Western Section of The Wildlife Society Symposium:

Mohave Ground Squirrel and Amargosa Vole:

Ecology and Conservation of Low-Profile Species in the Mojave Desert

Monday and Tuesday, February 22-23, 2016

Pomona, California

Photo: Dr. Philip Leitner

Photo: Don Preisler/UC Davis School of Veterinary Medicine
A one and one-half day symposium on the Amargosa vole and the Mohave ground squirrel, immediately before the 2016 Annual Meeting of the Western Section of The Wildlife Society.

In each of three sections, the similarities and differences between the only two listed small mammals in the Mojave Desert will be discussed:

SECTION 1 – *Ecological and Evolutionary Setting*

SECTION 2 – *Climate Change and Population Dynamics*

SECTION 3 – *Conservation, Threats and Management*

**Amargosa Vole** -- The Amargosa vole has one of the most restricted ranges of any mammal in North America. Distributed disjunctly in less than 1 km² of remnant wetland habitat in the Amargosa River in the Mojave Desert, it was listed as Endangered by federal and state agencies in the early 1980’s. It was virtually ignored for decades, but over the last five years a series of studies on its distribution, genetics, demography, population dynamics, habitat use, habitat condition, and disease all point to it being one of the most endangered mammals not only in the Mojave Desert but on the North American continent. Despite the isolated setting of the vole, the process of conserving its population represents a more general situation of how to implement effective management actions in an environment of competing interests, diminishing resources, and considerable political and environmental uncertainty.

**Mohave Ground Squirrel** -- The Mohave Ground Squirrel is endemic to the western Mojave Desert, with one of the smallest ranges among North American mammals at less than 20,000 km². It is listed as Threatened by the State of California, but a petition for federal listing was rejected by the USFWS in 2011. It has been impacted by multiple threats, including grazing, mining, off-road recreation, agricultural development, and urban expansion. Determining the habitat requirements of this species has presented a challenge for scientists. Renewable energy development may present a new challenge, while future climate change projections make its long-term future seem tenuous. Conservation planning to protect important habitat and linkages is urgently needed.
Schedule

MONDAY (February 22, 2016)

1:00-1:05  Welcome and Announcements
1:05-1:25  Symposium Introduction (Russell Scofield)

SECTION 1   Ecological & Evolutionary Setting (Phil Leitner- Moderator)

1:25 – 3:05  Amargosa Vole (100 minutes)

Deana Clifford – Conserving the Amargosa Vole: Where Have We Been and Where Are We Going?
Brian Croft - Working with Partners to Conserve Federally Listed Species Along the Amargosa River
Chris Conroy – California and Amargosa Vole Distribution and Genetics
Austin Roy - Range-wide Sign Surveys, Fecal Decomposition, and Predators of the Amargosa Vole
Chris McCriddy - Turning Sinks into Sources: Mixing Short and Long-term Management Strategies to Revitalize the Amargosa River’s Riparian Bird Community

3:05 – 3:30  Refreshment Break

3:30 – 5:00  Mohave Ground Squirrel (90 minutes)

Ed LaRue – History, Distribution and Conservation of the Mohave Ground Squirrel (Xerospermophilus mohavensis)
Barbara Leitner - Mohave Ground Squirrel Annual Cycle, Diet and Habitat Requirements
Marjorie Matocq - Genetics of the Mohave Ground Squirrel

5:00 – 5:15  SECTION 1 Wrap-up and Q&A

6:30  Informal, Optional “pizza session” Off-site (see flyer)

We are pleased to offer a comprehensive bibliography for the Mohave ground squirrel, compiled by Ed LaRue and reviewed by the MGS Technical Advisory Group. This document is available for download at:

TUESDAY (February 23, 2016)

7:45 a.m. Coffee, tea

SECTION 2 – Climate Change and Population Dynamics (Kathy Simon - Moderator)

8:30- 8:35 Summary of prior day, announcements

8:35 – 10:05 Amargosa Vole (90 minutes)

Rob Klinger – “It Never Rains In…”: State-space Modeling of Mojave Precipitation Patterns and Their Relationship to Amargosa Vole Habitat and Demography

Anna Godinho – Wetland Vegetation Dynamics and their Relationship with Climatic Variability in the Lower Amargosa River Watershed

Ashley Beechan - Spatial and Temporal Influences of Bulrush Production on Vole Population Dynamics

Janet Foley - Superimposing Myths of Metapopulation Persistence on a Reality of Patch Change and Loss: The Amargosa Vole Shell Game against Extinction

10:05-10:30 a.m. Refreshment Break

10:30 – 12:00 Mohave Ground Squirrel (90 minutes)

Kathy Simon – Challenges Associated with Studying Mohave Ground Squirrels

John Harris - Multi-year Population Dynamics of the Mohave Ground Squirrel from Coso Range Study Sites, Inyo County

Rich Inman - Mohave Ground Squirrel Habitat Suitability Modeling and Climate Change

12:00 – 12:15 SECTION 2 Wrap-up and Q&A

12:15 – 1:15 LUNCH

SECTION 3 – Conservation, Threats and Management (Robert Klinger - Moderator)

1:15 – 2:40 Amargosa Vole (85 minutes)

Stephanie Castle - Restoration of a Rapidly Degrading Marsh in Support of the Endangered Amargosa Voles

Risa Pesapane - Tecopa North: A Captive Colony of the Endangered Amargosa Vole

Patrick Donnelly - It Takes a Village: Restoring Historic Range for the Amargosa Vole in Shoshone, California

Susan Sorrels - Shoshone Village, a Study in Desert Ecosystems and Economic Sustainability

Chris Otahal - Development and Implementation of the Amargosa Wild and Scenic River Plan
2:40 – 3:05  Mohave Ground Squirrel (25 minutes)
Reagen O’Leary - State Regulatory Procedures for Projects in Mohave Ground Squirrel Range

3:05 – 3:30 p.m.  Refreshment Break

3:30 – 4:30  Mohave Ground Squirrel (60 minutes)
Scott Osborn - Mohave Ground Squirrel Conservation: The CDFW Sacramento Perspective
Amy Fesnock - Understanding the DRECP BLM Land Use Plan Amendment: What Do We Gain for Mohave Ground Squirrel Conservation?
Philip Leitner - Conserving the Mohave Ground Squirrel – What Will Work?

4:30 – 5:10 p.m.  FULL PANEL DISCUSSION
(include Section 3 Q&A in final panel discussion)

5:10 – 5:15 p.m.  Closure, Thank You, Symposium Evaluation

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Welcome Reception & Wildlife Photo Gallery

Tuesday, February 23  7-9pm  Extra Fee Required, $15

Join us to kick-off the 2016 Annual Meeting and make connections with new & old friends and colleagues. We will serve up a “slider buffet,” and a well-stocked no-host bar will also be available. We will also launch our wildlife photo exhibit. Check out what fellow Western Section members have been up to lately and celebrate the opening night of our 61st Annual Meeting! Relax, decompress…and we have more great events scheduled daily (and nightly) through Friday!
Conserving the Amargosa Vole: Where Have We Been and Where Are We Going?

Deana L. Clifford, California Department of Fish and Wildlife – Wildlife Investigations Lab, 1701 Nimbus Road, Suite D, Rancho Cordova, CA 95670, deana.clifford@wildlife.ca.gov, (916) 358-2378; Co-authors: Brian Croft, Janet Foley, Rob Klinger

The Amargosa vole (Microtus californicus scirpensis) has one of the most restricted ranges of any mammal in North America. With a disjunct distribution covering less than 1 km$^2$ of remnant wetland habitat in the Amargosa River in the Mojave Desert, it was listed as endangered by federal and state agencies in the early 1980’s. Although the voles were largely ignored for decades, a series of studies over the past six years on the voles’ distribution, genetics, demography, population dynamics, habitat use, habitat condition, and disease all indicate it is one of the most endangered mammals not only in the Mojave but on the North American continent. Aggressive multiple-institutional recovery efforts including creation of a refuge/captive breeding population, translocations and reintroductions, habitat creation and restoration and experimental field manipulations are being conducted. Although the goal is to maintain secure and self-perpetuating populations across the species range, the United States Fish and Wildlife Service did not identify de-listing criteria for this species because of a paucity of information on its biology and management needs. Recovery criteria that incorporate uncertainty have been utilized for other species and seem most appropriate for voles. Research focused on specific short and long-term threats to voles and metapopulation and source-sink dynamics would aid in the development of such recovery criteria, and allow for the development of testable hypotheses and ground conservation actions to be implemented in an adaptive management framework. Critically, it would also enable uncertainty to be incorporated into potential management alternatives and facilitate the evaluation of these scenarios to determine if de-listing or down-listing are possible.

Working with Partners to Conserve Federally Listed Species along the Amargosa River

Brian Croft, U.S. Fish and Wildlife Service, 777 East Tahquitz Canyon Way, Suite 208, Palm Springs, California, 92262, (760) 322-2070, Brian_Croft@fws.gov
The Amargosa River watershed is home to numerous endemic species restricted to isolated wetland, aquatic, wet meadow, and desert riparian habitats supported by ground-water discharge. These habitat types also support avian species that rely on them for nesting or stopover sites during migration. Sixteen of these species are listed as either, threatened, endangered, or candidates for listing under the federal Endangered Species Act. Climate change, loss of habitat, ground-water depletion, impacts to spring outflows, and non-native species are shared threats for the majority of these taxa. This presentation highlights a number of conservation efforts carried out by the U.S. Fish and Wildlife Service and its partners along the Amargosa River.

California and Amargosa Vole Distribution and Genetics

**Chris Conroy**, Museum of Vertebrate Zoology, 3101 Valley Life Sciences Building, University of California, Berkeley, California, 94720, (510) 643-7709, ondatra@berkeley.edu; Co-authors Janet Foley, Risa Pesapane

Conservation genetics has played a significant role in understanding the history and threats of many endangered plants and animals. The Amargosa vole poses several conservation challenges that we hoped to address with genetic tools. In this presentation, we will cover five main areas. First, we will discuss the origins of the Amargosa vole in relation to other Mojave Desert populations of voles using several classes of genetic markers. Second, we will discuss past and present uses of nuclear microsatellites to look for structure among the marshes around Tecopa. Third, we will discuss levels of diversity in immune function genes in Amargosa voles relative to other desert populations. Fourth, we will discuss progress in using Next Generation techniques to generate massive numbers of genetic markers for husbandry of a captive population and phylogeography among desert populations. Fifth, we will discuss the preliminary results of an annotated genome of a single Amargosa vole, and its potential role in better understanding the biology of this fascinating, endangered population.


**Austin Roy**, CDFW – Wildlife Investigations Lab, 1701 Nimbus Road, Suite D, Rancho Cordova, CA 95670, austin.roy@wildlife.ca.gov, (949) 291-8735; Co-authors: Deana Clifford; Anna Rivera, Stephanie Castle; Robert Klinger; Amanda Poulsen; Greta Wengert; and Janet Foley

The endangered Amargosa vole (*Microtus californicus scirpensis*) occurs only in discrete, dynamic marsh habitat patches in the Mojave Desert. Accordingly, determining whether or not voles are present in any given marsh is critically important for prioritizing conservation efforts, developing predictive occupancy models, and understanding threats to vole persistence. From 2012-2015 we characterized potential habitat patches as vole “present” or “absent” based on observation of vole sign: fecal pellets, runways, and vegetative clippings. Additionally, we documented changes in biomass and physical presentation of fecal pellets under field conditions over 1.5 years and calculated decay rates for fecal samples in two habitat patches. We also examined the role of predators in relation to vole presence at potential habitat patches. Our results show that fecal decay rates vary based on environmental factors and these variations should be taken into account when determining the use of vole sign in examining vole presence. Using animal sign alone may misrepresent actual occupancy rates due to difficulty in determining the relative age of sign observed. Further study of vole sign is essential to better understand the efficacy of using vole sign as an indicator of vole presence.

Turning Sinks into Sources: Mixing Short and Long-term Management Strategies to Revitalize the Amargosa River's Riparian Bird Community

**Christopher McCreedy**, Point Blue Conservation Science, 3820 Cypress Drive #11, Petaluma, CA 94954, (415) 717-7426, cmccreedy@pointblue.org; Co-author: Leonard S. Warren
Bird species that rely on desert riparian habitats in southwestern North America have undergone steep population declines since the twentieth century, and several are now listed as Endangered, Thretened, or of special concern.

In addition to habitat loss and degradation due to development and water diversions, riparian-obligate bird species may be negatively affected by conversion of native riparian vegetation communities to exotic salt-cedar (*Tamarix*), and by brood parasitism by the Brown-headed Cowbird (*Molothrus ater*). From 2005-2015, we monitored nests of all species on the Amargosa River in southeastern California. Our data set includes both pre- and post-*Tamarix* removal (which began in 2006) and pre- and post- Brown-headed Cowbird trapping, which began in 2007. Nesting success and territorial densities have increased dramatically for all open-cup nesting species since 2007, with proportional nesting success varying from 60-90% annually since the onset of cowbird trapping. State and Federally Endangered Bell's Vireo (*Vireo bellii*) productivity has increased from 4 from 2005-2008 to 136 fledglings produced from 2009-2015. Extensive surveys in 2015 lead us to extrapolate a conservative estimate of 200-300 Bell's Vireo fledglings produced in the greater Shoshone-Tecopa, CA area during the 2015 breeding season. By increasing host productivity, Brown-headed Cowbird trapping can provide rapid re-occupation of restored habitats by potential cowbird hosts, can provide a buffer of new recruits if productivity is locally depressed due to *Tamarix* removal, and can promote emigration of recruits to nearby, isolated desert riparian populations that may not otherwise be self-sustaining.

**Session 2: Climate Change and Population Dynamics**

“It Never Rains In…”: State-space Modeling of Mojave Precipitation Patterns and their Relationship to Amargosa Vole Habitat and Demography


The Amargosa vole (*Microtus californicus scirpensis*) is a federally and state listed endangered species whose range is limited to an area of about 1 km² of remnant wetlands in the lower Amargosa River watershed in Inyo County, California. Because it occurs almost entirely in vegetation dominated by bulrush (*Schoenoplectus americanus*) there is general concern that changes in precipitation patterns could alter the vole’s habitat to such a degree it could be driven to extinction. As an initial step in developing a greater understanding of the relationships among precipitation, bulrush vegetation, and vole demography I used Multivariate Autoregressive State-Space models (MARSS) to: (1) analyze and model temporal and spatial patterns of precipitation in the Mojave from 1950 through 2014; and, (2) predict the likely pattern of precipitation in the voles range within the same period of time. State-space models estimate parameters for higher-level processes while accounting for sampling error at lower “observation” levels, and MARSS models are particularly effective for analyzing multiple correlated time series. Monthly data from 19 stations within the Mojave ecoregional boundary were classified into wet, dry, and monsoon seasons then analyzed individually as well as pooled (total annual precipitation). Collectively, the models indicated the region where the vole occurs has been the driest one in the Mojave over the last 60 years. There were two asynchronous temporal patterns across the ecoregion but little spatial correlation among local patterns. Thus, predictions of the pattern of precipitation in the lower Amargosa River watershed were derived from the six stations closest to the voles range. A heuristic model was developed from the correlations between predicted precipitation patterns and vegetation production since 1984, providing a multi-scale framework for testable hypotheses that explain vole population dynamics under current climate conditions and justify projections under future scenarios.

**Wetland Vegetation Dynamics and their Relationship with Climatic Variability in the Lower Amargosa River Watershed**
The Amargosa vole (*Microtus californicus scirpensis*) occurs almost exclusively in wetland vegetation dominated by bulrush (*Schoenoplectus americanus*). Thus, information on dynamics of the extent, continuity, and condition of bulrush patches is critical for conservation of the vole. Our goals for the last year have been to: (1) analyze spatio-temporal dynamics in the Normalized Difference Vegetation Index (NDVI) from wetland vegetation over the last four decades; (2) relate dynamics in NDVI from bulrush patches to variability in precipitation; (3) analyze recent changes in bulrush cover from field data collected from 2012 through 2015; and, (4) model the relationships among bulrush cover, stem density, and biomass for eventual predictions of bulrush distribution and abundance for future climate scenarios. Time series models of NDVI derived variables indicated a high degree of spatial and temporal vegetation dynamics from 1985 – 2014. In general there was an increase in bulrush production through 2010 followed by a pronounced decrease through 2014, as well as a shift in the start and end of the growing season to earlier in the year. Dynamic linear regression models and cross-correlation analyses indicate precipitation was associated with NDVI indices of the amplitude, overall production, base level, and seasonal rate of bulrush production. Data from 648 vegetation plots show bulrush cover decreased 17% to 90% from 2012 to 2015, an empirical pattern consistent with the NDVI models. There were very strong correlations among bulrush stem density, biomass, and cover, thereby making modeling and forecasting of bulrush productivity under future climate scenarios quite promising.

While the wetlands in the lower Amargosa River have been dynamic, the patterns from the recent period of drought in the western United States have provided a window of potential future state changes in bulrush that could result in diminished quantity and quality of vole habitat.

**Spatial and Temporal Influences of Bulrush Production on Vole Population Dynamics**

*Ashley Beechan*, U.S. Geological Survey, Western Ecological Research Center - Yosemite Field Station.
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Evolutionarily, it is likely that the use of wetland vegetation by the Amargosa vole (*Microtus californicus scirpensis*) is a behavioral adaptation that has allowed it to persist in the extreme heat and aridity of the Mojave Desert. Ecologically though, it is less clear if its strong selection for wetland patches dominated by bulrush (*Schoenoplectus americanus*) is related more to top-down (predation) or bottom-up (food resources) processes. In this study we focused primarily on the importance of bottom-up processes on vole population dynamics by evaluating relationships that bulrush production (measured from Normalized Difference Vegetation Index [NDVI] data) had with individual, demographic, and population variables. We hypothesized that body mass, the proportion of reproductive individuals, the proportion of juveniles in the population, survival, recruitment, abundance, and population rate of change would be greatest in periods and in sites with high values of NDVI if bulrush production had an important influence on vole population dynamics. Per capita survival had no relationship with NDVI, suggesting predation or agonistic intra-specific interactions were primarily responsible for mortality. We did find strong support for our hypothesis based on relationships that spatial patterns of abundance and the proportion of reproducitively active adults had with NDVI, and moderate support based on the proportion of juveniles. However, relationships NDVI had with recruitment, age class proportions, temporal patterns of abundance, and rate of population change revealed complex relationships between bottom-up and density-dependent processes. The patterns indicate that multiple, often interacting factors drive the population dynamics of the Amargosa vole, and that these factors can vary in importance both spatially and temporally. Shifts in climate that reduce bulrush production would likely translate to consistently low negative rates of population growth and likely extirpation of the vole through demographic processes before outright habitat loss occurred.
Superimposing Myths of Metapopulation Persistence on a Reality of Patch Change and Loss: The Amargosa Vole Shell Game against Extinction

Janet Foley, School of Veterinary Medicine, 1320 Tupper Hall, University of California, Davis 95616, 530-754-9740, jefoley@ucdavis.edu

The critically endangered Amargosa vole became a highly specialized Mojave Desert endemic as the increasingly dry post-Pleistocene climate isolated marsh habitats on which the vole depends into tiny patches with only a single, marginal quality food-source for the vole, Olney’s three-square bulrush. Even within the last two decades, anecdotes suggest that there is less flooding, longer stretches among marshes of untraversable harsh alkaline desert playa, and erosion of genetic variability. Patches that might serve to constitute a metapopulation are increasingly isolated, have low colonization frequency, and are very small, suggesting that within-patch persistence is generally poor. Often, a Levin’s metapopulation model is invoked as an explanation for the persistence of a fragmented population, in part because it is comforting to think that colonization can balance extinctions and a species can persist. However, given stochasticity, a true Levin’s metapopulation is doomed to extinction. In the case of the vole, the scenario and theory are made even more complicated by the ephemeral nature of the patches. Here we examine data to support mainland-island vs. strict sense metapopulation dynamics to sustain the Amargosa vole. Understanding true patch dynamics is critical to predicting extinction and managing inter-patch connectivity to support this extremely vulnerable small mammal’s recovery.

Session 3: Conservation, Threats and Management

Restoration of a Rapidly Degrading Marsh in Support of the Endangered Amargosa Voles

Stephanie Castle, Department of Environmental Science and Policy, University of California-Davis, One Shields Avenue, Davis, CA 95616. (530) 752-4326 stcastle@ucdavis.edu; Co-authors: Eliška Rejmánková, Steve Parmenter, and Janet Foley

Amargosa vole (Microtus californicus scirpensis) (vole) is an endangered mammal with a highly restricted geographic range. This vole species has an obligate dependence upon Olney’s three-square bulrush (Schoenoplectus americanus) for cover, food source and other aspects of habitat. Recent data indicate catastrophic losses of both voles and their habitat resulting from hydrologic alteration and subsequent crash of vegetation within a primary habitat patch near Tecopa, CA. Restoration and rehabilitation of this marsh is thus imperative to promoting recovery of bulrush habitat and ensuring survival of extant voles. To inform management and rehabilitation/restoration of marsh habitat, a series of thinning and replanting treatments were completed in addition to modification of water flow throughout the marsh. Data collected over the course of 18 months indicate a significant positive effect of litter removal on bulrush resprouting ($p<0.0001$). Germination experiments and field observations show litter presence also has an inhibitory effect on seedling germination within the marsh. In addition, modifications of water levels within the marsh have lead to further regeneration of bulrush in the habitat area. These conclusions are directly guiding management decisions to restore vole habitat and conserve marsh habitats in the region.

Tecopa North: A Captive Colony of the Endangered Amargosa Vole

Risa Pesapane, School of Veterinary Medicine, 1320 Tupper Hall, University of California, Davis 95616, 530-754-9740, rrpesapane@ucdavis.edu. Co-authors Nora Allan, Austin Roy, Deana Clifford, and Janet Foley

In extreme cases of extinction risk, endangered species may be taken into captivity as both a way to ensure that the species will not be lost as a result of catastrophic events and for captive propagation for future reintroduction. The captive colony of Amargosa voles (Microtus californicus scirpensis) at UC Davis not only serves to protect this subspecies from extinction, but also offers a unique opportunity to study the biology of this highly specialized and
elusive rodent. In July of 2014, ten male and ten female Amargosa voles were trapped using Sherman rodent traps and transported from Tecopa, California to the UC Davis animal facility. Voles are housed in both indoor and outdoor cages that mimic natural conditions, albeit to different extents. Pedigree data is maintained using the animal management software PopLink and analyzed with the package Kinship2 in R. Reproductive and developmental data is collected during routine husbandry practices and behavior assessed by both observation and motion-triggered cameras. Over eighteen months, 30 breeding pairs have been created producing 138 progeny generating information previously unknown about litter size, gestation, parental care, development, and reproductive and social behavior of the Amargosa vole. Colony managers have also observed unforeseen pathologic processes leading to mortality and perplexing dietary challenges. Tecopa North is a successfully established captive breeding program capable of producing Amargosa voles for reintroduction in the wild. The colony has also revealed new knowledge gaps in the dietary needs of the vole that have broader implications for the release of animals from captivity, particularly species that are highly specialized for survival in marginalized habitat. This talk will present the current findings on the biology of the Amargosa vole, lessons learned for captive survival and reproduction, and proposed research to address the existing knowledge gaps.

It Takes a Village: Restoring Historic Range for the Amargosa Vole in Shoshone, California

Patrick Donnelly, Amargosa Conservancy, CA-127, Shoshone, California, 92384. (760) 852-4339
patrick@amargosaconservancy.org

The Amargosa vole is a critically endangered rodent endemic to the spring fed marshes of the Amargosa Basin in the Northern Mojave Desert. One of the most promising ideas from recent agency efforts to save the species is the reintroduction of the vole to its historic range in Shoshone, California, eight miles north of its extant habitat in Tecopa. Because the extant habitat is confined to isolated patches of habitat within a single marsh system, the vole is highly vulnerable to disturbance events. Creation of habitat in Shoshone provides the opportunity to create a lifeboat population. In the century or so since the vole lived in Shoshone, however, habitat conditions have changed dramatically. Thus the reintroduction of the vole to Shoshone Village requires a collaborative approach to conservation. The Amargosa Conservancy, a small conservation non-profit, is working with a private landowner, agencies, universities, and other non-profits to restore this habitat. This process includes gathering information about historic conditions, assessing current habitat types for restoration potential, organizing collaborative planning sessions, “re-setting” the habitat by clearing existing vegetation, recontouring land, promoting and outplanting desirable vegetation, and adapting plans on-the-fly as obstacles present themselves. Limited resources need to be deployed creatively to ensure restoration objectives are met within limited budgetary constraints. This talk will detail the planning efforts, initial forays into the on-the-ground restoration, and reflections on collaborative conservation in a diverse, multi-stakeholder partnership. Restoring habitat at Shoshone Spring for the Amargosa vole is a remarkable opportunity to rescue a species while demonstrating a novel approach to endangered species conservation on private lands.

Shoshone Village, a Study in Desert Ecosystems and Economic Sustainability

Susan Sorrels, Shoshone Education and Research Center, Shoshone, California 92384, (760) 852-4335, sesorrells@earthlink.net

As a child growing up in Shoshone the wetlands, the mountains and the canyons in and around Shoshone were my playground, and, as a child, I fell in love with the land and its habitants. As I grew up and traveled far away I often reminisced about the beauty and uniqueness of the Amargosa region. When I returned home and decided to stay and run the family businesses I was determined to do so in a way that honored the land and its habitants. This goal was almost overwhelming but I quickly learned that it was attainable through the power of partnerships. Through the years I have worked with USGS, NRCS, BLM, California Fish and Wildlife, US Fish and Wildlife, The Nature
Conservancy, the Amargosa Conservancy and other regional conservancies as well as other NGO partners. Our goals have included invasives control, habitat restoration, trail blazing and monitoring and protecting endangered species. I've also worked with many universities and, with a group of geology professors, established a field camp called the Shoshone Education and Research Center in Shoshone to facilitate scholars doing research in the Amargosa region. Shoshone Village also has reached out to the local community through partnerships with the Shoshone Museum, the Amargosa Conservancy, the BLM, other local businesses and SHEAR by offering educational programs such as talks and walks and, as a result, has created many advocates for the area. But one of our most rewarding partnerships has been with California Fish and Wildlife in our quest to save the Shoshone Pupfish, which was declared extinct in the 1930’s. We are accomplishing this goal by habitat restoration and expansion. We also will be working with the vole group to ensure the survival of the Amargosa Vole. The pupfish project not only has increased the odds of survival of the Shoshone Pupfish, and hopefully will accomplish the same goal for the Amargosa Vole, but it also serves as an example of the power of partnerships in achieving goals that protect and steward the land and its national treasures for future generations.

Development and Implementation of the Amargosa Wild and Scenic River Plan

Chris Otahal, Bureau of Land Management, Barstow Field Office, 2601 Barstow Road, Barstow, California, 92311, (760) 252-6033, cotahal@blm.gov

The Amargosa River segment in the vicinity of the towns of Shoshone and Tecopa, California, is a unique and highly bio-diverse island of green nestled within the extremely arid Mojave Desert. This area contains a plethora of wildlife and plant species, including several endemic species found nowhere else on earth. In recognition of this high bio-diversity, this segment of the Amargosa River was established by the Bureau of Land Management as an Area of Critical Environmental Concern (ACEC) in 2002 and later as a Wild and Scenic River (WSR) in 2009. The Barstow Field Office of the Bureau of Land Management is in the process of developing a Comprehensive River Management Plan (CRMP) for the Amargosa River WSR/ACEC. This presentation will discuss the development of this CRMP, outline the goals and objectives for managing the Outstanding and Remarkable Values for which the Wild and Scenic River was designated, and illustrate how on-going research is being integrated into the development and implementation of the biological focus area of the CRMP.

Mohave Ground Squirrel:

Session 1: Ecological & Evolutionary Setting

History, Distribution and Conservation of the Mohave Ground Squirrel (Xerospermophilus mohavensis)

Ed LaRue, Circle Mountain Biological Consultants, Inc., P.O. Box 3197, Wrightwood, CA 92397, (760) 964-0012, ed.larue@verizon.net

Discovered in 1886 in Lucerne Valley, San Bernardino County, California and formally described in 1889, the Mohave ground squirrel (MGS; Xerospermophilus mohavensis) is the only California-endemic squirrel species. It has the smallest known range of the three ground squirrel species with which it is sympatric, including white-tailed antelope squirrel (Ammospermophilus leucurus), California ground squirrel (Otospermophilus beecheyi), and round-tailed ground squirrel (Xerospermophilus tereticaudus). The species is known from only San Bernardino, Los Angeles, Kern, and Inyo counties, up to approximately 1,700 meters (5,600 feet) elevation, west of Mojave River. The area of the geographic range is approximately 20,000 km².
The earliest distributional studies were conducted by Wessman (1977) and Aardahl and Roush (1980). Results of protocol trapping surveys required by the California Department of Fish and Wildlife since 1988, live-trapping surveys by Leitner beginning in 2000, camera surveys by Leitner and Delaney beginning in 2009, and volunteer efforts since 2010 suggest that the occupied range has been reduced since 1993. Today, projects up to five miles beyond the 1993 range boundary are subject to protocol trapping surveys of three five-day periods between mid-March and mid-July.

Most of what we know of MGS ecology and natural history has come from studies by Recht in Los Angeles County in the mid-1970’s and by the Leitners in the Coso Range of China Lake Naval Air Weapons Center beginning in 1988. Radiotelemetry by Harris and Leitner has documented home range and juvenile dispersal. Matocq and Bell have carried out extensive genetics research. A current study is underway to determine the extent of hybridization between MGS and round-tailed ground squirrels, where they coexist west of Barstow.

The MGS was listed as Rare in 1971 and Threatened in 1984 by the California Fish and Game Commission. In 1995 and again in 2011, the U.S. Fish and Wildlife Service denied two petitions for federal listing. In 2006, the Bureau of Land Management designated a Mohave Ground Squirrel Conservation Area including 6,988 km² of public lands. CDFW’s 2015 Draft MGS Conservation Strategy should be released in 2016.

**Mohave Ground Squirrel Annual Cycle, Diet and Habitat Requirements**
Barbara M. Leitner, 2 Parkway Court, Orinda, CA 94563, (925) 253-8300, bleitner@pacbell.net

Much of what we know about the basic biology of the Mohave ground squirrel (MGS) is based on a 10-year study at four sites in the Coso Range in Inyo County, plus additional radiotelemetry work at Freeman Gulch in Kern County. These are the only multi-year research efforts conducted throughout the active season with animals marked for individual identity. Based on these observations, it appears that adults emerge from dormancy in February and mate in late February-early March. Young are born in late March-early April and become independent in May. Adult males can become dormant in May or June, with females following in June or July. The young may not accumulate enough fat reserves to enter dormancy until August. Mohave ground squirrels spend at least 6 months of the year physiologically inactive in deep burrows, thereby avoiding summer drought and winter cold. When winter rainfall is inadequate for sufficient spring vegetation growth, there is reproductive failure and early entry into dormancy. Almost all information on the diet is based on microhistological analysis of fecal samples collected from 1988-1996 at the Coso study sites. The diet was strongly dominated by foliage, with flowers and seeds becoming important later in the active season. Only 8 plant taxa (3 species of chenopod shrubs and 5 herbaceous species) made up almost 71% of the diet. In the spring of dry years (<80 mm winter rainfall), MGS relied heavily on foliage from chenopod shrubs (winterfat, spiny hopsage, and saltbush). In the summer of dry years, foliage from a few species of herbaceous plants was the most important dietary component. MGS have been recorded in all natural plant communities of the western Mojave Desert. There is some evidence that they are more likely to occur on sites with abundant winterfat and/or spiny hopsage. Although individuals are occasionally observed on steep, rocky sites, the great majority of occurrences have been on level to gently sloping terrain with relatively fine-textured soils suitable for burrow construction.

**Genetics of the Mohave Ground Squirrel**
Marjorie Matocq, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89512, (775) 784-4621, mmatocq@cabnr.unr.edu

Current patterns of genetic variation within the Mohave ground squirrel are the result of both historic and ongoing processes. The species is characterized by three genetic groups found in the northern, central, and southern portions of the range, respectively. The deepest genetic subdivision within the species coincides spatially with the Owens River system and this probable ancient barrier to gene flow still explains the greatest portion of genetic subdivision within the species. Nonetheless, we also find that localities that are connected by multiple potential linkages with suitable habitat experience more genetic exchange over time. Indeed, at the Freeman Gulch study site (Little Dixie Wash), an area characterized by suitable habitat and long-term occupation, we find that the spatial scale of genetic structure suggests large dispersal distances (~ 1 km), consistent with previous direct estimates. Another
factor that may be influencing genetic variation in certain Mohave ground squirrel populations is hybridization with round-tailed ground squirrels (Xerospermophilus tereticaudus). Recent analyses have identified definite evidence of hybridization between the species where their distributions meet. There is evidence of backcross individuals suggesting that at least some first generation hybrids are fertile. Further, backcrossing appears to occur in both parental directions leading to the potential for genetic introgression between the species.

Session 2: Climate Change and Population Dynamics

Challenges Associated with Studying Mohave Ground Squirrels
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Because of its elusive behavior and difficulty in trapping large numbers of individuals, the Mohave ground squirrel is a challenging animal to study, resulting in a situation where few lead researchers and institutions are involved and where sampling and modelling may provide less accurate or statistically defensible information than for other species. Although this species has been studied for almost four decades by Dr. Leitner, the amount of information that remains either largely unknown (range boundaries, specific habitat requirements), or relies upon one study (diet, annual and life cycles) is great. Few academic researchers and institutions have been involved, resulting in few existing peer-reviewed publications. Existing modelling, protocols, and permitting rely heavily on the work of one lead researcher, Dr. Leitner. Although he has consistently been and remains a diligent and committed researcher, the reliance on one researcher's analysis and interpretation of the existing data may result in missing perspectives. There is no lack of dedicated agency personnel, as well as volunteers, but all of these people need to balance other work demands and have very little time to focus on this animal. I am concerned that the result of this may be sampling methodologies and modelling that have thus needed to rely on less available data and fewer analyses than have been available for other species, and thus may be less reliable than those provided for species where a great deal of information and scientific discourse is available. The challenges that need to be overcome are to identify additional institutions and researchers to study an animal for which results can be a decades or more in the making, and to fund additional studies, many of which are very labor intensive and therefore expensive. One of the fundamentals of scientific exploration is in theorizing and debating results, and then interpreting these results into management in the natural world, a process that for the Mohave ground squirrel is currently built on a narrow foundation.

Multi-year Population Dynamics of the Mohave Ground Squirrel from Coso Range Study Sites, Inyo County
John H. Harris, Biology Department, Mills College, Oakland, CA 94613, (510) 504-2427, johnh@mills.edu

Mohave Ground Squirrel (Xerospermophilus mohavensis) populations have been monitored at two sites in the Coso Range of Inyo County, CA since 1990. Monitoring has provided data on the size of the adult population in spring following emergence from dormancy. This dataset provides the only long-term information about population dynamics for the species. The abundance of adult Mohave ground squirrels at these two study sites has varied greatly over the past 26 years. Mohave ground squirrel reproduction is closely linked to winter rainfall and spring production of herbaceous forage; reproduction appears to require minimum precipitation in the range of 65-80 mm during the period October 1 – March 31. Periods during which adult numbers were high were correlated with multi-year episodes of rainfall above the threshold for reproduction. Conversely, periods of drought resulted in low adult numbers. The recent 3-year drought is unprecedented in recent decades and demonstrates the sensitivity of Mohave ground squirrel abundance to long-term drought. This is of great concern given the potential impacts of future climate change. Finally, this multi-year record of extreme year-to-year variability in adult numbers illustrates the need for long-term monitoring of other key Mohave ground squirrel populations.

Mohave Ground Squirrel Habitat Suitability Modeling and Climate Change
Mohave ground squirrels, *Xerospermophilus mohavensis* Merriam, have a highly restricted range in the northwest Mojave Desert in California, USA. Their small range is further reduced by habitat loss from agriculture, urban development, military training, and recreational activities. Development of wind and solar resources for renewable energy has the potential to reduce existing habitat further. We used maximum entropy habitat models to describe current and future potential habitat while considering juvenile dispersal in the context of future renewable energy development in the region. Sixteen percent of historic habitat has been impacted or lost to anthropogenic development at present and an additional 10% may be affected by renewable energy development in the near future. We show that *X. mohavensis* habitat suitability is higher in areas slated for renewable energy development than surrounding areas. Under the B1 emissions scenario, previously assumed to be ‘more ecologically friendly’, our models predicted losses of up to 64% of extant habitat by 2080, while under the more drastic A2 emissions scenario, we suggest losses of only 56%. New potential habitat may become available to *X. mohavensis*, thereby offsetting as much as 6,330 km² (50%) of the current habitat lost. Habitat lost due to planned energy development was marginal compared to habitat lost from changing climate, but disproportionately affected current habitat.

**Session 3: Conservation, Threats and Management**

**State Regulatory Procedures for Projects in Mohave Ground Squirrel Range**
Reagen O'Leary, California Department of Fish & Wildlife, Central Region, 1234 E. Shaw Ave. Fresno CA 93710, (559) 243-4014 ext. 244, Reagen.OLeary@wildlife.ca.gov

This discussion will include California Department of Fish & Wildlife's role in environmental regulations and laws related to Mohave ground squirrel and their habitat including a broad brush overview of the following environmental regulations and laws: California Environmental Quality Act, California Endangered Species Act, Fish and Game Code, and California Code of Regulations, title 14, section 783.2. Regarding the California Environmental Quality Act, this presentation will include a discussion on its overall purpose, definition of a project, the document types, a review of the biological resources section, the authority to mitigate, and examples of mitigation measures for Mohave ground squirrel. In addition, this talk will include a discussion on the supporting biological surveys and reports that California Department of Fish & Wildlife staff utilize as supplemental information in a California Environmental Quality Act document when a project is within Mohave ground squirrel range. In discussing the California Endangered Species Act and related regulations, the presentation will include the State definition of ‘take,’ describe when a State Incidental Take Permit is warranted for a project, application requirements, common take minimization measures used, permit issuance criteria, and habitat management land requirements. This talk will also describe information California Department of Fish & Wildlife staff seek in biological survey reports to assess existing conditions of a project site and the potential for Mohave ground squirrel to be impacted by project activities. Mitigation strategies for Mohave ground squirrel and their current conservation needs will also be examined.

**Mohave Ground Squirrel Conservation: The CDFW Sacramento Perspective**
Scott D. Osborn, California Department of Fish & Wildlife, Wildlife Branch – Nongame Wildlife Program, 1812 Ninth Street Sacramento CA 95811, (916) 324-3564, Scott.Osborn@wildlife.ca.gov

The Mohave ground squirrel (*Xerospermophilus mohavensis*) was one of the first species to be listed when the California Endangered Species Act was enacted in 1971. Despite 45 years of CESA protection, the Mohave ground squirrel faces most of the same threats as when listed, plus newer threats, such as commercial-scale renewable energy development and climate change. The prospect of widespread renewable energy development in the Mojave Desert spurred CDFW to complete the MGS Conservation Strategy, which is currently in preparation for external expert review. When it is formally adopted by CDFW, the Conservation Strategy will provide CDFW’s policy and management recommendations for the species. CDFW works with the MGS Technical Advisory Group, a large group of agency, private sector, and NGO biologists and managers, to obtain input and disseminate information about the species and its conservation. Among the recent work products of the MGS TAG are a set of prioritized...
Conservation Actions and a list of necessary Research and Monitoring Activities. In 1987, CDFW promulgated a set of MGS survey recommendations for CEQA projects that may impact MGS (“the protocol”). The protocol should be updated to include a statistical basis for the number of survey visits and trap densities, as well as incorporate new methods for detecting the squirrel. In 2011, the U.S. Fish and Wildlife Service found that listing MGS as endangered or threatened under the federal Endangered Species Act was not warranted. A brief discussion of the ramifications of not listing the species under ESA will be presented.

Understanding the DRECP BLM Land Use Plan Amendment: What Do We Gain for Mohave Ground Squirrel Conservation?
Amy L. Fesnock, California BLM State Office, 2800 Cottage Way, Sacramento, CA 95825, (916) 978-4646, afesnock@blm.gov

The Desert Renewable Energy Conservation Plan and Land Use Plan Amendment Final Environmental Impact Statement was published in November 2015. It represents the Bureau of Land Management’s portion of the multi-agency Desert Renewable Energy Conservation Plan. To realize conservation within the California desert to its fullest extent, the private lands portion of the DRECP should be completed. There are limitations as to what BLM can provide in a Land Use Plan, based on its authorities (e.g. BLM cannot make designations on private lands). But until such time that the private lands portion of the DRECP is completed, there are several key advantages that the DRECP LUPA provides for species conservation. These advantages, some of which are not immediately obvious or easy to understand, will be discussed. Several examples of this follow. The amount of land identified for conservation purposes is substantially larger than previous Land Use Plan designations. Connectivity across the landscape is identified as a key management priority. The amount of allowable disturbance is smaller and not limited to authorized activities. The amount of compensation for impacts is similar to or greater than identified in existing Land Use Plans. The definitions of allowable uses are better defined. The scope and scale of conservation measures is broader and more clearly identified to allow for better implementation. While there is no “perfect” land use plan, the DRECP LUPA makes large strides to improve the conservation of wildlife and plants on BLM administered lands.

Conserving the Mohave Ground Squirrel – What Will Work?
Philip Leitner, Endangered Species Recovery Program, California State University, Stanislaus, Turlock, CA 95382, (925) 899-4948, pleitner@pacbell.net

First, we need to decide what the MGS conservation goals should be. Is the goal to restore the species so that viable populations exist throughout its historic range? Or should the goal simply be to protect important habitat that is currently occupied and prevent further decline in distribution and/or abundance? Unfortunately, restoration is probably not realistic. Approximately 1/3 of the original MGS range no longer supports the species. This includes most of the privately-owned land, particularly in the southern part of the range. It is not clear why MGS are absent from undeveloped lands in this area and therefore it is not clear how to bring them back. It appears that the most realistic conservation goal is protection of remaining MGS populations and their habitat, while maintaining connections between these populations. Since the existing populations and linkages are concentrated on BLM and military lands, it will be up to these federal agencies to provide leadership. This may be awkward, as the species is not federally-listed and federal agencies are therefore limited in the resources they can apply to its conservation. Furthermore, there could be conflicts due to military training and testing missions and due to the multiple use mandate of BLM, which must find room for renewable energy, mining, motorized recreation, and livestock grazing on its lands. A number of actions are needed to achieve the more limited goal of conserving existing populations and their habitat. Surveys should be conducted to confirm the distribution of MGS populations on federal lands. These populations should be monitored to determine trends in MGS distribution and abundance and in important habitat features. Such monitoring efforts will also help to test the validity of proposed climate change models. The potential adverse effects of interactions with the round-tailed ground squirrel should be investigated in depth. There are at least two areas in which acquisition and conservation of private lands should be pursued to secure connections between MGS populations on BLM and military lands. Improvement of occupied habitat is only
possible by reducing anthropogenic impacts such as motorized recreation and grazing, which may not be practical in many cases. Measures such as captive breeding and translocation seem unnecessary at this juncture.

Symposium Coordinator Biographies

Rob Klinger is an ecologist with the United States Geological Survey and works out of the Yosemite Field Station. He is a bit all over the place with his interests, but his conceptual BFF’s for the last few decades or so have been plant-animal interactions and population/community dynamics. He does moonlight with fire and invasive species topics though, especially when he can work on projects that buck the “conventional wisdom” on these issues. He bores rather easily so he prefers to work in fairly extreme environments (alpine, deep tropical lowland forests, deserts) so his attention doesn’t wander, making him fall asleep and snore loud. He can’t really imagine doing anything as enjoyable as ecological research (welllll…maybe flying really fast jets would be up there), but at times when the bureaucratic grind gets especially onerous he can be found reflecting with pleasure on his days as a ski bum or making a beautiful cast with his fly rod into a wide river at sunrise.

Phil Leitner has been associated with the Endangered Species Recovery Program of California State University, Stanislaus since 2001. However, his research interest in the state-listed Mohave Ground Squirrel goes all the way back to 1988. He has spent many months in the Mojave Desert using live-trapping, camera trapping, and radiotelemetry to investigate the current distribution, habitat requirements, and annual cycle of this elusive little rodent.

Kathy Buescher Simon has been a member of the TWS-Western Section since 1992 with breaks during time abroad serving as a Peace Corps Volunteer (Philippines 1990; Senegal 1997-99). Kathy grew up as a city kid on the south side of Chicago and came to California to attend the University of Redlands, where she graduated in 1989 with a degree in General Biology. After receiving her degree she worked as a “Hot Shot” for the Forest Service until she got her foot in the door of the wildlife group in the Klamath doing seasonal spotted owl surveys. She eventually came back to southern California and landed her first full-time wildlife job with a large environmental consulting firm where she first learned to love the Mojave Desert, where she still works today. In 2002 she started working on her own for several reasons - to gain flexibility with her schedule, to have the ability to choose jobs that were more meaningful.

She started working with Mohave ground squirrels in 1993 at Edwards Air Force Base under Mark Allaback and David Laabs from Biosearch Associates and found her passion in trapping small mammals, and particularly this elusive creature, maybe because catching these little guys poses such a challenge. She continues to work with the species today, helping Dr. Leitner as a field assistant for the Mohave ground squirrel workshop TWS sponsored in 2006 and completing volunteer trapping efforts for the Department every year since 2009, and trapping and now camera work whenever she can. She’s happy to work with new people and train people whenever she has the opportunity.
Thanks to our “Voleunteers”* for this symposium!! Alexa Lindauer and Steven Lee...
(*Did we really write that? Ouch!!)

TWS Certification, Recertification and Professional Development:
This Symposium contains 11 hours of content, or 0.9 equivalent semester hours. For initial certification as a Certified Wildlife Biologist (CWB) or Associate Wildlife Biologist (AWB), request 0.9 hours, probably in section 1b (Wildlife Biology) or 1d (Zoology). If needed, partial credit (up to 0.5 hours) could be requested under section 6 (Policy, Administration and Law). You can also round-up the 0.9 hours to 1.0 hour. In your course description be sure to mention that this was a TWS Western Section-sponsored Symposium.

For CWB Recertification or in support of obtaining a Professional Development Certificate, list this event as 11 hours under category 1 (Organized Activities).

Additional Questions? Contact your TWS Western Section Professional Development Committee.