Epilobium helleanum*), buttercup (*Ranunculus macounii*), coneflowers (*Rudbeckia laciniata*), bluegrass (*Poa pratensis*), and wild barley (*Hordeum* spp.). Rushes (*Juncus* spp.) and sedges (*Carex* spp.), common to habitat used by jumping mice, were less frequent in the diet, suggesting only occasional selection as food. Our data suggested that jumping mice may be adapted to seed maturity patterns of forbs and grasses to accumulate hibernation weight.

Information Gain versus Effort with Joint Models of Occupancy and Capture-recapture Data

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Capture-recapture techniques are often cost-prohibitive at large spatial and temporal scales, and projects frequently employ these techniques at smaller scales to reduce effort (time and money), potentially limiting the area for statistical inference. Recently, activity has increased in developing models that combine multiple sources of data for improved inference with parameters of interest, but with limited discussion on information gain versus effort with multiple data sources. We illustrate how joint models of occupancy and capture-recapture can be used to make

inference on abundance at a larger scale with a western bluebird (*Sialia mexicana*) example from ponderosa pine (*Pinus ponderosa*) forests of northern Arizona, USA. Within Southwestern ponderosa pine forests, fire is a common natural disturbance and secondary cavity-nesting birds, like the western bluebird, rely on cavities in snags for nesting, roosting, and protection from predators. Altered wildfire patterns in the region have increased the number of stand-replacing fires, increasing the size, number, and distribution of snags. Thus, managers require information for predicting fire effects on community structure. We use an 8-year data set of point count (distributed across the landscape) and banding data (at a subset of locations with nest boxes) to compare abundance estimates in a Bayesian hierarchical framework from separate models of occupancy and capture-recapture data with the joint model, and discuss differences in effort versus information gain. We also discuss how parameter estimates may vary between data types. Results from this study could be applied in a monitoring context to increase inference at spatial and temporal scales.

Updates from the Bat Cave: The Next Generation of Investigations

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Over the past year and half the Bat Ecology and Genetics lab has taken flight into two quickly expanding disciplines of genetics. First, in April of 2016 we opened NAU's first and only ancient DNA lab. This lab is dedicated to working with ancient, historic, and/or low quantity DNA samples. Then using that information to answer questions of evolution, historic movements and ecosystem dynamics. In the first year we have successfully extracted and sequenced DNA from ancient bat carcasses, along with other ancient samples. Also, we will be investigating our ability to use lake sediment cores combined with next generation sequencing techniques to understand ancient communities in North America. Secondly, we have been examining the capability of our Species from Feces DNA mini-barcode to amplify and identify bat environmental DNA. Previous tests in the lab have shown that the assay is sensitive enough to identify 1 rare fecal pellet in a sample of 200, as well as trace amounts of guano added to a controlled volume of water. The next steps are improving our collection technique to maximize usable bat DNA from water sources and continuing to improve our bioinformatic analysis to pull out the rare bat molecules.

Photo Identification as a Tool for Individual Recognition of Juvenile Freshwater Turtles: a Test with the Rio Grande Cooter

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Mark-recapture methods have been widely used in population demography studies. However, the technique often involves marking animals using procedures like toe-clipping, PIT-tagging, and tattooing, which are invasive and potentially harmful to the animals. In freshwater turtles, shell notching is one of the most commonly used technique, but this may increase the risk of infection and shell deformity in juveniles and hatchlings. Here, we explored the possibility of using naturally occurring plastral marks for individual identification of juvenile Rio Grande cooters (*Pseudemys gorzugi*). We also tested the efficiency of using computer assisted software (I3S Pattern+) for capture-recapture purposes. We compared the effectiveness of I3S Pattern+ against the 'by-eye' technique, by matching photographs of recaptures with the initial capture photos. The matching results of the program were generated into ranks ranging from 1–50, with the 1st rank being the most likely match. We found that plastron patterns are unique among individuals. 'By-eye' technique yielded higher correct matches (>92%), while I3S Pattern+ yielded 58%, 80%, and 90% correct matches within the 1st ranked image, among the top 5 ranked images, and among the top 10 ranked images, respectively. Additionally, we found the quality of photos significantly contributes to a reduction in the software effectiveness (i.e., <32% correct matches). Overall, plastron photo identification can be used as a non-invasive recognition technique for *P. gorzugi*; however, it is only effective in younger individuals as the pattern fades in larger turtles (i.e., >110 mm straight line carapace length).

Preliminary Results from a UAV Integrated Wildlife Radio Telemetry Localization System

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The very high frequency (VHF) radio tags are used pervasively in the tracking of small wildlife. However, they can be challenging and sometimes impossible to locate using traditional ground based measurements. Ground clutter, cancellation of direct and ground-reflected waves, and scattering of waves by fluctuating terrain lead to steep attenuation of the low power transmissions across the ground. Aircraft based measurements can help to increase the distance over which a tag can be detected, but the logistics and cost of manned aircraft flights preclude their use in most studies. Our group has worked to develop an unmanned aerial vehicle system that integrates a novel software defined radio (SDR) system to receive and relay radio data from the air to users on the ground. The system includes a modified hex-copter type vehicle, an onboard single board computer, a SDR front end, a directional VHF antenna, and the associated ground control station laptop for data collection and vehicle operation. In this presentation, we will discuss the system configuration and operation. We will also present preliminary testing results wherein the vehicle was flown at a distance from the tag at various locations in order to determine the localization precision of the system. Current and coming localization strategies will be discussed, as will future automation of the system.

Enhanced Rabies Surveillance

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Wildlife pose the greatest risk of rabies exposure. On a national level the USDA WS has been conducting enhanced rabies surveillance (ERS) to help with the monitoring of raccoon variant rabies on the eastern U.S. landscape. Program goals of the National Rabies Management Program (NRMP) were to increase sampling of suspect rabid animals through program and cooperator submissions and also to increase cooperator surveillance contacts. The NRMP was asked to quantitatively evaluate the quality of samples collected to determine the level of increase in high quality wildlife samples in space and time for improving oral rabies vaccination (ORV) decisions, and also to increase cooperator surveillance contacts to further the effectiveness of the enhanced rabies surveillance system. Using this template, Arizona Wildlife Services program has been conducting enhanced rabies surveillance to better assess the spatial and temporal use of the landscape by various rabies vector species. These projects include vampire bat surveys, road kill surveys, gray fox spatial ecology study, and rabies diagnostic testing (dRIT) in the lab. These efforts also involved increasing the matrix of collaborators to keep them informed of the current rabies situation and utilize their ability to collect suspect animals from a broader area of the state.

Phylogenomic Analysis of Bobwhite Quail in Southern Arizona and Mexico

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The masked bobwhite (*Colinus virginianus ridgewayi*), native to southern Arizona and Sonora, is a species of quail on the verge of extinction. Masked bobwhite populations rapidly declined in the mid 1800's due to widespread habitat destruction. Despite extensive efforts, reintroduction attempts failed and the masked bobwhite was federally listed as endangered in 1967. In 1985, the Buenos Aires Ranch in Sasabe, Arizona was acquired by the USFWS as a national wildlife refuge for the masked bobwhite. A captive breeding program was established with birds being periodically released. However, surveys conducted for over a decade have shown an overall downward trend in populations in the United States and Mexico. Previous studies have analyzed genetic relationships among northern bobwhites; however, little is known regarding the

relationships between masked bobwhite and its Mexican counterparts. The purpose of my research is to resolve taxonomic relationships among quail populations inhabiting geographic regions similar to that of the masked bobwhite. I employed a high-throughput targeted genomic capture approach, which is very useful for reconstructing the evolutionary history of many organisms. I used contemporary tissue and museum samples from nine bobwhite subspecies including Texas bobwhite (*C. v. texanus*), and seven Mexican sub-species. I isolated and sequenced approximately 5,000 conserved regions to construct phylogenetic trees to identify the closest extant relative of the masked bobwhite. The newly gained taxonomic information will aid the recovery efforts for the endangered masked bobwhite. This data will allow managers to make informed decisions regarding reintroductions of masked bobwhite.

Spatial Ecology Informs Disease Management in the Southwest

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Space use is a fundamental characteristic of species biology that informs habitat selection, inter- and intraspecific interactions, and disease etiology. Gray foxes (*Urocyon cinereoargenteus*) are considered a substantial reservoir for rabies in the southwestern U.S.; however, their spatial ecology is poorly known. Spatial overlap between gray foxes and other vector species is important for understanding potential for disease spill over. We employed remote wildlife camera traps to compare gray fox habitat selection and sympatry with other carnivores in the Pinaleño Mountains and the White Mountains of southeastern Arizona. We used occupancy modeling and resource selection functions to compare habitat selection between continuous and isolated forests. Results indicate that gray foxes select for areas of upper evergreen woodlands and Ponderosa Pine (*Pinus ponderosa*). Understanding how vector species use the landscape is important to control the spread of rabies, and knowledge of gray fox spatial ecology across an expansive geographic area can better inform disease control plans. 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 through One Health initiatives that recognize that the health of people is connected to the health of animals and the environment.

Predicting Habitat Suitability, Connectivity Corridor, and Gene Flow of the Mexican Spotted Owl

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Increasing fire size and severity in the southwestern United States have prompted implementations of landscape-scale forest restoration treatments, but the effects of these treatments on the Mexican spotted owl, a federally listed threatened species, are poorly known. The goal of this study was to identify core habitat areas, connectivity corridors, and gene flow of the Mexican spotted owl across areas that might be affected by these treatments. We used a

multi-scale optimization approach to model habitat selection and used a resistant kernel approach to model connectivity corridors. We used individual-based landscape genetics simulations to evaluate gene flow across our study area. Potential habitats of the Mexican spotted owl were strongly related to percent canopy cover, percent mixed-conifer, and slope. Areas with strong connectivity were significantly correlated with genetic diversity and effective population size. Our findings suggest the importance of protecting core habitat areas and landscape connectivity for conserving genetic diversity of the Mexican spotted owl. In addition, core habitat areas and connectivity corridors identified in this study can serve as baseline assessments to evaluate restoration treatment effects on the Mexican spotted owl across broad spatial extent. Managers should be cautious in implementing restoration treatments in areas with high connectivity. Together, these results will facilitate the development of management and conservation plans that are most compatible with both reducing fire risks and maintaining important habitats.

Cyclicity in Mount Graham Red Squirrels (*Tamiasciurus hudsonicus grahamensis*), a Clue to Developing an ex situ Propagation for Release Program

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Female Mount Graham red squirrels (*Tamiasciurus hudsonicus grahamensis*) are known to be receptive for breeding for a single day each season, and for perhaps only six hours during that season. If resources are abundant, they may have two breeding seasons in the wild, one in early spring, and again in late summer. This field observation of seasonal receptivity is believed to be true for each of the 25 *Tamiasciurus* sub-species. However, we discovered evidence of polyestrous cycles by tracking fecal steroid estradiol levels in an *ex situ* managed population. We tracked the fecal steroid estradiol concentrations of three *ex situ* managed female Mount Graham red squirrels for two consecutive years and discovered evidence of cyclicity throughout the year, with an average interval between cycles of approximately15-25 days. This work is part of an ongoing study to develop a consistent propagation release program for this endangered sub-species. We will continue to track metabolite hormones and incorporate male behavior responses to females to determine the ideal timing for attempting breeding introductions.

Update on Review of Wildlife Issues in Review of Renewable Energy Development Projects and Transmission Lines.

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Commonly seen renewable energy generation projects include wind turbines, solar photovoltaic, concentrating solar trough, and power tower technologies. Electricity transmission projects are built to support new generation projects. Wildlife issues include loss or change of habitat for all types of projects and impacts associated with operation and maintenance, which vary by technology. Mortality from collision has occurred at wind farms, solar photovoltaic, and solar

trough projects. Heat injuries have occurred at power tower projects. Potential regulatory issues include compliance with the federal Endangered Species Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act. Through National Environmental Policy Act documents Federal agencies attempt to analyze and disclose potential impacts of projects under review. Unanticipated impacts have occurred after construction of some projects and efforts, including monitoring and research, are underway to better understand and predict issues. Concurrently, energy markets are evolving, including the renewable energy element, as is related electricity transmission planning. Output at 3 major coal fired power plants in Arizona and New Mexico has been or will be reduced creating a need for alternate sources. An update on the status of major ongoing projects will be provided.

Monitoring the Effectiveness of Wildlife Crossings in a Rapidly Developing Sonoran Desert Ecosystem

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The Tucson-Tortolita-Santa Catalina Mountains wildlife linkage in Tucson, Arizona is one of the most threatened in the state. In response, Pima County and partners constructed a large wildlife bridge and a wildlife underpass across State Route 77, which bisects the linkage, in 2016. The Coalition for Sonoran Desert Protection is supplementing Arizona Game and Fish Department's four-year post-construction monitoring efforts with a pre- and post-construction wildlife camera participatory research monitoring study, focusing primarily on mammal species. Our objective is to develop a baseline and monitor changes in species richness and wildlife activity patterns in the study area. In addition, the project's goals include close collaboration and data sharing with partners, and to engage and train local residents as citizen scientists. We are using the data management and analysis protocols developed by Sanderson & Harris 2013. To date, we have collected 3 years of pre-construction data and two years of post-construction data, with 41 cameras deployed throughout the linkage, including 11 cameras at the wildlife crossing approaches, monitored and managed by 56 citizen science volunteers. No bait is used. We found 44 species, including notable records of American badger (*Taxidea taxus*), white-nosed coati (*Nasua narica*), and desert bighorn (*Ovis canadensis nelson*). Preliminary results also suggest increased mule deer (*Odocoileus hemionus*) activity west of the crossings post-construction. We continue to gather data to help inform adaptive management needs as wildlife fencing gaps are addressed, and to highlight the effectiveness of wildlife crossings in a rapidly developing Sonoran Desert ecosystem.

Estimating Prescribed Fire Effects on Semidesert Vegetation Components Important to the Masked Bobwhite Quail (*Colinus virginanus ridgwayi*) using a 30 Year Landsat Derived Fire History Data

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Prescribed fire plays a vital role in restoring vegetation and fuel bed conditions characteristic of frequent fire regimes in southwestern semidesert grasslands. However, current fire management activities implemented at the local-to landscape-scales must be compatible with specific habitat requirements for threatened and endangered birds. The Buenos Aires National Wildlife Refuge (BANWR) in southern Arizona was established in 1985 to provide habitat for threatened and endangered plant and animal species, with primary emphasis on the critically endangered masked bobwhite quail (*Colinus virginanus ridgwayi*). Masked bobwhite are known to occupy semidesert grassland sites of moderate elevation (240-760m) with abundant grass cover and seed producing plants, a high diversity of forbs and interspersed woody plant cover. I used BANWR fire perimeters to examine the effect of fire frequency over the last 3 decades on vegetation characteristics. Multivariate analyses indicate that semidesert vegetation composition on plots (n = 239 plots) is significantly different among fire frequency strata. Areas with high fire frequency were strongly correlated with high fine-fuel biomass dominance by *Eragrostis lehmanniana*, an invasive perennial bunch grass introduced from South Africa in the 1930s. Areas of low to moderate fire frequency may favor a greater abundance of native plants or lack site conditions suitable for *E. lehmanniana*.