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LAS CRUCES, NEW MEXICO

Wildlife Best Student Paper Competition

Matthew J. Gould: Ph.D. Student, Department of Biology, New Mexico State University, P.O. Box 30003, MSC 4901, Las Cruces, New Mexico 88003, mjgould@nmsu.edu.

Dr. James W. Cain III: Co-advisor, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife and Conservation Ecology, New Mexico State University.

Dr. Gary W. Roemer: Co-advisor, Department of Fish, Wildlife and Conservation Ecology, New Mexico State University.

Dr. William R. Gould: Co-PI, Department of Economics, Applied Statistics, and International Business, New Mexico State University.

Stewart G. Liley: Big Game Program Manager, New Mexico Department of Game and Fish.

Estimating abundance and density of American black bears (*Ursus americanus*) in New Mexico using noninvasive genetic sampling-based capture-recapture methods

Introduction

One of the main challenges for a resource agency in charge of managing game species is to set harvest levels that ensure the long-term persistence of populations. Due to financial constraints, management agencies often lack relevant estimates of vital rates for all populations or subpopulations for which they must set harvest quotas. There has been recent concern and criticism voiced by different segments of the public regarding harvest objectives set for black bears (*Ursus americanus*) in New Mexico. Some members of the public would like to see fewer bears harvested whereas others believe that sustainable harvest levels can be increased for many populations. Our objectives were to estimate the abundance and density of black bears >1 year of age in suitable bear habitat within 6 of the 14 bear management zones (BMZs) located in the Sacramento and Sangre de Cristo Mountains. Reported herein are the results for the first year of data collection in the Sangre de Cristo Mountains.

Methods

We sampled the population using two non-invasive genetic sampling (NGS) techniques: hair traps and bear rubs (Woods et al 1999, Kendall et al. 2008). We combined these genetic samples with tissue samples collected from bears harvested by hunters, those captured as part of research and management efforts, and bears removed by the New Mexico Department of Game and Fish (NMDGF) for depredation issues. Individual samples were genotyped across a suite of microsatellite loci.

Abundance was estimated using Huggins formulation of a closed-population capture-mark-recapture model (Huggins 1989, 1991). We used Akaike's Information Criterion (Akaike 1973) with small sample size adjustment (AIC_c) to rank models and used model averaging to estimate black bear abundance. Density was estimated using two approaches: in the first case we divided estimated abundance by the effective trapping area (ETA) (Dice, 1938, Wilson and Anderson, 1985), and in the second case we used a spatially explicit capture-recapture (SECR; Borchers and Efford 2008, Efford et al. 2013) model. Abundance and density estimates were generated for the northern

Sangre de Cristo Mountains, the northern Sangre de Cristo Mountains excluding Vermejo Park Ranch (VPR), and VPR only.

Results

We sampled 256 hair traps and 46 bear rubs and collected 1,762 and 133 hair samples from each method, respectively. These hair samples were then combined with 156 tissue samples provided by NMDGF, which resulted in 2,051 genetic samples. Success rate for genotyping DNA collected from hair and tissue samples was low (40%). A total of 470 individuals were detected across all sampling methods. Estimated abundance for the northern Sangre de Cristo Mountains was $\hat{N} = 1,407$ (95% CI = 1,182 – 1,779). For the northern Sangre de Cristo Mountains excluding VPR, estimated abundance was $\hat{N} = 1,133$ (95% CI = 907 – 1,416). Estimated abundance for VPR alone was $\hat{N} = 628$ (95% CI = 312-1,419). Estimated density was 18.3 bears/100 km² (95% CI = 15.4 - 23.1), 20 bears/100 km² (95% CI = 16.4 - 25.6) and 35.8 bears/100 km² (95% CI = 17.8 – 81.0) for these same three regions, respectively. Estimates using SECR models were higher: 21.5 bears/100 km² (95% CI = 17.5 – 26.3), 25.2 bears/100 km² (95% CI = 20.1 – 31.6) and 145 bears/100 km² (95% CI = 70.8 – 298), respectively.

Conclusions

Capture probability was low overall because 36% of the genetic samples failed to amplify enough to generate complete genotypes. This resulted in an inability to assign samples to particular individuals, which reduced the number of new captures and recaptures. These low capture probabilities affected our estimates of abundance and density and their associated confidence intervals. The low success rate for genotyping individual samples was caused by high-levels of DNA degradation, possibly from UV radiation. Model selection suggested time was the most influential variable in our data being present in the top model for all three spatial areas. Distance to edge appeared to play a small role in the Sangre de Cristo Mountains excluding VPR. While sex appeared to only have importance in VPR's data.

Empirical studies using SECR-based methods often report lower density estimates than those produced by a traditional CMR abundance estimate divided by an ETA - e.g. $\frac{1}{2}$ MMDM (Obbard et al. 2010). Our density estimates using the SECR approach, however, were higher than our density estimates derived using an ETA. SECR estimates often appear less precise, and potentially misleading, because density is directly estimated from a fitted spatial model. Thus all forms of uncertainty are included, however, SECR estimators may be preferred when capture probabilities are low (Ivan et al. 2013).

Our results suggest that the density of black bears in the northern Sangre de Cristo Mountains is higher than the density currently used by the NMDGF (17 bears/100 km²) to manage bears in this region. This latter value, however, falls within the 95% confidence interval estimated using the Huggins estimator for both the northern Sangre de Cristo Mountains and for the same excluding VPR but is less than the lower 95% confidence interval produced by the SECR method.

Management Implication

We provide density estimates that may be used to establish harvest objectives for the responsible management and future persistence of black bears in New Mexico.

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Jose Griego. New Mexico Highlands University, 810 National Ave. Las Vegas, NM
87701

Email: jgriego27@gmail.com

Advisors: Dr. Sarah Corey-Rivas, Dr. Jesus Rivas

Genetic structure and hybridization of the Northern Leopard Frog (*Lithobates pipiens*) along the Mora Watershed in northern New Mexico

The dramatic declines of the northern leopard frog, *Lithobates pipiens*, in the western US is a cause for concern particularly when combined with climate change altered habitats in the Southwestern US. Unfavorable environmental conditions may affect mating patterns between *L. pipiens* and *L. blairi* in zones of sympatry resulting in a higher frequency of interspecific mating opportunities (Cousineau and Rogers, 1991). DiCandia and Routman (2007) detected evidence of cytonuclear discordance between *L. pipiens* and *L. blairi* in populations residing in the Midwest regions of each species range. The nuclear marker used by DiCandia and Routman (2007) was used in another study by O'Donnell and Mock (2012) and found that the nuclear marker (FIB17) used in the 2007 research did not show the same patterns along the Mississippi River and Great Lakes Regions. In this study, we investigate population-level connectivity of *L. pipiens* across a landscape of agriculture, acequias, and protected lands and potential introgression with *L. blairi* using nuclear (FIB17 and microsatellites) and mitochondrial (ND1) markers. There exists a zone of sympatry between *L. pipiens* and *L. blairi* in northern New Mexico along the Mora River watershed. We collected samples (n=24) from three populations along the Mora and Sapello Rivers. Interestingly, we found cytonuclear discordance only in the Sapello River region of the watershed where frogs appear to be *L. pipiens* based on morphology and mtDNA, but have *L. blairi* FIB7 genotypes. Hybrids therefore appear to be the result of mating between *L. pipiens* females and *L. blairi* males. The Sapello area also had one individual with intermediate dorsolateral fold morphology between *L. blairi* and *L. pipiens*. No other sampling areas yielded frogs with cytonuclear discordance. Microsatellite analysis corroborates evidence of cytonuclear discordance, with gene flow among sampling sites along the Mora River (all *L. pipiens* morphology, ND1, and FIB7; $F_{ST} = 0.0001$) and genetic structure between the Mora (*L. pipiens*) and Sapello sites (*L. blairi* x *L. pipiens*; $F_{ST} = 0.235$). The Mora River remains a viable corridor for *L. pipiens* despite the diversity of land uses in the area. The introgression zone within the Mora Watershed transverses the ecocline from the Great Plains to Southern Rocky Mountains. These findings are important because it provides further evidence regarding how these populations may be affected by unfavorable conditions. The Sapello River location was previously overgrazed by cattle and little vegetation was present in riparian areas in comparison to all sites along the Mora River. Also, the Sapello River is a smaller river and therefore more susceptible to the effects of drought. Even though the confluence of these two rivers resides roughly 40km from each site, the distance coupled with drought did not allow for a dispersal corridor for each species. Future work will address the landscape attributes associated with presence and spread of *L. blairi* west into the foothills and the extent and impacts of the hybrid zone on *L. pipiens* in Northern New Mexico.

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Hsiang Ling Chen, *School of Natural Resources and the Environment, The University of Arizona*, Biological Sciences East, Room 325, 1311 East 4th Street, Tucson, AZ 85721, USA. cherlene@email.arizona.edu
ADVISOR: John L. Koprowski

Landscape of anthropogenic traffic noise influences occupancy and space use

Introduction

Anthropogenic habitat fragmentation, destruction, and disturbance are major threats to biodiversity. Noise that arises from infrastructure such as oil compressors can affect animal communication and behavior; reduce reproductive success and further influence habitat quality and animal distribution (Barber et al. 2010). Global road networks represent one of the most significant human impacts on nature and wildlife, and a spatially extensive source of anthropogenic disturbance and noise. Chronic traffic noise is often related to animal avoidance of areas adjacent to roads. However, few studies separate effects of traffic noise from other confounding environmental factors or forces related to distance from roads. Recently, acute effects of traffic noise on species richness of migratory birds were demonstrated by introducing traffic noise to roadless areas through playback experiments (McClure et al. 2013). Nevertheless, studies and evidence of chronic impacts of traffic noise on habitat quality and animal distribution are scarce. To better understand how habitat fragmentation and human disturbance affect animal population and to inform management and mitigation efforts for expanding anthropogenic disturbance, it is important to disentangle effects of traffic noise from distance to roads and environmental characteristics.

Methods

We used an endangered forest obligate, the Mount Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*; MGRS) as our study organism to test alternative hypotheses to explain negative effects of roads on animal distribution. Red squirrels are an ideal species to investigate effects of traffic noise on site occupancy, because they are territorial and often center their territories near conspicuous middens (Gurnell 1987). We focused on 3.7 km of 3 graded dirt roads with low (<10 vehicles/day) to high (50-100 vehicles/day) traffic volume on Mt. Graham. We developed a novel approach by combining traffic monitoring with noise mapping on the basis of a standardized traffic noise stimulus generated by controlled vehicle operation to investigate temporal and spatial heterogeneity of traffic noise. We used the Ordinary Kriging geostatistical interpolation method to create the surface of equivalent continuous sound level (Leq) and maximum power (Lmax) of the standardized traffic noise stimulus covered entire study area. We used data of squirrel presence or absence in 2013, telemetry, and three-dimensional remote sensing data (LiDAR, Light detection and ranging) to quantify environmental characteristics with site occupancy models and spatial analysis to assess influences of distance to roads, environmental characteristics, and traffic noise level on animal occupancy and space use. To understand if traffic noise affects red squirrel space use, we compared traffic noise levels at midden, at center of core home ranges, and within total home ranges.

Results

Sound pressure levels (Leq, Lmax) of the standardized traffic noise stimulus decreased with increased quadratic distance from roads, but we also found substantial spatial variation independent of distance to roads. Nearly 50 % of our study area is estimated to be affected by traffic noise, as traffic noise sound pressure did not diminish to base line ambient noise levels until 120 m from roads.

We included 149 middens in our occupancy modeling. Mean (SE) distance from middens to roads was 141.96 m (8.15) with a range of 10.15-394.36 m. Mean Leq and Lmax of traffic noise stimulus at middens was 37.13 dB (SE 0.47) with a range of 26.82-54.75 dB and was 43.27 dB (SE 0.63) with a range of 30.84-68.68 dB respectively. Detection probability was lower in summer and spring (0.81 and 0.59 respectively) when red squirrels fed on stored conifer cones from previous years, compared to detectability in fall and winter when fresh cones were consumed. The best occupancy model that only included midden characteristics contained live basal area and intercept. We used the model as the reference model to further examine effects of traffic noise, distance from roads and regional environment.

Because midden characteristics, traffic noise indices at midden, distance from midden to the nearest road, and regional environment were not highly correlated with each other, we were able to examine influences of these factors individually. Model fit improved when adding variables related to traffic noise and regional environment to the reference model. In contrast, distance from middens to roads did not affect midden occupancy; as addition of the variable to the reference model did not improve model fit. Influence of traffic noise level was greater than regional environment, as the model that only contained traffic noise variables had lower Akaike's Information Criterion (AIC) than the model that only contained variables of the regional environment. Our top model of midden occupancy was the model that included variables that quantified traffic noise level (Leq, mean daily traffic volume), regional environment (minimum canopy cover, maximum slope) and midden characteristics (live basal area). Red squirrels were more likely to occupy middens with lower traffic noise level (Leq), lower daily traffic volume, higher canopy cover, lower slope and higher live basal area. In general, predicted midden occupancy rate decreased to <50% when average traffic noise level (Leq) was > 45 dB (Fig 1).

We included 120 seasonal home ranges of 49 red squirrels that were resident at 49 middens in our analysis. Mean distance from a center of seasonal core home range to the midden was 36.65 m (SE 2.68). Noise levels of the standardized traffic noise stimulus at center of core home range did not differ from that at the middens (Leq: $t_{48} = -1.26$, $P = 0.21$; Lmax: $t_{45} = -0.96$, $P = 0.34$), but were lower than the mean of noise levels of total home ranges (Leq: $t_{114} = 2.61$, $P = 0.01$; Lmax: $t_{103} = 2.54$, $P = 0.01$).

Conclusions

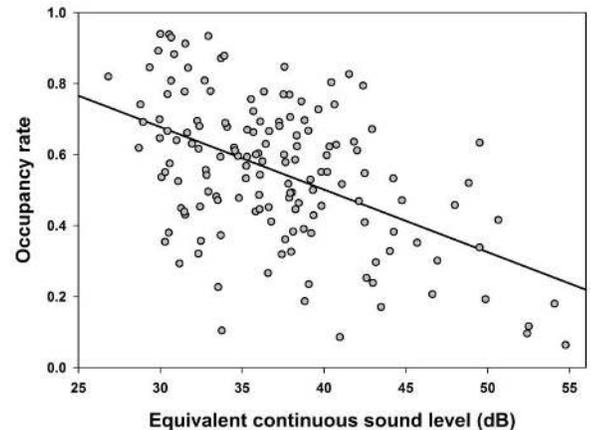


Figure 1. Estimated midden occupancy rate of MGRS as a function of equivalent continuous sound level.

Our study disentangled effects of traffic noise from confounding environmental characteristics and demonstrated the chronic impacts on animal distribution. Traffic noise is an influential disturbance and has chronic negative impacts on site occupancy by red squirrels. We showed a difference of 30 dB in traffic noise level can influence habitat quality and affect animal distribution and highlight the importance of considering the heterogeneity of traffic noise at a local scale when investigating the impact of noise on wildlife.

Significance

Impact of anthropogenic noise is of concern due to increasing human population, expanding infrastructure and energy development, and growth in air travel as well as motorized recreation at natural areas (Miller 2008; United Nations 2011). Understanding the auditory environment, the landscape of noise, spatial and temporal pattern of disturbance level, as well as immediate and chronic animal response to disturbance is critical to future conservation and management efforts.

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Erin Saunders, Masters Student, Northern Arizona University, School of Forestry, 200 E. Pine Knoll Drive, Flagstaff, Arizona 86011; Phone (520) 236-5750; ehs8@nau.edu

Advisor and Co-Author: Carol L. Chambers, Professor, Northern Arizona University, School of Forestry

Bat assemblage and selection of maternity roosts in a post-wildfire landscape

Introduction

Ponderosa pine forests in the southwestern U.S. have increased in density over the last 100 years following EuroAmerican settlement and subsequent changes in fire suppression, logging, and livestock grazing^{4, 6}. These changes dramatically increased the size and severity of wildfires^{5, 7}. Although wildfires rarely kill animals⁹, they have immediate consequences to bat populations by drastically altering vegetation which affects roosting and foraging. We documented effects of the 2011 Wallow Fire (217,721 ha) on bats 2- and 3-years post-wildfire. Our objectives were to describe (1) how the bat assemblage responds to change in vegetation and habitat elements and (2) landscape- and microsite-level roosting habitat used by reproductive female bats.

Methods

Objective 1: We randomly selected 19 ponds; 7 in low- and 12 in high-severity burn. We captured bats using mist nets and summarized captures per net hour (1 6-m net open for 1 hour) by species and for species richness. We used Estimate S3 to predict species richness at both low- and high-burn severity ponds.

Objective 2: We radio tagged reproductive females of 4 snag-roosting species (*Myotis occultus*, *M. volans*, *M. thysanodes*, *Idionycteris phyllotis*) to locate roosts. For ponderosa pine snag roosts (n = 50), we measured habitat characteristics⁸ and paired each roost with a randomly-selected comparison snag. We used binary logistic regression to predict use by bats and paired t-tests to determine if burn condition affected bat use. Habitat characteristics measured at each roost and comparison snag were diameter at breast height (dbh), decay class, aspect (converted to a measure of northness [1 = north, -1 = south]), percent bark, presence of exfoliating bark, and presence of fire scars.

Results

Object 1: Although similar 2 years post-fire, species richness was greater at low- (13 species) compared to high-severity (10 species) ponds 3 years post-fire (Fig. 1).

Objective 2: We located 67 roosts for 55 bats; 6 roosts were shared by ≥ 2 species. Snag roosts used by bats had larger dbh, less bark, were more decayed, north facing, and had more exfoliating bark and fire scars compared to randomly-selected snags. *Myotis occultus* selected ponderosa pine

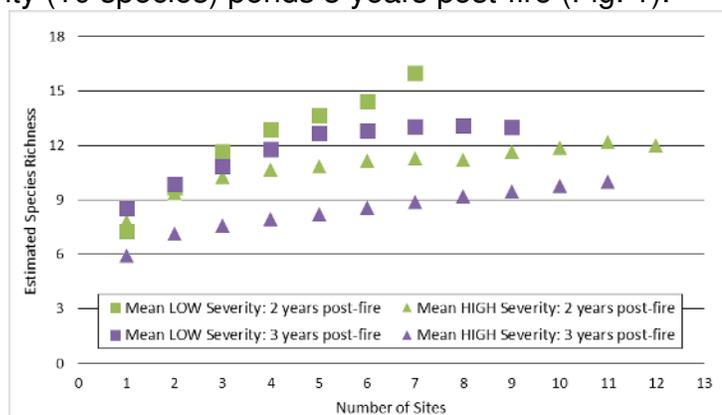


Figure 1: Bat species richness at low- vs. high-burn severity ponds 2- and 3-years post wildfire.

snags with little bole char (Fig. 2). We did not detect a difference in percent bole char for other species (Fig. 2). We located 3 roosts in ponderosa pine snags for *Idionycteris phyllotis*, a sensitive species for 3 federal agencies. Two snags were unburned (<10%) and 1 burned (100%).

Discussion

Objective 1: In our short-term study, wildfire appeared to have negative temporal effects with the bat assemblage declining over time. This contrasts with the only other study of wildfire effects on bats in which bat activity was greater in high-severity burn areas¹. Because that was an acoustic study our results may not be comparable.

Objective 2: We were excited to find bats used both unburned and charred snags. We found snags used by bats had larger dbh and exfoliating bark⁸. Bats might select north-facing snags because of fire pattern effects; north-facing slopes are generally cooler and moister thus may not burn as severely. In some cases, bats used burned snags that existed prior to the wildfire, even when these snags were 100% charred. This indicates high site fidelity at least 3 years following fire. However some species avoid charred snags (*Myotis occultus*). Retaining larger, taller snags that were unburned or recently burned as both can provide habitat for bats.

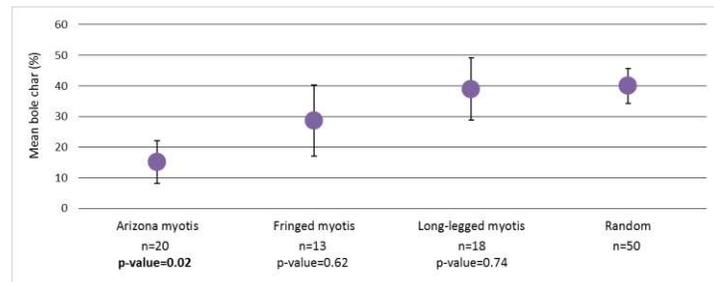


Figure 2: Mean bole char of roosts for 3 bat species and randomly selected snags.

Summary

We found winners and losers in response of bats to wildfire. *Myotis occultus* appeared sensitive to high-severity burn and selected unburned snags. However other species tolerated short term fire effects to a greater degree, roosting in unburned to fully charred snags. Some species may adapt to temporal changes in the landscape due to wildfire but others, like the *Myotis occultus*, may decline. Species that use fire-killed trees will encounter a pulse of roost structures for up to 10 years post-fire² but after snags fall it may take hundreds of years for forests to provide the size snag used by bats. We suggest that in the long-term, habitat for bats will decline if we cannot manage large, high-severity wildfires in the southwest.

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Brian A. Small. New Mexico State University 2980 S. Espina Dr. Las Cruces, NM
88001. basmall@nsmu.edu
Coauthors: Dr. Jennifer Frey (Advisor) and Dr. Charlotte Gard

Evaluation of habitat suitability for dam-building beaver in northern New Mexico

Introduction

Water is arguably the most limiting factor in arid and semi-arid ecosystems. Riparian systems serve as keystone elements in these landscapes (Stromberg 2010). Drought severity and rainfall variability are anticipated to increase in years to come (Seager et al. 2007). Beaver (*Castor canadensis*) are considered ecosystem engineers that can radically alter stream systems. Beaver dams have many beneficial environmental effects such as lengthening surface water retention periods, improving fish habitat, removing chemicals from waterways, mitigating floodwater damage, and decreasing stream bank erosion (Gurnell 1998). Beavers historically occurred in most perennial streams in the southwestern United States (Weber 1971). Historical overharvest due to the pressure of the fur trade market extirpated beaver from many areas (Jenkins & Busher 1979). Although eventually gaining some protection, beaver populations have been slow to recover and are now relatively sparse on the landscape, particularly in small order streams where their ecological impacts through dam building are most important. There is desire to restore beavers to small order streams so that beaver dam-building activities can benefit riparian systems and mitigate for climate change. Consequently, the goal of this study was to determine habitat requirements for beaver in northern New Mexico including four key aspects of their life history: summer diet, winter diet, building material, and competitors.

Methods

We collected data at active primary beaver dams and at control sites that lacked beaver dams (=absent site). Absent sites were locations that met the known physical requirements for presence of dambuilding beaver (i.e., perennial water; stream order 1-5, gradient < 10%) but beaver were not present. Vegetation measurements were achieved with plots along transects perpendicular to the stream. Transects started 20 m upstream and downstream from the dam. Three transects were spaced 20 m apart upstream, downstream, and on both sides of the stream. Plots (1.5 m²) were placed 0.5, 5, 10, 20, and 80 m from the greenline to estimate available woody forage (winter diet) for a site. Building material, which were all trees with diameter at breast height (dbh) > 4.5 cm, were measured and counted within each plot. Daubenmire frames nested within each plot were used to estimate available herbaceous forage (summer diet). Exotic and native ungulate grazing was determined with fecal pile counts and knowledge of the grazing policies within each site. Grazing policy was a binary variable: "grazing permitted" or "grazing not permitted".

Results

For summer diet vegetation variables, beaver presence was best predicted by plant cover, willow cover, and absence of upland grasses. For winter diet vegetation variables, beaver presence was best predicted by number of willows (*Salix* spp.). No

species of large diameter trees (i.e., building material) were good predictors of beaver presence. For ungulate competitors, both livestock grazing policy and cattle fecal piles were significant predictors of beaver presence. However, livestock grazing policy was a stronger predictor. Presence sites were negatively associated with upland grass, livestock grazing policy, cattle fecal pile counts, and juniper.

Conclusions

Beaver occupancy was 26 times more likely to be observed in areas where livestock grazing is excluded by policy when compared to sites where livestock grazing was permitted. Willows were the most profound vegetative predictor of beaver presence. Willows were present in dense thickets at sites with beaver dams, which was in sharp contrast to sparse and stunted growth of willows at sites with grazing. The grazing of exotic ungulates has a deleterious effect on willow growth when coupled with the herbivory of beaver (Kindschy 1989). Livestock have access to riparian corridors during the late spring and midsummer when willow growth and recovery is needed and grazing rest is essential.

Management Implications

Land managers in the American Southwest are exploring ways to retain surface water for extended periods of time to diminish the effects of drought. Restoring beaver into areas where they historically occurred may be both an economically and ecologically sound endeavor for improving availability of surface water and reversing soil and bank erosion. Livestock grazing has an impact on habitat suitability for dam-building beaver. Our study demonstrated the importance of willows for beaver and that willows can provide adequate dam building material in locations where woody plants with large diameter stems are absent. Among competitors, cattle grazing had the most influence on willow abundance. More research is needed to identify alternative management strategies for riparian zones than those currently in place.

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Colleen Svancara University of Arizona, 315 Biological Sciences East 1311 E. 4th
Street Tucson, AZ 85721 svancarc@email.arizona.edu

Advisor: Scott Bonar

Additional Authors: Aaron Lien, Wendy Vanasco, Laura Lopez-Hoffman, Scott Bonar,
George Ruyle

Identifying ranching leaders' opinions of jaguar conservation and concerns with endangered species management through focused interviews

Introduction

Successful conservation of endangered species requires land managers to understand the concerns of the public when designating critical habitat. The United States Fish and Wildlife Service designated critical habitat for jaguars (*Panthera onca*) in April 2014, in southern Arizona and southwestern New Mexico. Ranchers in the region have expressed concern and apprehension toward the designation. Given ranchers large capacity to provide habitat for jaguars and wildlife, understanding their concern about the critical habitat designation is important for federal agencies and policymakers, so that federal entities and rangeland managers can work cohesively for wildlife conservation. Our objective was to understand issues of special concern to ranchers, and investigate the larger political issues they have with federally designated jaguar critical habitat. We designed our techniques to be useful to others studying attitudes of communities about endangered species management.

Methods

Key informant interviewing is an accepted social science technique to obtain detailed data about a large community by interviewing a select sample of community leaders. We conducted semi-structured key informant interviews with nine leaders of the Arizona/New Mexico ranching community, located on the U.S./Mexico border, to identify their specific concerns about the designation of critical habitat for jaguars. Leaders in the borderlands ranching community were chosen based on their involvement with organized ranching groups, their interactions with management agencies, and previously expressed concern. We interviewed ranchers individually in their homes or offices and asked detailed questions about their attitudes toward jaguars, concerns related to designation of jaguar critical habitat, and attitudes towards wildlife conservation in general. We used qualitative analysis software, NVivo 10, to group interview responses and identify broader themes and categories.

Results

Interviewees were fully supportive of wildlife conservation and felt their activities were intrinsically important to providing habitat for wildlife. All interviewees agreed jaguars were a unique, rare species, but they were all against the designation of jaguar critical habitat. We identified three categories of concern: direct impacts to ranching operations, political concerns, and concerns related specifically to the border region. Interviewees' concerns about direct impacts to ranching operations included elimination or curtailment of livestock grazing on public land, increased government regulation, and banned hunting within the critical habitat boundary. Interviewees' political concerns

included apprehension that jaguar critical habitat was designated for ulterior motives and to achieve alternate agendas. Interviewees' regional concerns included disbelief that the region could support jaguars, impeding border security issues, and overall distaste for federal government involvement.

Discussion and Conclusion

Here we show that ranchers are supportive of jaguar and wildlife conservation, but they are primarily concerned with the limitations of endangered species policy and management on ranching operations. Interviewees' concerns about direct impacts of critical habitat on rangeland management are likely due to exposure to other highly publicized conflicts between resource users and agencies managing endangered species in other places (e.g., Levy 2003; Mouer et al. 2005). The interviewees' concerns likely reflect deeper-seated values pertaining to centralized government. Our study shows opinions about endangered species conservation are more complex and nuanced, and move beyond basic concerns about jaguar depredation. Most interviewees agreed critical habitat was designated using ulterior motives, suggesting distrust of federal institutions. Distrust is one of the largest barriers to effective natural resource management (Hendee 1984).

Although our study did not investigate causality of attitudes, we revealed that interviewees' attitude towards endangered species policy was a poor predictor of their attitude towards wildlife conservation, and jaguars specifically. Generally, our interviewees disliked federal restrictions that follow an endangered species, and not so much the species itself.

Management Implications

Because distrust of management agencies seems to be the greatest obstacle to engaging ranchers in jaguar conservation, wildlife biologists and managers should focus on trust-building to improve wildlife conservation. Government agents that build strong personal relations with local people are often the most trusted (Davenport et al. 2007). We suggest fostering trust through frequent, informal, positive interactions with the public (Davenport et al. 2007).

The working relationship between government agencies and the southern Arizona ranching community could also benefit by investigating the role of conservation incentives and collaboration. Conservation incentives encourage conservation and good land management by paying landowners to install and maintain certain management practices. We plan to research ranchers' preference for an incentive program that would provide payments in exchange for supporting jaguar habitat. Incentives may increase landowners' willingness to provide habitat for endangered species, although not exclusively (Sorice et al. 2011). Increasing land managers collaboration with ranchers will likely bolster trust and reinforce social norms of the community as well, to encourage widespread conservation and sustainable action (Sorice et al. 2011).

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Wildlife Presentations

Jana B. Ashling, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; jashling@nmsu.edu

James W. Cain III, U.S. Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88033; jwcain@nmsu.edu.

Stewart G. Liley, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, New Mexico 87507; Stewart.Liley@state.nm.us

Survival, cause-specific mortality, and habitat selection of mule deer in southern New Mexico

The New Mexico Department of Game and Fish (NMDGF) is currently facing dual management issues with some mule deer populations (*Odocoileus hemionus*) in the state. Many populations in southern New Mexico have failed to recover from previous population declines. However, mule deer populations near urban areas have increased, resulting in overabundant populations, leading to increased human-wildlife conflicts including damage to property and increased vehicle collisions in urban areas. A translocation program has been initiated with a simultaneous effort to reduce the high density problem populations and augment low density populations. Our goals are to assess the success of translocations by monitoring survival and habitat selection of translocated mule deer. We captured and collared 67 mule deer in 2013 and 61 in 2014. Mule deer were translocated to either the Peloncillo Mountains or the San Francisco River Valley. In year two, we compared a soft release versus a hard release. After capture, half of each group in their respective translocation sites were contained in a holding pen 2 acres in size with predator proof fencing for 15 days. Survival in the Peloncillo Mountains for 2013 translocated mule deer is 60% and 20% in the San Francisco River Valley. Main causes of mortality are mountain lion predation, disease, and hunter harvest.

Mélanie J. Banville, Central Arizona–Phoenix Long-Term Ecological Research, Arizona State University, Julie Ann Wrigley Global Institute of Sustainability, P.O. Box 875402, Tempe, Arizona 85287; Melanie.Banville@asu.edu

Heather L. Bateman, Arizona State University at the Polytechnic Campus, College of Letters and Science, 6073 S. Backus Mall, Mesa, AZ 85212; Heather.L.Bateman@asu.edu

Stevan R. Earl, Central Arizona–Phoenix Long-Term Ecological Research, Arizona State University, Julie Ann Wrigley Global Institute of Sustainability, P.O. Box 875402, Tempe, Arizona 85287; Stevan.Earl@asu.edu

Paige S. Warren, University of Massachusetts-Amherst, Department of Environmental Conservation, 160 Holdsworth Way, Amherst, MA 01003; pswarren@eco.umass.edu

Effects of urbanization on birds – less water and more development leads to simplified communities

Riparian zones are hotspots for biodiversity and provide critical resources for wildlife. Urbanization can affect biotic communities in riparian zones by altering land use cover from the surrounding landscape. Shifts in bird communities may occur slowly and there are few long-term studies in urban areas. The Central Arizona–Phoenix Long-Term Ecological Research (CAP LTER) program has been monitoring bird populations within the Phoenix metropolitan area and its immediate surroundings since 2001. We choose 12 monitoring sites in riparian habitats that vary across four habitat categories that feature natural or engineered settings with perennial or ephemeral flows. Here, we used long-term data to address three questions: (1) How does bird community vary among different riparian sites categories, (2) How do riparian site categories environmentally differ at the site-level and landscape-level?, and (3) How has riparian bird community changed over time? Using ordinations of the bird community, we found that spring and winter communities have different migrant populations. Engineered riparian sites support more urban-adapted bird species; whereas, natural riparian sites support more specialists. Environmental variables at both the site-level and landscape-level described differences across riparian site categories. Over time, bird communities across all site types decreased in abundance, species richness, and/or diversity. Bird communities in natural settings may have changed more in composition than communities at engineered sites. Overall, the riparian bird community is shifting toward more urban-adapted, resident species that are characteristic of riparian sites with less water and more impervious surface.

Sheryl L. Barrett, U.S Fish and Wildlife Service, Mexican Wolf Recovery Program, 2105 Osuna Road NE, Albuquerque, New Mexico 87113
Margaret Dwire, U.S. Fish and Wildlife Service, Mexican Wolf Recovery Program, 2105 Osuna Road, NE, Albuquerque, New Mexico 87113
Tracy A. Melbiness, U.S. Fish and Wildlife Service, Mexican Wolf Recovery Program, 2105 Osuna Road, NE, Albuquerque, New Mexico 87113
John K. Oakleaf, U.S. Fish and Wildlife Service, Mexican Wolf Recovery Program, 2105 Osuna Road, NE, Albuquerque, New Mexico 87113

Update on the Mexican Wolf Recovery Program

The Mexican wolf (*Canis lupus baileyi*) was extirpated from the wild by the 1980s as part of anti-predator campaigns in the United States and Mexico. We developed a binational captive breeding program with Mexico in the 1970s with seven remaining Mexican wolves. We now have a captive population of about 250 Mexican wolves in 55 facilities in the United States and Mexico, which are managed under the Mexican Wolf Species Survival Plan. From this captive population, we have established an experimental population in the Gila and Apache National Forests in New Mexico and Arizona, respectively. Based on our annual count, the 2013 experimental population was a minimum of 83 Mexican wolves, all of which were wild born. In 2013, the Fish and Wildlife Service proposed to reclassify the Mexican wolf as an endangered subspecies (versus its current listing as part of the endangered gray wolf) and to revise the boundaries and take provisions of the experimental population. Final decisions on these proposals are due in January 2015.

Paul Beier, School of Forestry, Northern Arizona University, Flagstaff AZ 86011-5018;
paul.beier@nau.edu

Fábio Suzart de Albuquerque, School of Forestry, Northern Arizona University, Flagstaff
AZ 86011-5018; fabio.albuquerque@nau.edu

How to prioritize sites for species representation when you have species data for 0% to 20% of the sites in your planning area

If a planner has species inventory data for all sites in a planning area, she can prioritize sites for their ability to represent species. But without wall-to-wall inventories, a planner has been unable to prioritize sites for species representation – until now. Here we show how to use Environmental Diversity (ED) to prioritize sites when you have NO species inventories, and how to use Predicted Rarity-Weighted Richness (PRWR) to prioritize sites when you have inventories for 15-25% of sites. ED (first proposed by Faith & Walker 1996, and promptly ignored), selects sites that best span multivariate space defined by freely-available abiotic data. If species have unimodal niches in abiotic space, these sites should represent species efficiently. We tested ED on 8 datasets, including the Arizona Breeding Bird Atlas (ABBA). Median efficiency in species representation was 42%, meaning that even with species data for zero sites in the planning area, ED was about 42% as effective as having species inventories for 100% of sites in its ability to improve on random selection of sites. We also invented and evaluated PRWR. PRWR does require species inventories for a subset of sites in the planning area, and performance improves as the percent of sites inventoried increases. But with species inventories for a mere 20% of sites, median efficiency was a whopping 65% across 6 test datasets, including ABBA. If additional tests confirm the utility of these two procedures, prioritizing sites for species representation will become much easier.

David L. Bergman, USDA-APHIS Wildlife Services, 8836 North 23rd Avenue, Phoenix, Arizona 85021

Terry B. Johnson, Endangered Species Advisement, 6021 West Donald Drive, Glendale, Arizona 85301

Bridget Fahey, US Fish and Wildlife Service, P.O. Box 25486, Denver Federal Center, Denver, Colorado 80225-0486

Tonie E. Roche, USGS National Wildlife Health Center, 6006 Shroeder Road, Madison, Wisconsin 53711-6223

Pete Gober, U.S. Fish and Wildlife Service, Post Office Box 190, Wellington, Colorado 80549

William E. Van Pelt, Arizona Game and Fish Department, 5000 West Carefree Highway, Phoenix, Arizona 85086-5000

Michael W. Miller, Colorado Parks and Wildlife, 317 West Prospect Road, Fort Collins, Colorado 80526

Daniel W. Tripp, Colorado Parks and Wildlife, 317 West Prospect Road, Fort Collins, Colorado 80526

Rachel C. Abbott, USGS National Wildlife Health Center, 6006 Shroeder Road, Madison, Wisconsin 53711-6223

Can a sylvatic plague vaccine for prairie dogs assist the black-footed ferret recovery program?

The Black-footed Ferret Recovery Implementation Team (BFFRIT) Executive Committee just finished its second year of a field study to evaluate a sylvatic plague vaccine (SPV) program for prairie dogs (*Cynomys* spp.) in the wild. The project is a component of the Western Association of Fish and Wildlife Agencies (WAFWA) Grasslands Conservation Initiative and the Black-footed Ferret Recovery Implementation Team. SPV could be the biggest breakthrough in recovery efforts for the black-footed ferret (*Mustela nigripes*) since the 1981 rediscovery of wild ferrets near Meeteetse, Wyoming, and its subsequent successful captive breeding program. If proven efficacious, the vaccine could enable agencies and stakeholder cooperators to maintain specific populations of prairie dogs at robust levels, thus enhancing rangewide conservation of those species, as well as potentially recover the black-footed ferret, while enabling control of other prairie dog populations to resolve site-specific population needs and human health concerns. The results of clinical and field testing in the early stages of developing this vaccine are preliminary but promising. A plan for broad-scale application is being developed for possible use when testing has been completed and if warranted, the vaccine would be registered for governmental use.

Cody J. Bergman, Barry Goldwater High School, 2820 W Rose Garden Ln, Phoenix, AZ 85027; hunting.codyb@gmail.com

Texas Chapter of The Wildlife Society's Wildlife Conservation Camp

The Texas Chapter of The Wildlife Society administers and operates the Wildlife Conservation Camp. The Wildlife Conservation Camp offers students ranging from sophomores in high school through incoming freshman in college an opportunity to be in the outdoors and learn about wildlife and natural resources. Each year the camp staff selects approximately 24 students based on the prospective student's application and their overall interest in the outdoors. The camp is held over seven days of the summer and classes run from 6am to 11pm. The students are grouped together into four teams based upon their age and experience. The camp focuses on four key areas of learning. Investigation: Aldo Leopold's "Land Ethics". Discovery: Species Identification; Wildlife & Plant Ecology; and Management Strategies. Exploration: Field Sampling & Research Techniques; Wetland Ecology; and Shooting Sports & Hunter Education. Observation: Animal Behavior; Habitat Diversity; and Wildlife Tracking, Trapping & Monitoring. The camp rotates to a new geographic location in Texas each year. Last year, the camp was hosted by the Rob & Bessie Welder Wildlife Foundation outside of Sinton, Texas. As an alumni of the camp, I will provide an overview of the camp history and learning experience from day to day as well as encouragement to future campers.

**Student

*Riley Bogart, University of Arizona, Undergraduate, 1422 East Lee Street, Unit 2, Tucson, Arizona 85719; rileybogart@email.arizona.edu

*Melissa Stevenson, University of Arizona, 2440 W. Los Alamos Street, Tucson, Arizona 85741; mns1@email.arizona.edu

Robert Fink, Arizona Game and Fish Department, 555 N Greasewood Road, Tucson, AZ 85745; rfink@azgfd.gov

Aletris Neils, University of Arizona, Biological Sciences East, Room 223, 1311 East 4th Street, Tucson, Arizona 85721; amneils@email.arizona.edu

Supplemental water methodology for reintroduced black-tailed prairie dog (*Cynomys ludovicianus*) colony in Arizona

During the last century black-tailed prairie dogs (*Cynomys ludovicianus*) have been extirpated in Arizona due to anthropogenic persecution. *C. ludovicianus* is a keystone species in arid grasslands and its benefits include constructing burrows, preventing brush encroachment, aerating soils, and providing food for predators. In 2008, The Arizona Game and Fish Department reintroduced *C. ludovicianus* into the Las Cienegas National Conservation Area in southeastern Arizona. The reintroduced populations have fluctuated, possibly due to low nutrient availability on the grasslands caused by a 20 year drought in Arizona. The objective of this study was to examine if *C. ludovicianus* drank supplemental water, and if so, which delivery method was preferred. A water pan, rodent water bottle, and carrots were randomly placed with corresponding camera traps in the prairie dog colony to document the preference of supplemental water for individuals. Results indicated preference for carrots, due to potentially providing water, nutrients, and a hard substance to wear down ever-growing incisors. Information from this study can provide valuable insight into management of small rodent populations being reintroduced to arid ecosystems with variable rainfall. Data still being analyzed.

**Student

Jasper Brusuelas, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; jkb@nmsu.edu

Nicole Harings, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; haringsn@nmsu.edu

Wiebke Boeing, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; wboeing@nmsu.edu

Response of spotted salamander larvae (*Ambystoma maculatum*) to salinity and temperature

Amphibian populations are on the decline worldwide due to numerous environmental and anthropogenic stressors, one being climate change. Climate change affects many environmental factors such as water temperatures and salinity. We conducted a laboratory experiment looking at the response of the spotted salamander (*Ambystoma maculatum*) larvae to different salinities (0.3, 3, 6 and 9 PSU) and temperatures (21°C or 24°C). Hatching success, survival, growth rate and metamorphosis of *A. maculatum* were observed in aquaria. Data were analyzed with 2-way ANOVAs and von Bertalanffy growth curves. Salinity significantly impacted both hatching ($p < 0.0001$) and survival ($p = 0.01$), while temperature and the salinity x temperature interaction had no significant effects. None of the embryos exposed to 6 or 9 PSU salinities hatched, regardless of temperature. Hatching success as well as survival of embryos in the 3 PSU treatments was lower than those in the 0.3 PSU treatments. Larvae in 21°C treatments achieved the largest asymptotic length and developed slower (development of appendixes) compared to those in the 24°C treatments, independent of salinity level (0.3 or 3 PSU). This study demonstrates that even moderate increases in salinity concentrations (3 PSU) can result in significantly reduced hatching and survival of *A. maculatum*. Increased temperature slowed growth and increased development. Increased temperature can lead to a faster drying of amphibian breeding habitats and might be a cue for amphibians to speed up metamorphosis.

Jordan M. Calvert, Texas Tech University, Box 42125, Lubbock TX 79409,
jordan.goetting@ttu.edu

Aaron Alvidrez, 56th Range Management Office, Luke Air Force Base, AZ 85309,
aaron.alvidrez@us.af.mil

Kerry L. Griffis-Kyle, Texas Tech University, Box 42125, Lubbock TX 79409,
kerry.griffis-kyle@ttu.edu

Assessing site and climatic factors that influence large mammal water site use with camera-traps

Free standing water for wildlife in the desert is thought to be crucial to the survival of some wildlife populations, and beneficial to the survival of others. The Sonoran Desert is an environment of extreme heat and aridity. Most climate models predict hotter and drier conditions in the future, making informed management of these waters increasingly important. We sought to assess how differences in site and weather related attributes of water sites influence use by desert mammals. We used a camera-trap system at 20 water sites (7 tinajas, 13 catchments) for two years on the Barry M Goldwater Range – East (U.S. Air Force) to document visitation by six desert mammal species: bobcat (*Felis rufus*), Coues white-tailed deer (*Odocoileus virginianus couesi*), coyote (*Canis latrans*), desert bighorn sheep (*Ovis Canadensis nelsoni*), mountain lion (*Puma concolor*), and mule deer (*Odocoileus hemionus*). We found white-tailed deer exclusively used catchments both years, while mountain lions used catchments exclusively in 2011, and both water types in 2012. Conversely, desert bighorn sheep used tinajas more often than expected, based on their availability. Density of water sites in the area and slope were also important factors influencing water use, varying by species. Weather variables, precipitation and temperature, played key roles in water site use for these large mammals. Wildlife biologists can use these results to optimize factors that increase water site use for their target species, while minimizing factors that increase water site use of possible predators or competitors.

**Graduate student

Emily R. Conant, Texas Tech University, Department of Natural Resources, Box 42125, Lubbock, TX 79409, USA; emily.conant@ttu.edu

Mark C. Wallace, Texas Tech University, Department of Natural Resources, Box 42125, Lubbock, TX 79409, USA; mark.wallace@ttu.edu

Warren C. Conway, Texas Tech University, Department of Natural Resources, Box 42125, Lubbock, TX 79409, USA; warren.conway@ttu.edu

Stewart G. Liley, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, NM 87504, USA; stewart.liley@state.nm.us

Ryan L. Darr, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, NM 87504, USA; ryan.darr@state.nm.us

Assessing pronghorn fawn survival and cause-specific mortality using vaginal implant transmitters

Pronghorn (*Antilocapra americana*) recruitment is important to maintain populations, and to support recently translocated population expansion. In 2013, extremely low fawn to doe ratios of 6:100 were observed in Fort Stanton, NM. Therefore, in 2014, vaginal implant transmitters (VITs) were used estimate fawn production in translocated pronghorn females. In January 2014, females ($n = 26$) were radiocollared, ultrasounded to determine pregnancy, and implanted with a VIT (Model M3930L, 21g; ATS, Inc., Isanti, Minnesota, USA) prior to translocation to Fort Stanton, NM from a private ranch in Cimarron, NM. VITs were equipped with both temperature and photo sensors, which activated precise event transmitter (PET) codes to indicate duration of VIT expulsion. Of the 19 VITs that were associated with live and known location females, 16 VITs were confirmed to have expelled and/or females were observed with fawns. Expelled VITs assisted in fawn capture from 10 different females. A total of 29 fawns were captured, from both females with VITs and opportunistic captures (either unmarked, local females or collared females from 2013) and outfitted with ear tag transmitters. Fawns were monitored twice daily to determine survival and cause-specific mortality. In 2014, fawn survival was 0% with the majority ($n = 25$; 86%) of mortalities presumably occurring from predation. The evidence of these mortalities was either ear tag transmitters found with no other evidence or ear tag transmitters found with pieces of ear. Current efforts are focused upon refining VIT technology, and estimating fawn survival in 2015.

**Student

Courtenay M. Conring, Texas Tech University, Department of Natural Resources Management, Lubbock, TX 79409; courtenay.conring@ttu.edu

Blake A. Grisham, Texas Tech University, Department of Natural Resources Management, Lubbock, TX 79409; blake.grisham@ttu.edu

Daniel P. Collins, United States Fish and Wildlife Service, Region 2 Migratory Bird Office, P.O. Box 1306 Albuquerque, NM 87103

Identification of migratory paths and new breeding grounds of greater sandhill cranes in the Lower Colorado River Valley

The lower Colorado River valley population (LCRVP) of sandhill cranes (*Grus canadensis*) is the smallest of the migratory sandhill crane populations in North America. Recent surveys found <30% of the estimated LCRVP of sandhill cranes are on their known breeding grounds in northeast Nevada and southwest Idaho during the summer, suggesting more information is needed regarding migratory routes and breeding ground distribution. In January 2014, we equipped 16 greater sandhill cranes on two study sites in southwest Arizona and southeast California with solar powered ARGOS satellite platform transmitter terminals. We used location class (LC) GPS (G) quality locations to identify migratory stopover, staging and breeding areas. We identified seven distinct stopover locations, including Wayne E. Kirch Wildlife Management Area and surrounding areas in Nevada. Pahrnagat National Wildlife Refuge in Nevada was used exclusively by cranes captured in Arizona, whereas Mojave National Preserve in California was used exclusively by cranes captured in California. The Ruby Valley in Nevada was used heavily as a staging area, but only during spring migration. Thirteen of 16 cranes were located on the known breeding grounds in northeast Nevada and southwest Idaho. One crane summered in Valley County, Idaho, an area that has not been documented as a breeding location for this population. The ultimate goal of this research program is to provide the framework for future habitat selection studies and reliable information to the Pacific Flyway Council for revision of the LCRVP management plan.

**Graduate Student

Rowan Converse, Bosque Ecosystem Monitoring Program, Bosque School, 4000 Learning Road NW, Albuquerque, NM 87120; rowan.converse@bosqueschool.org

Daniel Shaw, Bosque Ecosystem Monitoring Program, Bosque School, 4000 Learning Road NW, Albuquerque, NM 87120; dan.shaw@bosqueschool.org

Developing natural resource career pathways through citizen science

In an era where children often have limited access to outdoor experiences, many young people do not have the opportunity to discover careers in one of the environmental sciences. For over 18 years, the Bosque Ecosystem Monitoring Program (BEMP) has supported tens of thousands of K-12 students in a field-based citizen science program monitoring the impacts of the ecological drivers of flood, fire, climate, and human alteration on the Rio Grande and its riverside forest. The majority of BEMP students are from backgrounds underrepresented in science fields. Through BEMP, students conduct ecological, forestry, wildlife, and related studies and learn how to collect, manage, and analyze data. These experiences bolster field science and job readiness skills, and provide a pathway for learning and engagement with environmental careers. BEMP trains university interns to serve as mentors working directly with K-12 students; often, these interns participated in BEMP programming when they were K-12 students. Interns are further supported by BEMP with more advanced opportunities to develop their career interests. We believe that BEMP could serve as a model for citizen science programs introducing large, diverse groups of K-12 students to careers in natural resources.

Jason Corbett, Bat Conservation International, Director of the Subterranean Program,
PO Box 22159, Flagstaff, AZ 86002; jcorbett@batcon.org
Trish Cutler, White Sands Missile Range, Wildlife Biologist, Building 163, Springfield
Avenue, IMWE-WSM-PWE-ES, White Sands Missile Range, NM 88002;
patricia.l.cutler.civ@mail.mil

Subterranean surveys of White Sands Missile Range, New Mexico.

From the summer 2010 until the winter of 2013 subterranean surveys were conducted across the entirety of White Sands Missile Range (WSMR). The 3,200 square miles of this test, evaluation and research facility encompass a great variety of habitat types ranging from rugged mountains to flat valley bottoms. Concerned about the looming threat of white-nose syndrome (WNS) and needing a comprehensive survey of subterranean resources across the range to assist with enhanced resource management capabilities, WSMR and BCI joined in partnership to secure DoD Legacy funds. During the project, over 677 features were surveyed by the team at WSMR and another 100+ features at Fort Bliss, Kirtland Air Force Base, and several New Mexico National Guard sites. At WSMR, 46 roosts were located being used by 6 different species. The most common bat encountered was the Townsend's big-eared bat. A variety of cultural and historical resources were also documented in the course of survey efforts, and data on mine characteristics were collected to assist in potential site selection for military missions. The data collected during the course of this project will be critical, in years to come, to the natural resource managers charged with supporting the military mission while protecting fragile natural resources.

Christopher L. Coxen, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; clcoxen@nmsu.edu

Scott A. Carleton, U.S. Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88033; carleton@nmsu.edu

Daniel P. Collins, Migratory Game Bird Coordinator USFWS-Region 2 Migratory Bird Office P. O. Box 1306 Albuquerque, NM 87103; dan_collins@fws.gov

Modeling the demographics and movements of band-tailed pigeons in New Mexico

Survivability and recruitment estimates are critical for effective game species management. This project seeks to address the decades long gap in current demographic and habitat use data to advance the management of New Mexico and greater Four Corners region band-tailed pigeons. Our goal is to establish a standardized population monitoring protocol through the novel use of PIT tag based mark-resight survivability and recruitment models. In 2013, we secured three geographically distinct feed sites located on private land adjacent to the Gila, Lincoln, and Santa Fe National Forests. 126 birds were banded and tagged at one site in 2013. We expanded trapping to all three sites in 2014, adding another 300 unique birds to our total marked population across the three sites. Survivability models have been created for one subpopulation and additional modeling will be completed after the 2015 field season. Pigeon movement and habitat use data will be collected through archival geolocators and satellite PTTs. These data will be used in conjunction with nesting and foraging habitat suitability models for each National Forest to compare model predictions, movement pattern data, and geospatial forest management data to evaluate bird habitat use in response to management practices. We will also compare PTT bird habitat use data with our suitability models to determine their ability to inform Breeding Bird Survey (BBS) route placement to maximize sampling efficacy.

Ryan M. DeVore, Montana Fish, Wildlife, & Parks, Broadus, Montana, 59317;
rdevore@mt.gov

Mark C. Wallace, Texas Tech University, Department of Natural Resources
Management, Lubbock, TX 79409; mark.wallace@ttu.edu

Matthew J. Butler, Division of Biological Services, National Wildlife Refuge System, U.S.
Fish and Wildlife Service, Albuquerque, NM 87103; matthew_butler@fws.gov

Stewart L. Liley, New Mexico Department of Game and Fish, One Wildlife Way, Santa
Fe, NM 87507; stewart.liley@state.nm.us

Ashley A. Inslee, Bosque del Apache National Wildlife Refuge, U.S. Fish and Wildlife
Service, San Antonio, NM 87832; ashley_inslee@fws.gov

Philip S. Gipson, Texas Tech University, Department of Natural Resources
Management, Lubbock, TX 79409; philip.gipson@ttu.edu

Elk habitat use patterns in an arid riparian corridor managed for migratory water birds

Elk (*Cervus elaphus*) were depredated corn (*Zea mays*) at Bosque del Apache National Wildlife Refuge (BDANWR), New Mexico, USA, which interfered with the Refuge's ability to provide sufficient supplemental nutrition to overwintering sandhill cranes (*Grus canadensis*) and geese. We used 8,244 GPS locations collected from 9 adult female elk in a resource selection probability function to model fine-scale habitat and corn field use by the resident herd. When in cropland areas, elk use increased when alfalfa and corn were present, and was greatest at 0.14 km from uncultivated areas. When elk were in uncultivated areas, probability of use increased as canopy cover increased. Elk use exhibited a quadratic relationship with hiding cover density, which varied with distance to cropland. We validated predicted probabilities of use from our fine-scale model with an independent sample (1,106 locations from 12 VHF-collared females) from the same population and time period. The habitat model was successful in predicting elk use, as 84.1% of VHF locations fell within high or medium-high use cells. Corn use models indicated that elk use increased as the proportion of the corn field perimeter adjacent to alfalfa increased. Use declined as distance to uncultivated areas and the proportion of other corn fields at the same growth stage increased. Probability of elk use peaked when corn was 1.4–1.7 m high, which varied with distance to uncultivated areas. The results of this study can help direct habitat manipulations and the timing of elk hazing efforts aimed at reducing crop depredation.

**Graduate Student

Glen Dickens, Arizona Antelope Foundation, P.O. Box 12590, Glendale, Arizona 85318.
(520-247-4907), Gbdickens@Comcast.Net
John Millican, Arizona Antelope Foundation, P.O. Box 12590, Glendale, Arizona 85318.
(520-508-4272), J2dbmill@Msn.Com
Caroline Patrick, Arizona Antelope Foundation, P.O. Box 12590, Glendale, Arizona
85318. (520-419-1858), Cpatrick42@Gmail.Com
Shane Stewart, Arizona Antelope Foundation, P.O. Box 12590, Glendale, Arizona
85318. (602-616-0383), Info@Azantelope.Org
Tice Supplee, Arizona Antelope Foundation, P.O. Box 12590, Glendale, Arizona 85318.
(602-380-3722), Vsupplee@Earthlink.Net

Arizona Antelope Foundation Southeastern Arizona Grasslands Pronghorn Initiative

In 2011, 2013 and 2014 the Arizona Antelope Foundation was awarded 3 different National Fish and Wildlife Foundation grants totaling \$510,000 to support the AAF's 5-year Southeastern Arizona Grasslands Pronghorn Initiative initiated in April 2010. Matching non-federal contributions valued at \$510,000 include: AAF and private land owner project labor and materials; Pima County Sonoran Conservation Plan land acquisition funds and Arizona Game and Fish Big Game Tag Habitat Partnership Funds. The "Southeast Arizona Collaborative Grassland Workgroup", created in February 2010, collaboratively drafted a southeastern Arizona Regional Pronghorn Strategy to: Increase Pronghorn population numbers, distribution and connectiveness. Partners in this working group include: AAF, AGFD, BLM, USFS, SLD, USDA, USFWS, Pima County, Arizona Wildlife Federation, Nature Conservancy, Audubon Society, Tombstone High school and local ranchers/landowners. Long-term goals for this 6-year grant period 2011-17 are to:

- 1) establish a region-wide dynamic geodatabase with integrated multi-species layers to prioritize grasslands restoration/maintenance activities for pronghorn and other sensitive grassland species, 2) permanently record pronghorn travel corridors and remove or modify barriers, including fences, shrubs and trees, 3) target/plan grassland treatments/burns in priority habitat locations on an annual and long-term basis to benefit the highest number of keystone grassland species, 4) supplement at least one pronghorn population and increase numbers in two subpopulations and 5) improve grassland habitat in five pronghorn subpopulation zones. We discuss our progress to date and outline the multiple relationships that are ensuring that the initiative succeeds for the long-term benefit of southeastern Arizona's Pronghorn herds.

Joseph C. Drake**, Texas Tech University, Department of Natural Resources Management, Goddard Building, Box 42125, Lubbock, TX 79409; joseph.drake@ttu.edu

Nancy E. McIntyre, Texas Tech University, Department of Biological Sciences, Lubbock, TX 79409; nancy.mcintyre@ttu.edu

Kerry L. Griffis-Kyle, Texas Tech University, Department of Natural Resources Management, Goddard Building, Box 42125, Lubbock, TX 79409; Kerry.griffis-kyle@ttu.edu

Connectivity and isolation in the management of aquatic resources in the Sonoran Desert: Nested frameworks for maintaining biodiversity

Connectivity of aquatic resources in the Sonoran Desert has been severely altered by humans; water resources that were ephemeral are now permanent whereas others that were permanent are now gone. In general, highly connected landscapes have been considered beneficial to wildlife, but there are negative consequences to connectivity. Connectivity and isolation are natural elements of the landscape, but we may need to manage these at different scales because of tradeoffs between the needs of native species and protection against hyperconnectivity that facilitates expansion of invasives and diseases. Using graph theory and movement distances based on reported invasive American bullfrog vagility, we analyzed wetland networks comprised of natural and anthropogenic waterbodies. These networks are composed of habitat clusters that emerge at various dispersal distances, eventually coalescing to form a single network. We examined connectivity within a nested framework at the scale of the entire network as well as within clusters that emerge at bullfrog and native species dispersal distances. We identified clusters of connected wetlands important for native amphibians based on various structural metrics such as stepping-stones, hubs, and cutpoints. In addition we used circuit theory to identify corridors of dispersal among water sites. In so doing, we identified areas of potentially high ecological importance based on both graph theory and resistance mapping. Using a nested framework to identify important areas of connectivity, both for native populations and for invasives, can help managers plan for the connectivity of resources in a way that addresses sometimes conflicting management goals.

**Graduate Student

Viacheslav Fofanov, Informatics and Computing, Northern Arizona University, Bldg. 56, Room 120, 1297 S Knoles Dr., Flagstaff, AZ 86011-5621; sfofanov@hotmail.com

Faith M. Walker, School of Forestry & Center for Microbial Genetics and Genomics, Northern Arizona University, Bldg. 56, 3rd floor, 1298 S Knoles Dr., Flagstaff, AZ 86011-4073; Faith.Walker@nau.edu

*Colin J. Sobek, Center for Microbial Genetics and Genomics, Northern Arizona University, Bldg. 56, 3rd floor, 1298 S Knoles Dr., Flagstaff, AZ 86011-4073; cjs349@nau.edu

*Dan E. Sanchez, Center for Microbial Genetics and Genomics, Northern Arizona University, Bldg. 56, 3rd floor, 1298 S Knoles Dr., Flagstaff, AZ 86011-4073; Daniel.Sanchez@nau.edu

Carol L. Chambers, School of Forestry, Northern Arizona University, 200 East Pine Knoll Dr., Flagstaff, AZ 86011; Carol.Chambers@nau.edu

A DNA sequencing approach for characterizing microbial and bat species composition in mines from guano.

Bats (order Chiroptera) are known reservoirs for a variety of viral (Rabies, SARS, Nipah, Flu, Ebola), bacterial (*Bartonella spp.*, *Coxiella burnetti*), and fungal (*Histoplasma capsulatum*, *Coccidioides immitis*) zoonotic diseases. A systematic understanding of the prevalence, transmission, and geographic extent of these pathogens and their associations with wild bat populations has been limited due to bats' elusive and nocturnal nature and varied roosting habits. Roost-based guano sampling alleviates these difficulties, as guano is readily available, stationary, and contains sufficient genetic information for identification of both the bat species and their microbiota. We sought to profile the bacteria, fungi, and bat species associated with guano collected from roosts in two Arizona mines. DNA was isolated from pooled roost guano and species-resolving genes were sequenced (Illumina MiSeq) to identify contributing bacteria, fungi, and bat species. Reads for each panel were processed using standard microbiome characterization tools (Qiime). We identified 3 bat species, illustrating that site cohabitation and species composition varied between the two roosts. We also found a diverse profile of 14 bacterial and 11 fungal families. Of particular interest is the presence of *Coxiellaceae* - a bacterial family that contains multiple tick-borne pathogens, including *C. burnetti* which is a causative agent of Q-Fever in humans. Our results show that we can simultaneously capture a high degree of microbial diversity and identify the bat species involved.

Jay V. Gedir, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, P.O. Box 30001, Las Cruces, NM 88003; jgedir@nmsu.edu

James W. Cain, III, U.S. Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish, Wildlife, and Conservation Ecology, P.O. Box 30003, Las Cruces, NM 88003; jwcain@nmsu.edu

Grant Harris, U.S. Fish and Wildlife Service, Division of Biological Services, P.O. Box 1306, Albuquerque, NM 87103; Grant_Harris@fws.gov

Trey T. Turnbull, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, P.O. Box 30001, Las Cruces, NM 88003; ttbull@nmsu.edu

Predicting long-term pronghorn population dynamics in the southwest U.S.A. in response to climate change

Understanding how climate change will affect animal populations remains a major challenge, particularly in areas with highly variable precipitation patterns, like in the Southwest. We adopted an information-theoretic approach in a Bayesian framework to analyze long-term data from 17 pronghorn populations in Utah, Arizona, New Mexico, and Texas, to determine climatic factors that predict annual rate of population change (λ). We used these explanatory variables to project pronghorn population trends to 2090 in response to climate change under high and lower atmospheric CO₂ concentration scenarios using region-specific downscaled climate projection data. Climate projections on pronghorn range indicate increased temperatures across the region, and direction and magnitude of precipitation changes show high area-specific variance. Twelve populations demonstrated significant positive relationships between precipitation and λ , with late gestation and lactation being important periods, whereas temperature relationships were highly variable. We found little difference in pronghorn population projections between atmospheric CO₂ concentration scenarios, and our models predict that about half of the pronghorn populations in the Southwest will be extirpated or approaching extirpation by the end of the century. Findings will contribute to the development of conservation and management plans for pronghorn populations across the Southwest, enabling wildlife managers to make scientifically-informed decisions when developing management strategies.

J. Tomasz Giermakowski, Museum of Southwestern Biology and Department of Biology, University of New Mexico, MSC03 2020, Albuquerque, New Mexico 87131; tomas@unm.edu

Erika M. Nowak, Matthew J. Johnson, Jennifer A. Holmes, Colorado Plateau Research Station, Northern Arizona University, Flagstaff, AZ 86011; erika.nowak@nau.edu, matthew.johnson@nau.edu, jennifer.holmes@nau.edu

James R. Hatten, Western Fisheries Research Center, Columbia River Research Laboratory, U.S. Geological Survey, Cook, WA 98605; jhatten@usgs.gov

Future landscape suitability and actionable management for several species of reptiles in Arizona and New Mexico

Models of future climate in the southwest predict drastic changes in temperature and precipitation and different combinations of these changes are likely to affect populations of many animals. Additionally, the resulting modifications to the spatial configuration of suitable landscapes are also likely to have an effect. Combined, these changes might be especially damaging to reptiles because of their limited dispersal abilities. To provide spatially-explicit products useful for actionable management at landscape scales, we built models of suitability of current and future landscapes for several species of reptiles. Our objectives were to examine the effects of landscape fragmentation and individual species life history on the future expansion or contraction of ranges. To delineate currently suitable landscapes, for each species, we relied on conceptual models that identified crucial variables to include in the modeling process. Using the maximum entropy algorithm, we related values of selected variables to localities where each species has been documented. We then projected the suitability of landscapes into the future. For some species our results suggest significant negative changes in future landscape suitability (likely range contraction). Because our results also indicate that individual species will respond in their own ways to future changes in climate, species-by-species examination of models of distribution is important for effective management. In turn, consideration of reptiles in land management is very important for Arizona and New Mexico because the diversity and uniqueness of reptile fauna in both states is among the highest in the nation.

Nicholas D. Goforth, Texas Tech University, Department of Natural Resources Management, Texas Tech University, Box 42125, Lubbock, Texas 79409; nick.goforth@ttu.edu

Tigga Kingston, Texas Tech University, Department of Biological Sciences, Texas Tech University, Box 43131, Lubbock, Texas 79409; tigga.kingston@ttu.edu

Robin M. Verble-Pearson, Texas Tech University, Department of Natural Resources Management, Texas Tech University, Box 42125, Lubbock, Texas 79409; robin.verble@ttu.edu

Short-term effects of wildfire on bat activity

Bats are important components of forested ecosystems. Most bat species depend on forest habitats for roosting and foraging, and are also beneficial to forests (e.g., insect suppression). In the American Southwest, large and unprecedented wildfires are occurring more frequently. Although wildfires can be beneficial to bats (i.e., fires weaken trees and stimulate flowering plant growth, attracting wood-boring beetles, pollinators, and other prey insects; and create roost sites and thin cluttered forests), the relationships between bats and forest fires are still not well understood. In particular, we have a limited knowledge of how increasingly common wildfires may influence bat activity and community composition. The focus of this study is to determine how bat activity is influenced by wildfire, and more specifically, how burn severity and vegetation type affects activity levels in the years immediately post-fire. Acoustic surveys were conducted at the Valles Caldera National Preserve, New Mexico from June-October in 2013 and May-July in 2014 at four study sites within each treatment: unburned, the Las Conchas Wildfire of 2011, and the Thompson Ridge Wildfire of 2013. Dominant habitat types include montane mixed conifer and ponderosa pine forests and montane grasslands. Preliminary results suggest that bats are more active in burned areas than in unburned areas. Within burned areas, activity levels are higher in areas that burned at a lower severity, and lower in those that burned at a higher severity. These patterns are hypothesized to be a result of prey availability, but further analyses are needed to better understand this relationship.

**Student

William R. Gould, Applied Statistics Program, New Mexico State University; P.O. Box 30001, MSC 3CQ, Las Cruces, New Mexico 88011; wgould@nmsu.edu
Andy Ray, National Park Service Inventory and Monitoring Program, Greater Yellowstone Network, 2327 University Way, Suite 2, Bozeman, MT 59715; Andy_Ray@nps.gov
Debra Patla, Northern Rockies Conservation Cooperative, P.O. Box 2705, Jackson, WY 83001; dpatla@hughes.net
Blake Hossack, U.S. Geological Survey, Northern Rockies Mountain Science Center, 790 E. Beckwith Ave., Missoula, MT 59801; Blake_Hossack@usgs.gov
Rob Daley, National Park Service Inventory and Monitoring Program, Greater Yellowstone Network, 2327 University Way, Suite 2, Bozeman, MT 59715; Rob_Daley@nps.gov
Kristin Legg, National Park Service Inventory and Monitoring Program, Greater Yellowstone Network, 2327 University Way, Suite 2, Bozeman, MT 59715; Kristin_Legg@nps.gov

Occupancy estimation of amphibian breeding in Yellowstone and Grand Teton National Parks: On the usefulness of covariates

A long-term amphibian monitoring program has been developed as a means for monitoring ecosystem health in Yellowstone and Grand Teton National Parks. Annual surveys for breeding occupancy were conducted over years 2006-2012. We used multi-season occupancy estimation to assess changes in the occurrence of tiger salamanders, boreal chorus frogs and Columbia-spotted frogs at two scales: small watershed (catchment) and individual site. Catchments were randomly selected and all wetlands within catchments were surveyed for breeding occurrence. Tiger salamander occupancy at the catchment level has decreased since its high in 2008, whereas chorus frogs have increased during between 2006 and 2012. Spotted frog occupancy has been stable during this same time period. Use of covariates (e.g., habitat or climate variables) offers explanations for the observed dynamics but also brings with it some complications that will be discussed.

Cody P. Griffin, Texas Tech University, Department of Natural Resources Management, Box 42125, Texas Tech University, Lubbock, Texas 79409; cody.griffin@ttu.edu
Alixandra J. Godar, Texas Tech University, Department of Natural Resources Management, Box 42125, Texas Tech University, Lubbock, Texas 79409; alixandra.godar@ttu.edu
Blake A. Grisham, Texas Tech University, Department of Natural Resources Management, Box 42125, Texas Tech University, Lubbock, Texas 79409; blake.grisham@ttu.edu
Clint W. Boal, U.S. Geological Survey Texas Cooperative Fish and Wildlife Research Unit, Texas Tech University, Department of Natural Resources Management, Box 42125, Texas Tech University, Lubbock, Texas 79409; clint.boal@ttu.edu
David A. Haukos, U.S. Geological Survey Kansas Cooperative Fish and Wildlife Research Unit, Kansas State University, Department of Natural Resources and Environmental Sciences, 205 Leasure Hall, Manhattan, Kansas 66506; dhaukos@ksu.edu
Jim C. Pitman, Kansas Department of Wildlife, Parks, and Tourism, PO Box 1525, Emporia, Kansas 66801; jim.pitman@ksoutdoors.com
Christian A. Hagen, Oregon State University, Department of Fisheries and Wildlife, 500 SW Bond Street, Suite 107, Bend, Oregon 97702; christian.hagen@oregonstate.edu

Does weather influence lesser prairie-chicken demographic parameters disproportionately in the sand shinnery oak prairie compared to the sand sagebrush prairie?

Lesser Prairie-Chicken populations in the sand shinnery oak (SSOP) and sand sagebrush prairie (SSBP) ecoregions are found along a climate gradient in the southern Great Plains. Environmental conditions in the SSOP, located on the Southern High Plains of New Mexico and Texas, are warmer and dryer compared to the SSBP, located along the Arkansas River in Kansas. Precipitation and temperature influence nest and female lesser prairie-chicken survival in the sand shinnery oak prairie (SSOP), but the relative influence of environmental conditions on survival is unknown in the sand sagebrush prairie (SSBP). To assess the role of environmental conditions on nest and female survival, we collected demographic data in 2007-2012 in the SSOP and requested data collected from 1997-2002 in the SSBP. We used known-fate and nest survival models to assess the effect size of biologically relevant environmental variables on adult female and nest survival, respectively, for each ecoregion. Temperature during incubation had the greatest effect on female survival in the SSOP ($\beta_{\text{SmrTemp}} = -0.08$) and SSBP ($\beta_{\text{Cold}} = -0.12$; $\beta_{\text{Hot}} = -0.03$). However, the effect sizes of environmental variables for nest survival in the SSBP were much smaller (ten thousandths and hundred thousandths decimal places) compared to the SSOP (tens and hundredths decimal places). Our results suggest environmental conditions influenced nest survival more than female survival, and environmental variables disproportionately influenced nest survival in the SSOP. These preliminary data corroborate our earlier findings that suggest environmental variables are a contributing factor that influence Lesser Prairie-Chickens population dynamics on the Southern High Plains. **Graduate Student

Sarah L. Hale, University of Arizona, School of Natural Resources and the Environment, Biological Sciences East 325, Tucson, AZ 85721; Phone (520) 626-5616; shale@email.arizona.edu

John L. Koprowski, University of Arizona, School of Natural Resources and the Environment, Biological Sciences East 325, Tucson, AZ 85721; Phone (520) 626-5616; squirrel@ag.arizona.edu

Can the reestablishment of a keystone species manage woody encroachment across its former range?

Woody encroachment is a widespread phenomenon affecting grasslands and savannas worldwide. While its effects vary widely depending on local conditions, encroachment often can have adverse effects on an ecosystem. Several causes have been proposed in the literature, such as grazing of domestic livestock, fire suppression, climate change, and increasing atmospheric CO₂ levels; however, the widespread removal of a native grazer and keystone species, the prairie dog (*Cynomys* spp.), is one potential cause that has received little attention. Because woody encroachment has coincided with the removal of prairie dogs across their former range, we hypothesized that prairie dogs actively suppress woody plant growth on their colonies. To test this hypothesis, we installed exclosures around woody plants, and conducted artificial sapling experiments on and around 4 recently reestablished black-tailed prairie dog (*Cynomys ludovicianus*) colonies in southeastern Arizona. We found that, on colonies, woody plants inside exclosures grew faster than those left exposed to prairie dogs, and artificial saplings were rapidly destroyed. Our findings suggest that the reestablishment of this highly persecuted, yet ecologically critical, species could simultaneously function as a management tool for widespread woody encroachment across the North American west.

**Student

Richard E. Harness, EDM International, Inc., 4001 Automation Way, Fort Collins, CO 80525; rharness@edmlink.com

Trish Cutler, White Sands Missile Range, IMWE-WSM-PWE-ES, Bldg 163, Springfield Ave., WSMR, NM 88002; patricia.l.cutler.civ@mail.mil

Lori A. Nielsen, EDM International, Inc., 4001 Automation Way, Fort Collins, CO 80525; lnielsen@edmlink.com

White Sands Missile Range – Avian Protection Plan: power line bird protection in support of the military mission

White Sands Missile Range (WSMR) is the largest U.S. overland military installation, encompassing portions of five New Mexico counties and three rural electric service territories. The WSMR electric power grid is extensive and complex with hundreds of miles of distribution power lines. WSMR initiated an Avian Protection Plan (APP) in 2014 to reduce bird electrocution risk and animal-caused outages, ensuring regulatory compliance with the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act. EDM International, Inc. (EDM) prepared the APP, which included a field Risk Assessment (RA) conducted in 2012. Historically, WSMR has retrofitted hazardous poles and/or de-energized specific line spans in favorable habitat; however, this can result in at-risk configurations being unrecognized when lines are re-energized for new missions. EDM surveyed 80% of the power line grid, resulting in over 1,000 structures and areas with retrofitting recommendations. Each RA recommendation was assigned a risk prioritization ranking (1-4) based on factors including habitat and pole configuration (Dwyer et al. 2013). Poles with equipment and exposed jumpers and antiquated ground banks were highly associated with avian incidents and received the highest RA ranking, a value of 1. Retrofitting challenges included developing strategies to mitigate remote three-phase switch structures with prominent Golden Eagle (*Aquila chrysaetos*) presence, while balancing high levels of raptor use within the more populated Main Post cantonment area. The APP provides a short- and long-term planning tool to mitigate high-risk poles, making the power system more reliable thus supporting military mission readiness.

Robert L. Harrison, Department of Biology, University of New Mexico, Albuquerque, NM
87131. rharison@unm.edu

Noninvasive survey methods for mid-sized and small carnivores in New Mexico

A wide variety of noninvasive survey methods are now available for monitoring populations of mid-sized and small carnivores. Traditional methods included scent stations and searches for scats or tracks. Recently developed methods include DNA analysis of hair and the use of automatic digital cameras. The optimal method to use varies with several factors, particularly project goal, species, and location. Here I present evaluations of noninvasive survey methods for gray foxes, swift foxes, bobcats, ringtails, and badgers in New Mexico. To develop a relative abundance index or to determine distribution, I recommend hair snares for gray foxes, searches for scats for swift foxes and ringtails, searches for scats using detector dogs for bobcats, and automatic cameras at wildlife water sources or bait for badgers. To obtain absolute abundance estimates I recommend hair snares for gray foxes, searches for scats or hair snares for swift foxes, hair snares for ringtails, automatic cameras for bobcats, and automatic cameras at wildlife water sources or bait for badgers.

James R. Heffelfinger, Arizona Game and Fish Department, 555 N. Greasewood Road,
Tucson, AZ 85745; jheffelfinger@azgfd.gov

Tails with a dark side: whitetail and mule deer hybridization in North America

Different species of animals, even those closely related, are normally kept from breeding with one another by being geographically isolated, by using different types of habitat, or by having different courtship and breeding behavior. In the case of whitetails and mule deer, all 3 of these factors help keep the 2 species from interbreeding. These differences have worked remarkably well throughout their evolutionary coexistence. However, in rare cases this system breaks down and hybridization occurs. Hybrids have been reported from captive facilities as early as 1898 when a whitetail x mule deer cross was produced at the Cincinnati Zoo. The male hybrids are sterile, however, female hybrids are fertile and can breed back to 1 of the parental species. This hybridization between the 2 different deer species is extremely rare in most areas, but does occur in where their ranges overlap. Hybrid deer show characteristics that are intermediate between mule deer and whitetails. The most informative physical feature to diagnose a hybrid in the wild is the size and location of the metatarsal gland on the *outside* of the lower portion of the rear legs. Two loci visualized by protein electrophoresis have been used in the past as a genetic test of hybridization. New advances in genetic techniques have been developed and are now being employed to learn more about hybridization in *Odocoileus*.

Holly E. Hicks, Arizona Game and Fish Department, 5000 West Carefree Highway,
Phoenix, AZ 85086; hhicks@azgfd.gov
Jennifer Cordova, Arizona Game and Fish, 5325 North Stockton Hill Road, Kingman,
AZ 86409; jcordova@azgfd.gov

Field trials of an oral sylvatic plague vaccine in Gunnison's prairie dog colonies

Plague is an exotic zoonotic disease that was introduced to the United States in the early 1900's. Sylvatic plague is a bacterial disease caused by *Yersinia pestis* and is responsible for the declines of prairie dog (*Cynomys sp.*) colonies across its range. During an epizootic event, a prairie dog colony can experience greater than 90% mortality in a very short period of time. In an effort to protect prairie dog colonies from these epizootic events, scientists at the National Wildlife Health Center of the United States Geological Survey developed an oral sylvatic plague vaccine (SPV) that will vaccinate prairie dogs against the disease. The vaccine has proven quite effective in a lab setting with more than 90% of vaccinated prairie dogs surviving the infection. To understand its effectiveness on the ground, field trials were necessary to determine timing, methods, and density of bait distribution. Field trials are on-going range wide among all four types of prairie dogs in the U.S. and Arizona is only one of two sites that are conducting these trials on Gunnison's Prairie Dogs. If effective, SPV will be a tool that managers can use to prevent severe prairie dog declines in the event of a plague outbreak. SPV success could preclude the need to list Gunnison's, white-tailed, and black-tailed prairie dogs as well as possible eventual delisting of Utah's prairie dogs and their obligate black-footed ferret.

*Professional

Ed Jahrke, SSDV Habitat Implementation Program Manager, Arizona Game and Fish Department; 5000 W. Carefree Highway, Phoenix, Arizona 85086; Phone (623) 236-7482; ejahrke@azgfd.gov

Joe Currie, SSDV Habitat Planning Program Manager, Arizona Game and Fish Department; 5000 W. Carefree Highway, Phoenix, Arizona 85086; Phone (623) 236-7867; jcurrie@azgfd.gov

New materials for a time-tested design for wildlife water developments in Arizona

The Arizona Game and Fish Department's Special Services Development Branch (Development Branch) has been involved in the maintenance, redevelopment and new construction of wildlife water developments (developments) for many decades. The history of developments in Arizona has seen several generations of designs based on new ideas and material availability. The latest design from Development Branch uses rotationally-molded polyethylene water storage tanks, troughs and gutters. This approach combines industry-available materials, a wildlife-friendly water trough that will accommodate most species of wildlife and a basic overall design that has proven itself over decades of use. Pairing those components with a steel rain collection apron and a wildlife-friendly pipe rail fence creates a facility that generates a reliable source of water for wildlife. If constructed correctly, the development should last from 30 to 50 years with little maintenance under a wide variety of field conditions.

Paul W. Juergens, The Peregrine Fund, 5668 West Flying Hawk Lane, Boise, Idaho 83709; PJuergens@peregrinefund.org

Trish Cutler, White Sands Missile Range, IMWE-WSM-PWE-ES, Bldg 163, Springfield Ave, WSMR, NM 88002

Grainger Hunt, The Peregrine Fund, 5668 West Flying Hawk Lane, Boise, Idaho 83709; Grainger@peregrinefund.org

Golden eagle studies on White Sands Missile Range, New Mexico

The Golden Eagle (*Aquila chrysaetos*) has a widespread distribution throughout the Northern Hemisphere to include most of western North America. Golden Eagles have naturally high survival rates and high potential longevity. Nesting opportunities are limited especially in cliff nesting populations, and floater reserves of adult non-breeders develop in the population that can buffer losses among nesting pairs. However, anthropogenic mortality factors are becoming more prevalent. Sources of fatalities include lead poisoning, automobile collision, electrocution, wire strikes, and collision with wind turbine blades. This prevalence in human caused mortality in recent years coupled with the lack of knowledge regarding the size of the floater population has aroused concern for the species from the U.S. Fish and Wildlife Service. The U.S. Department of Defense White Sands Missile Range (WSMR), located in south-central New Mexico within the Chihuahuan Desert biome, has also recognized this concern. WSMR has begun cooperative research with The Peregrine Fund to gain an understanding of how eagles are distributed on WSMR, determine occupancy rates, and population size. We documented over 200 nests from aerial and ground-based surveys in 2013 and 2014 and continue to conduct ground-based surveys to determine occupancy. Habitats range from lowland basin grasslands and shrublands to rugged montane country, all of which are suitable for eagles. The information collected will augment WSMR's Avian Protection Plan, which offers guidance pertaining to infrastructure maintenance and development, mission planning, etc. to minimize or eliminate sources of avian injury and mortality. Data will also be used to develop a WSMR Golden Eagle Management Plan.

Rebekah Karsch, New Mexico State University, Las Cruces, New Mexico, USA;
karschrc@nmsu.edu

James W. Cain, III, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife
Research Unit, Las Cruces, New Mexico, USA; jwcain@nmsu.edu

Elise Goldstein, New Mexico Department of Game and Fish, Santa Fe, New Mexico;
USA, Elise.Goldstein@state.nm.us

Eric Rominger, New Mexico Department of Game and Fish, Santa Fe, New Mexico,
USA; Eric.Rominger@state.nm.us

Parturient desert bighorn sheep survival strategies: environmental characteristics at female parturition sites and lamb nursery and predation sites

Habitat characteristics at parturition sites may play an influential role in desert bighorn lamb survival, yet little is known about bighorn parturition sites because pregnant females isolate themselves prior to parturition and give birth in seclusion, making them difficult to find. Our goal was to examine habitat characteristics at parturition sites, and lamb nursery group and predation sites. We evaluated elevation, slope, terrain ruggedness and adult female visibility at parturition, nursery, and lamb predation sites by comparing them to paired random sites using conditional logistic regression, and used binary logistic regression to compare parturition sites to nursery sites, and predation sites to nursery sites. When compared to randomly available sites, odds of sites being parturition or nursery sites increased with increasing elevation, slope and ruggedness, but decreased with increasing visibility. Odds of a site being a predation site did not change with elevation, but increased with increasing slope and ruggedness, and decreased with increasing visibility. When compared to nursery sites, odds of a site being a parturition site decreased with increasing elevation, slope and ruggedness, but visibility was similar between the two. Odds of a site being a predation site increased with increasing elevation, slope and ruggedness, but decreased with increasing visibility when compared to nursery sites. Understanding factors that affect female parturition site selection, and how habitat characteristics at these sites differ from those at predation and nursery sites, can provide insight into strategies female bighorn employ both during and after parturition to promote lamb survival.

**Graduate student

Annika T.H. Keeley, Northern Arizona University, School of Forestry, 200 East Pine Knoll Drive, PO Box 15018, Flagstaff AZ 86011; atk25@nau.edu

Paul Beier, Northern Arizona University, School of Forestry, 200 East Pine Knoll Drive, PO Box 15018, Flagstaff AZ 86011; Paul.Beier@nau.edu

Jeff Gagnon, Arizona Game and Fish Department, Phoenix, Arizona; jgagnon@azgfd.gov

Do least-cost models predict animal movement?

Least-cost models are commonly used in conservation planning to identify areas that should be conserved as wildlife corridors. These models rely on estimates of landscape resistance which is a measure of how much a grid cell impedes an animal of a focal species moving through that location. If these resistance values are wrong, then land-use planners, transportation agencies, and other decision-makers may be implementing poor corridor designs. We used three models (expert opinion, resource selection functions, and step selection functions) to estimate resistance values. With each set of resistance estimates we calculated the costs of actual long distance movements of elk and bighorn sheep, and compared them to the costs of the least cost paths and 98 randomized paths between the beginning and end locations of the long distance movements. The mean rank of the observed paths was a measure of aptness of the models. Preliminary results indicate that aptness for the best model is moderate (e.g. 25-50). The best model performs better than chance, but not much better. If these results will hold for the final results (which I will present) practitioners should try to develop new models of resistance, for example, models based on genetic data.

**Graduate Student

Allyssa L. Kilanowski, Graduate Student, School of Natural Resources and the Environment, University of Arizona, Tucson, AZ 85721; Phone (520) 626-5616; akilanowski@email.arizona.edu

John L. Koprowski, Professor, Wildlife Conservation and Management, School of Natural Resources and the Environment, University of Arizona, Tucson, AZ 85721; Phone (520) 626-5616; squirrel@ag.arizona.edu

Reverse sexual dimorphism, behavioral phenotypes, and female reproductive success: What can we learn from a fossorial, forest obligate in a fragmented landscape?

Climate and anthropogenic forest change create numerous conservation challenges. Understanding the impact of such change on female fitness measures, such as home range size of a nursing female or litter size, can influence potential conservation strategies. Behavioral phenotypes, a set of repeatable behaviors in an individual that are the result of its genotype interacting with the environment, may affect reproductive success. We described behavioral phenotypes of a small mammal with reverse sexual dimorphism (females are larger than males), cliff chipmunks (*Tamias dorsalis*), a common fossorial granivore, in the Pinalenios Mountains, Arizona and examined 1) does age, sex, mass, and reproductive condition affect these behavioral differences and 2) does behavioral phenotype affect nursing female home range size or litter size. We found that mass and sex influences behavioral phenotype, whereas age and reproductive condition did not have an effect. We also found that behavioral phenotype does not affect nursing female home range or litter size. Our results indicate that reverse sexual dimorphism may explain differences in behavioral phenotypes; however, individual behavioral differences are not related to female reproductive success.

**Graduate Student

Sarah R. Kindschuh**, Graduate Research Assistant, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88033; skindsch@nmsu.edu

James W. Cain III, U.S. Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88033; jwcain@nmsu.edu.

Modeling black bear predation and scavenging using GPS cluster analysis

GPS cluster analysis has been used to estimate predation rates and to describe prey composition of many large carnivores but has not yet been tested for American black bears (*Ursus americanus*). As omnivores, black bears exhibit different movement patterns than other large carnivores, therefore it is unclear whether this method is suitable for describing black bear carnivory. We are evaluating the use of GPS cluster analysis in the Jemez Mountains of northern New Mexico to locate sites of black bear predation and scavenging of ungulates. We will test a range of cluster characteristics as predictor variables in logistic regression analysis to determine whether GPS data can be used to remotely locate black bear carnivory events. We captured 26 bears between 2012 and 2014 to deploy GPS collars that transmit location data via satellite. We investigated clusters of GPS locations in the field to determine whether each site is used for feeding on ungulate prey. We visited 775 clusters and identified ungulate prey at 70 clusters. Analysis will be conducted this winter with project completion expected in spring 2015. If our GPS cluster analysis model proves accurate for black bear movement data, this new technique could provide researchers with an efficient method of monitoring the impacts black bears have on ungulate populations.

**Graduate Student

Lauren A. Lien, Department of Fish, Wildlife and Conservation Ecology, New Mexico State University, Las Cruces, NM 88003 USA

Brian A. Millsap, Department of Biology, New Mexico State University, Las Cruces, NM 88003 USA & Division of Migratory Bird Management, U.S. Fish and Wildlife Service, 2105 Osuna Road NE, Albuquerque, NM 87113 USA

Kristin Madden, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, NM 87507 USA

Gary W. Roemer, Department of Fish, Wildlife and Conservation Ecology, New Mexico State University, Las Cruces, NM 88003 USA

Male brood provisioning rates provide evidence for inter-age competition for mates in female cooper's hawks (*Accipiter cooperii*)

Life history theory predicts that individuals should maximize lifetime reproductive success (LRS) by breeding as soon as they reach sexual maturity, yet many species delay breeding, either because there is an insufficient number of available mates or breeding sites or because it is less costly to delay breeding which subsequently yields higher LRS. Accipitriform species, such as Cooper's Hawks (*Accipiter cooperii*), exhibit both delayed breeding and delayed plumage maturation. However, in certain circumstances, first-year females in non-definitive plumage do breed and apparently compete with older females for high-quality breeding territories. We hypothesized that these young females are at a competitive disadvantage compared to older females and that older females would have both higher reproductive success and be able to acquire higher quality territories. We conducted brood counts and measured prey delivery rates by male Cooper's Hawks in an expanding urban population located in Albuquerque, New Mexico (USA) to assess our hypotheses. We found that older females did indeed have higher reproductive success fledging 1.6 (90% CI: 0.86 to 2.34) more offspring than younger females and that they occupied territories where males provisioned at higher rates (0.36 [0.03 to 0.69] more prey per 2-hour period). Our results show that older females fare better than first-year females but it is unclear if this is the result of active or passive competition. Older females initiated nesting 14.2 (9.9 to 18.6) days sooner than first-year females and first-year females were never observed to actively confront older females for breeding territories. Instead, first-year females actively competed against each other. Thus, delayed plumage maturation in Cooper's Hawks may serve to focus competition within age classes, and first-year females may defer to older females who, in a direct competitive interaction, would most likely prevail.

DeeAnne Meliopoulos, New Mexico State University, Department of Fish, Wildlife, and Conservation Ecology, 2980 South Espina Street, Knox Hall 136, Las Cruces, New Mexico 88003; deeannem@nmsu.edu

Dr. Martha Desmond, New Mexico State University, Department of Fish, Wildlife, and Conservation Ecology, 2980 South Espina Street, Knox Hall 129, Las Cruces, New Mexico 88003; mdesmond@nmsu.edu

Impacts of solar energy development on breeding birds of the Nutt Grasslands, NM

The Nutt grasslands of southcentral New Mexico are one of the important remaining tracts of desert grasslands. This research examines the effects of a recent solar development in this valuable and threatened ecosystem on grassland bird populations. Our objectives are to quantify avian abundance, community composition, and abundance of individual species at varying distances from the solar facility. The study design entails 150, 50 m radius plots within the solar facility and at 4 distance rings from the facility. Each distance ring has 30 randomly selected plots. We will use regression analysis and an information theoretic approach to examine avian abundance in relation to environmental noise levels, soil temperatures, insect abundance, vegetation cover and various edges. Daily nest survival of mourning dove (*Zenaida macroura*) nests and depredation rates will also be evaluated. We will present preliminary data analyses from our first season of data collection. This research will enable recommendations for future planning and siting of solar energy developments.

**Graduate Student

Jennifer Merems, Undergraduate of the College of Agriculture and Life Science,
University of Arizona; 1401 E University Blvd, Tucson, Arizona 85721; Phone
(520) 977-6296; jlmerems@email.arizona.edu

Aletris Neils, Mammalogy Instructor, University of Arizona; Biosciences East, Tucson,
AZ 8572; Phone (602) 717-2406; amneils@email.arizona.edu

Small mammal communities response to environment via barn owl (*Tyto alba*) pellets in Namibia

Small mammals play a vital role in ecosystems as seed dispersers, prey for predators, and population control for invertebrates. Small mammal abundance and diversity is an important measure of the overall ecosystem quality; however, virtually nothing is known about the small mammal community in Namibia. To gather information on this system, an analysis of owl pellets, an unbiased, noninvasive sampling method, was conducted. Pellets were collected from a mating pair of Namibian Barn Owls (*Tyto alba*) residing on Farm Kiripotib in Namibia and their offspring after the increased rainy season of 2011, after the decreased rainy season of 2013 and after an average rainy season of 2014. Throughout 2014, pellets were collected monthly to be analyzed to see monthly variation in diversity. This data provides a window into the biodiversity and abundance of small mammals in central Namibia and show how these communities respond to annual precipitation. By analyzing these pellets, it was found that there is evidence that Namibian small mammal biodiversity is higher during a more than average rainy season. Range expansion was also found in certain species. Data still being analyzed.

** Student

Melissa J. Merrick, Wildlife Biologist Senior and PhD candidate, University of Arizona School of Natural Resources and the Environment, Wildlife Conservation and Management, Box 210043, Tucson, AZ 85721; Phone (520) 626-5616; mmerrick@email.arizona.edu

John L. Koprowski, Professor and Director Red Squirrel Monitoring Program, University of Arizona School of Natural Resources and the Environment, Wildlife Conservation and Management, Box 210043, Tucson, AZ 85721; Phone (520) 626-5616; squirrel@ag.arizona.edu

Identifying structural thresholds and landscape resistance for natal dispersal movements in an endangered forest obligate

How animals perceive habitat and make movement decisions, especially during natal dispersal, is important for understanding landscape features that limit connectivity, and for predicting how landscape changes may influence population dynamics. A better understanding of movement thresholds is critical for implementing habitat management plans for threatened and isolated animal populations, and for restoring habitat connectivity. Herein we examine forest structural thresholds associated with natal dispersal movements in an endangered forest obligate, the Mt. Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*), constrained to the Pinaleño Mountains in southeastern Arizona. From 2010-2013, we radio collared 94 juvenile red squirrels, and quantified 6 LiDAR-derived forest structural characteristics at 9,424 animal locations. We calculated thresholds for use and created habitat suitability and probability of use surfaces to identify areas likely used or avoided by dispersing juveniles. Finally, we calculated least-cost and landscape resistance surfaces to identify likely natal dispersal corridors and barriers to movement. Modal responses for LiDAR-derived structural variables are as follows canopy cover: 71.42 %, mean tree height: 14.2 m, standard deviation tree height: 5.9, live basal area m²/ha: 62.8, total basal area m²/ha: 81.4, slope: 11.1 %. Mt. Graham red squirrel natal dispersal is sex biased, and distances are much greater than reported for other red squirrel populations (males 1,022.1 m; females 341.2 m). Expanded dispersal movements, combined with the loss of 45% (14,160 ha) of the forest above 2135 m highlights the urgent need to identify areas currently promoting movement and manage for increased landscape connectivity in future forest management plans.

** Student

Andrew R. Meyers, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, Las Cruces, New Mexico 88003; ameyers@nmsu.edu
Scott Carleton, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, Las Cruces, New Mexico 88033; carleton@nmsu.edu

Use of Conservation Reserve Program (CRP) habitat by lesser prairie-chickens in Eastern New Mexico

The lesser prairie-chicken (*Typanuchus pallidicinctus*) is a threatened species under the Endangered Species Act. Research in Kansas has shown the Conservation Reserve Program (CRP) grasslands are highly used by lesser prairie-chickens for breeding, nesting, and brood rearing. Lesser prairie-chicken use of CRP in New Mexico has not been documented and there is disagreement as to its importance in their life history. Our objective was to determine if and why lesser prairie-chickens use CRP habitat in Eastern New Mexico. We captured 30 LPC in the spring of 2014 and monitored their movements throughout the breeding season in relation to CRP and other habitat types. Lesser prairie-chickens utilized CRP habitats in lower proportion than their availability and used native shinnery oak (*Quercus havardii*) dominated habitats in much higher proportion to their availability. Further conservation of the lesser prairie-chicken habitat in Eastern New Mexico should consider switching focus from CRP and focus more on conservation of native shinnery oak rangelands.

** Student

Marcus Miller, USDA Natural Resources Conservation Service, 1201 NE Lloyd Blvd., Suite 1000, Portland, OR 97217; marcus.miller@por.usda.gov
Casey Burns, USDA Natural Resources Conservation Service, 125 South State Street, Room 4010, Salt Lake City, UT 84138-1100; casey.burns@ut.usda.gov
Shane Green, , USDA Natural Resources Conservation Service, 125 South State Street, Room 4010, Salt Lake City, UT 84138-1100; shane.green@ut.usda.gov
Jamin Johanson, USDA Natural Resources Conservation Service, 42 Engdahl Drive, Dover-Foxcroft, ME 04426; jamin.johanson@me.usda.gov
Byron Lambeth, USDA Natural Resources Conservation Service, 230 N. 1st Avenue, Suite 509, Phoenix, AZ 85003; Byron.lambeth@az.usda.gov
Stu Tuttle, USDA Natural Resources Conservation Service, Arizona State Office, 1585 S. Plaza Way, Suite 120, Flagstaff, AZ 86001; stu.tuttle@az.usda.gov

Using literature review and state and transition models for the development of wildlife interpretations for ecological sites on the Colorado Plateau of Arizona and Utah, USA.

State and Transition Models (STMs) depict changes in plant communities resulting from both ecosystem dynamics and anthropogenic perturbations. Ecological Site Descriptions (ESDs) are documents that summarize the natural range of variation in plant communities for a particular type of land, and within each ESD the STM describes potential alternative ecological states that can occur on a particular ecological site. These changes in plant community may be due to natural and/or anthropogenic stressors, and result in altered plant community composition and habitat structure. The responses of wildlife use to changing habitat in terms of species composition, abundance, relative abundance, and diversity have been documented in numerous articles across various ecosystems in the Southwestern U.S. In an effort to incorporate these important and repeatable patterns of wildlife response to changing habitat, we have reviewed 216 papers which identify specific relationships between plant communities described in ESDs and the wildlife habitat requirements of species of the Colorado Plateau. Understanding the relationship between the floral and faunal community and how changes to either can affect the other allows for the development of habitat interpretations which can be used in decision support for planning management actions.

Stephanie M Muise, Northland College, 1411 Ellis Ave Ashland, WI 54806,
muises467myemail.northland.edu

Katie Stumpf, Department of Biology Assistant Professor, Northland College. 1411 Ellis
Ave, Ashland WI 54806, kstumpf@northland.edu

Potential correlation of invasive species ecological shifts and nesting success of southern willow flycatchers

The effects of invasive species within the middle Rio Grande has been monitored for many years with particular attention on nesting success of Southwestern Willow Flycatchers (*Empidonax trailii extimus*). For example, studies have shown that parasitism is correlated with increased risk of predation of Southwestern Willow Flycatcher nests in Nevada and northern Arizona (Stumpf 2012). However, there have not been studies that examine predation trends with respect to invasive riparian plant species. It is not only the Tamarisk that may cause decline, but the shift of predators that follow may lead to additional pressures to each nest. We predict that predation rates have increased at a faster rate in comparison to parasitism or abandonment, indicating that movement of nesting sites to tamarisk could be a compounding factor in declining nest success. We used call-back survey data from the US Bureau of Reclamation from 2004-2013 to reveal potential trends and correlations between nesting substrate of *E. t. extimus* populations and reproductive success. Preliminary results indicate that the movement of *Tamarisk* spp has no negative effects on predation and ultimately reproductive success. However, this correlation must be further researched to establish the complex nature of interactions between Southwestern Willow Flycatchers and invasive vegetation.

Jason M. Myrand, School of Natural Resources and the Environment, The University of Arizona, Tucson, Arizona 85721; jmyrand@email.arizona.edu**

Lisa D. Lang, School of Natural Resources and the Environment, The University of Arizona, Tucson, Arizona 85721; lisadlang@email.arizona.edu**

Brian T. Cooke, School of Natural Resources and the Environment, The University of Arizona, Tucson, Arizona 85721; bcooke@email.arizona.edu**

David E. Brown, School of Life Sciences, Arizona State University, Main Campus, Tempe, AZ debrown@asu.edu

Randall D. Babb, Information and Education Program Manager, Arizona Game and Fish Department, Region VI, Mesa, AZ. rbabb@azgfd.gov

Aletris Neils, Mammalogy Lecturer, University of Arizona; Executive Director, Conservation CATalyst, 3755 West Driscoll Lane, Tucson, AZ. amneils@email.arizona.edu

Impacts of natural and anthropogenic influences on jackrabbit populations in desert grasslands of Southern Arizona

Anthropogenic prescriptions on the environment have unforeseen consequences on wildlife. These actions geared towards grazing species may have negative effects on these lagomorph populations. *Lepus alleni* and *Lepus californicus* both serve as important seed dispersers and provide food for predators in Southern Arizona grasslands. Since little research has been done on lagomorphs we investigated effects of anthropogenic activities on lagomorphs in Arizona. Our objective was to compare the effects of grazing, vegetation height and precipitation on lagomorph populations. The research took place on a 224.26-hectare section of the Buenos Aires National Wildlife Reserve (BANWR) and a 264.58 section of the King Anvil Ranch (KAR) just north of Sasabe, Arizona. Single observer transect surveys have been conducted on jackrabbits from 2011 - 2014 at both sites. We conducted a visibility survey at each site using the visual obstruction measurement method (Robel pole) and a laser rangefinder to determine the effect of vegetation height on jackrabbit visibility. Nighttime spotlight surveys were conducted to support the previous survey data on jackrabbit populations. Results from the walking line transect method showed that more jackrabbits were detected at BANWR than at KAR. In addition, results from the visibility survey showed less lagomorphs are visible in areas with taller grasses. Precipitation was not significantly correlated with jackrabbit populations at either BANWR or KAR. (P-value = 0.8427 and 0.142 respectively) Results from the spotlight dual observer survey further indicate higher jackrabbit detection at KAR. These results can influence better-informed and successful conservation management strategies for lagomorphs.

** Student

Ashwin Naidu, School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona 85721; ashwin@email.arizona.edu

Robert R. Fitak, Institut für Populationsgenetik, Veterinärmedizinische Universität Wien, Veterinärplatz 1, 1210 Wien, Austria; robert.fitak@vetmeduni.ac.at

John Clemons, Arizona Desert Bighorn Sheep Society Inc., P.O. Box 21705, Mesa, Arizona 85277; clemonsjp@aol.com

Sophia S. Amirsultan, School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona 85721; sophiesa@email.arizona.edu

Ron W. Thompson, Primero Conservation, Box 16106, Portal, Arizona 85632; leoneroronatsulross@gmail.com

Alexander Ochoa, School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona 85721; alexocho@email.arizona.edu

Melanie Culver, U.S. Geological Survey – Arizona Cooperative Fish and Wildlife Research Unit, School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona 85721; mculver@email.arizona.edu

Spatially explicit population structure analyses reveal barriers to gene flow among mountain lions in southwestern United States and northwestern Mexico

Natural and anthropogenic landscape features that restrict movement of wide-ranging terrestrial species can potentially restrict gene flow among their populations, which may ultimately be detrimental to the persistence of the species and its habitat. We used spatially explicit Bayesian clustering models to investigate contemporary population genetic structure of mountain lions (*Puma concolor*) in southwestern U.S. and northwestern Mexico, and to explore the potential impact of landscape features such as rivers and interstate highways. We performed spatial genetic analyses on 401 DNA samples genotyped at 11 well-utilized *Felis catus* (FCA) microsatellite loci. Our analyses revealed a substantial level of genetic structuring among mountain lions with maximum statistical support for the occurrence of four subpopulations. Geographic visualization of the four subpopulations identified based on these data suggested that major highways, specifically Interstate-10 west of the metropolitan area of Phoenix, Interstate-40, and Interstate-17, may be barriers restricting gene flow among mountain lions. We comment on the possibility of combined effects of natural and anthropogenic barriers, and isolation-by-distance, being the underlying cause of observed population genetic structure. These data reveal potential consequences of anthropogenic impacts on mountain lions and their habitat. Wildlife managers, stakeholders, and conservation planners can use this information in guiding management decisions for mountain lion populations, and in prioritizing corridors that may restore habitat connectivity and gene flow for wildlife.

** Student

Dakota P. Neel, Texas Tech University, Box 42125, Lubbock TX, 79409;
dakota.neel@ttu.edu

Warren C. Conway, Tech University, Box 42125, Lubbock TX, 79409;
warren.conway@ttu.edu

Mark C. Wallace, Tech University, Box 42125, Lubbock TX, 79409;
mark.wallace@ttu.edu

Stewart G. Liley, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe,
NM, 87507; stewart.liley@state.nm.us

Pronghorn activity and behavior associated with anthropogenic water source developments in New Mexico

Free standing water is considered to be a limiting factor in the abundance and distribution of pronghorn (*Antilocapra americana*) in the desert southwest. Nonetheless, few studies exist on pronghorn behavior associated with man-made water sources. In New Mexico, the majority of anthropogenic water sources are developed exclusively for livestock operations. However, in recent years there has been an increase in wildlife specific water developments. Our study is located on the Sand Ranch located in southeast New Mexico. Remote camera traps were used to document pronghorn behavior and use at 20 water sources of various size and design. Camera traps were deployed in conjunction with the release of translocated pronghorn in February, 2013 and will continue to be operated until June, 2015. To date, nearly 200,000 images have been collected where pronghorn use was primarily diurnal, and groups of up to 25 individuals were documented. Understanding pronghorn activity and behavior, directly related to water sources, will assist in management decisions. Future projects, including water site selection and water source design, as well as estimating recruitment, and evaluating sites for future translocation projects may consider former camera trap surveys.

**Graduate Student

Alexander Ochoa, School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona; alexocho@email.arizona.edu
Eduardo Eizirik, Centro de Biologia Genômica e Molecular, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil; eduardo.eizirik@pucrs.br
David E. Brown, School of Life Sciences, Arizona State University, Phoenix, Arizona; david.e.brown@asu.edu
Carlos A. López-González, Facultad de Ciencias Naturales, Universidad Autónoma de Querétaro, Queretaro, Mexico; posgrado.mrb@uaq.mx
Ivonne Cassaigne, Instituto de Ecología, Universidad Nacional Autónoma de México, Mexico City, Mexico; icassaigne@yahoo.com
Rodrigo Medellín, Instituto de Ecología, Universidad Nacional Autónoma de México, Mexico City, Mexico; medellin@ecologia.unam.mx
Ron W. Thompson, Primero Conservation, P.O. Box 16106, Portal, Arizona 85632; leoneronatsulross@gmail.com
Melanie Culver, United States Geological Survey – Arizona Cooperative Fish and Wildlife Research Unit, and School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona; mculver@email.arizona.edu

Genetic diversity and structure of jaguars (*Panthera onca*) from Arizona, US, and Sonora, Mexico

The jaguar (*Panthera onca*) is the largest Neotropical felid and the only extant representative of the genus *Panthera* in the Americas. In recorded history, the jaguar's range has extended from southern United States, throughout Mexico, Central and South America. Previous genetic studies have found high historical levels of gene flow among jaguar populations over broad areas. However, information about their northernmost population in Arizona, US, and Sonora, Mexico, is currently lacking. Therefore, a need is apparent to have this jaguar population included in an overall molecular taxonomy and evolutionary study. We genotyped 26 nuclear microsatellite loci and sequenced the mtDNA control region to examine the genetic diversity and structure of jaguars from the Northwestern Jaguar Recovery Unit (NJRU; Southern Arizona and Mexican Pacific coast). We observed a general trend of decreased nuclear and mtDNA genetic diversity of NJRU jaguars when compared to jaguar populations from Southern Mexico, Central and South America. In addition, we found significant NJRU nuclear and mtDNA population differentiation with respect to tropical jaguar populations. Population structure Bayesian analyses performed in this study are consistent with the presence of two historical jaguar lineages from South America and Mexico. The NJRU population is of conservation interest because peripheral populations have a greater likelihood of suffering from local extinctions in the short-run. This study encourages international cooperation for enhancing connectivity among different jaguar populations and promoting integral management strategies for the conservation of this species.

** Student

Michelle L. Reilly, Northern Arizona University, Department of Forest Science Po Box 15018, Flagstaff AZ 86011; mlr326@nau.edu

Dr. Paul Beier, Northern Arizona University, Department of Forest Science Po Box 15018, Flagstaff AZ, 86011; Paul.Beier@nau.edu

Derek Sonderegger, Northern Arizona University, Department of Mathematics and Statistics, 173 Adel Mathematics Building, Flagstaff AZ, 86011; Derek.Sonderegger@nau.edu

Effects of non-motorized human recreation on habitat use of medium and large-sized mammals in the San Francisco Bay ecoregion

According to the Outdoor Industry Association, in the U.S. outdoor recreation generates 646 billion dollars in consumer spending yearly and creates 6.1 million direct jobs. Although 80 percent of Americans live in urban areas, recreation systems that include federal, state, regional, and local parks make recreation opportunities easily accessible. Recreation has the potential to seriously impact habitat used by wildlife through disruption of normal activities. Disruption of daily maintenance routines increases energy expenditures and lessens the amount of time wildlife can spend foraging. Avoidance of suitable habitat further impacts wildlife populations. Human recreation is correlated with a significant shift of carnivore communities with a greater number of native species detected in areas that do not permit human recreation. Thus recreation has the potential to affect community-level diversity in an area but detailed information about the variables that influence this is not known. We investigated how different levels of non-motorized recreation impacts habitat used by a suite of species. Camera traps were used to collect data on habitat use for mammal species in Northern California. By using a Bayesian hierarchical model, we were able to model habitat use as a function of recreation and other covariates while simultaneously accounting for imperfect and heterogeneous detection and occupancy. Some species may be more affected by recreation than others and determining the level that causes an impact for each species in various landscape types and natural areas will allow managers to take this data into account in future trail location and land management activities.

**Graduate Student

**Quinn H. Robinson, Dept. of Fish, Wildlife, and Conservation Ecology, PO Box 30003,
MSC 4901, New Mexico State University, Las Cruces, NM 88003,
quinn.h.robinson@gmail.com

David Bustos, White Sands National Monument, PO Box 1086, Holloman AFB, NM
88330, David_Bustos@nps.gov

Gary W. Roemer, Dept. of Fish, Wildlife, and Conservation Ecology, PO Box 30003,
MSC 4901, New Mexico State University, Las Cruces, NM 88003,
groemer@nmsu.edu

The application of occupancy modeling to evaluate intraguild predation in a model carnivore system

Intraguild predation (IGP) is an extreme form of competition that involves a dominant predator (IG predator), a subordinate predator that is also a superior exploitative competitor (IG prey), and their shared prey. Theory predicts three possible equilibria, which parallel increasing resource enrichment: exclusion of the IG predator, stable coexistence, and exclusion of the IG prey. Here, we report on the existence of two concurrent states in a model carnivore system dominated by IGP. Using species occurrence data obtained from randomly distributed remote cameras, we modeled the probabilities of detection and occupancy of the kit fox (*Vulpes macrotis*) and their IG predator, the coyote (*Canis latrans*), at White Sands National Monument, New Mexico, using a recently developed conditional two-species occupancy model. Kit foxes persisted in habitats of low resource abundance, which could not support coyotes. Coexistence occurred in adjacent habitats of higher resource enrichment, with coyote occupancy strongly correlated with small mammal abundance. The odds of a coyote being present vs. absent in prey-rich habitats was 332:1 (± 0.006) whereas the odds of a coyote being present vs. absent in prey-poor habitats was 1:4 (± 0.11); thus, coyotes were much more likely to be present in prey-rich habitats. Kit foxes were more frequently photographed in prey-poor habitats avoided by coyotes. The odds of kit foxes being present vs. absent at a site where coyotes were absent was 7.9:1 (± 0.082) which was greater than the odds of kit foxes being present vs. absent at a site where coyotes were present (2.2:1 ± 0.081). These findings indicate that kit foxes avoid coyotes, but that their adaptations to arid conditions enable them to exploit habitats unsuitable for coyotes. Consequently, the primary driver of this spatial separation is the inability of coyotes to use prey-poor habitats, rather than kit fox avoidance of coyotes. Our results reveal the existence of concurrent IGP states within the same ecological community, which is consistent with theoretical predictions, and highlight the power of the conditional two-species occupancy model to illuminate how the abundance of shared prey shapes the competitive dynamic in ecological systems dominated by IGP.

**Mason J Ryan, Department of Biology and Museum of Southwestern Biology,
University of New Mexico, MSC03-2020, Albuquerque, New Mexico 87131, USA;
mjryan42@gmail.com

**Ian M Latella, Department of Biology and Museum of Southwestern Biology,
University of New Mexico, MSC03-2020, Albuquerque, New Mexico 87131, USA;
pituophian@gmail.com

J. Tomasz Giermakowski, Department of Biology and Museum of Southwestern
Biology, University of New Mexico, MSC03-2020, Albuquerque, New Mexico
87131, USA; tomas@unm.edu

The decline of another southwestern anuran species? Recent population trends of the Arizona Toad in west-central New Mexico

The global amphibian crisis is broad in scope and urgency with an estimated 43% of all species in decline and 32% of species threatened with extinction. While tropical declines have received a lot of attention, amphibian declines in the arid southwestern United States is also a pressing issue. The fungal disease *Batrachochytrium dendrobatidis* (*Bd*) has been implicated as a primary mechanism for many declining amphibians; but non-disease factors also pose significant, additive threats. The Arizona Toad (*Anaxyrus microscaphus*), native to Arizona, Nevada, Utah, and New Mexico, is one of the few riparian breeding toads in the southwestern United States. Population declines of the Arizona Toad have been reported from Arizona, Nevada, and Utah with these declines being attributed to non-disease factors including hybridization with the native Woodhouse's toad and habitat modification. The Arizona Toad's population status, trends and threats are currently unknown in New Mexico. To fill this gap we conducted weekly field surveys during the breeding season (March–May) in 2013 and 2014 to evaluate the species' current population status and threats in New Mexico. Our findings suggest marked declines, but we find no evidence of threats from hybridization or anthropogenic habitat modification. Instead, drought, possibly disease, and other factors appear to be proximate threats to Arizona Toad populations in New Mexico. Coupled with the previously documented threats in neighboring states, the long-term persistence of the Arizona Toad is in question, especially in light of our recent findings in New Mexico.

**Graduate Student

Jamie S. Sanderlin, Rocky Mountain Research Station, U.S. Forest Service, 2500 S. Pine Knoll Dr., Flagstaff, Arizona 86001; jlsanderlin@fs.fed.us

William M. Block, Rocky Mountain Research Station, U.S. Forest Service, 2500 S. Pine Knoll Dr., Flagstaff, Arizona 86001; wblock@fs.fed.us

Joseph L. Ganey, Rocky Mountain Research Station, U.S. Forest Service, 2500 S. Pine Knoll Dr., Flagstaff, Arizona 86001; jganey@fs.fed.us

Jose M. Iniguez, Rocky Mountain Research Station, U.S. Forest Service, 2500 S. Pine Knoll Dr., Flagstaff, Arizona 86001; jiniguez@fs.fed.us

Samuel Cushman, Rocky Mountain Research Station, U.S. Forest Service, 2500 S. Pine Knoll Dr., Flagstaff, Arizona 86001; scushman@fs.fed.us

Effects of wildfire on avian communities in the Arizona Sky Islands

The avifauna within the Sky Islands of southeastern Arizona includes species found nowhere else in the U.S. Thus, birdwatchers from across the globe visit the region, providing a vibrant state and local ecotourism industry. RMRS scientists initiated a study on birds across montane forest and woodland types in the Santa Rita, Santa Catalina, Huachuca, Chiricahua, and Pinaleño Mountains (Coronado National Forest) from 1991 to 1995. Since then, the region has been under increased stress from ongoing droughts and wildfires, likely associated with climate change. We know little about fire effects on Neotropical migratory birds in this region, as well as habitat associations. Our objectives were to determine if bird distribution patterns and species diversity changed over time and if changes were attributable to fire and climate change. Secondly, we wanted to determine the impacts of fire severity and time since fire on these avian communities. During spring and summer 2014, we resampled birds at 28 of the original transects ($n = 328$ count stations). We used multi-species, multi-season occupancy models in a Bayesian hierarchical framework to estimate species richness and community dynamics, while accounting for imperfect detection. We used time since fire and fire severity to assess temporal and spatial variation in fire effects. Preliminary results indicate positive and negative responses to fire by individual species, and changes in community dynamics. By re-measuring vegetation and birds following wildfires, our study can provide strategies for managing resilient forests, provide guidance with post-fire restoration, and assist with conserving avian community structure.

Ehan Sandoval, University of Arizona, School of Natural Resources and the Environment, The University of Arizona, Biological Science East, Room 325 1311 East 4th Street Tucson, Az 85721 bmx259@email.arizona.edu

Kristin Ulvestad, University of Arizona, School of Natural Resources and the Environment, The University of Arizona, Biological Science East, Room 325 1311 East 4th Street Tucson, Az 85721 knu@email.arizona.edu

Julia Muldoon, University of Arizona, Department of Molecular and Cellular Biology, The University of Arizona, Life Sciences South Building, 1007 E. Lowell Street, PO BOX 210106 Tucson, Az 85721 jbmuldoon@email.arizona.edu

Caitlin McCurry, University of Arizona, School of Natural Resources and the Environment, The University of Arizona, Biological Science East, Room 325 1311 East 4th Street Tucson, Az 85721 cmccurry@email.arizona.edu

Juliana James, University of Arizona, School of Natural Resources and the Environment, The University of Arizona, Biological Science East, Room 325 1311 East 4th Street Tucson, Az 85721 jjames2@email.arizona.edu

Aletris Neils, University of Arizona, School of Natural Resources and the Environment, Saguaro Hall 107, 1311 E. 4th St. Tucson, Az 85721, PhD candidate amneils@email.arizona.edu

Assessment of biodiversity in the Northern Jaguar Reserve in Sonora, Mexico and its influence on the jaguar (*Panthera onca*)

The jaguar, *Panthera onca*, is the largest felid native to the Americas. It ranges from tropical areas in South and Central America to dense thornscrub and oak foothills in northern Mexico. The northern-most population lies 100 miles south of the U.S-Mexico border in the 50,000 acre Northern Jaguar Reserve in Sonora, Mexico, and is of special interest for conservation because it is found in an atypical habitat for the species. Several factors such as habitat loss, government imposed anti-predator programs, hunting, and conflicts with ranchers have resulted in declines of the species in this range. In contrast to populations in South and Central America, little is known about what species are present in the area and how they may influence the jaguars on the Reserve. Therefore, we will analyze camera trap data collected on the Reserve between April 2011 and June 2012 to create an index of what species are present to help determine potential biodiversity in the area. We will also measure the effects of abiotic factors, such as precipitation, moon phase, and seasonality on the species present. Analysis is currently underway, but preliminary results will be ready by January 2015.

** Student

Virginia Seamster, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, MSC 4901, PO Box 30003, Las Cruces, NM 88003; seamster@nmsu.edu

Ken Boykin, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, MSC 4901, PO Box 30003, Las Cruces, NM 88003; kboykin@nmsu.edu

Esteban Muldavin, Natural Heritage New Mexico, UNM Biology Department, MSC03 2020, 1 University of New Mexico, Albuquerque, NM 87131; muldavin@unm.edu

Rayo McCollough, Natural Heritage New Mexico, UNM Biology Department, MSC03 2020, 1 University of New Mexico, Albuquerque, NM 87131; rayo@unm.edu

Keith Dixon, NOAA/GFDL, 201 Forrestal Road, Princeton, NJ 08540; keith.dixon@noaa.gov

Assessing the effects of climate change on the distribution of suitable environmental conditions for key species in the south central United States

Climate change, and its effects on species and biological communities, is a critical issue. Identifying areas to protect in a changing environment is especially important in the South Central United States, which generally is projected to experience warmer temperatures and increased occurrence of drought and heat waves. We have completed the first year of a two year project focused on assessing the effects of climate change through 2070 on the distribution of suitable climatic conditions for species of conservation concern in New Mexico, Oklahoma, and Texas. We used information from multiple sources, including agency reports, species range maps, and project stakeholder feedback, to select 20 vertebrate focal species. We selected four General Circulation Models (GCM) and three greenhouse gas emissions scenarios and developed a preliminary set of bioclimatic-envelope models for a relatively hot and dry GCM by emission scenario combination. Ultimately projections of climatic conditions suitable for the focal species will be developed for all 12 GCM by emission scenario combinations and information on suitable land cover will be included. Project results will be incorporated into a publicly accessible web-based viewer (i.e., the New Mexico Crucial Habitat Assessment Tool) intended to facilitate landscape-scale conservation planning and climate adaptation efforts. These results will allow for comparison between present day and multiple potential future distributions of climatic conditions suitable for species that resource managers consider to be important. This adds a valuable layer to the process of identifying areas that should be conserved and species that are potentially vulnerable to climate change.

Michael W. Shafer, Department of Mechanical Engineering, Northern Arizona University, Bldg. 69, Flagstaff, Arizona, 86011. Michael.Shafer@nau.edu
Carol L. Chambers, School of Forestry, Northern Arizona University, 200 East Pine Knoll Dr., Flagstaff, AZ 86011; Carol.Chambers@nau.edu

New paradigms in wildlife data collection

Wildlife tracking and bio-logging date back to the 1940s in their simplest form, while modern devices use suites of digital sensors, microcontrollers, and wireless data communication. Despite these advances, there has always been a fundamental relationship between power consumption and the amount of science that can be conducted. For birds, there are now commercially available devices that use solar cells to supplement their daily energy budget, but solar power may not be applicable for many species that are nocturnal, subterranean, aquatic, or spend significant time beneath dense forest canopies. Additionally, some species are too small to carry solar cells. Here we explore new paradigms for wildlife data collection. Novel technologies that harvest energy from the animal or its environment show promise as a method of extending the life or power budget of tracking and bio-logging tags. We present recent work in the area of piezoelectric energy harvesting demonstrated on flying birds as a method to convert mechanical work to electrical energy. We also present potential sources of energy for marine wildlife tags. In addition to energy harvesting, the recent expansion of small unmanned aerial vehicles (sUAV ["drones"]) into the consumer market has provided an opportunity to drastically alter the types of data that can be collected, in addition to reducing the time required to collect it. We are developing a sUAS system, integrated with a VHF receiver and antenna to radio track bats. The system concept will be presented, along with design challenges, expected operational procedures, and plans for future use.

Grant E. Sorensen, Texas Tech University, Department of Natural Resources Management, Goddard Building, Lubbock, Texas 79409; grant.sorensen@ttu.edu

Mark C. Wallace, Texas Tech University, Department of Natural Resources Management, Goddard Building, Lubbock, Texas 79409; mark.wallace@ttu.edu

Philip S. Gipson, Texas Tech University, Department of Natural Resources Management, Goddard Building, Lubbock, Texas 79409; philip.gipson@ttu.edu

Robert D. Cox, Texas Tech University, Department of Natural Resources Management, Goddard Building, Lubbock, Texas 79409; robert.cox@ttu.edu

James W. Cain III, U.S. Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88033; jwcain@nmsu.edu.

Ecology of adult female Rocky Mountain mule deer following habitat enhancements in north-central New Mexico

Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) population declines in their southernmost region, in particular north-central New Mexico, have been attributed to malnourishment. To test the hypothesis of malnutrition, we monitored 48 adult female mule deer and key browse quality from 2011 to 2013 after habitat enhancements were initiated. There was a strong selection for treated areas across all seasons and years. Adult female mule deer average study period survival was 0.88 (SE=0.027). Survival was only minimally explained by selection for treated brush ($\beta = 0.00006443$). Predation accounted for 81% of known mortalities with mountain lion (*Felis concolor*) predation accounting for 60% of mortalities. Femur marrow fat levels indicated that only one individual was in poor condition (<12%) at time of death. Mulching increased the crude protein content of brush over non-mulched brush two years post mulch but this effect was not detected after 2.5 years. In no case, did deer that selected for treated brush have diets with greater fecal nitrogen. Reproductive performance was high with 96% pregnancy rate and 88% twinning rate. Despite persistent drought conditions, adult female mule deer survival was high and similar to other estimates found in the region. Mulching did not improve deer diet quality. There was no evidence in our study to suggest that adult female mule deer populations were limited by malnutrition. High nutrient availability, femur marrow fat levels, and cause-specific mortality results point to a stronger role of predation over nutrition in limiting mule deer populations in north-central New Mexico.

**Graduate Student

Scott Sprague, Arizona Game and Fish Department, Wildlife Contracts Branch, 5000 W. Carefree Highway, Phoenix, Arizona 85086; ssprague@azgfd.gov
Ryan Nosek, Arizona Game and Fish Department, Habitat Branch, 5000 W. Carefree Highway, Phoenix, Arizona 85086; rnosek@azgfd.gov
Ray Schweinsburg, Arizona Game and Fish Department, Wildlife Contracts Branch, 5000 W. Carefree Highway, Phoenix, Arizona 85086; rschweinsburg@azgfd.gov

Wildlife collision mobile device data collection application

Data on the occurrence of wildlife-vehicle collisions is essential to understanding the relationship between ecosystems and transportation infrastructure. This data is often collected during targeted investigations on specific roadway projects. There have been ongoing efforts by Arizona Game and Fish Department and Arizona Department of Transportation to establish a more comprehensive approach to collecting this data across the state. To date this has taken the form of collision cards which present data collection challenges associated with the distribution and collection of cards. Substantial processing issues arise from inconsistent formats and missing data on returned cards. The AGFD GIS group and the AGFD Wildlife Contracts Branch's Highways and Connectivity group have worked together to generate a mobile device tool for simple and standardized wildlife collision data collection. A "roadkill" project built for esri's ArcGIS Online interface and ArcGIS Collector application is in the beta testing phase. This tool allows AGFD personnel to efficiently log collision records using their mobile devices using defined schema that ensures the uniformity of data records. Following successful beta testing, this tool will be rolled out to all AGFD personnel interested in participating in this data collection effort. Ultimately, the goal is to expand the user base to include ADOT and other agency personnel.

Cody R. Strong, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; crstrong@nmsu.edu

Scott A. Carleton, U.S. Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; carleton@nmsu.edu

William Gould, New Mexico State University, Department of Business, Guthrie Hall 211, Las Cruces, New Mexico 88003; wgould@nmsu.edu

Clay Nichols, U.S. Fish and Wildlife Service, Arlington, Texas 76011; clay_nichols@fws.gov

Randy Howard, Bureau of Land Management, Roswell, New Mexico 88201; rlhoward@blm.gov

Grant Beauprez, New Mexico Department of Game and Fish, Portales, New Mexico 88130; grant.beauprez@state.nm.us

Investigating lesser prairie-chicken (*Tympanuchus pallidicinctus*) seasonal habitat use, reproduction, and survival to understand patterns of declining lek attendance

The Lesser Prairie-chicken (LPC) is widely recognized to have experienced a significant decline of population and range over the past century. In southeastern New Mexico on the Sand Ranch Area of Critical Environmental Concern (SRACEC), LPCs have exhibited an alarming trend of lek abandonment indicative of a population decline. Intensity of abandonment and vegetative structure both vary across the study area with an observed southward to northward trend of abandonment. We investigated breeding ecology, survival, movement patterns, and habitat use of LPCs on the Sand Ranch during the 2013 and 2014 breeding seasons in order to illuminate the cause of this decline in relation to vegetative structure, habitat use, and demographic patterns. Individuals were captured during lekking periods between March and June in 2013 and 2014. These birds were then tracked via VHF radio and satellite PTT transmitters in order to understand survival rates, movement patterns, and habitat use. During the study LPC had high survival rates and low recruitment during both years (82%/0% and 61%/18%, respectively). Most LPC in this study remained within 6km of the lek of capture except for one male that moved 18km two months following release. We found significant differences in vegetation structure across the study area and observed a high degree of avoidance of mesquite (*Prosopis sp.*) habitat patches for nesting, brooding, and adult breeding season movements. LPC preferred shinnery oak prairie where 100% of successful nests, 71.4% of brood use points, and 94.84% of all bird use points were located. Results from this study indicate that mesquite encroachment is a significant and potentially habitat limiting impact on LPC in this study area and should be removed.

Casey Taylor, New Mexico Highlands University, Department of Natural Sciences, Ivan Hilton Science Building, 810 National Avenue, Las Vegas, New Mexico 87701; crt7686@gmail.com

Dr. Sarah Corey-Rivas, New Mexico Highlands University, Department of Natural Sciences, Ivan Hilton Science Building, 810 National Avenue, Las Vegas, New Mexico 87701; sjcorey@nmhu.edu

Dr. Jesus Rivas, New Mexico Highlands University, Department of Natural Sciences, Ivan Hilton Science Building, 810 National Avenue, Las Vegas, New Mexico 87701; rivas@nmhu.edu

Does a bear live in the woods? an analysis of urban black bear populations in northern New Mexico

Conflicts between humans and Black bears (*Ursus americanus*) have increased in the recent decades, due to human encroachment on wildlife habitats and anthropogenic attractions in urban areas. Urban bears are rather common in New Mexico where bears are often seen in town and foraging around dumpsters. Conventional wisdom states that once a bear has come to town they do not leave, these bears stop being a participant of the rural ecosystem and become urban animals. The purpose of this study is to assess the magnitude of the urban bear problem by determining the abundance, and movements of these urban populations, in comparison with rural populations. Transects were randomly assigned within the city limits and in the neighboring areas to determine relative abundance of Black bears by counting scat and bear sign. Scat and hair samples were collected to identify individual animals through the use of microsatellite analysis, as well as tracking movement patterns. Telemetry was used to track the movements of two sows (one with two cubs) through the summer and fall of 2013. I found more scat in town than in the neighboring areas ($t=2.98$, $df=13$, $p=.005$, one tail). Both sows were collared in town but moved to rural areas in the fall, presumably seeking hibernation dens and local oak mast. My results suggest that this population of Black bears are not permanently urban bears. Instead, they come into town during summer months, likely attracted by constant availability of high calorie food.

** Student

Stu Tuttle, USDA Natural Resources Conservation Service, Arizona State Office, 1585 S. Plaza Way, Suite 120, Flagstaff, AZ 86001; stu.tuttle@az.usda.gov
Richard (Rick) Gooch, US Fish and Wildlife Service, 5275 Leesburg Pike, Falls Church, VA 22041; richard_gooch@fws.gov
Marcus Miller, USDA Natural Resources Conservation Service, 1201 NE Lloyd Blvd., Suite 1000, Portland, OR 97217; marcus.miller@por.usda.gov

Recovery for an ecosystem or a single species? An NRCS case study using the southwestern willow flycatcher

The Working Lands for Wildlife Initiative (WLFW) is a national partnership between the USDA Natural Resources Conservation Service (NRCS), the U.S. Fish and Wildlife Service (Service), and State Wildlife Agencies. The **WLFW** provides financial and technical assistance to privately owned ranches, farms, and forestry operations interested in seeking to conserve targeted wildlife species protected under the U.S. Endangered Species Act (ESA) without creating additional ESA regulatory responsibilities. One of the seven-targeted species is the Southwestern Willow Flycatcher (*Empidonax traillii*) (SWFL). Because numerous listed species are found within or nearby SWFL habitat, nearly all conservation practices planned by NRCS would require additional consultation with the Service prior to implementation. Additionally, landowners are wary of discussing a single listed species, while typically being open to ecosystem approaches to habitat restoration. Therefore, NRCS chose to include 83 species in the consultation for an ecosystem approach. Although the SWFL remains the focus species, addressing all potential species in one range-wide consultation gives NRCS the option to expand the WLFW program to recover and protect more habitats and encourage more private landowners to participate in species recovery. We discuss advantages and disadvantages to each approach as well as the actual consultation with the Service.

Chase Voirin, Conservation Genetics Laboratory, School of Natural Resources and the Environment, University of Arizona, 1311 East 4th Street, Tucson, AZ 85721; crv@email.arizona.edu

Melanie Culver, U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, School of Natural Resources and the Environment, University of Arizona, 1311 East 4th Street, Tucson, AZ 85721; mculver@email.arizona.edu

Mule deer diet analyses: Comparing past with present techniques

Wildlife biologists have used dietary richness as a proxy to assess species richness of plants in mule deer, *Odocoileus hemionus*, diet. Past studies have used non-invasive methods, such as microhistology, to assess dietary richness (i.e. the presence of unique plant species in a given diet) for mule deer. However, microhistology has several drawbacks including accuracy in differentiating plants at the level of species in a given diet. Genetic techniques present new avenues for analyzing herbivorous wildlife diet. Additionally, few studies have compared microhistological and genetic diet analyses for any species of animal. Our objective was to compare both microhistological and genetic diet analyses through dietary richness found in fecal matter of mule deer, with the hypothesis that the genetics technique would show greater dietary richness than microhistology in the form of a greater number of unique plant species identified in each sample. Mule deer fecal samples were collected on the Navajo reservation from two distinct populations of deer. Individual and population level diet analyses were conducted using both microhistological and genetic techniques. Preliminary genetic results differentiating chloroplast DNA in samples indicated a possible high coverage of plant species identified for both individual and population level diet analyses, while microhistological results are forthcoming. Our study will conclude with the comparison of dietary richness of plant species found from both diet analyses. Management implications from this study may present innovative methods for determining mule deer dietary richness, and may also be used for a broad range of herbivorous species.

**Graduate Student

Faith M. Walker, School of Forestry & Center for Microbial Genetics and Genomics, Northern Arizona University, Bldg. 56, 3rd floor, 1298 S Knoles Dr., Flagstaff, AZ 86011-4073; Faith.Walker@nau.edu

Charles H.D. Williamson, Center for Microbial Genetics and Genomics, Northern Arizona University, Bldg. 56, 3rd floor, 1298 S Knoles Dr., Flagstaff, AZ 86011-4073; Chase.Williamson@nau.edu

Dan E. Sanchez, Center for Microbial Genetics and Genomics, Northern Arizona University, Bldg. 56, 3rd floor, 1298 S Knoles Dr., Flagstaff, AZ 86011-4073; Daniel.Sanchez@nau.edu

Colin J. Sobek, Center for Microbial Genetics and Genomics, Northern Arizona University, Bldg. 56, 3rd floor, 1298 S Knoles Dr., Flagstaff, AZ 86011-4073; Colin.Sobek@nau.edu

Carol L. Chambers, School of Forestry, Northern Arizona University, 200 East Pine Knoll Dr., Flagstaff, AZ 86011; Carol.Chambers@nau.edu

Species from feces: A tool for genetically identifying bats

Bat guano is an untapped reservoir of information, having great potential as a DNA source because it is abundant in caves even when bats are not present, and is stationary and easy to collect. Three technologies have recently come of age that together have great potential to determine species identity from guano: reliable DNA typing from feces, DNA barcoding (species-specific genetic identifiers), and bioinformatic analysis. Taking advantage of these advances, we have developed a mini-DNA barcode assay that targets a segment of mitochondrial gene cytochrome oxidase I that we have found to be highly discriminatory among Chiroptera globally, usually down to the species level, and that readily accommodates fecal DNA. We have successfully applied our system to fecal pellets at least 3 months old, and to individual feces and pooled feces, such that questions can target specific fecal pellets or long-term roost sites. In several instances our genetic approach has revealed field misidentification of mist netted species. Our Species from Feces tool has enormous application in the U.S., where bats are under threat from white-nose syndrome, and worldwide, since many bat species are vulnerable or facing extinction.

******Krysten M. Zummo, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003, zummokm@nmsu.edu

Scott Carleton, US Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003

Effects of habitat restoration and climate change on scaled quail in south central New Mexico

Scaled quail (*Callipepla squamata*) have been experiencing population declines in the southwest for the past few decades. The factors thought to be contributing to this decline include the encroachment of shrublands on desert grassland habitat and shifts in the summer monsoon season. In New Mexico, the Bureau of Land Management has implemented chemical treatments to control creosote in an effort to reclaim these habitats. Our objectives in this study were to examine seasonal habitat use of scaled quail in relation to these treatments, as well as to understand how temperature and humidity affect reproductive success. We captured and placed VHF collars on 55 quail in the West Potrillo Mountains of south central New Mexico. Quail were tracked weekly to obtain habitat use points and to locate nesting hens. Nests had an iButton® placed inside the nest bowl and another 3 inches outside of the nest to collect temperature and humidity data. Preliminary data indicates that hens are buffer nest temperatures, but have a limited ability to buffer humidity. Overall, temperature and humidity did not have an effect on nest success. Brood success was poor during the early breeding season. Adult selected, nest, and brood points will be analyzed by comparing habitat patch use versus availability in GIS. Further analysis will look at vegetative microhabitat selection of nest and brood points.

******Student

Wildlife Posters

Isidro Barela, New Mexico State University; Department of Fish, Wildlife and Conservation Ecology 2980 South Espina, Knox Hall 132 P.O. Box 30003, MSC 4901 Las Cruces, NM 88003-8003; ibarel01@nmsu.edu

Jennifer K. Frey, New Mexico State University; Department of Fish, Wildlife and Conservation Ecology 2980 South Espina, Knox Hall 132 P.O. Box 30003, MSC 4901 Las Cruces, NM 88003-8003; jfrey@nmsu.edu

Use of woody forage plants by the American beaver (*Castor canadensis*) in the Chihuahuan Desert

Survival of the American beaver (*Castor canadensis*) is influenced by many factors, including availability of suitable forage. In terms of diet, beavers are considered choosy generalists, meaning that while the diet may include a large number of different plant species, only a few species make up the bulk of the diet. Beavers prefer herbaceous vegetation, but may rely entirely on the bark of woody species when herbaceous vegetation is not available, such as during the winter in cold climates. However, little is known about foraging habits of beavers in arid environments. We report preliminary findings of a study aimed at evaluating availability and use of woody species by beavers along the Rio Grande in Doña Ana County, New Mexico, which is within the Chihuahuan Desert. Since the Rio Grande currently flows intermittently during most of the year, we used Geographic Information System and aerial photos to construct a map of pooled water to predict distribution of beavers. We conducted field surveys to determine occurrence of beavers at predicted sites and to measure habitat variables and forage utilization. Beavers were exceptionally rare and absent from the majority of the study area due to lack of water. Occupied sites were depauperate in most key forage plants and were dominated by stands of saltcedar and willows. Forage use was primarily willows, but also included saltcedar, screwbean mesquite, and cattails.

**Student

Kristen A. DaVanon*, Biology Department, New Mexico State University, Las Cruces, NM

Lindsey Howard, Biology Department, New Mexico State University, Las Cruces, NM

Brandon T. Bestelmeyer, Jornada Experimental Range, USDA Agricultural Research Service, Las Cruces, NM

Karen E. Mabry, Biology Department, New Mexico State University, Las Cruces, NM,

Robert L. Schooley, Department of Natural Resources and Environmental Sciences, University of Illinois

The effects of urbanization on state change mediated by predator-prey interactions

Historical state changes from grass-dominated to shrub-dominated vegetation have been common in desert grassland areas of the southwestern United States and northern Mexico, triggered by historical episodes of heavy livestock grazing. Recent urbanization within shrub-dominated areas may reduce the activity of native predators specializing on small mammals, reducing predation risk, and resulting in relative increases in herbivory and granivory rates. To test this hypothesis, we compared herbivory rates, the abundance of rodents, and activity levels of lagomorphs and carnivores across an urbanization gradient within Chihuahuan Desert areas of Las Cruces, NM, USA. We used live-trapping to estimate rodent abundance, seedling-trays to measure herbivory rates, and wildlife cameras to measure lagomorph and carnivore activity. Herbivory rates were higher in the high density suburban developments than the other classes but did not differ between low density exurban and wildland areas. Small mammal live-trapping, however, did not indicate differences in rodent (kangaroo rat and pocket mouse) abundance among different levels of urbanization. This result suggests that changes in rodent abundance is not responsible for increased herbivory rates observed in high density suburban developments. While jackrabbit activity was similar across the gradient, there was more activity by cottontails and coyotes in high density exurban areas. Our results indicate that the interaction of urbanization with predator-prey dynamics may influence the recovery of herbaceous plant species within shrub-dominated states of the Chihuahuan Desert.

*Graduate Student

Ryan M. DeVore, Montana Fish, Wildlife, & Parks, Broadus, Montana, 59317;
rdevore@mt.gov

Mark C. Wallace, Texas Tech University, Department of Natural Resources
Management, Lubbock, TX 79409; mark.wallace@ttu.edu

Matthew J. Butler, Division of Biological Services, National Wildlife Refuge System, U.S.
Fish and Wildlife Service, Albuquerque, NM 87103; matthew_butler@fws.gov

Stewart L. Liley, New Mexico Department of Game and Fish, One Wildlife Way, Santa
Fe, NM 87507; stewart.liley@state.nm.us

Ashley A. Inslee, Bosque del Apache National Wildlife Refuge, U.S. Fish and Wildlife
Service, San Antonio, NM 87832; ashley_inslee@fws.gov

Philip S. Gipson, Texas Tech University, Department of Natural Resources
Management, Lubbock, TX 79409; philip.gipson@ttu.edu

Elk population dynamics at Bosque Del Apache National Wildlife Refuge, New Mexico, USA

Crop depredation by wildlife is a frequent concern for natural resource managers and mitigation of this issue is often an important task for wildlife agencies. Elk (*Cervus elaphus*) are depredating corn (*Zea mays*) at Bosque del Apache National Wildlife Refuge (BDANWR), New Mexico, USA, which is interfering with the Refuge's ability to provide sufficient supplemental nutrition to overwintering sandhill cranes (*Grus canadensis*) and geese. We estimated annual adult survival and calf recruitment rates of elk from 2011–2013 at BDANWR. Natural adult survival was high (mean = 98.3%; 95% CI = 95.0–100.0%). Calf recruitment was lower than in some populations, and ranged from 13.0 to 36.7 calves:100 cows at time of recruitment (mean = 21.9; SD = 12.9). Using this information, we constructed a harvest management model to determine annual harvest quotas required to stabilize the growth of this elk herd. The female segment of the herd is growing at an annual rate of 9.1% (95% CI = -1.1 to 24.1%). To stabilize the growth rate of female elk, 8.0% (95% CI = -1.1 to 19.4%) of cows would need to be harvested annually. We estimated an adult elk abundance of 40.0 (SE = 4.57; 95% CI = 33.80–52.65) in 2012 and 61.1 (SE = 7.21; 95% CI = 49.93–78.81) in 2013. Our harvest model provides Refuge staff with valuable information needed to stabilize the elk herd. Further, our approach outlines a simple, easily implemented modeling technique that can be used for the management of other ungulate herds.

**Graduate Student

Sarah L. Hale, University of Arizona, School of Natural Resources and the Environment,
Biological Sciences East 325, Tucson, AZ 85721; Phone (520) 626-5616;
shale@email.arizona.edu

John L. Koprowski, University of Arizona, School of Natural Resources and the
Environment, Biological Sciences East 325, Tucson, AZ 85721; Phone (520)
626-5616; squirrel@ag.arizona.edu

Population dynamics of a recently reestablished keystone species: the black-tailed prairie dog

The keystone species concept was introduced over 40 years ago, and refers to any species that plays a critical role in its community that is disproportionately large relative to its abundance. The black-tailed prairie dog (BTPD: *Cynomys ludovicianus*) has been described as a keystone species in grassland ecosystems because it provides a suite of important services (e.g. they provide burrows for other species, increase water percolation, reduce woody encroachment, provide food for carnivores, etc.). The BTPD was once widely distributed across the North American west, but has been viewed as a pest, and control programs over the past century have reduced their numbers to 2% of historical populations. In Arizona, this species was extirpated from its historical range by 1960. In 2008, the Arizona Game and Fish Department began reestablishing the BTPD at Las Cienegas National Conservation Area in Southeastern Arizona. To assess the success of this reestablishment effort, we have monitored 3 of the 4 recently reestablished BTPD colonies at Las Cienegas since 2011. We have found that population sizes are remaining relatively stable; however, recruitment has varied year to year, and may be related to the proportion of reproductive females that are yearlings.

**Student

Lindsey K. Howard, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 1200 S Horseshoe Dr., Foster Hall 361, Las Cruces, New Mexico, 88003; lkhoward@nmsu.edu

Karen E. Mabry, New Mexico State University, Department of Biology, 1200 S Horseshoe Dr., Foster Hall 361, Las Cruces, New Mexico, 88003; kmabry@nmsu.edu

Does population density affect spatial genetic structure in Merriam's kangaroo rats?

Dispersal, an individual's movement away from its birth site, is important in a species' ability to adapt in a changing environment. There are a variety of environmental factors that can influence dispersal, one of which is population density. Possible relationships between dispersal patterns and population density include positive density dependent dispersal and negative density dependent dispersal. Studying spatial genetic structure is an indirect but effective way to make inferences about dispersal patterns. In this study, we examine the spatial genetic structure of a Merriam's kangaroo rat (*Dipodomys merriami*) population, across three different time periods of varying population density, using spatial genetic autocorrelation analyses. We predicted that higher population densities would either cause (1) more pronounced spatial genetic structure, or (2) less pronounced spatial genetic structure. Spatial genetic structure was not detected during any trapping period during the study, which could be due to a variety of factors including *D. merriami* social structure and mating distances.

**Undergraduate student

Gizelle Hurtado, New Mexico State University, Biology Department, MSC 3AF, Foster Hall, P.O. Box 30001, Las Cruces, New Mexico 88003; gmh11@nmsu.edu

Karen Mabry, New Mexico State University, Biology Department, MSC 3AF, Foster Hall, P.O. Box 30001, Las Cruces, New Mexico 88003, kmabry@nmsu.edu

Endoparasite prevalence in kangaroo rats may be influenced by urban development

Urban development can fragment and degrade remnant habitat. These alterations in habitat can have profound impacts on wildlife populations. These impacts may influence the prevalence of pathogens along wild land - urban gradients. I investigated the influence of urbanization on populations of Merriam's kangaroo rat (*Dipodomys merriami*) and their pathogens. I hypothesized that urban development would affect the prevalence of endoparasites in kangaroo rats in urban areas versus wild land areas. I live trapped kangaroo rats at 10 sites in and around Las Cruces, NM: 5 urban and 5 wild land, from June to November 2013, and collected fecal samples from 70 kangaroo rats. Endoparasite presence was determined using fecal flotation, and both roundworms and protozoans were detected. Roundworm (*Mastophorus dipodomis*) prevalence was higher in wild land populations, but (*Pterygodermatites dipodomis*) prevalence did not differ between urban and wild land populations. Further, protozoans were only detected in wild land populations and kangaroo rats with multiple infections of different pathogens were only detected in wild land populations. These results indicate that kangaroo rat endoparasite prevalence may be influenced by the impacts of urban development on physical, biological or behavioral factors. Increased availability of anthropogenic resources or fragmentation acting as a barrier to transmission may be physical factors. Alterations to plant cover or intermediate host abundance may be biological factors and there may be behavioral differences in kangaroo rat populations between urban and wild populations that may influence endoparasite prevalence. The mechanism(s) driving these differences requires further investigation.

** Graduate Student

Amanda Jones, University of New Mexico, Museum of Southwestern Biology, 1
University of New Mexico, Albuquerque NM 87131, jonesak@unm.edu

Mammals of the Greater Gila Ecosystem

The Greater Gila ecosystem supports high biotic diversity because it is at the confluence of multiple biomes. This region has undergone natural transitions as well as anthropogenic modifications. Climate projections suggest the region will be heavily impacted by drying conditions in the future. To provide rigorous baselines to assess potential response of mammals to changing conditions, I am conducting literature, museum and field surveys of the mammal fauna of the Greater Gila Ecosystem in New Mexico. For this study I have gathered data on mammal occurrences, community composition, habitat affinities, elevational distributions, migration/hibernation timing, and reproductive timing and success. . With increasing threats to biodiversity, there is a growing need for natural history data and increased sampling to provide the critical materials that will be needed for new investigations of changing conditions. As the climate becomes warmer and drier documenting changes in species' distributions, phenology, and reproduction will be invaluable contributions in terms of conservation.

**Student

Cheyenne N. Lattin, Eastern New Mexico University, Department of Biology, 1500 S Ave K, Roosevelt Hall, Portales, New Mexico 88130; cheyenne.lattin@enmu.edu

Analysis of Necrophagous beetles of eastern New Mexico

Necrophagous beetles, Coleopteran have not been researched in the High Plains region in the forensic science or the ecological fields. This region consists of eastern New Mexico, west Texas, and southwestern Oklahoma. Entomology has become increasingly important in forensic science because the research have proven instrumental in solving criminal matters. Forensic entomology is used to determine the time of death, called the Post Mortem Interval (PMI), location of death, time and presence of inflicted wounds, and poison or toxins in the system. One of my objectives is to characterize and identify the necrophagous and other species of Coleopteran that coincide with the carrion and its decomposition. The other objective is to identify which species are occurring within a season and how they are coming and leaving the carrion. I have four sites on the Eastern New Mexico University Natural History Museum's land, which is located in Roosevelt County, New Mexico. I am placing one fresh still born calf out at each these marked sites, at the beginning of each decomposition season. Three are tests sites and one is a control site. Using pitfall traps, surrounding the carrion, I am collecting species that comes in or out of the area and off the carrion itself during each stage of decomposition up to the stage of dry remains. I am taking the specimens back to the lab for pinning and identification. There seems to be a correlation with temperature, the rate of decay, and the presence of the type of species found.

**Student

Natasia Mitchell, Department of Natural Resources Management, Texas Tech University, Lubbock, TX 79409; natasia.mitchell@ttu.edu
Benjamin Skipper, Department of Biology, Angelo State University, San Angelo, TX 76909; benjamin.skipper@angelo.edu
Clint Boal, U.S. Geological Survey, Texas Cooperative Fish and Wildlife Research Unit, Texas Tech University, Lubbock, TX 79409; clint.boal@ttu.edu

Abundance and land cover associations of migrant and wintering birds of prey in the southern Great Plains

Wind energy development is a rapidly advancing source of renewable, non-carbon emitting energy in the Southern Great Plains. However, it is not without environmental cost in terms of potential mortality and disturbance to wildlife. Birds of prey in particular appear to be susceptible to direct mortality from wind turbines. Each winter, the Southern Great Plains experiences an influx of birds of prey that migrate through the area or settle in for the winter. However, little contemporary or quantitative information is available regarding the composition, abundance, or distribution patterns of these birds across the landscape. We initiated bird of prey surveys along 51 50km road survey transects in the Southern Great Plains of eastern New Mexico, the panhandle of Texas, and western Oklahoma. Our goal is to determine species richness, abundance, and species-specific land cover associations in the region to assess potential risk of energy development to migrating and wintering birds of prey. We will use a distance sampling approach to estimate species-specific detection rates and resulting density estimates across the region. We have completed October surveys, with mid-December and early January surveys pending. Final analysis of the survey data will be presented.

**Graduate Student

Brett J. Montgomery, Arizona State University, Polytechnic School in Ira A. Fulton
School of Engineering, 7001 East Williams Field Road, Mesa, AZ, 85212;
bjmontg1@asu.edu

Logan L Salaki, Arizona State University, Polytechnic School in Ira A. Fulton School of
Engineering, 7001 East Williams Field Road, Mesa, AZ, 85212; lsalaki@asu.edu

Heather L. Bateman, Arizona State University, Department of Applied Science and
Mathematics, 7001 East Williams Field Road, Mesa, AZ, 85212;
heather.l.bateman@asu.edu

Wildlife strikes at airports: What are the contributing factors?

In the U.S., less than 20 percent of wildlife strikes are reported, which leaves a large portion of incidents unaccounted for. Although wildlife strikes at airports often go unreported, since the early 1990s the number of wildlife strikes has increased 5-fold and the number of damaging strikes has increased 1.5-fold. Goals for this project include determining if biological and landscape variables are good predictors of wildlife strikes. We define response variables as the number of reported wildlife strikes per 10,000 airport operations. We studied 30 large airports in the western U.S. and 7 major airports around Phoenix, Arizona. In Phoenix, airports varied from having 1.28 strikes per year per 10,000 operations to having 57.81 strikes from 2009 to 2013. We determined bird richness by using the citizen-science database “eBird,” and measured species richness within a 15 kilometer area of each airport. Species richness between hotspots ranges from 131 to 320. Seasonal differences were determined using a chi square analysis for the 7 Phoenix metropolitan airports as well as the 30 western U.S. airports. Our results showed that there is a seasonal difference in wildlife strikes in the majority of our airports. We will also use land use data from CAP LTER to determine any environmental factors such as vicinity to water, tree cover, or flyways located within 5 kilometers from airports using ArcGIS. These results are important because they are helpful in determining the factors influencing wildlife strikes based on the number of strikes reported.

Linda S. Ramirez, Arizona State University at the Polytechnic Campus, College of Letters and Science, 6073 S. Backus Mall, Mesa, AZ 85212;
Linda.S.Ramirez@asu.edu

Heather L. Bateman, Arizona State University at the Polytechnic Campus, College of Letters and Science, 6073 S. Backus Mall, Mesa, AZ 85212;
heather.l.bateman@asu.edu

Pairing mitigation and education: How a wildlife Inventory of Rancho Del Cielo in Vail, Arizona provided undergraduate field-experience

The Bureau of Reclamation, Phoenix office, acquired 160 acres of land adjacent to Colossal Cave Mountain Park in Vail, Arizona. Rancho Del Cielo, (also known as Barnes property), was purchased as replacement mitigation for biological resource impacts as part of the Water Settlement Act (Bureau of Reclamation, 2001). Arizona State University is currently conducting literature searches and on-the-ground surveys of vegetation, mammalian, avian, and herpetofauna species to document habitat value. Wildlife and Applied Biology students conducted surveys during winter, spring, summer, and fall seasons in 2014. Students used the following techniques to document occurrences of mammalian and herpetofauna species: track, trail cameras, live Sherman trapping, funnel traps, noosing, and visual encounters. Birds were identified by sight and sound during morning and evening surveys. Vegetative surveys were conducted in three habitat types using transects to sample plant frequency. Overall, a diverse wildlife community was observed including 14 mammalian species, 58 avian species, 12 herpetofauna species, and 139 plant species. Mountain lion, bobcat, collared peccary, and white-nosed coati were frequently detected using the wash habitat. During spring surveys, 6 individual Gila monsters were photographed and likely using a south-facing rocky hillside for overwintering. Bird species found on the property include neo-tropical migratory species and secondary-cavity nesters. This diverse species-assemblage likely reflects habitat availability, prey resources for carnivores, rocky hibernation sites for protected reptiles, and substrate for cavity-excavating birds. Additionally, this project has provided educational opportunities and field-based experiences for over 30 undergraduate students to learn wildlife and vegetation techniques.

**Graduate Student

Tiffany A. Sprague, Arizona State University, School of Letters and Sciences, 6073 S. Backus Mall, Mesa, Arizona 85212; tiffany.sprague@asu.edu

Herpetofauna abundance and species richness in predicted linkage areas

Habitat fragmentation as a result of human activity has profound, often negative, impacts on wildlife. In an effort to maintain habitat connectivity, preliminary predicted wildlife linkages were established across Arizona to connect key habitat areas. Target species, including some herpetofauna species, have been identified for many of these linkages, but it is generally unknown how or if these corridors will accommodate most herpetofauna species. The goal of this study was to determine if herpetofauna abundance and species richness is different within predicted linkage areas versus non-linkage areas. Road-cruising surveys were conducted on roads that intersect three modeled habitat corridors near Phoenix, Arizona. All herpetofauna detections were recorded, identified to species whenever possible, and mapped. Randomly-sampled 500-m segments of linkage and non-linkage areas were analyzed for herpetofauna abundance and species richness. At two of the three survey sites and when all three survey areas were compared as one unit, results indicated that mean herpetofauna abundance and species richness per segment did not differ between linkage and non-linkage areas. However, one of the three sites, White Tanks–Belmonts–Vultures–Heiroglyphics Linkage, showed greater mean species richness per segment in non-linkage areas compared to linkage areas. These results suggest that some modeled linkages may not account for the full suite of herpetofauna species within the contextual landscape. Further research is needed as this was only a short-duration study and likely did not identify all herpetofauna in each area.

**Graduate student

MacKenzie Walz; Bosque School Wildlife Student. 4000 Learning Rd NW, Albuquerque, NM 87120 (505) 898-6388 mackenzie.walz@bosquestudents.org

Casey Garrity; Bosque School Wildlife Student. 4000 Learning Rd NW, Albuquerque, NM 87120 (505) 898-6388 casey.garrity@bosquestudents.org

Elijah Martinez; Bosque School Wildlife Student. 4000 Learning Rd NW, Albuquerque, NM 87120 (505) 898-6388 elijah.martinez@bosquestudents.org

Operation Turtle: Investigating aquatic turtles in Albuquerque

We continued research started in 2013 by Hartman and Astorga investigating aquatic turtle species in and along ponds and ditches adjacent to the Rio Grande in northern Albuquerque (NM). Phase one of the project was Hartman and Astorga's work of conducting a population survey of turtles solely by observation during the fall of 2013. In summer and fall 2014 we returned to their study sites of 5 ponds and their adjacent ditches and drains in the Albuquerque area to conduct phase two of this project. We did this by way of catching, marking, releasing, and recapturing live turtles using baited hoop traps and sweep nets, totally 686 hours of trap effort. We collected data for presence/not-detected, relative species abundance, and a population estimate of turtles along the ponds and drains in our studied area. To mark turtles we inserted AVID pit tags and filed scutes. We had 41 captures consisting of 27 individual aquatic turtles. Our relative abundance results from capture methods were 55.6% painted turtle (*Chrysemys picta*), 37.0% red-eared slider (*Trachemys scripta elegans*), 3.70% snapping turtle (*Chelydra serpentina*), and 3.7% unidentified which is consistent with the observation only findings of Hartman and Astorga.

**Student

Fisheries Presentations

Guillermo Alvarez, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 132, Las Cruces, New Mexico 88003; galvarez@nmsu.edu

Colleen A. Caldwell, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, 2980 S. Espina, Knox Hall 132, Las Cruces, New Mexico 88003; ccaldwell@ad.nmsu.edu

Acute and sublethal toxicity effects of piscicide CFT Legumine™ (5% Rotenone) on tadpoles of the Chiricahua leopard frog (*Lithobates chiricahuensis*)

Rotenone is a piscicide used in the eradication of fishes. While extensive use has resulted in the characterization of its toxicity in fishes, effects on non-target aquatic species (i.e., amphibians) is lacking. Our objectives were to characterize the acute and sublethal responses of CFT Legumine™ (5% rotenone) on a range of larval stages of the federally-listed Chiricahua leopard frog (*Lithobates chiricahuensis*). The target nominal concentration of 1.0 mg/L CFT Legumine™ was applied to early (Gosner 21-25) and late (Gosner 31-36) larval stages. The acute or lethal concentration at which 50% of the population died (LC₅₀) was obtained using 48 h static renewal of the toxicant. The earliest larval stages exhibited the greatest sensitivity with an LC₅₀ of 0.42 mg/L. In contrast, the later larval stages exhibited lower toxicity with an LC₅₀ of 1.29 mg/L. Moreover, survivors of the 48 h exposure to nominal concentration of 1.0 mg/L demonstrated slower development rates and higher post-exposure mortality than the controls from all age groups tested. This research demonstrated target applications would eliminate the earliest life stages of this imperiled amphibian with longterm sublethal effects in time to metamorphosis.

**Student

Bryan D. Bakevich, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, New Mexico 87507; bryan.bakevich@state.nm.us

Rio Costilla progress, challenges, and Impacts of large-scale native sport fish restoration

Rio Grande cutthroat trout, like many native fishes of the Southwest, have experienced significant declines during the last century. However, over the past few decades, the Rio Grande Cutthroat Trout Conservation Team has been implementing management actions to conserve this valued native sport fish. In particular the Rio Costilla restoration project, although not yet completed, has already had a significant positive impact on its conservation status. The Rio Costilla restoration project area encompasses approximately 120 miles of stream habitat, 20 small lakes, and a 250 acre reservoir located on Vermejo Park Ranch and U.S. Forest Service land in northern New Mexico and southern Colorado. This effort consists of constructing fish migration barriers and using piscicides (i.e., liquid and powdered rotenone formulations) to eradicate nonnative brook trout, brown trout, rainbow trout, and cutthroat trout hybrids above those barriers. As of 2014, nearly 70 miles of stream and have been restored to genetically pure, self-sustaining populations of Rio Grande cutthroat trout. The last seven of the 20 lakes were renovated in 2014 and stocked in October of that year. We've demonstrated significant progress so far, but new challenges await us in the coming years.

Wiebke J. Boeing, New Mexico State University, Department of Fish, Wildlife & Conservation Ecology, 2980 S. Espina, 132 Knox Hall, Las Cruces, New Mexico, 88003; wboeing@nmsu.edu

Neeshia Macanowicz, New Mexico State University, Department of Fish, Wildlife & Conservation Ecology, 2980 S. Espina, 132 Knox Hall, Las Cruces, New Mexico, 88003; neeshia@nmsu.edu

Habitat diversity, water quality, and biotic factors drive benthic macroinvertebrate communities in desert sinkholes

Bitter Lake National Wildlife Refuge in New Mexico, USA, is a unique habitat with a complex of aquatic sinkholes. The sinkholes display a wide range of environmental factors including depth (0.07-13.4 m), salinity (6-156 PSU), and fish abundance (0-40 m⁻³). Benthic macroinvertebrates were sampled in 41 sinkholes using Hester-Dendy samplers, light traps, and ponar grabs. Additionally, we measured abiotic (depth, oxygen, pH, salinity, Secchi depth, and temperature) and biotic (fish, zooplankton, macrophytes, and phytoplankton) factors. The relationship of environmental factors and benthic communities was assessed using canonical correspondence analysis. Water boatmen (Corixidae) were the most common family (detected in 78% of the sinkholes) as well as the most abundant (up to 2,000 individuals from a single sinkhole), but their abundance was low in sinkholes with higher fish abundance. Salinity, Secchi depth, macrophytes, and zooplankton abundance were the most important variables to describe benthic macroinvertebrate compositions. Families that associated with low salinity and high zooplankton abundance belonged to the orders Gastropoda and Diptera. Secchi depth positively influenced other families belonging to Gastropoda as well as Odonata, Amphipoda, and Ephemeroptera. Interestingly, benthic taxa diversity was highest in the mesosaline (6-18 PSU) and again in the hypersaline (103-156 PSU) range.

Morgan E. Brizendine, Arizona Cooperative Fish and Wildlife Research Unit, School of Natural Resources and the Environment, University of Arizona, 324 Biosciences East, Tucson, AZ 85721; mobriz@email.arizona.edu

David L. Ward, U.S. Geological Survey, Grand Canyon Monitoring and Research Center, 2255 North Gemini Drive, Flagstaff, AZ 86001; dlward@usgs.gov

Scott A. Bonar, Arizona Cooperative Fish and Wildlife Research Unit, School of Natural Resources and the Environment, University of Arizona, 104 Biosciences East, Tucson, AZ 85721; sbonar@ag.arizona.edu

William J. Matter, School of Natural Resources and the Environment, University of Arizona, 309 BioSciences East, Tucson, AZ 8572; wmatter@email.arizona.edu

Use of ultrasonic imaging to evaluate egg maturation of humpback chub *Gila cypha* in the Grand Canyon

Humpback chub *Gila cypha* are endangered cyprinids endemic to the Colorado River drainage and are adapted to live in fast currents of warm, turbid water. Although nine known aggregations of humpback chub currently exist in the main stem Colorado River in the Grand Canyon, little is known about their reproduction. We hypothesized that Colorado River water temperatures below Glen Canyon Dam are too low due to hypolimnetic dam releases for female humpback chub to develop mature eggs for spawning. Ultrasonic imaging is a non-lethal method that has been used to determine sex and maturity of a variety of freshwater, anadromous, and marine fishes. However, these studies typically use captive fish in a laboratory and not wild fish in the field. Our goal was to develop ultrasonic imaging, a non-lethal method, to identify gamete development and to evaluate gamete maturity in female humpback chub in the Grand Canyon. We developed a standardized protocol for ultrasonically scanning humpback chub in the field and compared egg development in female fish from the main stem Colorado River, Little Colorado River, Havasu Creek, and Shinumo Creek. It is already known that female humpback chub develop eggs in the Little Colorado River. We also found egg development to an extent in the main stem Colorado River and Havasu Creek.

**Student

Herman Campos, New Mexico State University, Department of Fish, Wildlife, and Conservation Ecology Las Cruces, NM, 88003; hcampos@nmsu.edu

Wiebke Boeing, New Mexico State University, Department of Fish, Wildlife, and Conservation Ecology Las Cruces, NM, 88003; hcampos@nmsu.edu

Barry Dungan, New Mexico State University, Chemical Analysis and Instrumentation Laboratory, Las Cruces, NM, 88003; bdungan@nmsu.edu

Tanner Schaub, New Mexico State University, Chemical Analysis and Instrumentation Laboratory, Las Cruces, NM, 88003; tschaub@nmsu.edu

Nitrogen media affects the productivity of *Nannochloropsis salina* cultures algal biovolume, lipid signatures and densities of invasive organisms

Marine algae from the genus *Nannochloropsis* are the ideal organism for the advancement of biofuel technology. Nutrient limitation is an important factor in inducing the production of lipid. We hypothesize that the source of nitrogen will have a strong effect on productivity of *Nannochloropsis salina* and densities of invasive organisms. The experiment was conducted in aquaria over 28 days and under different nitrogen sources: ammonium chloride (NH_4Cl), ammonium hydroxide (NH_4OH), sodium nitrate (NaNO_3), urea ($\text{CH}_4\text{N}_2\text{O}$), and a mixture of all these sources. Growth parameters were analyzed using a FlowCAM. Lipid content was analyzed by transesterification and analysis of fatty acid methyl esters by gas chromatography mass spectrometry. The highest growth rate was observed in urea treatments but these algae had the smallest cell size. Sodium nitrate and the mixture of nitrogen sources had relatively high growth rates and large cell size, thus they had the highest biovolume. Lipid content by weight was highest in the mixture of nitrogen but the culture also contained the highest densities of invading organisms. This experiment suggest that the source of nitrogen can create trade-offs between maximum growth rates versus productivity. A mixture of nitrogen sources induced high biovolume and the highest accumulation of lipids, but there was also a higher density of invading organisms in this treatment. Implementing ecological concepts to maximize algae yields is an important step towards mass producing affordable biofuels derived from algae. The form of nutrient utilized is important and should be based on harvesting goals.

**Student

Shawn R. Denny, New Mexico Department of Game and Fish, 1912 West Second Street, Roswell, New Mexico 88201; shawn.denny@state.nm.us

Use of cold branding in marking channel catfish

Cold branding (freeze branding) has been used for many years in both the livestock and fisheries industries. The process uses branding irons cooled with liquid nitrogen to freeze the epidermal layer leaving a permanent “scar”. New Mexico Game and Fish had a need to distinctly mark multiple Channel Catfish (*Ictalurus punctatus*) cohorts for a stocking evaluation. Freeze branding techniques from Illinois (walleye) were modified and tested on both sub-adult and fingerling Channel Catfish on a small scale. Short term evaluation showed that brands on the ventral surface were the most recognizable. From this information a marking process was developed including the use of Aquis20 (synthetic clove oil) as a sedative under INAD permitting. A long-term mark retention study is ongoing with double marked (branded and fin clipped) Channel Catfish being stocked into multiple waters for future recapture and evaluation of long term mark retention.

Nicole L. Eiden, Arizona Game and Fish Department, Division of Wildlife Management,
5000 W Carefree Hwy, Phoenix AZ 85086; neiden@azgfd.gov
Bill Stewart, Arizona Game and Fish Department, Division of Wildlife Management,
5000 W Carefree Hwy, Phoenix AZ 85086; bstewart@azgfd.gov

A landscape approach for fisheries data compilation and predictive modeling

Effective fisheries management requires a strong data foundation to inform science-based decisions and drive native and sport fish conservation activities. In preparation for a shift towards integrated multispecies planning at a watershed scale, the Arizona Game and Fish Department (AZGFD) has been developing a fisheries data management system called Fisheries Information System (FINS) with an initial focus on data mining, and subsequent compilation and standardization of fish survey and stocking records. FINS data is integrated within a Geographic Information System (GIS) by georeferencing observations to an existing national spatial framework. To demonstrate the conservation utility of FINS, researchers at the University of Washington are developing predictive models for the Verde and Little Colorado watersheds using approximately 135,000 records queried from the FINS dataset. These models will be ground-truthed using data collected for previously unsurveyed reaches. AZGFD's goal of producing a defensible data set for native and sport fish conservation is well underway. This presentation will provide a status update for work performed under grants from the Desert and Southern Rockies LCCs.

Jennifer L. Johnson, U.S. Fish and Wildlife Service, Arizona Fish and Wildlife
Conservation Office, P.O. Box 39, Pinetop, Arizona 85935;
Jennifer_Johnson@fws.gov

Jeremy B. Voeltz, U.S. Fish and Wildlife Service, Arizona Fish and Wildlife
Conservation Office, P.O. Box 39, Pinetop, Arizona 85935;
Jeremy_Voeltz@fws.gov

Evaluation of long-term mechanical removal of brown trout from Apache trout recovery streams

The primary strategy for achieving recovery of threatened Apache Trout *Oncorhynchus gilae apache* is to protect populations of Apache Trout through natural or artificial barriers and reduction or removal of nonnative trouts above these barriers using various techniques. The U.S. Fish and Wildlife Service and White Mountain Apache Tribe have jointly been conducting recovery activities for Apache Trout on the Fort Apache Indian Reservation for decades. Efforts to reduce or remove Brown Trout *Salmo trutta* in several Apache Trout recovery populations on the Reservation began in 2003 and occurred periodically until 2007. Following a significant long-term funding commitment from the National Fish and Wildlife Foundation, we began intensive removal efforts on three streams in 2008-2014. Due to successful results, we have begun mimicking our techniques on other streams and our presentation will highlight the successes, failures, and lessons learned.

Sharon Lashway, Arizona Game and Fish Department, Mesa, AZ, 85209;
slashway@azgfd.gov

Conservation and mitigation program: An overview and progress update of Arizona's newest conservation program

The Conservation and Mitigation Program (CAMP) was created in 2011 to reduce and offset impacts of the Arizona Game and Fish Department's (AGFD) Sportfish Stocking Program as identified through the ESA and NEPA process as the result of Section 7. The CAMP is responsible for fulfilling conservation and mitigation measures for threatened and endangered (T&E), Candidate, and sensitive species that may be affected by the AGFD sportfish stocking program. There are 45 mandatory measures that CAMP will be responsible for fulfilling within the next ten years. The Tucson and Mesa Region of the Arizona Game and Fish Department is currently working towards meeting these measures through various projects specifically working with the Chiricahua Leopard frog (*Rana chiricahuensis*), the Northern Mexican gartersnake (*Thamnophis eques megalops*), headwater chub (*Gila nigra*), and roundtail chub (*Gila robusta*).

Dominique Lujan, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, 2980 South Espina Street, Knox Hall Room 132, Las Cruces, New Mexico 88003; domlujan@nmsu.edu

Colleen A. Caldwell, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, 2980 S. Espina, Knox Hall Room 132, Las Cruces, New Mexico 88003; ccaldwell@ad.nmsu.edu

Matthew P. Zeigler, New Mexico State University, Department of Fish, Wildlife and Conservation Ecology, 2980 South Espina Street, Knox Hall Room 132, Las Cruces, New Mexico 88003; zeiglerm@nmsu.edu

Robert Parmenter, Valles Caldera National Preserve, 090 Villa Louis Martin, Jemez Springs, New Mexico 87025; bparmenter@vallescaldera.gov

Differences in the resiliency of a montane grassland stream to a prescribed burn and a severe wildfire

Prescribed fire is a management tool used to reduce fuel loads and recover community structure and function through nutrient cycling. In contrast, wildfire severity may be so great as to result in time to recovery taking decades. The Las Conchas wildfire ignited 26 June 2011 in northcentral New Mexico and spread at a rate of 10,530 ha in the first 14 hours, burning a total of 63,420 ha before being fully contained 1 August 2011. The wildfire burned over 30% of the Valle Caldera National Preserve including an open meadow (Valle Toledo) treated in 2005 to a prescribed burn to evaluate short and long term effects of a cool fall burn on a grassland meadow stream. The Las Conchas wildfire provided an opportunity to compare the effects of the prescribed burn with a severe wildfire six years later on fish density and sediment carbon:nitrogen (C:N) as an indirect measure of ash contribution. The 2005 prescribed burn resulted in no detectable differences in density of adult brown trout before or after the burn (56-80 fish/100 m²). In contrast, populations of brown trout decreased and have remain suppressed three years post-wildfire (0.4-12.1 fish/100 m²). Average C:N ratios were not detectably different between pre- and post-prescribed burn (11.5 – 13.4) indicating very little contribution of ash to the stream. In contrast, C:N ratios increased immediately after the Las Conchas wildfire in 2011 (18.5 ± 2.39) and have remained elevated for three years post-wildfire (2014: 22.6 ± 4.50).

**Student

Eric M. Mammoser, New Mexico Department of Game and Fish, 2715 Northrise Dr.,
Las Cruces, NM 88011; Eric.Mammoser@state.nm.us

Kevin T. Gardner, New Mexico Department of Game and Fish, 2715 Northrise Dr., Las
Cruces, NM 88011; Kevin.Gardner@state.nm.us

Fish community's response to change water storage levels at Elephant Butte Reservoir

Annual and inter-annual water storage in Elephant Butte Reservoir changes with winter snow pack, monsoon rain, and irrigation demands. Those changes become more apparent during extended drought periods when water storage in the Reservoir is already low. In the early 2000's, Elephant Butte Reservoir experienced a dramatic drop in water storage, reaching near historic lows by 2004. Since then storage has fluctuated annually, at or near historic lows. Fish population surveys using electrofishing and experimental gill nets have been conducted since 1990 and 2003 respectively. This long term data set was used to monitor the fish community's population response to the changing and subsequent persistent low water storage levels. Most of the game and non-game fish have been on a declining trend since low water storage levels began. The purpose of this study is to get a better understanding how these changes in water storage levels effects the fish community on a long term scale, allowing fishery managers to most effectively use resources and promote what fishing opportunities are available.

Renee M. Martin, Southwestern Native Aquatic Resources and Recovery Center, 7116 Hatchery Road / P.O. Box 219, Dexter, NM 88230; Renee_Martin@fws.gov
Morgan L. Robinson, Southwestern Native Aquatic Resources and Recovery Center, 7116 Hatchery Road / P.O. Box 219, Dexter, NM 88230; Morgan_Robinson@fws.gov
Wade D. Wilson, Southwestern Native Aquatic Resources and Recovery Center, 7116 Hatchery Road / P.O. Box 219, Dexter, NM 88230; Wade_Wilson@fws.gov

Isolation and characterization of twenty-five novel microsatellite loci in Colorado pikeminnow

Colorado pikeminnow (*Ptychocheilus lucius*) is a federally endangered cyprinid endemic to the Colorado River system in the southwestern United States. Extant wild populations only occur in the upper basin, and a captive broodstock is maintained to supplement wild populations. Twenty-five species-specific polymorphic microsatellites were developed using Illumina paired-end sequencing. Across 32 samples, *P. lucius* exhibited 4 to 25 alleles per locus, and observed and expected heterozygosities per locus ranged from 0.625 to 1.000 and 0.685 to 0.934, respectively. Tests for Hardy-Weinberg equilibrium were non-significant. Cross amplification was characterized in eight other cyprinids. These microsatellite markers will be useful for genetic monitoring of *P. lucius* captive and wild populations as well as other cyprinids.

Hannah M. Moore University of Arizona, Department of Ecology and Evolutionary Biology, Tucson, AZ 85721: hm Moore@email.arizona.edu

Jessica E. Gwinn University of Arizona, Department of Ecology and Evolutionary Biology, Tucson, AZ 85721

Floyd Gray U.S. Geological Survey, 520 N. Park Ave. Tucson, AZ 85719

Peter N. Reinthal, University of Arizona, Department of Ecology and Evolutionary Biology, Tucson, AZ 85721

Algae as bioindicators of stream function in acid mine drainage systems: qualitative analyses of algal communities in Santa Cruz Watershed

Acid Mine Drainage (AMD) alters stream characteristics usually via an input of acidic and metal-laden water from abandoned mines and tailings. In the Santa Cruz watershed, many geologic workings, tailings, and mine drainages periodically discharge metal-rich, acidic water and leachates into surrounding streams. These impacted aquatic systems are characterized by increased acidity and metal levels. Algae communities can be used as bio-indicators of stream function as indicated through decreased biodiversity and primary production. Here we examined algal communities in two sites in the Patagonia Mountains: Harshaw Creek, with neutral pH and low metal content and Alum Creek, with inputs from mine tailings and adits, which has relatively low pH and elevated metals content. We qualitatively analyzed the algae community structure during pre- and post- monsoon seasons, February 2011 and July 2011, respectively. Harshaw Creek had higher algae generic richness (14 total genera present with five of those being Chrysophyta, six Chlorophyta, and three Cyanophyta/ Dinoflagellates) than Alum Gulch (seven genera present with four being in Chrysophyta and three Chlorophyta) in both seasons. Based on these preliminary findings, we investigated algae diversity of both sites in 2013 and 2014 using quantitative techniques. We used a Sedwick rafter slide to determine the relative abundance of the algae, as indicated by average cell counts, present at each location. Fluorometric techniques were then used to examine the amount of chlorophyll A, a key biochemical component in photosynthesis, in each stream. Such information is crucial to understand the impacts of abandoned mines on aquatic resources and biotic communities in the Santa Cruz drainage.

**Student

Ethan Mower. New Mexico Department of Game and Fish. Glenwood Hatchery. P.O. Box 67, Glenwood, New Mexico 88039; Ethanb.mower@state.nm.us

Differences in growth rate and size variations in hand fed vs demand fed rainbow trout

Feeding strategy is an integral part of any hatchery operation. Many different strategies have been developed for rainbow trout aquaculture. Feeding methods typically fall into 3 categories: hand feeding, demand feeding and automatic feeding. Hand feeding is often advocated as a method which can increase growth rates; however it is a significant drain on hatchery manpower. New Mexico hatcheries vary between demand feeding and hand feeding, but no effort has been made to quantify differences in growth between the two methods. My objective was to quantify and compare the difference in growth rates and size variation between groups of fish that were demand fed and hand fed. I measured length and weight of two identical lots of fish subjected to the two different methods over a three month period. Hand fed fish exhibited a significant increase in growth ($p > 0.1$), and a decrease in size variation. The results indicated better and more uniform growth in hand fed fish, but growth must be high enough to justify the increased effort.

Christina R. Perez, U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, School of Natural Resources and the Environment, 1311 E. 4th Street, Biological Sciences East 325, Tucson, Arizona 85719; cperez3@email.arizona.edu

Scott A. Bonar, U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, School of Natural Resources and the Environment, 1311 E. 4th Street, Biological Sciences East 325, Tucson, Arizona 85719; sbonar@ag.arizona.edu

Jon J. Amberg, U.S. Geological Survey Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Rd., La Crosse, Wisconsin 54603; jamberg@usgs.gov

Chris Rees, U.S. Geological Survey Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Rd., La Crosse, Wisconsin 54603; crees@usgs.gov

William T. Stewart, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix, Arizona 85086; bstewart@azgfd.gov

Curtis Gill, Arizona Game and Fish Department, 7200 E. University Dr., Mesa, Arizona 85207; cgill@azgfd.gov

Chris Cantrell, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix, Arizona 85086; ccantrell@azgfd.gov

Correlation of eDNA (Environmental DNA) surveys with traditional fish sampling surveys in standing waters

Methods involving examination of deoxyribose nucleic acids in water samples (environmental DNA or eDNA) have shown promise for characterizing fish species presence in water bodies. Assuming aquatic vertebrates release eDNA into the water proportional to their biomass, eDNA may also be effective for estimating species biomass and relative abundance. Further evaluation of the procedure is necessary to identify its utility in standard fish monitoring surveys. We are investigating the correlation of fish species presence and relative abundance collected by traditional methods such as electrofishing and gill netting to eDNA water sampling techniques in a large reservoir (Theodore Roosevelt Lake, Arizona) and small (< 200 ha) Arizona lakes. Our specific objectives are to examine relationships between gill netting and boat electrofishing CPUE of Gizzard Shad *Dorosoma cepedianum* and Largemouth Bass *Micropterus salmoides* and number of DNA copies of Gizzard Shad and Largemouth Bass from adjacent water samples in Lake Roosevelt. Also, to examine relationships between gill netting and electrofishing presence of Gizzard Shad and Largemouth Bass and presence of Gizzard Shad and Largemouth Bass DNA from adjacent water samples in Lake Roosevelt. In the small lakes we will examine the relationship between these measures for Largemouth Bass using boat electrofishing. We are evaluating the use of eDNA for estimating possible extent of imbalance in fish communities; its utility for obtaining fisheries information from small or remote sites; and its utility for providing an early-warning tool for identifying presence and abundance of non-desirable fishes.

**Student

Sally J. Petre, Arizona Game and Fish Department, Research Branch, 5000 W Carefree Hwy, Phoenix, Arizona 85086; spetre@azgfd.gov

Bill Stewart, Arizona Game and Fish Department, Research Branch, 5000 W Carefree Hwy, Phoenix, Arizona 85086; wstewart@azgfd.gov

Jessica Gwinn, U.S. Fish and Wildlife Services, Ecological Services Office, 2321 West Royal Palm Road, Suite 103, Phoenix, Arizona 85021, Jessica_gwinn@fws.org

The fate of stocked trout in Arizona streams

Population dynamics of stocked trout are largely understudied in Arizona streams. Factors that influence stocked trout population density and abundance have the potential to affect angler catch rates and overall angler satisfaction. The objective of this four year study was to evaluate cost-effective stocking practices that maintain or improve angler use in Arizona streams. We conducted creel surveys on six streams to estimate angler use and satisfaction and catch per unit effort. We also implanted radio tags into trout stocked to evaluate their movement and survival/mortality. Here, we present preliminary results from year two of this four year study. Creel surveys suggest numbers of fish stocked meet angler needs in all six streams; however, further study results may reveal if streams are being overstocked. Radio telemetry found 60% of fish stayed in the pool they were stocked into, and over 50% of fish survived to day 14 post stocking. We will continue studying how manipulation of stocking practices affects angler catch and use, and continue radio telemetry to understand stocked trout movement and survival in different streams. This information of catch, persistence and movement coupled with angler satisfaction will enable us to understand population dynamics of stocked trout and make informed decisions on stocking practices and stocking densities in the future.

John S. Pittenger, Blue Earth Ecological Consultants, Inc., 1345 Pacheco Street, Santa Fe, New Mexico 87505; john@blueearthecological.com
John Caldwell, New Mexico Department of Game and Fish, One Wildlife Way, Santa Fe, New Mexico 87505; john.caldwell@state.nm.us
Patrick C. Morrow, White Sands Missile Range, Environmental Stewardship Branch, Building 163, Springfield Avenue, White Sands Missile Range, New Mexico 88002;patrick.c.morrow.civ@mail.mil

Assessment of long-term monitoring of White Sands pupfish

Annual monitoring of White Sands pupfish (*Cyprinodon tularosa*) has been conducted consistently at four sites since 1995. Previously, monitoring data were analyzed by paired t-test and linear regression of site means of catch per unit effort (*C/f*). We assessed power to detect trends in *C/f* by using site totals of *C/f* (as opposed to means), testing total *C/f* data for normality and applying transformations when appropriate, and subjecting the normalized total *C/f* data to linear regression analysis. The analysis was conducted on the whole data set (1995 to 2013) and the portion of the data set generated by a revised monitoring program implemented in 2008. No trends in total *C/f* were found at the two Salt Creek sites in either data set. The 2008-2013 data set showed a significant increasing trend in total *C/f* at the Upper Marsh site at Malpais Spring. A significant declining trend was detected at the Middle Marsh site at Malpais Spring in the 1995-2013 data set, but these data failed to meet the constant variance assumption. Power to detect trends was then assessed using the programs TRENDS and MONITOR. Alternative sampling schemes were tested for improving power to detect trends and provide more robust information regarding status of the species. Recommended modifications included biennial sampling, increasing the spatial distribution of sample sites, optimizing sample size, and increasing the number of sampling occasions per survey.

Elizabeth L. Roesler, Texas Cooperative Fish and Wildlife Research Unit, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409; 806-742-2842; elizabeth.roesler@ttu.edu

Timothy B. Grabowski, U.S. Geological Survey, Texas Cooperative Fish and Wildlife Research Unit, Texas Tech University, Lubbock, Texas 79409; 806-742-2851; t.grabowski@ttu.edu

David Rogowski, Department of Natural Resources Management, Texas Tech University, Lubbock, Texas 79409; Arizona Game and Fish Department, Flagstaff, Arizona 86004; 928-774-5045; drogowski@azgfd.gov

Assessing habitat-use patterns and survey methodologies of the endangered snail, *Pecos Assiminea*, at Bitter Lake National Wildlife Refuge

Pecos Assiminea is an endangered, semi-aquatic snail endemic to two spring systems located in eastern New Mexico and west Texas. Basic biological information needed for effective monitoring and conservation is currently lacking for this species. Our objectives were to compare the effectiveness of surveys using two gear types, quadrats ($n = 433$) and weathered wooden tiles left on the substrate ($n = 549$), for estimating *Pecos Assiminea* distribution and relative abundance, and determine *Pecos assiminea* habitat use at two sites at Bitter Lake National Wildlife Refuge (BLNWR) in New Mexico. *Pecos Assiminea* presence in the quadrat surveys was associated with soil temperature, distance to the water's edge, and percent cover of common reed, kochia, saltgrass, and bulrush. Detection of snails was higher in the surveys of wooden tiles than those using quadrats. However, there was no clear relationship between population densities estimated by the quadrats and the probability of individuals being found on the wooden tiles. Wooden tiles seem to be a cost effective method of determining *Pecos Assiminea* presence, but they may not be capable of generating reliable estimates of abundance or habitat use. Our data will inform planned restoration and conservation actions for *Pecos Assiminea* at BLNWR.

**Student

David L. Rogowski, Arizona Game and Fish Department, 5000 W. Carefree Hwy,
Phoenix AZ 85086; drogowski@azgfd.gov

Bill Stewart, Arizona Game and Fish Department, 5000 W. Carefree Hwy, Phoenix, AZ
85086; bstewart@azgfd.gov

Little fish big river- dam operations and fish life history

Glen Canyon Dam on the Colorado River, Arizona was completed in 1963. The resulting cold water releases created a popular rainbow trout tailwater fishery known for trophy size rainbow trout from the 1970-1980s. Initially Glen Canyon Dam was operated in response to power demands resulting in fluctuations in water of 4.5 m within a day. There was little natural reproduction occurring, therefore rainbow trout were stocked to sustain the fishery. In 1991 operations at the dam were significantly changed in response to environmental and cultural concerns. Variance in flows were significantly reduced. By the mid-1990s most rainbow trout within the system were naturally produced and stocking ceased in 1998. Arizona Game and Fish Department has been monitoring the Lees Ferry fishery since the early 1980's using angler surveys and boat electrofishing. Analyses have shown that while angler catch rates have increased to an all-time high (~2 fish/hour) the number of large fish has decreased. I believe that the reduction in variance of flow accounts for this life history shift. I found that flow variance is positively correlated with median length of ripe male rainbow trout, as well as percent of large fish (>405 mm) captured during electrofishing surveys. Consistent flow levels have allowed rainbow trout to naturally reproduce every year, thereby increasing density and competition for a limited food base. Thus, selection favors fish that mature and reproduce early, resulting in smaller fish, a concern for the status of this important blue ribbon fishery.

Jack E. Ruggirello, Graduate Assistant, University of Arizona; Biological Sciences East Room 325, Tucson, Arizona 85721; Phone (845) 542-8882; jackr@email.arizona.edu

Scott A. Bonar, Unit Leader and Associate Professor, USGS Arizona Cooperative Fish and Wildlife Research Unit; 104 Biological Sciences East, University of Arizona, Tucson, AZ 85721; Phone (520) 621-1193; sbonar@cals.arizona.edu

Olin G. Feuerbacher, Fish Biologist, US Fish and Wildlife Service, Ash Meadows Fish Conservation Facility; 1042 E. Warm Springs Road Amargosa Valley, NV 89020; olin_feuerbacher@fws.gov

Chelsea Powers, Laboratory Technician, University of Arizona; Biological Sciences East Room 325, Tucson, Arizona 85721; cpowers1@email.arizona.edu

Spawning ecology and captive husbandry of endangered Moapa dace

Moapa dace, *Moapa coriacea*, is an endangered cyprinid endemic to the Warm Springs area of southeastern Nevada. Moapa dace are listed as federally endangered because of their limited range, low abundance, and deleterious impacts from introduced species. Spawning by Moapa dace has never been documented; consequently environmental conditions required for this aspect of their life history are unknown. Underwater cameras were deployed in an attempt to capture Moapa dace spawning activity. Thirteen spawning events were identified and Moapa dace displayed behaviors consistent with broadcasting cyprinids. Nonparametric contingency table analyses were utilized to ascertain whether or not Moapa dace selected specific conditions to spawn. For spawning, Moapa dace selected depths ranging from 30 to 34 cm, water velocities from 0.11 to 0.17 m/s, and cobble substrate. Replicating these conditions will aid in efforts to breed Moapa dace captive. Prior to this work, Moapa dace had never been successfully held in captivity for any length of time. Moapa dace were extremely difficult to propagate. We were only able to propagate Moapa dace through one of 14 treatments. Different types of cover and different sized substrates were introduced; photoperiod, water chemistry, and temperature were manipulated; and a hormone bath and injection were applied. The successful treatment occurred in an artificial stream with an additional submersible pump to direct subsurface flow along the substrate, and a variety of substrate sizes and artificial plants. This work suggests conditions should closely mimic those experienced by fish in the wild, incorporating stream conditions and minimal human disturbance.

Jeff A. Sorensen, Arizona Game and Fish Department, 5000 West Carefree Hwy,
Phoenix, Arizona 85086; jsorensen@azgfd.gov
Scott P. Lerich, National Wild Turkey Federation, PO Box 1281, La Luz, New Mexico
88337; slerich@nwtf.net

Turkeys, snails and crayfish... oh my! Three fork springsnail habitat improvement 2014

Arizona's smallest endangered species, the tiny Three Forks springsnail (*Pyrgulopsis trivialis*), is getting some help from a unique partnership of natural resource agencies and non-government organizations. The Arizona Game and Fish Department has partnered with the National Wild Turkey Federation, the Nature Conservancy, the Phoenix Zoo, U.S. Forest Service, and U.S. Fish and Wildlife Service to improve and protect habitat for the snail in the White Mountains of central-eastern Arizona. The springsnail lives in shallow rocky springs in Boneyard Bog, along Boneyard Creek, and up until 2004, at Three Forks along Forest Road 249. In spring and summer 2014, the partners modified two of the historic springboxes at Three Forks to improve habitat for the snail and removed hundreds of invasive crayfish that were in residence.

Springsnails will be repatriated to those springboxes if the improvements are successful in keeping crayfish out at the end of the three-year study. Along Boneyard Creek, the partners installed enclosure fencing around six of the eight snail-occupied springs. These enclosures are designed to keep elk and livestock out of the springhead and springrun habitat, while still allowing access for smaller wildlife. Elk wallowing and trampling by livestock have degraded some of the springsnail habitat in the past. Annual monitoring of the modified habitats and control sites will be conducted over the next three years.

Roy Ulibarri, Arizona Cooperative Fish and Wildlife Research Unit, School of Natural Resources and the Environment, University of Arizona:
royulibbarri@email.arizona.edu

Scott Bonar, University of Arizona, Department of Ecology and Evolutionary Biology,
Tucson, AZ 85721, U.S. Geological Survey, 520 N. Park Ave. Tucson, AZ 85719

Melissa Mata, U.S. Fish and Wildlife Service

Glenn Selby, Navajo Nation Department of Fish and Wildlife

Chris Kitcheyan, U.S. Fish and Wildlife Service

Habitat suitability criteria for Navajo Nation subunit bluehead sucker (*Catostomus discobolus*) and Zuni bluehead sucker (*Catostomus discobolus yarrowi*).

Desert fishes are some of the most endangered in the United States. Many species exist for which the critical habitat needs are poorly known. The Zuni Bluehead Sucker *Catostomus discobolus yarrowi* is one example – an imperiled fish recently listed as endangered under the U.S. Endangered Species Act of 1973. Based on the proposed listing rule the majority of Zuni Bluehead Sucker populations are located in streams on the Navajo Nation in Arizona. Additionally, new genetic information raises the possibility that Bluehead Suckers *Catostomus discobolus* on the Navajo Nation may be a distinct genetic unit closely related to the Zuni Bluehead Sucker. Little is known about the ecological requirements of the Zuni bluehead sucker, and such knowledge is critical for their conservation. This information allows managers to conserve existing suitable habitat, and if needed, to modify existing streams to create more suitable habitat. We sampled three streams including Whiskey, Crystal, and Tsaile Creek, in the Chuska Mountains to develop habitat suitability criteria for Navajo Nation genetic subunit Bluehead Suckers. We also sampled Kinlichee, Black Soils, and Scattered Willows Wash on the Defiance Plateau to develop habitat suitability criteria for Zuni Bluehead Suckers. To capture fish three sampling techniques were used: electrofishing, seining, and snorkeling. Sites sampled in each stream were recorded as occupied or unoccupied. Environmental characteristics (stream width, velocity in m/sec, depth, substrate, instream cover, overhead cover, macro habitat and temperature) were also measured at all sites. Environmental characteristics of occupied sites were compared to those of all available sites to identify habitat that was suitable and preferred for each target species.

**Student

David Ward, U.S. Geological Survey, Grand Canyon Monitoring and Research Center,
2255 North Gemini Drive Flagstaff, Arizona 86001; dlward@usgs.gov

Rylan Morton-Starner, U.S. Geological Survey, Grand Canyon Monitoring and Research
Center, 2255 North Gemini Drive Flagstaff, Arizona 86001; rmorton-
starner@usgs.gov

Ben Vaage, U.S. Geological Survey, Grand Canyon Monitoring and Research Center,
2255 North Gemini Drive Flagstaff, Arizona 86001; bvaage@usgs.gov

Shaula Hedwall, U.S. Fish and Wildlife Service, 2500 South Pine Knoll Drive, Flagstaff,
Arizona 86001; Shaula_Hedwall@fws.gov

Eradication of invasive aquatic species using carbon dioxide and liquid ammonia

Eradication of nonnative aquatic species for the purpose of reintroducing native fish is often difficult because very few effective methods are available for removing aquatic organisms. This creates the need to evaluate new chemicals that could be used as management tools for native fish conservation. Carbon dioxide and ammonia are by-products of fish metabolism and are naturally present in the environment at low levels, yet are known to be toxic to most aquatic species. We evaluated the effectiveness of using carbon dioxide (baking soda + muratic acid) and liquid ammonia (29 %) as fisheries management tools in a series of small ponds in northern Arizona. Carbon dioxide (200 ppm) was effective at removing invasive green sunfish, *Lepomis cyanellus*, and smallmouth bass, *Micropterus dolomieu*, from small pools while allowing native roundtail chub, *Gila robusta*, to be captured and salvaged. Carbon dioxide however was not completely effective at removing invasive fishes as pond size increased and was not effective for removing northern crayfish, *Orconectes virilis*. The relatively large quantities of baking soda (1.5 g/3.78 liters) and muratic acid (2 ml/3.78 liters) required to impact fish likely limits this method of creating high carbon dioxide levels to smaller bodies of water (<379,000 liters). Ammonia was effective at eliminating green sunfish in a 2,840,000 liter earthen pond when dosed at 0.25 ml/3.78 liters, but crayfish eradication in a 2,100,000 liter earthen pond was not effective even at 1.5 ml/3.78 liters. Liquid ammonia may provide a simple, cost-effective way to manage invasive fishes even in relatively large bodies of water with no harmful residues.

Lisa K. Winters, Arizona Game & Fish Department, 5000 W. Carefree Highway,
Phoenix, Arizona 85086; LWinters@azgfd.gov
David Rogowski, Arizona Game & Fish Department, 5000 W. Carefree Highway,
Phoenix, Arizona 85086; DRogowski@azgfd.gov

Factors affecting hoop net CPUE in Little Colorado River, AZ

The Little Colorado River is a warm, saline, unregulated tributary to the Colorado River in Arizona and vitally important as spawning and rearing habitat to native desert fishes. Standardized sampling with hoop nets is conducted each spring over a three week period by Arizona Game & Fish in the lower 1,200 m of the Little Colorado River, with catch per unit effort (CPUE) used as an index of relative abundance of fish species. We investigated CPUE at two scales, mean daily CPUE (n=271) and individual net CPUE (n=3105 net sets) from 2004-2014. Regression tree analyses were conducted with humpback chub, flannelmouth sucker, bluehead sucker, and speckled dace mean daily catch rates from 2004-2014. The regression trees included spatio-temporal and environmental variables such as day of year, turbidity, flow, and temperature to explain the daily variance in catch rates. Additionally, we used zero-inflated models to relate individual net catch rates to river kilometer and other readily measurable variables. Day of year explained the most variation in catch-per-unit-effort of humpback chub, with more fish caught later in the spring. Turbidity and flow explained the most variation in flannelmouth suckers, flow for bluehead suckers, and temperature for speckled dace. These results show catch rates are strongly influenced by spatio-temporal and environmental variables that are encountered during sampling in the Little Colorado River and these influences should be accounted for when estimating population size or drawing conclusions on relative trends of these native fish.

Kirk Young, U.S. Fish and Wildlife Service, Arizona Fish and Wildlife Conservation Office, 2500 S Pine Knoll Drive, Flagstaff, Arizona 86001; (928) 556-2124; kirk_young@fws.gov

Michael J. Pillow, U.S. Fish and Wildlife Service, Arizona Fish and Wildlife Conservation Office, 2500 S Pine Knoll Dr., Flagstaff, Arizona 86001; (928) 556-2107; michael_pillow@fws.gov

Use of portable passive integrated transponder (PIT) antennas to supplement hoop and trammel net surveys in Grand Canyon

The capture efficiency of traditional fish sampling methods is often called into question in larger aquatic systems such as the Colorado River in the Grand Canyon. Current technology may allow biologists to supplement survey data and assess capture efficiency of tagged fish in such systems. In this pilot study, portable Li-ion powered PIT tag antennas (Marsh and Associates) were deployed along with traditional fish sampling gears (trammel and hoop nets) in the Colorado River, Grand Canyon in July and September, 2014. Up to two baited antennas were deployed nightly during two 18 day surveys and increased total unique contacts by 10%, and unique contacts of humpback chub (*Gila cypha*) by 27%. Portable PIT tag antennas appear to be a practical technique alongside traditional gear in study areas where PIT tags are abundantly deployed.

Matthew P. Zeigler, New Mexico State University, Department of Fish, Wildlife, and Conservation Ecology, 2980 S. Espina St, Knox Hall 132, Las Cruces, New Mexico, 88003; zeiglerm@nmsu.edu

Kevin B. Rogers, Colorado Parks and Wildlife, Aquatic Research Group, PO Box 775777, Steamboat Springs, Colorado, 80477; kevin.rogers@state.co.us

James J. Roberts, U.S. Geological Survey, 2150 Centre Ave., Bldg. C, Fort Collins, Colorado 80526; jroberts@usgs.gov

Andrew S. Todd, U.S. Geological Survey, Crustal Geophysics and Geochemistry Science Center, Box 25046, Mail Stop 946D, Denver Federal Center, Denver, Colorado 80225; atodd@usgs.gov

Kurt D. Fausch, Colorado State University, Department of Fish, Wildlife, and Conservation Biology, Fort Collins, Colorado 80523; kurt.fausch@colostate.edu

Predicting persistence of Rio Grande cutthroat trout populations in an uncertain future

Native western U.S. salmonids are expected to be adversely affected by climate change and its synergistic influence on other stressors. Rio Grande cutthroat trout (RGCT; *Oncorhynchus clarki virginalis*) have lost a significant amount of habitat (89%) owing to the introduction of nonnative salmonids and habitat loss. Currently RGCT are restricted to 117 small (median size: 5.8 km) isolated patches of stream habitat in New Mexico and Colorado. Predicted future changes in climate (i.e., temperature and precipitation) could further threaten these remaining populations which remain at risk of extirpation from interactions with nonnative salmonids (i.e., brook trout, brown trout, and rainbow trout) and stochastic disturbances (i.e., wildfire, debris flow, and drought). We developed models using outputs from dynamically downscaled future climate projections to predict stream temperature and summer baseflow for each patch currently occupied by RGCT. These stream temperature and summer baseflow predictions were then coupled with a Bayesian network (BN) that integrates the risks of nonnative salmonids, whirling disease, habitat conditions, and stochastic disturbances to predict the probability of persistence for RGCT populations in the 2040s and 2080s. The BN model will be beneficial to management agencies by allowing them to prioritize restoration activities. Specifically, this BN model will identify major threats to the persistence of individual RGCT populations and allow for the assessment of different management activities aimed at alleviating these threats. The flexibility of the BN model allows it to be applied to other native southwestern salmonids which face similar threats from nonnatives and climate change.

Fisheries Posters

Meredith C. Campbell, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 148, Las Cruces, New Mexico 88003; meca@nmsu.edu

Teresa D. Lewis, U.S. Fish and Wildlife Service, Southwestern Fish Health Unit, Southwestern ARRC, PO Box 219, Dexter, NM 88230; teresa_lewis@fws.gov

Colleen A. Caldwell, U.S. Geological Survey New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University, Department of Fish Wildlife and Conservation Ecology, 2980 South Espina, Knox Hall 125, Las Cruces, New Mexico 88033; ccaldwel@nmsu.edu

Detection of Asian tapeworm *Bothriocephalus acheilognathi* utilizing a non-lethal molecular screening tool

In recent decades the invasive Asian tapeworm *Bothriocephalus acheilognathi* has parasitized endangered populations of cyprinids in the Lower Colorado River. Currently, positive identification of *B. acheilognathi* infection is confirmed by necropsy and visual examination of the gut via microscopy. Successful development of a molecular marker as a non-lethal diagnostic tool will provide managers with a viable alternative for quantifying *B. acheilognathi* prevalence in endangered fish populations. Within the initial stages of a study assessing *B. acheilognathi* prevalence in the wild, we optimized methods for swabbing fish via the anogenital pore to screen for infections via extraction and PCR. The molecular methodology utilizes DNA extraction from a swab and polymerase chain reaction (PCR) to amplify sequences of ITS2 and the V4 region of the 18S r RNA gene in *B. acheilognathi*. The methodology was tested with swabs taken from 60 bonytail chub from a federal fish facility. All fish were necropsied and assessed via microscopy for infection. Ultimately, the goal of this research is to determine whether the PCR will be effective for management to replace terminal sampling to confirm *B. acheilognathi* infection. This research will provide managers with the information needed to control the spread of *B. acheilognathi* into uninfected watersheds or treat already infected populations.

**Graduate Student

Hunter Falco, Department of Fish, Wildlife and Conservation Ecology, 2980 S. Espina Street, Knox Hall, Room 132, Las Cruces, New Mexico 88003;
hrfalco@nmsu.edu

Dominique Lujan, Department of Fish, Wildlife and Conservation Ecology, 2980 S. Espina Street, Knox Hall, Room 132, Las Cruces, New Mexico 88003;
domlujan@nmsu.edu

Colleen A. Caldwell, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, 2980 S. Espina, Knox Hall Room 132, Las Cruces, New Mexico 88003; ccaldwell@ad.nmsu.edu

William Knight, U.S. Fish and Wildlife Service, Southwestern Native Aquatic Resources and Recovery Center, 7116 Hatchery Road, Dexter, New Mexico 88230;
William_Knight@ fws.gov

Manuel Ulibarri, U.S. Fish and Wildlife Service, Southwestern Native Aquatic Resources and Recovery Center, 7116 Hatchery Road, Dexter, New Mexico 88230;
Manuel)_Ulibarri@ fws.gov

Reproductive potential of wild Rio Grande silvery minnow (*Hybognathus amarus*)

The Rio Grande silvery minnow (RGSM; *Hybognathys amarus*) was listed as federally endangered in 1994 and currently inhabits less than 7% of its historic range. The majority of wild-caught adults are age 1 with a smaller portion represented by 2+. However, captive propagated stocks have maintained year classes up to 4+ years of age. Information is needed to determine the fecundity of the various age classes of hatchery-reared and wild-caught RGSM. Our objectives were to determine fecundity of 1, 2, 3 and 4 year old adult RGSM (collected from the wild but maintained in captivity), compare fecundity among age classes, and compare egg counts to volumetric estimates. Spawning trials were conducted on four age classes (year hatched:age class): 2009:4, 2010:3, 2011:2, 2012:1. We counted all eggs of five individuals (n=5) from each age class through printed photos of eggs. Fecundity (number of eggs) increased among the age classes from an average of 2,113 eggs (± 218.7 , standard error) in age 1 (2012) to 10,924 (± 777.7) in age 4 (2009) female RGSM. Our actual counts were very close to volumetric estimates. The average difference between actual counts and volumetric estimates was 4.0% for 2012 age class and 11.0% for 2009 age class. Volumetric estimates were usually slightly less than the actual counts.

**Undergraduate Student

Christina R. Perez, U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, School of Natural Resources and the Environment, 1311 E. 4th Street, Biological Sciences East 325, Tucson, Arizona 85719; cperez3@email.arizona.edu

Scott A. Bonar, U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, School of Natural Resources and the Environment, 1311 E. 4th Street, Biological Sciences East 325, Tucson, Arizona 85719; sbonar@ag.arizona.edu

William T. Stewart, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix, Arizona 85086; bstewart@azgfd.gov

Curtis Gill, Arizona Game and Fish Department, 7200 E. University Dr., Mesa, Arizona 85207; cgill@azgfd.gov

Chris Cantrell, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix, Arizona 85086; ccantrell@azgfd.gov

Comparison of length frequency, condition, and growth of select sport fish species in Arizona with those in other areas of North America

Standardization of sampling techniques allows for more precise comparison of data. We are incorporating data collected using standard AFS fish sampling methods from large and small Arizona lakes into the AFS standard sampling website tool (fisheriesstandardsampling.org) to improve this diagnostic tool for the Southwest. Data includes fish species, condition, length frequency, growth, and CPUE using standard netting and electrofishing techniques. We are currently using AFS standard core gill nets and boat electrofishing in a large reservoir to sample fish populations. In the spring of 2015 we will sample smaller aquatic systems using only standard boat electrofishing. We are identifying, measuring (mm total length [TL]), and weighing (grams [g]) all fish captured. Length, weight and species data from all surveys is then entered into the AFS standard sampling website tool (fisheriesstandardsampling.org) to calculate length frequency, condition and CPUE for each lake. All data entered into the website was validated by hand calculations. The recent development of North American standard fish sampling protocols allows for fish sampling data to be compared more precisely across local, state, and national borders. This diagnostic tool will greatly improve the ability of Southwestern fisheries biologists to diagnose fisheries problems specific to this region.

**Graduate Student

Chelsea J. Powers, University of Arizona, Department of Ecology and Evolutionary Biology, 3146 E. Kleindale Rd, Tucson, Arizona 85716;
cpowers1@email.arizona.edu

Scott A. Bonar, University of Arizona, USGS Arizona Cooperative Fish and Wildlife Research Unit, Department of Natural Resources and the Environment. 104 Biological Sciences East, University of Arizona, Tucson, Arizona;
SBonar@ag.arizona.edu

Display of underwater high-definition videography of Gila chub to increase public awareness and conservation

Gila Chub (*Gila intermedia*) endemic to southwestern United States are endangered due mostly to anthropogenic causes. In an effort to increase awareness and conservation of this animal, we will be placing a large screen television projecting facts and high-definition recorded underwater footage of Gila chub at a local visitor center (negotiations underway with Sabino Canyon). Alongside the display, we will be collecting data on visitor use and interest from on-site surveillance and a concluding survey. We will use this data to analyze dwell time (how long people are staying at the exhibit) both of our exhibit and other exhibits in the visitor center. We will then compare dwell time at our exhibit to others. In the survey we will be asking demographic questions (gender, highest education level, and age) as well as questions on prior and post awareness of the fish local to that area. From this information we hope to gather a better understanding of the visitor center audience and fine-tune future exhibits and other conservational efforts towards the target audience.

**Undergraduate Student

Roy M. Ulibarri, University of Arizona, USGS Arizona Cooperative Fish and Wildlife Research Unit, 1311 E. 4th ST., Tucson, Arizona, 85721; royulibbarri@email.arizona.edu

Scott Bonar, University of Arizona, USGS Arizona Cooperative Fish and Wildlife Research Unit, 1311 E. 4th ST., Tucson, Arizona, 85721; sbonar@ag.arizona.edu

Chris Rees, USGS-Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Rd., La Crosse, WI 54603; crees@usgs.gov

Jon Amberg, USGS-Upper Midwest Environmental Sciences Center, 2630 Fanta Reed Rd., La Crosse, WI 54603; jamberg@usgs.gov

Detecting and quantifying biomass of Navajo Nation subunit bluehead (*Catostomus discobolus*) sucker and Zuni bluehead sucker (*Catostomus discobolus yarrowi*) using Environmental DNA

Advances in technology have allowed development of DNA based methods to detect and monitor aquatic species. This new method of species monitoring in aquatic environments is referred to as environmental DNA (eDNA), and has typically been used to detect invasive species in aquatic environments through water samples. This study focuses on the use of eDNA to detect and quantify biomass of a native species. We selected five streams on the Navajo Nation in northern Arizona and northern New Mexico to compare traditional fish sampling methods and eDNA sampling of the Navajo Nation genetic subunit of the Bluehead Sucker *Catostomus discobolus* and the Zuni Bluehead Sucker *Catostomus discobolus yarrowi*. We sampled Navajo Nation genetic subunit of Bluehead Suckers on Whiskey, Crystal, and Tsaile Creek, in the Chuska Mountains. Zuni Bluehead Suckers were sampled on Kinlichee and Black Soils Creeks on the Defiance Plateau. Fish sampling was conducted using three different techniques: electrofishing, snorkeling, and seining. Our water collection methods closely followed the protocol of United States Fish and Wildlife Service. Water samples were collected and stored in an ice chest in the field, processed later that day, and shipped to the United States Geological Services (USGS) Upper Midwest Environmental Sciences Center in Lacrosse, WI for eDNA processing. These tests will evaluate whether eDNA sampling can be used in select surveys of Southwestern stream fish populations.