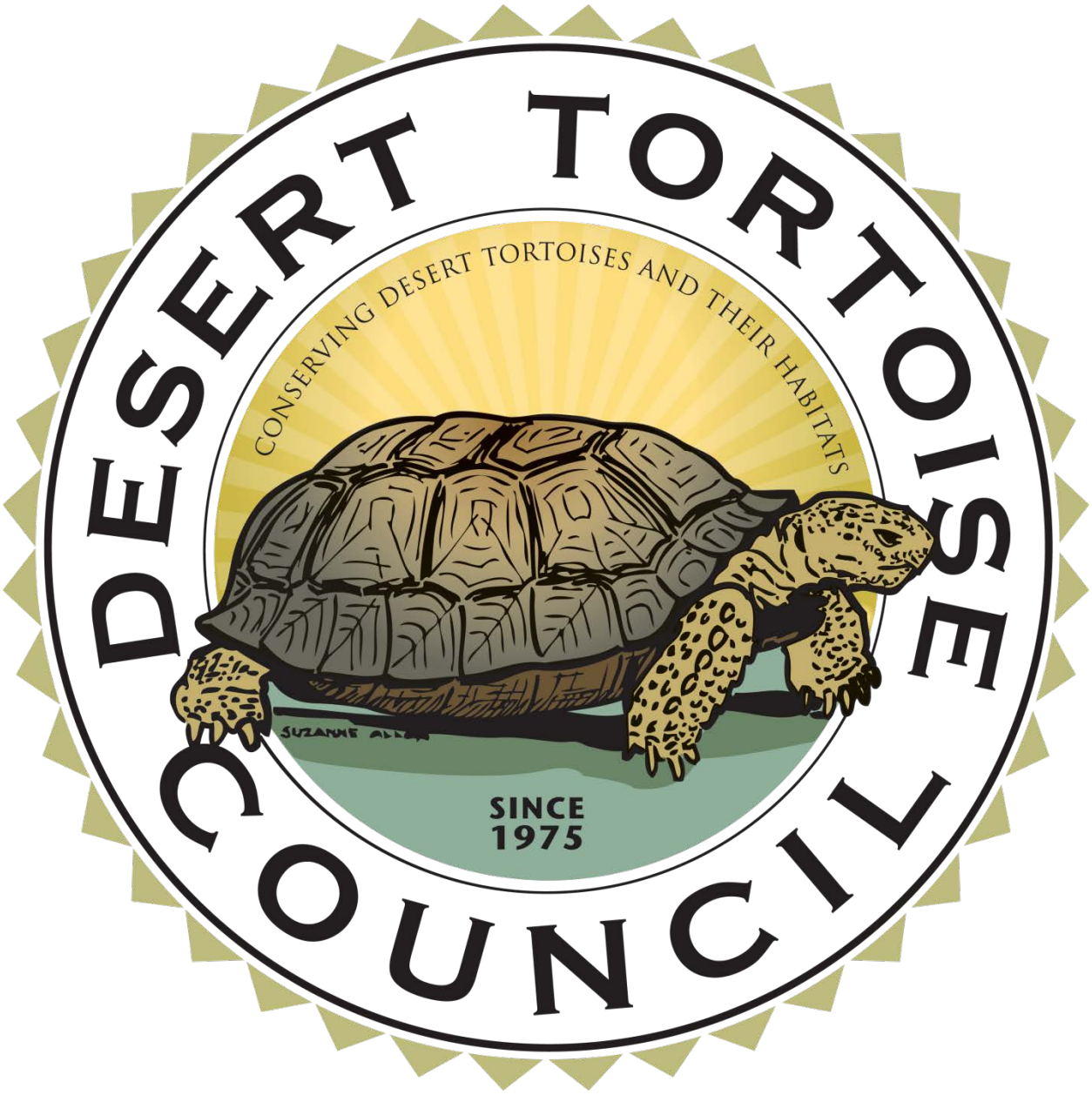

ABSTRACTS

42nd Annual Meeting and Symposium

Sam's Town Hotel and Gambling Hall, Las Vegas, Nevada

February 24–26, 2017

FORTY-SECOND ANNUAL MEETING AND SYMPOSIUM
THE DESERT TORTOISE COUNCIL

Sam's Town Hotel and Casino, Las Vegas, NV
February 24–26, 2017

ABSTRACTS OF PAPERS AND POSTERS

(Abstracts arranged alphabetically by last name of first author)
*Speaker, if not the first author listed

STUDENT PAPER

A Framework for Restoration to Support Desert Tortoise Recovery in the Western Mojave

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The Bren School of Environmental Science and Management Master's group project, Operation Desert Tortoise, has partnered with the Desert Tortoise Council and is working with the Desert Tortoise Preserve Committee, Inc. to design the framework for restoration for a portion of the eastern expansion parcels of the Desert Tortoise Research Natural Area (DTRNA). Overall, desert tortoise populations have declined by 27 – 67% in the past ten years (USFWS, 2015), and experts in the desert tortoise community are concerned that if these populations are further reduced, recovery may simply not be possible. With human-caused habitat loss and degradation being the greatest threats to the desert tortoise, the framework for restoration seeks to increase the amount of viable desert tortoise habitat by identifying needed restoration actions, including field assessments, an implementation timeline, success criteria and performance measures, a monitoring timeline and cost comparisons for each action. The framework includes the creation of a site assessment tool that prioritizes restoration actions that have long lasting effects on desert tortoise habitat, thus, providing managers with a decision support tool to help assess the quality of a parcel in terms of its restoration potential as well as identify restoration actions needed to improve or maintain that quality. Using this type of framework for restoration efforts, land managers can select the most well-suited and cost-effective treatments. They will also be able to establish an adaptive management strategy based on data generated during the monitoring process. Although this framework for restoration is currently associated with a specific site, the general idea is that the framework itself and decision making process associated with it can be replicated at other sites. Through identifying priority restoration areas, limited resources can be better allocated, giving desert tortoise populations a better chance for recovery.

PLENARY ADDRESS

Restoring and Conserving Nutritionally Rich Diets for Desert Tortoises

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The nutritional requirement of the desert tortoise has often been overlooked in conservation efforts, but this is changing. We review current principles of desert tortoise nutrition, the status of favorable and unfavorable forage plants in tortoise habitats, and techniques for restoring key forage plants, including a field project at the Large-Scale Translocation Site in southern Nevada. Desert tortoises are selective foragers, often targeting particular native annual forbs such as desert dandelion (*Malacothrix glabrata*), desert plantain (*Plantago ovata*), Mojave lupine (*Lupinus odoratus*), and lacy phacelia (*Phacelia tanacetifolia*), along with certain herbaceous perennials (e.g., desert wishbone-bush, *Mirabilis laevis*). Recent experiments illustrate that diets consisting of non-native annual grasses result in poor health or even death of tortoises. Non-native annual grasses dominate most current desert tortoise habitats. This underscores that developing reliable treatments to restore a diverse "menu" of native annual forbs in habitats infested by non-native grasses should be prioritized. In our 2013-2014 field project designed to improve forage offered by the habitat to tortoises, an integrated suite of treatments including fencing, seeding, and pelletizing seed increased the availability by 600% of the preferred native annual forb desert plantain. While no studies have yet attempted to link actively restoring favored forage plants with measures of tortoise health, this study demonstrates that the first step in this endeavor—actively enhancing a habitat's forage quality—is feasible.

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Desert Tortoise: Conserve, Protect, Recover

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The Center for Biological Diversity continues our conservation and recovery campaign for the desert tortoise and its habitat in California, Nevada, Utah and Arizona through science-based advocacy, participation in administrative processes, public information and litigation. For over 20 years, the Center has consistently supported increased protections for the desert tortoise (DT) as

the path to desperately needed species recovery. Currently, our desert tortoise protection campaign is focused on protecting habitat and animals from improper development of renewable energy, mining, off-road vehicles, grazing and other destructive activities and development proposals. Some of the tortoise conservation projects that the Center has been focused on in the past year include: renewable energy projects including local planning; new National Monument designations; the development and adoption of the Desert Renewable Energy Conservation Plan in California; challenging the proposed translocation of 1,100 West Mojave tortoises for Marine Corps training in Twentynine Palms expansion area; appealing the ISDRA (Algodones Dunes) management plan; protecting other species that share some habitat with DT including flat-tailed horned lizard; supporting the expansion of Joshua Tree National Park; opposing the Eagle Crest Pumped Storage project and monitoring implementation of the revised Desert Tortoise Recovery Plan. Despite the generally bleak picture of decreasing numbers, on-going habitat losses for the species and a presumably antagonistic federal administration upcoming, some successes have been achieved that may result in increased conservation, for example, the designation of the new National Monuments, and the adoption of the Desert Renewable Energy Conservation Plan.

U.S. Fish and Wildife Service Update on the Desert Tortoise Recovery Activities

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Major activities within the Desert Tortoise Recovery Program in 2016 included 1) a reinvigorated level of range-wide monitoring surveys, including six strata in California and three strata in Nevada/Arizona/Utah. 2) The first annual cycle of strategic recovery implementation directed by the Desert Tortoise Management Oversight Group (MOG) was completed. In 2015 the MOG agreed to a set of range-wide priorities on which to focus recovery activities, and in 2016 agencies implemented a number of projects developed by the Recovery Implementation Teams (RITs) related to these priorities. The RITs are actively developing and preparing to implement numerous new projects in 2017. 3) We coordinated monitoring of the Eldorado Valley translocation site. Two years of post-translocation surveys reflect the increased density from tortoises released from the former Desert Tortoise Conservation Center. 4) Continued work on captive-tortoise management included registration/micro-chipping clinics for private tortoise custodians and a third sterilization clinic for privately held tortoises in collaboration with Tortoise Group, the Nevada Department of Wildlife, and others in Las Vegas.

Recurring Themes in Models of Anthropogenic Impacts to Agassiz's Desert Tortoises

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For several years we have collected data on populations of Agassiz's desert tortoises, their habitats, and potential positive and negative anthropogenic impacts to the species and its habitats using from 200 to 760 randomly located hectare plots at multiple sites. At four of the sites, we developed models to evaluate relationships between presence of desert tortoises (live, dead, burrows, scats, and other sign), vegetation associations, and anthropogenic impacts. Three sites were in the Mojave Desert (Jawbone-Butterbread Area of Critical Environmental Concern, El Paso Mountains, Fremont Valley and western Rand Mountains) and one was in the Colorado Desert (Chemehuevi Valley). Anthropogenic variables included grazing by cattle, sheep, and feral burros; off-highway vehicle use; roads; trash; mines; and other evidence of land use. Drawing on these replicates of studies conducted in different localities, we will report on recurring patterns of positive and negative associations between tortoise presence, vegetation type, and anthropogenic variables.

From Density Estimates to Translocation: Lessons from 8,500 Acres of Solar Development in the Mojave Desert.

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Over the last eight years Ironwood Consulting Inc. has worked on four large solar projects (Desert Sunlight, Stateline, Silver State South, and Playa) during all phases of development, including pre-project impact assessment, permitting, construction, and operations. Collectively, these projects required clearance surveys performed on 8,500 acres and translocation of over 200 desert tortoises. We implemented the Service's density estimation formula in the 2010 survey protocol and are now able to compare actual densities resulting from clearance surveys to pre-project estimates. We found that the formula resulted in accurate point estimates. The guidance found in the desert tortoise manual and project translocation plans needed to be reconciled during project implementation, and lessons learned from our experience may be valuable to future translocation projects. Post-translocation monitoring for each project varied in terms of frequency and duration. We compare each project's requirements and assessed desert tortoise movement, injury, and mortality. These projects resulted in low rates of injury and mortality during the monitoring periods to date. Data collection and management systems were improved during the process and the resulting product proved effective for all stakeholders including the solar companies and wildlife agencies.

Bucks and Does and Jacks and Jennies: Mule Deer and Donkeys in the Sonoran Desert

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Desert mule deer (*Odocoileus hemionus eremicus*) and bighorn sheep (*Ovis canadensis* ssp.) are the largest native ungulates occurring in the Sonoran Desert. Feral ass (*Equus asinus*), frequently referred to as donkeys, are native to northeastern Africa but are a free-ranging, naturalized species in western North America. The persistence of feral donkeys in designated herd management areas is ensured by Public Law 92-195—the Wild and Free-roaming horses and burros act of 1971—that guarantees their continued abundance both within and outside of herd management areas. Donkey management and removal of excess animals is complicated by inadequate census methods, insufficient funding, the Wilderness Act of 1964, the Public Rangelands Improvement Act of 1978, the Federal Land Policy and Management Act of 1976, sentimental arguments of some members of the public, and uninformed politicians pandering for votes. Further, section 4600 of the California Fish and Game Code makes it illegal to kill, wound, capture, or possess any "undomesticated burro" in that state. Impacts of donkeys to bighorn sheep have been more fully researched than impacts to desert mule deer. Nevertheless, donkeys have the potential to compete with mule deer and other native species besides bighorn sheep. Distribution of deer and donkeys in the southeastern California study area was similar with respect to (1) distances to roads, catchments, and rivers and canals in winter; (2) normalized-difference-vegetation index and distance to catchments in spring; (3) distance to rivers and canals in summer; and (4) slope in autumn. Diet analyses revealed biologically significant overlap during the abundant-forage season. Diets of mule deer had high proportions of browse in all seasons and low proportions of grasses and forbs, whereas diets of donkeys contained less browse and more grasses and forbs. In the absence of additional common-sense legislation and funding adequate to ensure compliance with PL 92-195, donkeys will continue to increase in number, and the potential for consequences to native species, including the desert tortoise, will be exacerbated.

Sexual Segregation and its Implications for Deer Inhabiting Arid Environments

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The concept of sexual segregation was formally proposed by Charles Darwin. Among mammals, ruminants have been the focus of most research on this phenomenon. Sexual segregation has been defined traditionally as the differential use of space (and often habitat and forage) by sexes outside the mating season, but other hypotheses related to activity patterns do cannot explain the spatial separation of sexes or their differential use of habitats and forages. Sexual segregation is especially common among sexually dimorphic ungulates, and members of the Cervidae are classic examples of sexual dimorphism. Males are generally much larger than females and, thus, are less vulnerable to predation than are smaller females. As a result, males are

able to exploit habitats and concomitant nutritional resources not available to females, who bear the burden of bearing and rearing offspring. Although the sexes are together during the mating season, they generally are separated spatially for the majority of the year, a factor that confounds the conservation and management of mule deer and white-tailed deer inhabiting arid environments and elsewhere. The conservation and management of these desert-adapted ruminants, as well as other sexually dimorphic ungulates, requires recognition that males and females behave as if they are different species for much of their annual cycle. These differences have important ramifications for many activities associated with the conservation of mule deer and white-tailed deer, among which are the influences of sexual segregation on the results of population surveys and the subsequent manipulation of populations, the manipulation or enhancement of habitat for the benefit of the taxon, and the consequences of the spread of diseases or parasites, all of which must be considered in the context of conservation and management, particularly in arid and unpredictable environments where resource availability can vary substantially from year to year.

Burrowing And How it Shaped Gopher Tortoise Evolution: Evidence from the Fossil Record and Beyond

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Modern gopher tortoises represent two very distinct but related clades, strongly supported by both morphological and molecular evidence. We prefer the historical designation, *Xerobates*, for the more conservative complex (*Xerobates agassizii*, *X. morafkai*, *X. evgoodei*, *X. berlandieri*) while reserving *Gopherus (*sensu stricto*)* for the more specialized group (*G. polyphemus*, *G. flavomarginatus*). The two clades have been distinct since at least the late Oligocene, approximately 26 million years ago (Ma). Gopher tortoises, endemic to North America, are the only truly fossorial land turtles. There is evidence (i.e., morphologic, taphonomic) that ancestral Eocene gopher tortoises were already committed burrowers despite living in a generally equitable climate. Early Oligocene gopher tortoises (*Oligogopherus*) are even more structurally specialized for digging and are often found preserved within their burrows. These same tortoises offer plausible ancestral morphotypes for both *Xerobates* and *Gopherus*. From the early Miocene (~22 Ma) onwards the two clades become geographically and ecologically separated. *Gopherus* primarily occupied grassland and savannah habitats in the central and southeastern portions of U.S. and adjacent Central Mexican Plateau. *Xerobates* appears to have been largely confined to the southwestern U. S. and the neighboring Pacific rim of Mexico. *Gopherus* is an obligate burrower restricted to friable, sandy soils. It employs the head and neck as a buttress when extending the burrow. This behavior accounts for the distinctive structure of the skull, cervical vertebrae and associated regions of the shell. *Gopherus* possesses the most inflated inner ear cavity of any chelonian; it houses the largest otolithic mass known for any terrestrial vertebrate. *Xerobates* does not burrow in the same manner and the skull, neck and associated shell are unspecialized; its inner ear is of normal proportions and contains a relatively small to tiny otolith. Living *Xerobates* dig in a wide variety of soil types and are best regarded as facultative burrowers. *X. berlandieri* is secondarily non-fossorial. Structural and physiological considerations strongly imply that the

unique inner ear of *Gopherus* permits a tortoise to assess the surface environment, and especially the risk of emerging, while still within the protection of the burrow. The proposed mechanism involves receiving and interpreting relevant ground vibrations (seismic signals) of both abiotic and biotic origin. Its proper function also seems to dictate some aspects of burrow design. *Xerobates* lacks an equivalent sensory mechanism and is far less constrained in its burrowing behavior. In *Gopherus*, specialization for "seismic hearing" leads to reduced sensitivity to aerial sound as compared to *Xerobates*. The divergent sensory capabilities of the two gopher tortoise lineages may well reflect long-term occupation of contrasting geoseismic regions within North America. If so, it would be the first instance in which plate tectonics are shown to substantially influence the evolution of a sensory system within a terrestrial vertebrate.

POSTER

Best Management Practices for California Sensitive Reptile and Amphibian Highway Crossings

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Our primary goal is to provide Caltrans (California Department of Transportation) and other agencies Best Management Practices (BMP) guidance for the construction and of wildlife crossings for amphibians and reptiles in California by 2020. Funded by Caltrans, this 5-year project includes assessment of over 160 species of herpetofauna to road related risks, a global literature review identifying information gaps, and field studies to address information gaps to inform the BMP's.

Our first goal was to assess road risk for amphibian and reptile species in California in order to prioritize mitigation efforts. This involved assessment of over 160 species of frogs, toads, salamanders, snakes, lizards, and chelonids. Risk was scored based upon a suite of life history and space-use characteristics associated with negative road effects. One hundred percent of chelonids and 74% of snake species were ranked at above average risk from roads within their terrestrial and/or aquatic habitats, in comparison to 55% of toad species, 45% of frog species, 17% of salamanders and 14% of lizard species. *Gopherus agassizii* was ranked "Very High" in this assessment.

In conjunction with this, we are in the process of completing a global literature review to determine what is known regarding the effectiveness of barrier structures and the permeability of crossings to different amphibian and reptile species groups. This will allow us to identify knowledge gaps that reduce our ability to make informed recommendations for BMPs and to prioritize any field studies needed to address these gaps.

We invite the Council attendees to share their knowledge from past or current studies to inform this effort for the Desert Tortoise. This includes evaluation of road research priorities and study areas to include specific roads of concern and existing underpasses or culverts. We have the opportunity to collaborate on studies to inform this effort in the next several years.

Novel *Anaplasma* Species in the Environmentally Threatened Florida Gopher Tortoise

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This study reports a novel *Anaplasma* species in gopher tortoises in Florida. Members of the family *Anaplasmataceae* are obligate intracellular bacteria that replicate within membrane bound vacuoles in the cytoplasm of cells in vertebrate and invertebrate hosts. In 2015-2016, three gopher tortoises seen at the University of Florida CVM presented with anemia and intracytoplasmic inclusions in red blood cells. Pan-bacterial 16S rRNA PCR and sequencing of blood resulted in sequence consistent with a novel *Anaplasma* sp. that is most closely related to but basal to the clade containing *A. marginale, A. ovis*, and *A. centrale*, all of which cause clinically significant anemia in ruminants. After treatment with doxycycline (10 mg/kg) for up to 200 days, anemia resolved. Blood from one tortoise was used to infect a monolayer of ISE6 tick cells, and bacteria morphologically similar to *A. marginale* grew within parasitophorous vacuoles in the cell line. The 16S rRNA gene was amplified from genomic DNA extracted from infected cultures. For further phylogenetic characterization, novel consensus PCR assays targeting the groEL and sucB genes were designed. Bayesian and maximum likelihood phylogenetic analysis found that this agent was the most basal member of the *Anaplasma* clade tropic for erythrocytes. Archived gopher tortoise red blood cells from 40 animals with low packed cell volumes (PCV <20) were available from a 2003-2006 study of 12 wild populations in North and Central Florida. Interestingly, analysis of 16S rRNA sequences from these samples revealed that 14 tortoises were infected with the same *Anaplasma* species isolated from the blood of the clinically ill animal. Specific TaqMan assays for the tortoise *Anaplasma* groEL and sucB genes were designed and validated, enabling rapid, specific, sensitive, and quantitative testing. The clinical presentation of significant anemia associated with *Anaplasma* in an environmentally threatened species could have conservation implications as well as potentially impact health of animals with co-infections. Its isolation in cell culture will aid further studies to develop diagnostic tests and to investigate potential tick vectors and infectivity for other wildlife and domestic animal species.

STUDENT PAPER

Broad Host Range of *Mycoplasma agassizii*: Exposure and Infection in Chelonian Species

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Mycoplasma agassizii is a primary etiologic agent of upper respiratory tract disease (URTD) in free-ranging desert and gopher tortoises in the U.S. Although narrow host specificity traditionally has been considered a feature of mycoplasmal species, there have been increasing reports in avian species that suggest host range may not always be as restricted as previously thought. Given the documented detection of *M. agassizii* in *Gopherus* and *Testudo* species in both North America and Europe, we sought to determine the host range of this pathogen. We screened 2,773 sera from 33 chelonian species by ELISA and 455 nasal lavage/swab samples from 25 species by PCR/culture. Not including gopher and desert tortoises, 30/33 species tested were positive by ELISA and 16/25 species tested were positive by PCR/culture. Clinical isolates obtained from 10 different tortoise species representing 8 genera in Testudinae were confirmed to be *M. agassizii* by sequencing of the 16S rRNA gene. The 16S rRNA sequences between isolates obtained from both free-ranging and captive tortoises showed high homology. There were limited substitutions and indels compared with the consensus sequence, with the majority (12 nt) of differences coming from the isolate obtained from the radiated tortoise (9 substitutions, 2 insertions). In contrast, isolates from the three wild *Gopherus* species had limited sequence variation (≤ 3 nt differences), none of which were in common. Isolates from other hosts had 0 to 4 nt differences. Our results demonstrate the ability of *M. agassizii* to colonize a wide range of tortoise species, particularly within the Testudinidae. Therefore, *M. agassizii* should be considered as a differential diagnosis in diverse chelonian species presenting with URTD. The broad host range of the pathogen also should be considered as a risk factor for pathogen transmission across multiple species when establishing husbandry and breeding protocols.

Coping with Water and Heat Stress: Behavioral and Physiological Adaptations of Desert Ungulates

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Ungulates inhabiting arid environments must cope with factors affecting thermoregulation and water balance, including high solar radiation and ambient temperatures, limited availability of

water and thermal cover, and unpredictable food resources. Factors that influence the heat load imposed on an animal by the environment include direct and reflected solar radiation, thermal radiation, air temperature, wind speed, and vapor pressure deficit; the environmental heat load plus the metabolic heat produced by the animal compose the overall heat load. To deal with the conflicting challenges of maintaining body temperature within acceptable limits and minimizing water loss, desert ungulates use a variety of physiological, morphological, and behavioral adaptations. Behavioral mechanisms are most commonly used to avoid challenging environmental conditions, whereas morphological and physiological adaptations typically function to allow ungulates to tolerate heat and water stress. The physiological adaptations possessed by desert-adapted ungulates for thermoregulation and maintenance of water balance have been the subject of numerous studies involving a wide range of species. This presentation will include a discussion of the physiological, morphological, and behavioral mechanisms used by ungulates to maintain temperature and water balance in arid environments, including facultative water turnover rates, concentration of urine and feces, evaporative and non-evaporative cooling, adaptive heterothermy, diet and water balance, activity budgets, use of microclimates, morphological adaptations, and body orientation, among others. The goal of this presentation will be to review available scientific literature on thermoregulation, water balance, and the effects of dehydration in desert ungulates with an emphasis on desert mule deer and other ungulates in western North American deserts.

Clark County Multiple Species Habitat Conservation Plan Update

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The Clark County Desert Conservation Program (DCP) continues to administer the Multiple Species Habitat Conservation Plan (MSHCP) on behalf of the Cities, Clark County, and Nevada Department of Transportation as mitigation for an Endangered Species Act Section 10 incidental take permit for desert tortoise and 77 other species of plants and animals. The DCP has collected mitigation fees for 3,520.62 acres of take (e.g., development) during the period of January through December 2016, leaving 72,069.36 acres of authorized take remaining under the current permit. The 2017-2019 Implementation Plan and Budget will allocate up to $11,422,245.00 for implementation of conservation projects that benefit covered species. Highlights of the program's efforts towards conservation of desert tortoises during the past year include: completed a fourth year of a desert tortoise occupancy monitoring project; worked in coordination with the U.S. Fish and Wildlife Service to complete post-translocation monitoring in the Eldorado Valley; continued a post-translocation telemetry project on the Boulder City Conservation Easement; completed the first year of a study examining subsidized predators at the Boulder City Conservation Easement; and performed numerous outreach programs to teach children and adults about the desert tortoise and the value of desert conservation.

Informing Landscape Approaches and Species-Level Conservation Needs: Quantifying Potential Threats from Development to Sonoran Desert Tortoise Habitat to Evaluate and Inform Conservation Actions

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There is increasing support for adopting landscape approaches to resource management to help achieve diverse conservation and resource objectives across landscapes. Monitoring threats that affect multiple resources across broad extents is critical for informing landscape approaches. However, there remains a need to assess potential threats to individual species of conservation concern, and to inform management actions implemented to protect habitat for those species. Thus a key question is to what extent generalized indicators of potential resource threats can inform species-level conservation actions. We considered the utility of one generalized indicator of development (the surface footprint of terrestrial development) for evaluating and informing conservation actions for the Sonoran desert tortoise. A rangewide assessment of potential threat from development to Sonoran desert tortoise habitat has not been possible previously because of different methods used to quantify development in different ecoregions. We identified 78,228 km^2 of potential desert tortoise habitat. The surface development footprint encompasses 496 km^2 of this habitat, and includes areas of cultivated agriculture (52% of the surface footprint), impervious surfaces (primarily urban, 34%), transportation (7%), mines (6%), and energy development (0.4%). Because of the pattern of existing development, only 8% of potential habitat has no development within 2.5 km, a distance at which desert tortoises are sensitive to the effects of roads. Desert tortoise habitat protected by federal and state-level designations had lower development levels than habitat outside of these areas. We also identified areas of relatively undeveloped habitat near existing protected areas that may represent opportunities for additional protection or mitigation actions. Overall, we found that the generalized indicator of development was useful for evaluating the effectiveness of past conservation actions and informing potential future conservation actions when used in conjunction with biological data and in the context of relevant laws, policies, and plans guiding conservation actions.

Raven Management in California

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Over the past decade, the U.S. Fish and Wildlife Service has partnered with federal agencies, researchers, and other organizations to jointly carry out a program of common raven

management in the California Desert. This talk will provide a summary of the program including an overview of the 2016 Raven Workshop, the current status of funding mechanisms, projects that have been completed or are ongoing, and regulatory documents that provide for its implementation.

Adaptive Management Lessons Learned at Ivanpah Solar Electric Generating Systems (ISEGS)

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Ivanpah Solar Electric Generating Systems (ISEGS) is located in Ivanpah Valley, San Bernardino County, California. During the course of construction and operations, adaptive management has been used in an effort to protect site wildlife on a dynamic alternative energy site. Though simple, these lessons have helped reduce the impact to desert tortoises and other wildlife.

With approximately 16.2 miles of fence line at ISEGS there were opportunities for adaptive management. Initially black silt fence was installed as a requirement of the Storm Water Pollution Prevention Plan. The silt fence was removed in an effort to reduce impact to wildlife. Installation of shade structures along fence lines provided refuge to small mammals, reptiles, and desert tortoises. During warmer temperatures there was an increase in biological monitors along the fence line to look for heat stressed wildlife.

ISEGS has over 80 quarantine pens and two head start facilities which housed adult, sub-adult, juvenile, and hatchling tortoises for a total of more than five years. One of the early challenges was discovering that hatchling tortoises could fit through 1 x 2 inch tortoise exclusion fence. Another challenge was identifying each tortoise when multiple hatchlings or juveniles were placed within one head start pen with a natural desert landscape.

Seventy-two juveniles were located on site during construction. A majority of these tortoises were found during special searches for juveniles. Teams of biologists were sent into areas where juveniles were previously found to conduct concentrated searches for juveniles. These concentrated searches accounted for an additional 27 juveniles found.

Radio telemetry of more than three hundred tortoises has provided insight to best practices for tracking desert tortoises. Initially tortoises were affixed with a transmitter on the first right or left costal scute. The antenna was then attached to the second and third right or left costal scute with the remaining antenna hanging free. Epoxy gel was used on all transmitters and tubing for antenna attachment. Anecdotal observations suggested that gel epoxy degrades over time making the attachment less superior to either epoxy putty or more frequent replacement of epoxy gel. Additionally attaching the entire length of the antenna on adult tortoises appears to contribute to fewer damaged transmitters thereby lowering incidents of missing tortoises.

Process- and Scale-based Determinants of Survival for Translocated Mojave Desert Tortoises in the Ivanpah Valley, California.

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Considering the rapid pace of renewable energy development, there is a need to assess the impacts of mitigation-driven translocations on sensitive species, including the federally protected Mojave desert tortoise (*Gopherus agassizii*), which is distributed widely across a global solar energy hotspot. In cooperation with multiple project partners, we developed an effectiveness monitoring program for tortoises occupying portions of the Ivanpah Valley in southern California, and adjacent to the world's largest solar thermal power plant. Beginning in April of 2012, 372 tortoises were enrolled in a study aimed at understanding the effects of short-distance (< 500 m) translocation on tortoise survival and other key demographic parameters. We established three principal study groups: translocated, resident, and control. Within and among these groups, we are using five years of telemetry and environmental data to investigate tortoise movement patterns, habitat use, health status, genetics, and response to climate and anthropogenic factors. In this presentation, we focus on results for translocation effects on tortoise temperature regulation and behavior, body condition, growth, and mortality, as well as multi-scale movement patterns and burrow use. Based on the relatively short-term thermal effects we observed following translocation, and lack of negative effects on condition, growth, or mortality, our research suggests relatively minimal impacts following short-distance translocation releases in spring. Relationships between inter-burrow movement and weather confirmed expected thermoregulatory or resource-exploiting behaviors and suggest the potential for more restricted movement in a warmer future. Measuring and monitoring these and other relationships will allow us to isolate and quantify the effects of translocation on survival probabilities. Our study is an important step for science-based, mitigation-driven actions implemented to evaluate and reduce impacts of translocation from development on the Mojave desert tortoise and other sensitive species.

Progress Towards a Sonoran Desert Tortoise Genome to Advance Conservation and Wildlife Management

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The increasing availability of genome sequences has opened up evolutionary and population genetic analyses of speciation and demographic history at genome-wide scales. This has been demonstrated in recent genomic studies of the African elephant, giant panda, wolf, peregrine falcon, and giraffe. Findings from such studies can advise conservation strategies for wildlife management of isolated and fragmented populations and reveal the hybridization history of species of special concern. In the southwestern Mojave, Sonoran, and Sinaloan deserts, the recently defined *Gopherus* species complex (*G. agassizii*, *G. morafkai*, and *G. evgoodei*) presents a unique conservation challenge, and an exciting system in which to better understand speciation through genomic analysis. The genome of Mojave Desert Tortoise (*G. agassizii*) was recently sequenced, and availability of the Sonoran Desert Tortoise (*G. morafkai*) genome would permit fine-scale analyses of what genomic features differentiate these species, and what implications does this information have for managing the species individually. We report new evolutionary genomic analyses from the *G. agassizii* genome effort, and progress in genome sequencing and annotation for *G. morafkai* as a conservation resource, from an adult male from northern Pima County, AZ.

Exploring Desert Deer Ecology through Ecoimmunology

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What determines the abundance of parasites in a population? For the host, immune defenses are the last line of defense against a parasite infection, and thus they directly affect the survival outcome of a parasitic challenge and determine persistence and transmission of parasites. At a fundamental level, mounting an immune response is expensive in energy and resources and, thus, the principle of allocation predicts that trade-offs will occur with other energetically demanding tasks, such as survival or reproduction. Therefore, how much an individual invests into immune defenses depends on the endogenous and exogenous factors including parasite prevalence in the environment, individual nutritional state, genetic background, and intraspecific competition. The rapidly growing field of ecoimmunology provides theoretical frameworks and practical tools to explore relationships between an individual's investment in immune defenses and the individual's ecological and evolutionary state. Furthermore, these individual-level decisions about investment in immunity scale up to influence demographic characteristics and life-history traits because of their influence on survival and reproduction. Therefore, understanding immune function in wild animals is important for predicting how animal populations will respond to management, and I recommend that managers integrate data on immune function into larger

studies of population dynamics and management of populations. I will use examples from desert mule deer to illustrate these points.

Transcript Profiling Improves Assessment of Health and Immune Function in the Agassiz's Desert Tortoise

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Agassiz's desert tortoises (*Gopherus agassizii*) are subjected to a myriad of ecological and environmental stressors as human development and land use practices increase across the Mojave Desert, USA. Despite more than 20 years of intensive efforts to improve conservation for this threatened species and desert ecosystems, tortoise populations continue to decline. Recent research using gene transcription profiling in tortoises has proved useful in identifying immune or physiologic responses and overall health. We combined standard analytical blood diagnostics (e.g. hematological, biochemical, trace elements) with transcript profiles in both clinically abnormal and normal tortoises. Necropsy and histology evaluations from clinically abnormal tortoises revealed multiple physiological complications. Transcript profiling proved to be important for the identification of ill tortoises, as they increased molecular reactions for genes responding to environmental toxicants, oxidative stress, microbial and bacterial infections, and malnutrition. In addition, we monitored health responses following a facilitated transmission of the pathogenic bacteria, *Mycoplasma agassizii*, in naïve adult individuals and measured innate and induced immune reactions in tortoises over time. We found no differences in transcript profiles in tortoises (control, exposed, infected, reference) before or during the first three months of the experiment; however, exposed and diseased tortoises down-regulated their over-all immune responses the following spring as they emerged from winter dormancy.

The Role and Implications of Expanding Boundaries at the Desert Tortoise Research Natural Area

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For more than forty years, the Desert Tortoise Preserve Committee, Inc. has managed and protected the Desert Tortoise Research Natural Area (DTRNA) in a cooperative effort with the Bureau of Land Management. For the majority of that time, the Natural Area has remained its current size of 39.5 mi2, covering a vast expanse of Fremont Valley and parts of the Fremont-Kramer Area of Critical Environmental Concern. While the size and location of the DTRNA has proven to be effective for the protection of desert tortoise habitat, it is crucial that the boundaries are expanded to include more critical habitat and corridors to other important tortoise populations. This past fall, with support from 8minutenergy Renewables, LLC, the Desert Tortoise Preserve Committee began the process of expanding the protected area of the DTRNA onto 2,700 acres of

adjacent land. While this expansion increases suitable habitat for desert tortoises and offers additional opportunities for research, there are numerous threats to desert tortoise habitat that remain. Continued cooperation between environmental organizations and renewable energy corporations as well as additional research on newly acquired land will improve habitat management and advance desert tortoise conservation efforts.

California BLM: Tortoise Update

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In 2016, BLM continues to work on signing routes, restoring habitat, public outreach, and acquisitions of private land. Desert Renewable Energy Conservation Plan was signed in September 2016 and the BLM has begun implementing this Land Use Plan Amendment. Brief status updates will be provided. We continue to look for ways of leveraging the effectiveness monitoring associated with renewable energy projects into larger research projects and coordinating the data to better inform us on impacts to tortoise.

White-tailed and Mule Deer in the Arid Southwest: Taxonomy and Niche

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Deer are part of the wonderful group of mammals that walk around on their modified toenails called hooves. The word "Ungulate" is simply Latin for toenail (*Unguis*). Only two species of medium-sized deer inhabit the Southwest Deserts: the mule deer and white-tailed deer. The term "desert mule deer" is a loosely-used term for those mule deer found in the arid deserts and desert grassland or shrublands. Desert mule deer habitat varies from creosote-mesquite dominated Chihuahuan desert, to a palo verde-saguaro Sonoran desert community, upper desert grasslands, pinyon-juniper, dense chaparral, and oak woodlands. They can be found from 200-7,300 feet in elevation, but most desert mule deer are found below 4,500 feet. In Sonoran desert and desert grassland areas, large mesquite-lined washes are important habitat components for cover and forage. Coues' white-tailed deer occur from central Arizona and New Mexico southward into Mexico and occupy relatively rough, wooded terrain with steep canyons. Typical whitetail habitat in the northern part of their range is mixed oak woodland, but they can be found anywhere from ponderosa pine-mixed conifer habitat at 10,000 feet down to the upper limits of semi-desert grassland. Most Coues' whitetails are found between 4,000 and 7,000 feet elevation, but in Sonora, Mexico they occupy the lower Sonoran Desert and at these lower elevations there is considerable overlap in habitat use with desert mule deer. The vegetation associations occupied by desert mule deer and white-tailed deer in the Southwest are just the opposite of what occurs in the rest of the West. In most areas of the West where both deer species are found, mule deer inhabit the higher mountain areas and whitetails occupy the lower valleys and river systems. This habitat preference is reversed in the Southwest, where whitetails are found in the mountains and desert mule deer

occupy the lower-elevation valleys and foothills. Because of the interspersion of whitetail and desert mule deer habitat, the Southwest has an extensive zone where the two species overlap and coexist. This results in the animals being in proximity to one another throughout the year, including the breeding season. At times, mixed groups containing whitetails and mule deer are observed and hybridization is known to occur.

Nutritional Ecology of Deer in Arid Lands

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Arid and semi-arid environments where desert tortoises and Texas tortoises live present nutritional challenges to mule deer and white-tailed deer. Forage biomass is often low and forage quality is moderate. However, forage resources are highly variable and dependent on precipitation. During dry periods, shrubs and cacti are primary forage resources because they are abundant. Most shrub and cactus species are only moderate in nutritional quality, supporting adult maintenance requirements but not high levels of production. Some species produce mast (fruits, nuts, and pods) that maybe seasonally important for deer. During wet periods, herbaceous forages become available. Forbs and succulent grasses are high in nutritional quality, enabling adults to accumulate nutritional reserves and produce large, healthy fawns, and supporting high growth rates and survival in young deer. Deer have several adaptations that enable them to exist in this challenging environment. Deer are medium-sized ruminants, big enough to benefit from having a rumen to increase digestion of plant fiber but not so large as to require large amounts of forage that may not be available in arid environments. Deer are ruminants with a rumen and reticulum in which forage is fermented by symbiotic microbes and microbial products are absorbed, an omasum that regulates passage of food from the rumen and promotes absorption, and an abomasum in which acid digestion occurs. Their rumen is relatively small and therefore they require a high-quality diet relative to larger ruminants. Deer have a narrow muzzle that enables a high degree of selection. Many of the shrubs eaten by deer contain high concentrations of secondary plant chemicals. Salivary proteins, rumen microbes, and metabolic detoxification pathways enable deer to consume heavily defended browse species. Selecting a diverse diet enables deer to avoid toxicity. Diverse vegetation communities enable deer of different sexes and ages to select different diets and increase the likelihood of good forage resources being available as environmental conditions change. Supplementation studies demonstrate that nutrition is limiting for deer in arid environments. Thus, management actions that promote diverse, productive vegetation communities will benefit deer populations in arid environments.

POSTER

A New Species of *Xerobates* from the Early Pleistocene of Sonora, Mexico: Implications for the Pleistocene Biogeography of Gopher Tortoises

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A new species of *Xerobates* from the earlier Pleistocene of Pozo Coyote, Sonora, Mexico, represents a non-fossorial gopher tortoise closely related to *Xerobates berlandieri*, a species now restricted to the Gulf of Mexico drainages of Mexico and Texas. It has been hypothesized (Murphy et al, 2016) that *X. morafkai* diverged from *X. agassizii* 3 to 5 million years ago (Ma) following the embayment of the lower Colorado River at about 5.3 Ma. However, the fossil record of *X. agassizii* complex *(agassizii +morafkai+evgoodei)* in Arizona is limited to the latest Pleistocene and Holocene (McCord, 2002; Van Devender, 2002). The earlier Pleistocene records of gopher tortoises within or near the current geographic ranges of the *X. agassizii* complex in Arizona instead belong to the *Gopherus* complex *(polyphemus+flavomarginatus+ donlaloi*), while earlier Pleistocene gopher tortoises in southern California are referable to the *X. agassizii* group. The Pleistocene record is further complicated by the occurrence of a new species of a *Xerobates berlandieri*-like tortoise from northwest Sonora, immediately adjacent to the current distribution of *X. morafkai.* As the fossil record now stands, it does not appear to support the hypothesis of separation of *X. agassizii* and *X. morafkai* by the Colorado River embayment 3-5 Ma. Alternative scenarios include the possibility that these tortoise populations diverged in the late Pleistocene (>1 Ma) or that speciation occurred in geographically limited areas or environments poorly sampled by the fossil record. The new Sonoran fossil appears to have co-existed with a *Gopherus* complex-like tortoise. The possible co-association of a Late Pleistocene *X. berlandieri* (=*X. auffenbergi* Mooser 1972) on the southern Mexican Plateau with yet another *Gopherus* complex-like tortoise suggests that at the extremes of their Pleistocene ranges, *Xerobates* and *Gopherus* may have experienced limited sympatry, while likely remaining ecologically separated. Finally, the existing fossil record of gopher tortoises offers no evidence to support the idea that ancestral *X. berlandieri* reached its present geographic distribution via dispersal from the Pacific southwest across the southern U.S. or northern Mexico. A more likely scenario is that the ancestors of *X. berlandieri* first arose on the Pacific slope of Mexico (the new Sonoran fossil reflecting part of this earlier distribution) and subsequently spread eastward across the southern Mexican Plateau to the Gulf Coast.

Department of Fish and Wildlife and the Desert Tortoise Our State Reptile

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State laws have been in place since 1939 in California to protect the desert tortoise. In August of 1989, the tortoise was officially listed by the Fish and Game Commission as threatened under the California Endangered Species Act (CESA). CESA allows take with a permit for scientific, educational, management, or incidental take to an otherwise lawful activity provided the take is minimized and fully mitigated. In addition to an Incidental Take Permit (ITP), a Memorandum of Understanding for Handling Tortoises is needed and CDFW regional staff reviews the qualification of each person who will be working under the MOU. The Department also issues MOUs for research and studies on desert tortoise and permits for possession of Captive Tortoises.

In the past, there was no charge for applying for ITPs. As of September 2016, fees were enacted through Senate Bill 839 for ITPs and Consistency Determinations. This bill also increased the punishment for taking endangered, threatened or candidate species.

Several years ago the process for obtaining an MOU for handling of a listed species for scientific research was changed so that a Scientific Collecting Permit was not needed.

From Grassroots to Solid Gold – A Conservation Success Story

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In 2001, two researchers who simply wanted to know more about the desert tortoise in Mexico gathered a group of biologists together and travelled to Tiburon Island. That trip inspired an expanding effort throughout much of Sonora and northern Sinaloa to document tortoise locations and collect data on morphology, genetics, behavior, and habitat associations. From 2005 through 2013, we made annual research trips to Mexico, with Mexican associates gathering data in the intervening months. Several important papers resulted from this research, not the least of

which was the description of a new species of desert tortoise, *Gopherus evgoodei*, in 2016. The naming rights for the new species were auctioned and these funds augmented through a combined effort from several conservation organizations. The funds were then entirely donated to purchase the 1000 acre Rancho San Pablo, to augment the existing Reserva Monte Mojino (ReMM) in Sonora, Mexico. Nature and Culture International (NCI), an international conservation organization focusing on tropical forest conservation, created ReMM in 2004 and continues to expand and manage this high quality, largely intact tract of Tropical Deciduous Forest. In August 2016, nearly 50 Mexican and American biologists from varying disciplines gathered at Rancho San Pablo to inventory the plant and animal biota on this heretofore unstudied parcel. Data were collected on *G. evgoodei*, other turtles, snakes, lizards, amphibians, bats, rodents, larger mammals, birds and plants. Here we recount this success story of international collaboration and entirely positive efforts.

Quadstate Local Governments Authority

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During the past 18 years Quadstate Local Governments Authority's (Quadstate) membership has been fully engaged in protecting and working to recovery the desert tortoise. Quadstate is made up of nine counties and one city government located in both the Mojave and Sonoran Desert Tortoise Habitats. Local governments have a stake in tortoise habitat management and tortoise recovery on behalf of their own interests and their constituents. While concerned about recovery and assuring compliance with the ESA, local governments are charged with assuring the management of economic activities on public lands is using professional and scientific means that strike a balance in the spirit of conservation.

Last year Riverside County joined Quadstate adding another voice for local government in the desert tortoise arena. Quadstate's membership represents a population of over 5 million people located within the desert tortoise habitats. We are involved in all aspect of the desert tortoise management, protection and recovery. As a participant in the Desert Landscape Conservation Cooperative we await the initiation of the Mojave Pilot Project and hopeful that the additional funding will reduce threats to the tortoise population and improve the habitat conditions in that three state area. We are a member of the Recover Implantation Team and the Management Oversight Group and encouraged with their efforts to implement activities that both protect and improve the desert tortoise and their habitats. We support the USFWS and as a member of the raven workshop look forward to implementing actions that will reduce the raven population that will eliminate or reduce their threat to the tortoise. We are fully engaged in all planning efforts that have an impact on local governments and the tortoise habitats to ensure that the local interests are addressed.

Coalition for a Balanced Environment

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The Desert Tortoise Preserve Committee has formed an affiliated group with the mission of tackling the raven population explosion. The Coalition for a Balanced Environment brings together private sector companies and conservation organizations to assist local, state and federal government agencies in implementing the Desert Tortoise Recovery Plan. The initial effort is to act on the recommendations of the Desert Tortoise Recovery Implementation Teams with respect to raven food subsidies.

With assistance from the Desert Tortoise Council, the Coalition conducted a pilot study of raven food subsidy sites at desert communities nearest the Desert Tortoise Research Natural Area. Dumpsters at 111 fast food restaurants, businesses, and parks in Ridgecrest, California City and Mojave were monitored for five weeks, along with raven numbers. After this baseline period, an outreach effort was made to the restaurant managers and owners, who were given information about raven visits to their businesses, damage caused by predatory ravens, and signs that could be posted. They were asked to insure that their dumpsters were closed at all times. City staff were also contacted about the Coalition's efforts to reduce trash subsidies to ravens. Follow-up visits were made, and compliance with closures generally increased while raven numbers decreased. California City showed the greatest increase in compliance and decrease in ravens at dumpsters, followed by Ridgecrest. Mojave had a slight increase in non-compliance in post-outreach surveys.

The Coalition plans to repeat this pilot study in a more scientifically rigorous fashion, and will be offering new educational materials, signs, and information on raven-proof dumpsters. The Coalition will continue work with waste hauling companies and the local governments to increase compliance and reduce food subsidies.

The Coalition consists of a range of organizations affected by abnormally high raven populations: companies in the solar industry, Resource Conservation Districts, agricultural interests, high-tech avian repellent developers, a nuisance bird birth control company, and conservation organizations. Using the best ideas from this variety of sources, the Coalition will forge a path towards humane reductions in numbers of ravens and a more balanced ecosystem, in the desert and elsewhere.

Recovery Progress at Mojave National Preserve

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Recovery efforts for the desert tortoise at Mojave National Preserve (MOJA) in 2016, included ongoing land acquisition, exotic invasive weed control, raven control, project monitoring, and research towards population augmentation. Two parcels of land were acquired totaling 1.5 acres in critical habitat and 125.2 acres outside of critical habitat within desert tortoise range.

Acquisitions since 1994 total 24, 804 acres with 7,730 in critical habitat. Sahara mustard was controlled (4000 gal. of plant material) along a 7 mile stretch of Kelbaker road within desert tortoise critical habitat. 53 active raven nests were monitored recording 41 juvenile tortoise mortalities under 10 nests as part of the annual 508 mile powerline survey. USDA Wildlife Services subsequently removed 17 ravens associated with these mortalities. In 2016, MOJA monitored multiple construction projects including facility construction, major road realignments at eight sites, chip and seal resurfacing on 108 miles of road, emergency storm road repairs, California Edison tower retrofitting, and CalNev gas pipeline maintenance. Standard Operating Procedures for projects are being revised to better direct permit and contract development. Grazing monitoring focused on forage biomass and grazing utilization. Preliminary forage biomass estimates for spring of 2016 ranged from 2 to 735 lbs/ac within an area of higher production. Utilization within critical habitat was low (<5%) but exceeded 50% in higher elevations outside critical habitat. MOJA, USFWS and BLM are initiating evaluation of alternatives to reduce tortoise mortality on roads including exclusionary fencing and seasonal road closures. A proposal was submitted to restore additional piospheres located in the Fenner Valley using Recovery Implementation Team competitive funding. Ten tortoises were reported killed and one injured on roads within the Preserve. Research by Savannah River Ecology Lab and the University of California, Davis on juvenile tortoise survivorship is ongoing at the NPS Ivanpah Desert Tortoise Research Facility.

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50 Years of Conservation Planning in the California Desert: A History of the California Desert Conservation Area

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Last year was a milestone year for the California desert: it marked the 40th anniversary of the creation of the California Desert Conservation Area (CDCA), it saw the designation of two new BLM national monuments, and it saw the designation of over 3 million acres of California Desert National Conservation Lands through the Desert Renewable Energy Conservation Plan (DRECP), which sets forth a suite of conservation and management actions (CMAs) so that the California desert can be better managed as a total ecosystem. These CMAs emphasize protecting critical habitat, providing connectivity, maintaining ecological processes, restoring past disturbances, and preserving sensitive vegetation communities. There has been nearly 50 years of conservation planning and implementation on BLM lands in the California Desert, starting with the initial studies of the 1960s which called for a comprehensive Desert Plan, through the extensive surveys and studies of the 1970s leading to the 1980 CDCA Plan, the bioregional plan amendments of the early 2000s and now the DRECP. The BLM planning process and implementation have benefitted the conservation of the desert tortoise, which depends so much on the proper care and management of the BLM lands in the California desert.

PLENARY ADDRESS

25 Years of Desert Tortoise Recovery: The Challenges of Managing a Tortoise Population at an Urban Interface

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In the mid-1990's, Washington County, Utah was one of the fastest growing counties in the United States. Population growth fueled conflict between economic development and protection of Utah's only native turtle, the desert tortoise. Located at the edge of three geographic areas, the Mojave Desert, the Great Basin Desert and the Colorado Plateau, southwest Utah is biologically diverse, containing an array of species that are unique, some found nowhere else on earth.

Following the listing of the Mojave desert tortoise in 1990, two Recovery Units, based on unique morphological, ecological and genetic characteristics, were identified in Utah, the Northeastern Mojave and the Upper Virgin River, with the latter existing entirely in Utah and significantly smaller than other recovery units (USFWS 1994, USFWS 2011). To resolve conflicts and in an effort to provide long term protection to the desert tortoise, Washington County, under Section 10 of the Endangered Species Act, partnered to create the Washington County Habitat Conservation Plan (HCP; WCC 1995). The HCP allowed property owners to develop more than 12,000 acres of tortoise habitat and to "incidentally take" up to 1,200 desert tortoises. In exchange, a 62,000 acre reserve, managed as the Red Cliffs Desert Reserve (Reserve), was set aside for the long term protection of the desert tortoise. In an effort to extend long term protection of the desert tortoise and a myriad of other unique ecological resources, federal lands in both Recovery Units were designated as National Conservation Areas (NCA) in 2009, creating the Beaver Dam Wash and Red Cliffs NCA's.

The State of Utah has been committed in the protection and recovery of desert tortoises and actively engaged in habitat protection, restoration, translocation and population monitoring. In 1997, the Utah Division of Wildlife Resources designed and implemented a monitoring program within the Reserve to determine long term population trends (McLuckie 2016), a critical component of both the Desert Tortoise (Mojave Population) Recovery Plan (USFWS 2011) and the HCP (WCC 1995). Tortoises within the Reserve have experienced an annual decline of 3.6% since regional monitoring began in 1999 and an overall population decline of approximately 50% across the Reserve, attributed to a severe drought in 2002 and wildfires in 2005 (McLuckie 2016).

We estimate there are 1,755 adult tortoises in the Reserve and densities are higher than those reported for Mojave populations range wide (USFWS 2016). Since 2007, the tortoise population appears to have stabilized and there is no evidence of a further decrease in tortoise densities (McLuckie 2016). Stable populations are likely a result of recovery actions implemented as part of the HCP, including protection of existing habitat, restoration of degraded habitat (e.g., disturbed, burned), fencing on the perimeter of the Reserve, community education programs, and law enforcement presence. Efforts to recover tortoises including, monitoring, translocation, and habitat restoration will be discussed.

Local, state and federal partnerships are critical to successfully implement the HCP and recover desert tortoises. For millions of years, the tortoise has evolved adaptations to allow it to survive in the desert; its ability to persist in a harsh and unrelenting environment is testimony to its resilience. It will take a similar resolve and commitment to successfully manage and protect the Reserve and recover the desert tortoise in the face of continued population growth.

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Antlers of Southwestern Ungulates: A Hornographic Obsession or a Valued Ecological Indicator?

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Antlers of Cervidae are bony outgrowths that are a product of sexual selection, and play important roles in mating by bolstering reproductive success of males through attraction of females, and as weapons in male-male combat and display. By extension, sexual selection has favored the development of large antlers and, indeed, size and symmetry of antlers are heritable and are considered honest signals of phenotypic quality. Nevertheless, antlers and their comparable counterparts within the animal kingdom, are structures that are nonessential to survival and are costly to produce. Growth of antlers requires resources beyond those necessary for body growth or maintenance and thus, are not only products of sexual selection and genetic contributions, but are a product of the environment. Antlers have critically important biological functions, and animals with large antlers captivate imaginations, adorn walls, and hold a strong place in the outdoor industry. Indeed, animals with exceptionally large antlers grace the glossy covers of popular magazines and advertisements, thereby creating a “hornographic culture” relative to society’s fascination with trophy animals. Understanding what can influence a sexually dimorphic character that is nonessential to survival, yet so important given its biological and sociological

salience, is key to managing populations of large mammals and understanding how an ever-changing environment may influence those characters.

Connectivity of Desert Tortoise Populations Bridging Man-made and Natural Constrictions in Habitat

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Recent decades across the Mojave Desert have witnessed expansive urbanization, changes in the density of invasive species, increased wildfires, and increased interstitial development of the infrastructure needed to support burgeoning human populations throughout the region. Recent initiatives aimed at reducing the nation's dependence on foreign oil, and avoiding severe environmental consequences of fossil fuel exploration and consumption have shifted energy infrastructure in the Southwestern United States toward renewable energy development. The industry thus far has focused predominantly on utility scale development, which consumes large tracts of public and private lands throughout the desert. The southwestern deserts, are well suited physically for renewable energy deployment, however, they also host fragile ecosystems and many sensitive species. As urbanized areas, energy development sites, and their associated infrastructure alter and fragment the valleys of the Mojave Desert, conservation corridors are invoked with increasing frequency as mitigation tools - with the intention of maintaining gene flow and population connectivity for a myriad of species, including the desert tortoise. Recently several large solar facilities in and around Ivanpah Valley (straddling the Nevada/California border) were constructed on public lands that are firmly within desert tortoise habitat. In consideration for siting for these facilities corridors were identified that ideally serve to maintain demographic as well as genetic connectivity both within the greater Ivanpah Valley, as well as to populations in adjacent valleys connecting these populations to the rest of the species range. We implemented research in 2015 to quantify the connectivity among sample populations in and between "conservation corridors", through open habitat, and through the narrow mountain passes connecting these populations to other populations occupying adjacent valleys that comprise tortoise habitat on the landscape. By measuring demographics, genetics, movements, social structure, and habitat condition and change among 10 sites placed throughout the greater Ivanpah Valley, we quantify habitat use and responses of tortoise populations relative to these large scale disturbances. We report findings from the first two years of research on demographics, movements and initial genetic and spatial population structure.

Desert Tortoise Council Activities – 2016

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Two years ago I presented the Council's 5-year strategic plan prepared by the Board of Directors (BOD). The BOD uses this as a guiding document that establishes priorities and focuses actions of the BOD to meet our 5-year vision to be an advocate for science-based conservation and a leader in the recovery and protection of the desert tortoise. We had a 15-member BOD, with Dr. Glenn Stewart stepping down after 41 years and being replaced by Dr. Larry LaPré; there are two open BOD positions vacated by Jason Jones and Dr. Scott Abella. The BOD had a productive 2016. One of the major strategic goals is to increase collaboration with agencies. The BOD have provided "best management practices for desert restoration" developed by Drs. Scott Abella and Kristin Berry; met with agency biologists in NV to discuss assisting with tortoise projects; and provided 14 letters commenting on proposed projects in CA, NV, UT, and AZ that may impact tortoises. In collaboration with agency partners, we held one basic techniques workshop with 84 attendees and one advanced health assessment workshop. We are developing a 5-day workshop to address the certification requirements of an Authorized Tortoise Biologist—the first training will be offered this spring. There are 508 members of the Council, and our total assets, as of December 31, are $288,791. The BOD use these funds for tortoise conservation. The BOD has authorized contributing $20,000 to the management of Bolson tortoise habitat at San Ignacio el Rancho, MX, and pledged $20,000 to the Mexico Tortoise Project to acquire land at the Reserva Monte Mojino at Alamos, Sonora for Goode's thornscrub tortoise. The BOD established the Glenn Stewart Student travel award, and made one award of $500. Funding of $500 was provided to the Turtle Survival Alliance. The workshops are our major source of funds, and a short video was produced to solicit funds for habitat restoration. Though we are slowly expanding our use of social media, our website, managed by Mary Cohen, continues to expand and provides increased transparency of BOD actions. The 2018 symposium will be held at Sam's Town. The 2019 symposium is being planned for AZ; holding the symposium in AZ will increase costs. The BOD is looking for ways to off-set costs and add value with special field trips. As for all organizations, it takes people to get things done, and there is a lot do.

Managing Deer Habitat on a Changing Biological, Regulatory, and Social Landscape: the Arid Southwest

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White-tailed (*O. virginianus*) and mule deer (*Odocoileus hemionus*) are widely distributed across the arid Southwest and have tremendous social, recreational, and economic value. For more than half a century, resource managers, conservation groups, and others have invested enormous amounts of time and money improving habitat for these species. However, the biological, social,

and regulatory landscape on which these activities occur has changed dramatically over that period. Explosive urban growth and associated infrastructure developments have consumed deer habitat and created barriers to animal movements. Native plant communities are experiencing recurrent drought, climate change, fire regimes outside the historical range of variability, and invasion by exotic weeds. A large proportion of deer habitat is on public lands, placing management in a social arena strongly influenced by the changing demographics of the Southwest. Management paradigms on those lands are also shifting, away from multiple-use and toward ecological restoration and more restrictive land-use designations. Formerly commonplace practices such as development of man-made water sources (catchments) and chemical or mechanical vegetation treatments have become controversial and are fodder for administrative or legal challenges. The compliance burden for habitat projects on U.S. Forest Service and Bureau of Land Management lands (e.g., NEPA, cultural resources) has increased many-fold and often consumes the bulk of agency staff time and budgets available for habitat projects. But, all is not gloom and doom. Despite these unprecedented changes and challenges, white-tailed and mule deer populations remain largely robust, providing abundant opportunities for consumptive and non-consumptive recreation. Maintaining them into the future will require continued dedication by managers, scientists, and conservation advocates, as well as creative partnerships to accomplish on-the-ground work.

Return to the Harquahala Mountains and Hualapai Foothills Sonoran Desert Tortoise Demographic Plots

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In Arizona, the Sonoran Desert Tortoise has been the subject of monitoring for multiple decades. One of the longest term monitoring efforts conducted on Sonoran Desert Tortoises during this time has been demographic monitoring by a partnership between the Bureau of Land Management and the Arizona Game and Fish Department. Between July and October 2016 surveys were conducted at two Sonoran Desert Tortoise population trend study plots. A span of eleven and twelve years had elapsed since the last time these two plots had been surveyed. Here we will provide an overview of our monitoring strategy, the long-term monitoring plots, and recent evaluations. Finally, we will highlight the outcome of the 2016 return to the Harquahala Mountains and Hualapai Foothills long-term monitoring plots. We will compare population estimates, sex ratios, age structure, and mortality in these populations over their course of study. Recommendations regarding the monitoring strategy for Sonoran Desert Tortoises will be provided based on current knowledge and logistics.

Predators and Their Influence on Mule Deer in Arid Environments

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Predator-prey relationships are complex and can invoke great interest from biologists, livestock producers, hunters, and wildlife enthusiasts. The role of predators in reducing or suppressing mule deer populations is often debated. Observational research papers may estimate kill rates of predators (e.g., mountain lions eat a deer per week), but these results offer little in helping a wildlife manager understand the influence of predation on a given mule deer population. Deer are subject to density-dependant processes, and where deer populations are in relation to their carrying capacity determines if predator-caused mortality is additive or compensatory. Deer populations well below their maximum sustained yield (1/2 of carrying capacity) are more susceptible to being in a predator pit and generally experience additive mortality, whereas deer populations approaching carrying capacity tend to experience compensatory mortality. Mule deer populations, especially in arid environments, can fluctuate based on habitat conditions, weather, and other environmental factors. Weather and predation are not always independent of each other, and predation on mule deer may be exacerbated during drought years because of less hiding cover for fawns, fewer small and medium sized prey (e.g. rodents and lagomorphs), and decreased body condition of deer. Additionally, stalk and ambush predators, such as mountain lions, tend to take deer in proportion to their availability relative to age and body condition, whereas cursorial predators, such as coyotes, tend to take younger and older deer and deer in poorer body condition. These differences in stalk and ambush versus cursorial methods of predation may influence deer populations differently. Finally, wildlife managers are sometimes asked to implement predator management to bolster deer populations, and a summary of predator removal strategies that may benefit mule deer populations will be presented.

Lasers and 3D Printing as Raven Management Tools: A Hardshell Labs Progress Report

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We report on results of two preliminary raven management initiatives. Pistachio orchards represent an important concentrated source of food for ravens in the western Mojave Desert. In August-October 2016, we drove large numbers of ravens from a pistachio orchard in Inyokern, CA using a high-powered laser. Raven numbers were reduced by 81% in a matter of four days of firing and by 98% by day 9 and remained at that level throughout 15 days of firing. For 14 days of the post-firing phase no ravens consumed pistachios and numbers only started to gradually increase thereafter.

We have developed model juvenile tortoises, using state-of-the-art 3-D printing technology, as a way of monitoring raven predation and to use for conditioned taste and scare

aversion. Initial field deployment of the models, called Techno-Torts™, resulted in the captures of over 15 video clips and numerous still photos of ravens, coyotes, kit foxes and turkey vultures investigating and attacking the faux tortoises. We present examples of these interactions and discuss further plans for equipping the models as aversive training devices.

How to Navigate Difficult Situations on Projects

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Renewable energy at an industrial scale is an important part of achieving energy independence for the United States. However, the political backing that supports energy development in the western part of the country has also resulted in the neglect or abuse of natural resources. While a great deal of effort is placed on properly siting and permitting a project, little or no oversight happens once the project enters construction and continues into operations and maintenance. This has led to a "power vacuum," often filled by the project proponent's "environmental" staff who often ensure the least amount of information leaves the project and is reported to wildlife agencies and the public. Specific examples of such behavior are provided and suggestions made for biologists on the ground in achieving their goals of proper monitoring oversight.

Sonoran Desert Tortoises and Arizona Highways

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Arizona's transportation infrastructure poses challenges to the conservation of Sonoran Desert Tortoises (SDT; *Gopherus morafkai*) through direct mortality and habitat fragmentation. Highway projects to address increasing traffic volumes and aging assets provide additional challenges; but they also provide opportunities to avoid, minimize, and mitigate the effects of existing and new infrastructure. Arizona Department of Transportation has engaged in projects to address SDT-related concerns and has shown a commitment to SDT conservation by signing on as a participating agency to the Candidate Conservation Agreement for the SDT. Fencing is a widely applied tool to curb road mortality and promote wildlife connectivity when used in conjunction with culverts or other crossing structures. In Arizona, research along U.S. Highway 93, State Route 87 (northeast of Phoenix), and Twin Peaks Road (northwest of Tucson) reported substantial issues with the integrity of SDT fencing treatments. These and other studies have monitored use of crossings and culvert use for SDT, and to date, none have documented unassisted crossings via below- or above-grade structures. Surveillance of crossings is underway to evaluate crossing/fencing network treatments on State Route 77 (SR77; northeast of Tucson) and State

Route 86 (SR86; west of Tucson). A GPS-based assessment of SDT movements relative to SR77 is also being conducted. The fencing specifications on SR77 and those on SR86 are unique among implemented designs in Arizona. This variation in fence design should provide insight into specifications that are more robust to structural failures. Another SDT movement study is underway to inform design and construction activities for the South Mountain Freeway, in south Phoenix, which will incorporate wildlife crossings and fencing. Data from previous SDT surveys and movement studies is being utilized to provide guidance on pending/potential transportation projects such as Interstate-11, the "North-South Corridor", re-alignment of State Route 95, Rainbow Valley Parkway (southwest of Phoenix), and potential upgrades to State Route 79 (southeast of Phoenix).

Density Dependence in Life Histories and Population Dynamics of Large Mammals: Examples from Mule Deer and White-Tailed Deer

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Density dependence is an important component of both the life histories and population dynamics of ungulates, such as mule deer and white-tailed deer. Life-history characteristics related to ungulate populations tend to be a continuum that changes with population size relative to carrying capacity. Carrying capacity is generally defined as the equilibrium between ungulates and their food supply. Estimating carrying capacity can be especially difficult in arid environments because of fluctuating resource availability and time lags in responses of ungulate populations to changes in carrying capacity. Indeed, populations rapidly responding to sudden increases in high-quality forage may cause a population to overshoot carrying capacity, and result in a population decline in the future. Additionally, carrying capacity is generally not a good place for a population to be because of the nutritional stress and greater mortality exhibited by populations near carrying capacity. Mortality shifts from additive at low densities to largely compensatory as populations approach carrying capacity. Effects of density dependence in arid environments may be difficult to detect because of maintenance forage that may sustain adults in poor nutritional condition but may simultaneously yield insufficient nutritional resources to enhance productivity of females and, ultimately, a population increase. Where an ungulate population is relative to carrying capacity and the likelihood of fluctuations in resource availability in the local environment are essential to understanding population dynamics as well as the appropriate management and conservation of populations exhibiting strong density dependence.

Providing Context for the Benefits of Roadside Mitigation Fencing in Recovering and Protecting Desert Tortoise Populations

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Land managers and wildlife biologists continue to seek the most effective means for protecting and recovering the Mojave Desert Tortoise. This is especially true given opportunities to extend protection or recovery measures in response to mitigation required for development of some projects on public lands in the southwestern US. Here, we present the results of several studies aimed at quantifying the impacts of roads on desert tortoises and at identifying opportunities for improved management to reduce road impacts. In two studies, we found that the distance at which roads reduce desert tortoise abundance in adjacent habitat increases with road size and traffic volume. Noticeable reductions extended for at least 306 m along interstate highways compared to 230 m along two-lane county roads, whereas mostly untraveled dirt roads showed no signs of road effects. Tortoises were also smaller and younger closer to large roads, likely because it is challenging to survive to larger size when the risk of being killed on roads is high. The installation of barrier fencing could result in reclaiming as much as 30.6 ha of habitat for each km of fencing along one side of an interstate, and 23.0 ha along a county road by eliminating tortoise mortality from vehicles. Tortoise movement data that we obtained from GPS loggers recording at 15-min intervals showed that tortoises spent more time at a road and along a newly installed barrier fence than they did away from these areas. Carapace temperatures were higher along the road (+3.2 ^{o}C) and the fence (+1.1 ^{o}C) than away from them, but tortoises displaced by the newly installed barrier fencing had a greater frequency of temperatures in excess of their estimated upper thermal limit (43 ^{o}C), likely leading to the death of one animal. In sum, biologists must be careful to monitor possible immediate or temporary negative effects of new barrier fencing on desert tortoises to reap the longer-term benefits of reduced road mortality and reclaimed road-effect zones.

Ecological Constraints Imposed by Burrowing Behaviors Drove the Evolution of Divergent Sexual Size Dimorphism in the North American *Gopherus* Tortoises

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The North American *Gopherus* tortoises are a monophyletic group that includes two sister clades with a number of divergent traits that reflect their relative commitment to burrowing and fossorial behaviors. The two clades, including the *agassizii* (*G. agassizii*, *G. berlandieri*, *G. evgoodei*, and *G. morafkai*) and *polyphemus* (*G. flavomarginatus* and *G. polyphemus*) clades, also exhibit a divergence in sexual size dimorphism (SSD), with the *agassizii* clade species exhibiting male-biased SSD and the *polyphemus* clade species exhibiting female-biased SSD. Previous researchers suggested that *polyphemus* clade tortoises evolved female-biased SSD due to reduced male-male aggression. I tested an alternative hypothesis, that cover sites (burrows) provide a

constraint to the evolution of body size in *Gopherus* species. Specifically, I hypothesize whether the size of burrows occupied by females provided an ecological constraint to males in the *polyphemus* ancestor, a species that exhibited higher population densities, increased burrow sharing, and a deeper commitment to a fossorial existence than its *agassizii* clade ancestor. I examined burrow use in gopher tortoises (*G. polyphemus*) and determined that smaller males are able to access burrows inhabited by any adult female, and that the largest males can access burrows occupied by all but the smallest adult females. Smaller males used more burrows and visited adult females of all sizes, whereas larger males used fewer burrows and visited larger females. By evolving a smaller body size, males of the ancestral *polyphemus* form shifted the energy demands of burrow excavation to females, allowing them to expend more energy in tracking females. The *polyphemus* ancestor likely speciated by inhabiting woodland openings and edges, environments that were more productive and likely occupied by more predators, favoring high density populations, more secretive and fossorial behaviors, and increased burrow sharing, behaviors that, coupled with the ecological constraint of burrow size, provided selection for female-biased SSD.

STUDENT PAPER

Bolson Tortoise Burrows and their Role as Refuges for Vertebrates at the Biosphere Reserve of Mapimi

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The Bolson tortoise (*Gopherus flavomarginatus*) is among the most endangered tortoises in the world. Recent estimations suggest that the species occupies about 10% of its former distribution, most of which is inside the Biosphere Reserve of Mapimi (BRM) in Durango, Coahuila, and Chihuahua, Mexico. The Bolson tortoise has been viewed as flagship species to support protection efforts for the desert ecosystem within the reserve, yet few studies have been carried out to understand its role in influencing biodiversity of the vertebrate community. One of the most important behaviors of the Bolson tortoise is excavation of burrows that not only provide refuges from predation and extremes in temperature for the tortoise, but potentially for many other desert vertebrates. Between May 2014 and January 2016, we used motion-triggered cameras at burrow entrances to survey fauna associated with the burrows. During the survey effort, we recorded use of bolson tortoise burrows by 36 different vertebrate species. Accidental use of the burrows was the most common behavior observed, which included use as a refuge for small to medium-size organisms or as a foraging microhabitat for several birds, reptiles and mammals. The most representative group was mammals with 17 recorded commensal species, accounting for nearly 61% of the mammals present in the BRM. Eleven bird species representing 5% of the birds reported in the BRM, and eight reptile species representing 22.2% of the total species reported inside the reserve, were also recorded. Of the 36 species registered during the study, seven are protected by Mexican law. Though use of the burrows by most animals was not obligate, tortoise

burrows appear to play an important role in the ecology of the BRM, and this study serves to emphasize the importance of the Bolson tortoise in the Chihuahuan desert, especially for the vertebrate fauna of the BRM.

STUDENT PAPER

Genetic Diversity and Conservation of the Bolson tortoise, *Gopherus flavomarginatus*

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Currently the Bolson tortoise occupies less than the 90% of its former Pleistocene distribution and populations continue to decline. There are several efforts to promote the conservation of the species inside the Biosphere Reserve of Mapimi (BRM), however, the genetic characteristics of tortoise populations have not yet been considered. In this study we evaluated the genetic diversity of *G. flavomarginatus* using two mitochondrial genes (COI and D-loop) and one nuclear gene (RAG2), with the purpose of integrating genetic considerations into conservation strategies. We collected samples from 40 wild individuals and 36 captive individuals. We did not detect variation in the gene COI, and only one wild individual exhibited a different haplotype for the gene D-loop. For the nuclear gene, we found 14 haplotypes and a population differentiation (Fst) of 0.132. The genetic variability was higher in one colony outside the BRM and in the captive colony than was observed in the wild colonies inside the BRM. Despite the detection of some variation, our results indicate that the Bolson tortoise has the lowest genetic variation of the genus. Our study underscores that while genetic diversity is scarce, any remaining genetic variation should be maintained in wild colonies. According to the reserve managers, there are some depauperate tortoise colonies inside the reserve that were affected by past human poaching, and these colonies are good places to promote repopulation programs inside the BRM, particularly in areas that still support native vegetation, proper weather conditions, and empty burrows that can be used for reintroducing individuals. Understanding current genetic composition of wild and captive colonies is the first step for establishing a captive breeding program that reinforces the genetic diversity of wild populations, and the results of our research provide baseline information for starting the program.

Desert Tortoise Management and Research in Joshua Tree National Park

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Joshua Tree National Park (JOTR) protects nearly 800,000 acres of public land of which 240,000 is considered high quality desert tortoise habitat. The park has supported the recovery of the tortoise through participation of region wide planning efforts, management of habitat, educational outreach and scientific research. JOTR staff and managers are active in efforts that promote the recovery of the tortoise through education, information exchange and research. The park is also an active participant in the Colorado Desert workgroup under the California Mojave RIT to guide future recovery efforts in the region. Within the park, educational specialists provide desert tortoise educational presentations to many of the local (Morongo Basin and Coachella Valley) schools. The park also has an active habitat restoration program that works to return impacted habitats to functional ecosystems for tortoises and other animals. Desert tortoise awareness talks are given to all NPS employees, construction workers and even researchers doing work in the park that may impact the desert tortoise. Since 2007, the park's wildlife staff has been tracking desert tortoises near roads as part of a study to understand the effect of roads on tortoise movement patterns. Currently, the park is analyzing the data with some interesting preliminary results.

Monitoring Populations of Mule and White-tailed Deer: Implications for Harvest

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Monitoring populations of wildlife is challenging to do effectively in a cost-efficient manner. Sampling theory is taxing in practice because meeting all assumptions associated with a particular sampling technique is difficult, if not impossible, under field conditions. Meeting statistical rigor may be expensive in financial and human resource-hour expenditures. Seeking robust methods that tolerate deviations from assumptions are important, as well as recognizing the power and accuracy needed to make management decisions. Populations and harvests lend themselves to monitoring somewhat independently. Population monitoring focuses on the characteristics of the population (e.g., estimated size, male to female ratio, recruitment) and infers the degree of exploitation that the population may tolerate. Harvest monitoring generally examines the characteristics of the harvest (e.g., harvest per 100 hunters, age distribution of harvested males) and infers the observed degree of exploitation of the population based on comparisons with studied populations. Populations managed conservatively are generally more appropriate to monitor through harvest characteristics, whereas populations managed for maximum harvests (e.g., low male to female ratios) are more appropriate to monitor through population characteristics. Those populations managed most intensively require the most statistically robust sampling designs and survey effort. Yet, conversely, populations that are conservatively managed for older age class harvests (i.e., large-antlered deer) often receive more scrutiny from interested publics than do populations that are managed closer to maximum sustained yield. Ensuring the most economically

feasible (in financial and human resource-hour expenditures) and biologically appropriate surveys are implemented represent both a technical and adaptive challenge for management agencies.

Desert Mule Deer Conservation: Moving from Wildlife Disease to Health

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Mule deer (*Odocoileus hemionus*) are subject to the usual suite of pathogenic agents, bacteria, parasites, virus and prions and there is ample literature reporting incidences of diseases in individual animals or populations. Diseases such as chronic wasting disease may impact local population viability but, unlike bighorn sheep (*Ovis canadensis*), disease does not appear to be a primary driver of population declines. Rather than a focus on specific diseases of mule deer, wildlife managers and health professionals may be better served by integrating disease into a broader program of wildlife health. To determine the overall health of a population, it should be evaluated as to its vulnerability, resiliency, and sustainability when faced with key threats such as habitat degradation, fragmentation or loss, climate instability, competition with livestock or elk, and proximity to captive cervids. As a population's vulnerability to these threats decreases, and resiliency increases, the incidence of pathogen exposure could lessen and the impact of any individual disease event on a population may decrease in importance. Shifting the focus of disease investigation and management away from adding another pathogen to the list, and instead, to assessing its importance to the overall wildlife health program for a population will improve integration of disease with the key factors affecting conservation of desert mule deer.