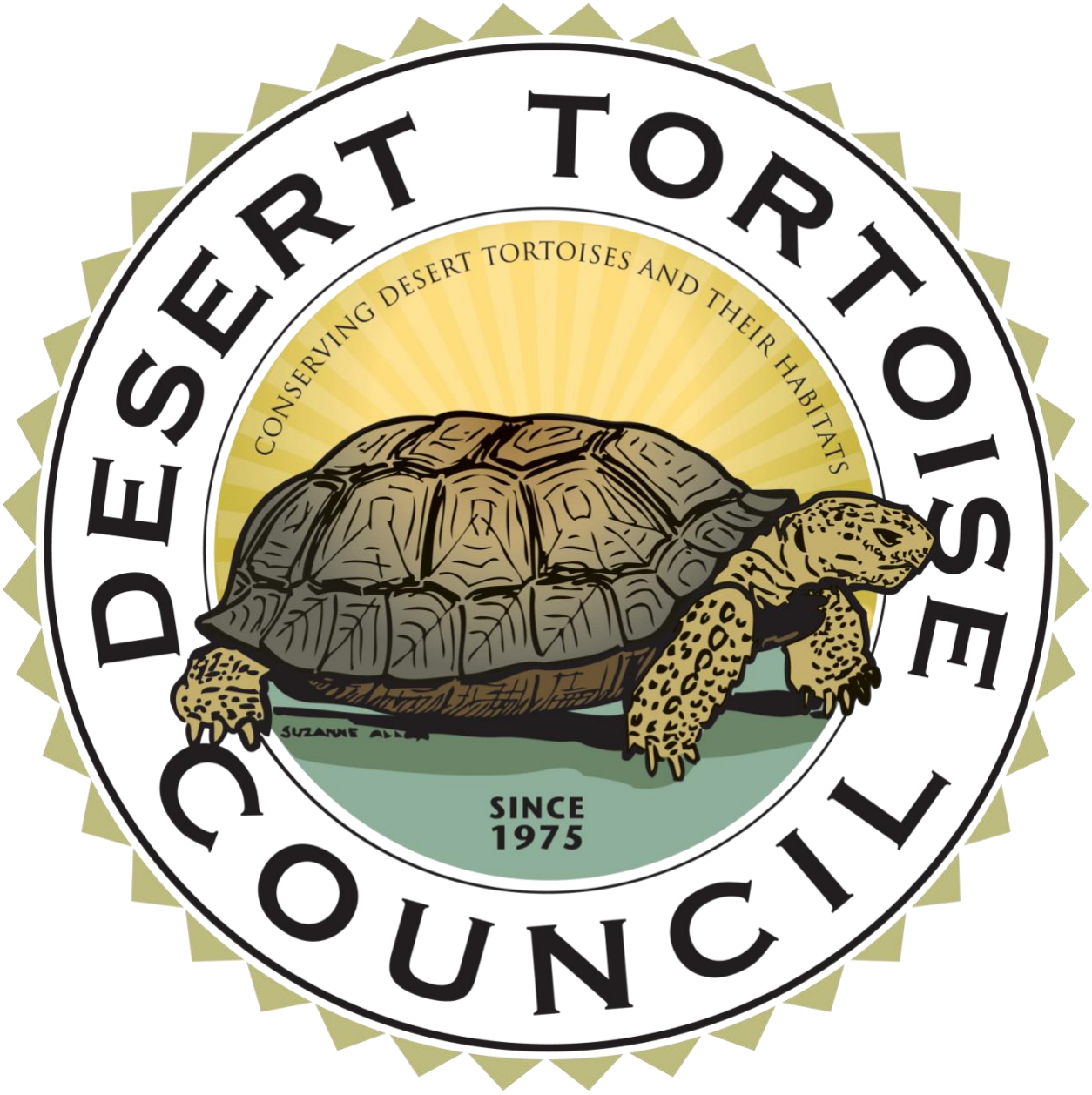

Draft ABSTRACTS

43rd Annual Meeting and Symposium

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

February 23–25, 2018

FORTY-THIRD ANNUAL MEETING AND SYMPOSIUM
THE DESERT TORTOISE COUNCIL

Sam's Town Hotel and Casino, Las Vegas, NV
February 23–25, 2018

ABSTRACTS OF PAPERS AND POSTERS

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

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

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Major activities within the Desert Tortoise Recovery Program in 2017 included: 1) Range-wide monitoring surveys were conducted in seven of ten strata in California and four of seven strata in Nevada/Arizona/Utah. 2) Population augmentation, one of the 6 recovery strategies in the recovery plan, is an increasing focus of regional planning based on current opportunities. For instance, a General Conservation Plan is in development with the Mohave County Board of Supervisors with voluntary conservation measures that will facilitate establishing a single augmentation site for displaced animals in this part of the range. 3) USFWS personnel continue to work directly on projects that enhance priorities of the Desert Tortoise Management Oversight Group (MOG) and Recovery Implementation Teams (RITs). In particular, we continue to expand efforts to reduce raven predation. 4) Addressing another focus identified by the MOG and RITs, work by our Southern Nevada and Palm Springs offices with state and federal agencies is prioritizing areas for fencing roads and building passages to reduce mortality and fragmentation caused by roadways. This work by our regulatory colleagues highlights the benefits of coordinating the regulatory and recovery functions in our offices. 5) An increasing number of projects reflect this sort of team effort, with several personnel from our four offices working on revisions the guidelines for surveys to inform biological assessments. 6) A team of USFWS biologists also contributed to the Desert Tortoise Council's inaugural training and evaluation of tortoise biologists.

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Desert Tortoise: Still Protected but Still Declining…

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Through science-based advocacy, participation in administrative processes, public information and litigation, the Center for Biological Diversity continues our conservation and recovery campaign for desert tortoise and its habitat in California, Nevada, Arizona, and Utah. Over the last 20 years, the Center has consistently supported increased protections for the desert tortoise as the path to desperately needed species recovery. Some challenges that the Center focused on in the past year include protecting and supporting current safeguards and programs that protect desert tortoise and other desert plants and animals from an environmentally hostile federal administration. In coalition with others, we have increased the drumbeat of support for desert national monuments in California and Nevada which add a higher level of protection for desert tortoise. We've engaged in the implementation of the Desert Renewable Energy Conservation Plan (DRECP) in California to help assure its proper implementation. We continue to engage on poorly sited "grandfathered" solar projects that are not subject to the DRECP. We continue the struggle to limit ORV impacts in tortoise habitat from both authorized and unauthorized use and are anticipating a new West Mojave Plan release in early 2018. We are engaged in the Piute-El Dorado ACEC plan because it is key in mitigating impacts from the Dry Lake SEZ and protecting and enhancing populations of desert tortoise in that area. We have had some recent success in our ongoing legal challenges to the Southern Nevada Water Authority's pipeline water grab. We have been challenging BLM oil and gas leasing within desert tortoise critical habitat in eastern Nevada. We are engaging in yet another round of input on the BLM Las Vegas Resource Management Plan revision. We are fighting back against a massive military land grab, as the Nevada Test and Training Range seeks to expand into Desert National Wildlife Refuge. Working with Counties in California, we've focused on local conservation efforts to move conservation forward through a new non-regulatory process called Regional Conservation Investment Strategy, currently in play in northern Los Angeles County and San Bernardino County.

Population Augmentation as a Recovery Strategy for the Mojave Desert Tortoise (*Gopherus agassizii*)

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Declines in Mojave desert tortoise populations led the species to be listed as Threatened under the Endangered Species Act in 1990. Much work is focused on removing threats and improving tortoise habitat within conservation areas. However, tortoises are still displaced by development or other human activities from habitat that is less important for species recovery.

Historically, these tortoises have been moved out of harm's way into nearby habitat irrespective of its location relative to recovery areas. Meanwhile, even with successful threat mitigation within conservation areas, it will likely require decades for depleted tortoise populations to rebound to sustainable levels because it takes about 15 years for juvenile tortoises to reach maturity and begin producing offspring of their own. Therefore, the U.S. Fish and Wildlife Service is developing a strategic population-augmentation program. We are identifying specific locations within conservation areas or other important habitat to focus efforts to more quickly increase tortoise numbers. Positive short-term results from desert tortoise translocations include no homing tendencies when moved long distances, establishment of home ranges, comparable survival and reproductive output to resident tortoises, and detectable increases in population density. This suggests that a targeted augmentation program will provide a "boost" to depleted tortoise populations where we are focusing management efforts. Monitoring these tortoises will also provide a means to evaluate the success or effectiveness of those management efforts.

STUDENT PAPER

Ticks and Tick-borne Pathogens of Mojave Desert Tortoises

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Disease outbreaks result in high mortality and reduced fitness in wildlife, and that ticks are often responsible for spreading disease in wildlife populations as well as in human populations. Soft-ticks in the genus *Ornithodoros* (*O. parkeri* and *O. turicata*) occur throughout the Mojave and have been documented to frequently parasitize Mojave desert tortoises. However, ticks often are not identified to species nor life stage when collected. These tick species carry the pathogen *Borrelia*, which is responsible for Tick-borne relapsing fever (TBRF). The potential for ticks to transmit disease to desert tortoises, and other desert wildlife and people has not been well documented. Using expertise in sequencing techniques, epidemiology, infection kinetics and wildlife ecology to determine the role tick-borne pathogens play in the Mojave Desert burrow ecosystems, this study aims to identify ticks to species found in the Mojave Desert burrow ecosystems and ticks attached to tortoises and to determine the pathogen prevalence in ticks collected in the Mojave desert. We identified 170 ticks collected from desert tortoises using microscopy and morphological characteristics. Out of the 170, 61% were identified as *Ornithodoros parkeri*, 14% were *O. turicata* and the remaining 6% were not identifiable. Of the 170 ticks collected from tortoises and analyzed for *Borrelia*, all tested negative for the pathogen.

A positive *Borrelia* sequence collected from a person infected with TBRF after being bit by a tick in the study area was used as a positive control. Future plans for this research include further research into a possible borreliacidal effect of an enzyme found in tortoise blood (similar to that found in western fence lizard blood). Continued research will contribute to the large gap of knowledge in relation to ticks and desert tortoises in the desert southwest and how conservation of this iconic animal may lead to better public health.

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

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We 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 over a period of several years. At five sites, we developed models to evaluate relationships between presence of desert tortoises (live, dead, burrows, scats, and other sign), vegetation associations, and anthropogenic impacts. Four sites were in the Mojave Desert (Jawbone-Butterbread Area of Critical Environmental Concern, El Paso Mountains, Fremont Valley/western Rand Mountains, and the El Mirage Recreation Area) 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; shooting; and other evidence of land use. Drawing on these studies conducted in different localities using similar methods, we will report on recurring patterns of positive and negative associations between tortoise presence and distribution, vegetation type, typical anthropogenic variables, and mortalities.

Desert Tortoise/Desert Biome Student Project

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High School students are often not aware of their local environment. To educate and inspire students to learn and care about their environment Peter and I designed a student project that begins with learning about the Mojave Desert and the Mojave Desert Tortoise, *Gopherus agassizii* as our representative organism. Students research threats to the Desert Tortoise and ecological issues in the Antelope Valley. Within this project students learn ecological concepts including human impact on the environment, feeding relationships between organisms in the desert and population studies. Students will research and write a magazine article or report on the Desert Tortoise and the area in which it lives. The article or report will include where and how the Desert

Tortoise lives, and threats to its survival. Students will also suggest or design a solution to one of the threats to the Desert Tortoise.

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Upper Respiratory Tract Disease Overview: Past, Present, and Future

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In 1991, *Mycoplasma agassizii* was isolated from desert tortoises with clinical upper respiratory tract lesions. Subsequently, experimental infection studies in both the desert and gopher tortoise confirmed that this pathogen could cause the same clinical signs and histological lesions in the respiratory tract that were found in naturally infected animals. Based on studies in wild and artificial populations, a clearer pattern of the disease and its potential impacts is now available. In most aspects, disease dynamics are very similar to other chronic respiratory mycoplasmoses. When a naïve population is initially exposed to the pathogen, factors that are likely to contribute to establishment of the disease include a critical threshold of infected individuals that are actively shedding enough microbes to constitute an infectious dose as well as adequate population density of susceptible individuals and contact events. Population studies suggest that until the threshold approaches 25%, transmission events are relatively slow. However, once that critical threshold is breached, both seroconversion rates and observed overt clinical disease increase. This is the acute stage of the disease, characterized by increased clinical signs and, in some cases, increased mortality events. Data from gopher tortoises suggests that this disease stage resembles sexually transmitted disease dynamics, and thus STI contact/network models may be a new consideration for naïve populations transitioning to URTD-positive. Once established, like most mycoplasmal infections, the population enters an enzootic, endemically stable stage: animals are clinically silent, the pathogen is still present, the damage to the epithelial surface is still present, overt clinical signs are absent, and mortality events are rare. The length of the endemically stable stage is likely a function of stressors – environmental, biological, and anthropogenic. Transmission and mortality events are low during the enzootic stage. However, there are also epizootic, or recrudescent, stages, where animals show clinical signs, have nasal discharge, and may be actively shedding microbes. Using matrix population and Markov chain models, we found that the impact of disease on host population dynamics depended primarily on how often a population underwent an epizootic state, rather than how long the epizootic persisted. Given the frequency of environmental stressors (drought, fire, habitat degradation, deceased availability of food resource) in the desert environment, these epizootic events are likely to occur at a high frequency. Additionally, recent studies have provided insights into how clinical disease (severe nasal exudate) impacts normal biological function: decreased ability to find food, increased movement patterns, and aberrant basking. Looking to the future, the availability of tools for transcriptomics, genomics, and virulomics are likely to provide deeper understanding of the virulence of the pathogen, the host cellular immune response, and host:pathogen interactions.

STUDENT PAPER

Challenges of Virulence Testing in Reptilian Mycoplasmas: Validation of a Model System

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Mycoplasmas cause acute and chronic infections in a wide range of avian, mammalian and reptilian hosts. Although complete genome sequences are available for many major *Mycoplasma* sp., there is still a limited understanding of specific virulence factors. Defining these virulence mechanisms may be a key factor in understanding how a pathogen causes host damage and disease. Additionally, the host immune response is crucial in determining the severity of mycoplasmal disease. Studies to assess pathogenicity and variation amongst clinical isolates/strains of a pathogen have typically been conducted *in vitro* using cell lines or *in vivo* using experimental infections of the natural host or a surrogate host, most commonly mice. There are drawbacks and limitations to studying the reptilian *Mycoplasma* sp. using these systems. The primary limitation is the temperature growth restriction. Most *Mycoplasma* sp. from reptiles do not grow above 30 C. Reptilian cell lines are limited, and mammalian cell lines require higher temperatures. Cell lines, even if available, lack an intact immune system, a major drawback to studying host-pathogen interaction. Many Chelonian species are federally protected, and when possible, alternatives to experimental infections in these species are ethically desirable. Mammalian and avian surrogate hosts cannot be used due to temperature restrictions of the pathogen. Therefore we have developed an alternative model for virulence testing of reptilian *Mycoplasma* isolates using the invertebrate *Galleria mellonella. G. mellonella* has been used to study virulence differences of many major bacterial and fungal pathogens, but not *Mycoplasma* sp. *G. mellonella* has an innate immune system, with crucial immune activation mechanisms such as toll-receptor signaling, microbial killing and apoptotic pathways. Unlike other invertebrates, *G. mellonella* larvae can grow between 15-37C, important for the reptilian *Mycoplasma* sp. which do not grow above 30 C. In order to address critical knowledge gaps, we validated the *G. mellonella* invertebrate model to test the virulence potential of four reptilian pathogens: *Mycoplasma alligatoris, Mycoplasma crocodyli, Mycoplasma agassizii* strain PS6 and *Mycoplasma agassizii* strain 723.

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 2,335.98 acres of take during the period of January to December 2017, leaving 69,303.29 acres on the permit. The 2017-2019 Implementation Plan and Budget allocated $11,422,245.00 for the funding of staff and projects. Highlights of the past year include completion of a fifth year of a desert tortoise occupancy monitoring project, completing occupancy analysis of 5 years of data and covariates, worked in coordination with the

Fish and Wildlife Service to complete a progress report on the post-translocation telemetry project on the Boulder City Conservation Easement (BCCE) as well as facilitate a second release of 38 adult tortoise on the BCCE in the fall, completion of a pilot project to determine if tortoise can be detected from drones, completion of a second year of range-wide monitoring in Nevada, and preformed numerous outreach programs to teach children and adults about the desert tortoise.

Status and Migratory Behavior of the Western Burrowing Owl: Parallels between Burrowing Owls and Desert Tortoises

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Western burrowing owls (*Athene cunicularia hypugaea*) have declined throughout their range, but conventional methods for estimating population trends overlooked declines. Western burrowing owls are a species of national conservation concern in the U.S. and are federally endangered in Canada. More recent analyses suggest substantial population declines over the past 60 years. However, the population declines vary temporally (i.e., are not linear over the past 60 years) and spatially (i.e., are not consistent across the species range). I will show the timeframes when their population declines were most severe, and identify the regions within their range where declines have been most pervasive. The distribution of the western burrowing owl is larger than, and completely overlaps, the distribution of desert tortoise (*Gopherus* spp.). Like desert tortoises, western burrowing owl breeding densities are very low and their distribution is patchy. I will present analyses comparing population trends of burrowing owls within the range of the desert tortoise versus those outside the range of the tortoise. Western burrowing owls lay their eggs in underground burrows created by other burrowing animals (they don't dig their own burrows). Burrowing owl populations are thought to be limited by availability of suitable nest burrows in some regions and they use burrows created by desert tortoises, so declines in tortoises may affect burrowing owl populations. One obvious knowledge gap for burrowing owls is our limited information regarding their migratory routes, wintering locations, and breeding dispersal. To address this gap, we deployed geolocators on 296 owls and solar-powered satellite transmitters (PTTs) on 34 owls at locations throughout the U.S. All owls that bred in Oregon and Washington wintered in the U.S. and migratory behavior differed between sexes: females wintered in California whereas most males wintered in Washington. In contrast, most burrowing owls that we tagged in the interior U.S. states migrated to Mexico for the winter. Owls had stronger site fidelity to their wintering locations than to their breeding sites. Over 90% of the owls that nested in (and migrated from) Colorado, Wyoming, South Dakota, Nebraska, and Montana took a multi-day break from migration in northwestern Texas (with most of these stopovers near Lubbock, Texas). These results identify important stop-over and wintering locations where continent-wide burrowing owl conservation should be focused. I will also present patterns in land-use of burrowing owls and latitudinal patterns in life history traits.

Return to the Harcuvar Mountains, Bonanza Wash and Four Peaks 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 2017 surveys were conducted at three Sonoran Desert Tortoise population trend study plots. A span of ten and fifteen years had elapsed since the last time these three 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 2017 return to the Harcuvar Mountains, Bonanza Wash, and Four Peaks 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.

POSTER

Biodiversity of Amphibians and Reptiles at the Camp Cady Wildlife Area, Mojave Desert, California

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We examined the biodiversity of amphibian and reptile species living in and near constructed ponds at the Camp Cady Wildlife Area (CCWA) in the Mojave Desert of San Bernardino County, California based on field work from 1998-1999, 2015-2016, and searches for museum specimens using VertNet.org. A total of 11 species (172 captures), including two frogs and toads, one turtle, three snakes, and five lizards were captured at terrestrial drift fences with pitfall traps encircling two ponds (0.5 hectares) on the property in 1999. In addition, we found two other species represented in museum collections from the CCWA: the Pacific treefrog (*Pseudacris regilla*) and the desert spiny lizard (*Sceloporus magister*). One species, the southwestern pond turtle (*Actinemys pallida*), was commonly observed from 1998-1999 and documented as a breeding population. However, the species

was extirpated at CCWA sometime after 2014 when the last individuals were photographed and none have been detected since then despite attempts to do so. Biodiversity of amphibians and reptiles at CCWA is relatively low compared with sites elsewhere in the Mojave Desert with more elevational diversity. The number of species we documented accounts for approximately 28 percent of the reptile and amphibian species reported from the Mojave Desert by previous researchers. Thus, our sample likely represents a subsample of easily detected species. The herpetofauna inhabiting CCWA was notable for including riparian obligates like the western toad (*Bufo boreas*), *P. regilla* and *A. pallida*. Other species are typical of those that are expected in the low-elevation creosote scrub-dominated ecosystem in the area.

When it Comes to Surviving in the Desert, Gila Monsters Ignore the Lizard Playbook: Delayed Hatching Emergence as Another Non-lizard Survival Strategy

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It has previously been suggested that Gila monsters, *Heloderma suspectum*, are poorly adapted to living in the desert. However, this is nonsensible since Gila monsters have resided in the Sonoran Desert for as long as it has existed in its current state. While Gila monsters do not use strategies that are typical of other desert lizard, they are indeed highly adapted for their environment. Gila monsters use an assortment of strategies that we see in other reptiles. For example, like tortoises, Gila monsters store water in their bladder and use a defense mechanism that is not based on speed. Here we review known adaptive strategies of Gila monsters and report on a newly discovered strategy, one that has previously only been described in aquatic turtles – nest overwintering by hatchlings. We present data on the timing of emergence from natural nests, the effect of natural temperature cycles on incubation duration, and the opportunistic discovery of actively hatching Gila monster eggs. Briefly, Gila monsters oviposit their eggs in July, the eggs hatch in late fall, but the hatchlings do not emerge from the nest until late spring through mid-summer of the following year, with the emergence of individuals from a single nest occurring over a 2-3 month period.

Estimates of High and Invariant Survival for Translocated Tortoises in the Ivanpah Valley

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Translocation is a potentially useful tool for wildlife managers to mitigate the impacts of development on species of conservation concern. Moving individuals to a new location is challenging, however, and many translocation attempts have failed. Robust post-translocation monitoring plans are therefore important for assessing whether or not a translocation was successful and how its design can be improved in the future. Here, we test the efficacy of short-distance (< 500 m) translocation designed to mitigate the impacts of renewable energy development on the Mojave desert tortoise (*Gopherus agassizii*) in the Ivanpah Valley of southern California. We translocated 73 tortoises away from the project's construction site and intensively monitored them (via radio-tracking) for a period of five years. For comparison, we used the same protocols to monitor tortoises that were not subject to translocation, some of which were located within the translocation release area ('resident' tortoises; n = 112) while others were located in nearby habitat ('control' tortoises; n = 149). Results of known-fate survival models indicated that translocated tortoises did not suffer from lower survival than resident and control tortoises, either immediately post-translocation or over the entire five-year period. In addition, translocated tortoises were not differentially impacted by physical (e.g., soil and vegetation properties, barriers to movement, precipitation) and biological factors (e.g., tortoise size, body condition, home range size) that were used to model variation in survival. Based on these findings, our translocation protocol—designed to minimize stressful environmental conditions during the period immediately following translocation—may be useful for developing other translocation projects for desert tortoises in the Mojave Desert. This study highlights the benefits of combining rigorous scientific monitoring with mitigation-driven management actions to reduce the impacts of development on species of conservation concern.

Geologic History and Genomic Divergence between *Gopherus agassizii* and *G. morafkai*

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Organisms evolve and adapt in response to their environment, yet that environment changes over time. Understanding the speciation history of southwestern desert tortoises and the

external forces that drove their divergence is necessary to identify what external pressures they are sensitive to, and how historical responses of the two species may have differed. The southwestern US is host to a complicated geologic and climatic history over the past several million years that is thought to have played a major role in facilitating the divergence of these lineages. Here, we summarize paleomonsoon history, evolution of the lower Colorado River region, and recent glaciations to explain how these processes may have influenced evolution and divergence of these species and their ecological differences. We will outline our approach for how we are testing these hypotheses by generating population genomic (large-scale DNA) data from individuals of both species. This work is ongoing and represents an interdisciplinary effort to learn what factors have governed these species' evolution in the past, in order to understand how they may respond to long-term future threats of climate change, disease, and urbanization.

Invasive Plants and Habitat Selection Influence the Success of Translocated Juvenile Desert Tortoises

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Landscape-scale habitat changes including urbanization, wildfires, and invasive species are rapidly increasing throughout the southwestern United States. While extensive research and conservation efforts have been directed towards understanding the effects of altered habitats in adult tortoise populations, little is known about habitat features that may support younger tortoise cohorts. To understand the relationship between habitats and the ecological requirements for juvenile tortoises, we conducted a multi-year study (Fall 2014–Spring 2017) using translocated captive juvenile Mojave desert tortoises (*Gopherus agassizii*) at four desert sites in Clark County, Nevada, USA. We surveyed site features including annual and perennial vegetation, soil textures, rodent burrows, climate, etc. at each site. In addition, we monitored growth, health, movement, and survival for juvenile tortoises. After evaluating habitat and climate patterns during the project, we found that annual plant production best explained patterns of improved performance (growth, survival) in juveniles. Annual plants were highly variable both in production and species richness throughout 2015 and 2016, with less production in 2015. Consequently, we also recorded limited growth for most juveniles throughout that year. We found that juveniles generally grew more, increased movement and home range, and had higher survival in habitats with less invasive non-native annual vegetation (e.g. *Bromus rubens*, *Schismus barbatus*) compared to sites with increased native forage plants. Our findings support previous research on the potential negative effects of non-native annual plants for young tortoises. When possible, reducing non-native vegetation or protecting habitats from potential plant invasions and other disturbances may improve recruitment and conservation for this species.

Fences Actually Work, We Have Proof

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In the last 40 years, the Desert Tortoise Preserve Committee, Inc. acquired and managed desert tortoise habitat at the Desert Tortoise Research Natural Area (Natural Area) and other areas throughout the Mojave and western Sonoran deserts. These acquisitions and accompanying stewardship were undertaken in conjunction with partners, including the Bureau of Land Management and California Department of Fish and Wildlife. At the Natural Area and adjacent expansion areas, >45 miles of hogwire fence protect tortoises and >32,000 acres of habitat, as well as other sensitive, rare and threatened species (e.g., burrowing owls, Mohave ground squirrels, Barstow woolly sunflower). Several linear miles of fence was extended to the ground in areas with heavy off-road vehicle traffic outside.

Fences are a critical management tool for tortoise recovery and recovery of habitat for many species. In the first Recovery Plan published by the U.S. Fish and Wildlife Service in 1994, fences and habitat were recommended as management actions. The protective measures taken at the Natural Area in the 1970s and culminating in formal establishment of the Natural Area in 1980 have had positive effects on the population inside the fence compared with outside and in critical habitat. A recent, published study demonstrated that density of tortoises was 6X greater within the Natural Area than in the unfenced adjacent critical habitat.

In 2018, we will fence 4.5 miles of habitat, and vigorously attack the arrival of Sahara mustard. Our actions at the Natural Area include acquisition of inholdings and more efforts one habitat restoration. Drawing on the successes we have experienced using fencing as a management tool, we will present our case for why it should be considered throughout the geographic range and further steps that can be taken to restore desert habitat.

California BLM: Update on Tortoise Management Actions

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In 2017, BLM continued to work on projects such as signing routes, restoring habitat, and public outreach. Management of existing renewable energy project continues. No new projects were approved in 2017; there are 5 projects under review for potential approval in 2018-2019. We provided translocation areas for MCAGCC required tortoise translocations. We provided financial support for USFWS LDS surveys, but with shrinking budgets, and current population trends, we wonder if limited funds should continue to support monitoring or should be shifted to increasing habitat restoration efforts.

Guidelines for Translocations of Mojave Desert Tortoises (*Gopherus agassizii*)

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The U.S. Fish and Wildlife Service is completing a revision to the guidelines for preparing plans to translocate Mojave desert tortoises from project sites. We incorporated information from previous translocations and monitoring efforts to base the update on the best available science. The guidance covers topics that include estimating the number of tortoises that will be affected, selecting recipient sites, assessing the health of the tortoises, and conducting post-translocation monitoring. In the future, tortoises removed from projects may be translocated to regional augmentation sites that are identified as important for persistence of the species; however, there will be situations when projects need to develop plans that do not involve translocation to regional sites. It is important that new translocation projects be designed in a research or effectiveness-monitoring framework to address questions related to the success or impacts of translocation of desert tortoises so that new information can be applied to further reduce risks, minimize impacts, and improve the success of translocations.

2017/18 Desert Tortoise Recovery Implementation Teams and Management Oversight Group Update: Priorities and Progress

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The Desert Tortoise Recovery Implementation Teams (RITs), which are three geographically defined teams, consist of representatives from Federal, state, local, and non-governmental organizations. The RITs work collaboratively to identify recovery action project priorities, based on Recovery Action Plans, for funding and implementation. The Desert Tortoise Management Oversight Group (MOG), which consists of executives representing Federal, state, and local agencies, provides oversight and guidance to the RITs in setting priorities for recovery actions and funding for project implementation. Based on feedback from the RITs, the MOG recently added "Fire Management Planning and Implementation" to their existing top five recovery priorities. RIT recovery action projects that were funded and implemented for 2017/18 addressed a range of priorities such as reducing predator subsidies, targeted predator control, raven monitoring, habitat restoration, land acquisition, education programs, and transportation ecology studies. The RITs also identified several local recovery action priorities, such as land acquisition to achieve consistent habitat management, desert tortoise barrier fencing and connectivity, restoration of roads in OHV closure areas, development of strategic proactive fire management plans, and use of imaging tools to identify priority areas for habitat restoration and enhancement. The RITs will focus on developing recovery action project proposals to address both new and existing priorities, and submit lists of prioritized projects ready to be funded to the MOG.

Are Females Smellier than Males: Survival and Predation in Translocated Juvenile Desert Tortoises

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Information on translocated juvenile desert tortoises (*Gopherus agassizii*) is lacking, especially with tortoises of known gender. Sixty juveniles (30 male, 29 female, 1 unknown) (99-151mm MCL) were translocated from the Desert Tortoise Conservation Center to the Nevada National Security Site in September 2012. They were monitored weekly from March to October and at least monthly November to February through November 2017 to determine survival rates, causes of mortality, and evaluate the effectiveness of translocating juvenile tortoises. Twenty-seven (45%) (18 male, 9 female) tortoises survived, which is comparable to survival rates in natural populations. The main source of mortality (76%) was coyote and kit fox predation. Predation was skewed with 71% (n = 17) female mortality versus 29% (n = 7) male mortality. This female bias was not due to an increased presence aboveground which would make them more susceptible to predator detection. On average, female tortoises spent significantly more time in their burrows ($p = 0.01$) and less time out in the open ($p = 0.02$) than males, and females and males did not differ significantly in distance traveled ($p = 0.76$). We hypothesize that juvenile females might be identified by canid predators on the basis of odor. We collected oral, cloacal and chin/forelimb swabs from resident adult and translocated juveniles of known gender during fall 2015 and analyzed them using headspace gas chromatography/mass spectrometry to determine chemical signatures. Linear discriminant analyses (LDA) were conducted from chromatographic peak data for each sample type to discriminate sex among juvenile tortoises. Excellent models (cross-validation error rates ranging from 6 to 15%) were produced for the three sample types. Among the chemical predictors employed in these models, several tentatively identified as alkyl alcohols differed significantly between the sexes of juvenile tortoises. Work is ongoing to determine differences in tortoise chemical signatures and if these differences contribute to increased female mortality by canids.

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Desert Tortoise Occupancy in Association with Landscape Predictors Using Multiple Methods and Years

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The Clark County Desert Conservation Program began field sampling for the desert tortoise occupancy monitoring program on the Boulder City Conservation Easement (BCCE) in the spring of 2013. The goal of the study is two-fold: 1) to determine relationships between landscape predictors and the probability of desert tortoise occupying a given site on the landscape, and 2) to evaluate the utility of occupancy sampling for long-term monitoring of desert tortoise on the BCCE and elsewhere. We leveraged the five years of data collection (consisting of 1,710 plot surveys at 80 plots across years) by developing a new class of occupancy model. We built a Bayesian state-space model that simultaneously used two separate detection methods (live desert tortoise and active burrow) and accounted for imperfect detection of desert tortoise both within and among years. Detection probability, given true presence, was highly variable among years both for live tortoises and active burrows. Desert tortoise were encountered more frequently in portions of the BCCE that were farther from roads, had lower topographic roughness, had lower areal coverage of creosote (*Larrea tridentata*), and higher areal coverage of white bursage (*Ambrosia dumosa*). We used these relationships to develop a predictive raster surface of the relative expected frequency of desert tortoise encounters as a function of landscape variables and tested the predictive surface against an independent set of telemetered desert tortoise locations within the BCCE. The predictive surface performed well at predicting the frequency of desert tortoise occurrence (Pearson's $r = 0.95$, $p = 0.014$). These results provide spatially-explicit guidance for habitat restoration within the BCCE, guidance for use of occupancy monitoring to quantify desert tortoise occupancy dynamics, and a flexible framework for modeling desert tortoise occupancy in general.

The 2017 Tortoise Translocation by the Marine Corps Air Ground Combat Center (Combat Center)

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In 2017, the Combat Center translocated 1043 *Gopherus agassizii* from base expansion areas to nearby lands on the Combat Center and nearby lands of the Bureau of Land Management. Most (n=929) of these tortoises were translocated from 8 to 22 April, but 114 were translocated in autumn, from 2 to 4 October 2017. We translocated 172 small tortoises (i.e., carapace length, CL < 160 mm) and 871 large tortoises (CL > 159 mm). We used radiotelemetry to track approximately 20% (203) of the translocatees, and similar numbers of residents (234) and controls (250), with small tortoises being, 33, 22 and 32 of those, respectively. During radiotelemetry monitoring, 13

(6%) translocatees, 6 (3%) residents and 15 (6%) controls died between the time of translocation and 31 December 2017. None of the small, radiotracked tortoises died. Mortalities of the tracked animals were largely (ca. 50%) due to predation (mostly by coyote), overheating (not able to right; ca. 20%) or unknown causes. The radiotelemetry monitoring will continue for at least five years on the three groups, through 10 years on 150 animals (50 per group), and for 30 years of population level monitoring, although additional monitoring may be performed. Monitoring will also facilitate evaluations of health and disease status, population assimilation, and effects of post-translocation densities, historic livestock grazing, and constrained release methods. We are in the process of implementing affiliated conservation measures, including: establishing special use areas on the Combat Center, installing 52 km of exclusion fence between training areas and recipient or control areas, monitoring and controlling predators on- and off-base, and conservation measures in the Ord-Rodman Area of Critical Environmental Concern (law enforcement patrols, installing approximately 70 km of fencing, and rehabilitating unauthorized routes).

QuadState Local Governments Authority, a Coalition of Local Governments Engaged in Land Management in the Mojave and Sonoran Deserts

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Organized nineteen years ago as a coalition of Mojave Desert counties, QuadState Local Governments Authority's purpose was to secure local government engagement in desert tortoise management. Counties became concerned regarding the regulatory framework that was driving agency decision-making. Its formation opened communication with Fish and Wildlife Service (FWS). Over the ensuing period of time we have entered litigation on land use plans, and our portfolio expanded to include additional public land issues, but remains heavily oriented toward desert tortoise issues.

Local governments historically have been too little engaged in a variety of public land issues within their jurisdictions. Yet these local government officials are a source of local knowledge, input, and support for resolving issues and concerns. QuadState was formed as an interstate joint powers authority to give it official standing and recognition as an agency which could interface with the land and wildlife agencies as a partner and representative.
The Authority continues to work with BLM and FWS on tortoise recovery issues. We participate with the Management Oversight Group (MOG), and provide representation on the Recovery Implementation Teams (RITs). Additionally we have continuing involvement with the Arizona Interagency Desert Tortoise Team (AIDTT).

Our expanded portfolio includes the Desert Landscape Conservation Cooperative (DLCC). One of 22 LCC's nationally, it has interests in landscape management. The Eastern Mojave and Madrean Landscape Conservation Design Projects are two of three pilot programs adopted. Both are likely to focus on tortoise habitat conservation, and both must involve a cooperative effort among federal, state and local officials. We trust with our help as a catalyst for cooperation, coordination and collaboration for stability and recovery, and that local governments will be a full partner in these projects and implementation.

A Drone-Based Desert Tortoise Detection Evaluation: Operational Wildlife Survey Implications

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Drone-based desert tortoise detection could complement or replace ground-based alternatives if drone imagery could produce comparable detectability and more coverage at lower cost. For that reason, Clark County Nevada Desert Conservation Program (DCP) funded a project to evaluate drone-based benefits relative to ground-based alternatives. The project produced airborne imagery covering about 3 km^2 within the Boulder City Conservation Easement (BCCE). Imagery resolution was limited to 1 cm/pixel GSD to get competitive coverage compared to ground-based coverage. Automatic detection was employed to reduce manual image analysis effort. Since tortoise are difficult to distinguish from desert pebbles at 1 cm GSD, a novel image collection and analysis process was used. The process computes pixel level differences between closely aligned images covering the same ground on different flights. Resulting pixel differences can readily show where a tortoise was present on one day but not the other day. Pixel alignment required the drone imagery to cover the same region on two consecutive days. On each day, about 10,000 photos were taken and then combined to produce about 300 orthomosaics. Each orthomosaic for day 1 was pixel-aligned with its day 2 counterpart so that nearly all pixels for each pair were within a few centimeters of each other. All images were put on an external drive along with a web application that allows photos, orthomosaics and sightings to be closely examined on any computer browser. Copies of the external drive may be examined by observers to find tortoise visually or by analysts to find them automatically. Tortoise images at 1 cm GSD were too fuzzy to distinguish individual characteristics clearly. But if tortoises could be automatically detected in the field, then drones could get close-up shots on the spot (see above photo). Promising related results and developments underway will be presented at the Symposium.

Potential Impacts of Off-Highway Vehicle Use to Wildlife in the Southwest: Kit Foxes as a Case Study

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Off-highway vehicle (OHV) use is an important recreational activity, but has also become a management concern due to multiple potential impacts on natural resources. This concern is especially acute in arid lands of the Southwest, where sensitive desert environments and species experience exceptionally high levels of OHV recreation. As the demand for more OHV recreation sites increases, management agencies are forced to reassess the ways in which they meet recreationists' needs while maintaining the condition of habitat and its wildlife. Previous research has examined and documented negative impacts of OHV use on desert soils and plants, and a number of studies have documented reduced diversity, density, and biomass of reptiles, small mammals, and plants in OHV use areas versus in control sites. However, we still have a limited understanding of how OHVs may impact wildlife, and little information exists to guide OHV management in reducing potential negative impacts. To address these information needs, the Arizona Game and Fish Department (AGFD) conducted a research project during 2010-2013 in 2 areas of the Sonoran Desert in central Arizona to examine the potential impacts of OHV use on kit foxes (*Vulpes macrotis*) in the Sonoran Desert. We used an observational approach to determine the importance of road density to kit fox space use, relative to other measured environmental variables. We found road density to be the most important predictor of space use for kit foxes, relative to other measured environmental variables. Space use was negatively associated with road density during winter (Oct–Mar), which coincided with kit fox breeding denning, and pupping activities and was the season of relatively higher OHV use. Road density in OHV use areas is an important seasonal predictor of, and can negatively influence, kit fox space use. OHV road networks may lead to effective habitat loss for kit foxes and managers must consider how OHV recreational opportunities should be balanced with habitat conservation for species like kit fox.

Assessing Multi-scale Reptile and Amphibian Biodiversity: Mojave Ecoregion Case Study

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The ability to assess, report, map, and forecast the life support functions of ecosystems is absolutely critical to our capacity to make informed decisions that help maintain the sustainable nature of our environment now and into the future. Because of the variability among living organisms and levels of organization (e.g. genetic, species, ecosystem), biodiversity has always

been difficult to measure accurately, especially within a systematic manner and over multiple scales. In answer to this challenge, we have developed an approach that uses deductive habitat models for all the terrestrial vertebrates of the conterminous United States and clusters them into biodiversity metrics that relate to ecosystem service-relevant categories that reflect elements of A) Biodiversity Conservation; B) Food, Fiber, and Materials; and C) Recreation, Culture, and Aesthetics at 30m (Landsat) resolution. Collectively, these metrics provide a consistent scalable process from which to make geographic comparisons, provide thematic assessments, and to monitor status and trends in biodiversity. Currently, we include 1590 terrestrial vertebrate species (621 bird spp., 365 mammal spp., 322 reptile spp., and 282 amphibian spp.) for the conterminous U.S. In the present study, we identify and map reptile and amphibian biodiversity metrics for the Mojave Ecoregion. We focus on species richness metrics including all reptile species richness; all amphibian species richness; taxa groupings, e.g. snakes, lizards, frogs, and toads; and special status species. These metrics were then mapped based on potential species occurrence within the Mojave Desert and compared at finer scales within specific ecosystems to demonstrate the multi-scale utility of the approach. In these examples, geographic patterns differed among metrics and across the study area. Additionally, our approach incorporates built-in extensibility so that as other metrics become identified, they can be explored and added to the system.

STUDENT PAPER

The Desert's Canary: A Narrative Examination of the Socio-Political Role of the Threatened Desert Tortoise

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Through story, personal experience is connected to broader meaning. Consequently, conservation can be particularly important to people who have come into contact with a *flagship species*, or a charismatic animal used to inspire public interest. This case study will examine stakeholder narratives in the California Desert—particularly the Morongo Basin—where the desert tortoise (*Gopherus agassizii*) acts as a representative of the landscape. The tortoise holds special significance to residents of the U.S. southwest given the status of the tortoise as "threatened" under state and federal Endangered Species Acts (ESAs), its position as both California and Nevada's state reptile, and its role in passing the 1994 Desert Protection Act. Desert tortoise populations have been declining quickly since the 1950s, in large part due to developments such as military base expansion, utility-scale solar projects, use of large swaths of critical habitat for grazing, OHV recreation, increased predation, disease, and more. As a threatened species under the ESA, the tortoise is used politically to fight against habitat degradation. This study utilizes mixed qualitative methods with the goal of capturing stakeholder's narratives to discover how stories about the species are deployed in development debates. The goal of this thesis is to explore 1) how stakeholder narratives of the desert tortoise reveal the social and cultural significance of the species, 2) how narrative is then utilized in community resistance to large-scale development in the California Desert, and 3) how a conservation community narrates the ongoing loss of a keystone/iconic species from the landscape. The conservation-reliant status of the tortoise, coupled with protection of biodiversity that is accomplished by deploying the species in development

debates, highlights the need for more research on the social, political, and cultural significance of the tortoise.

Changing Landscapes, Perpetual Protection: A 30 Year Retrospective on Land Acquisition

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Over the past three decades, land acquisition and conservation efforts have evolved from government-initiated resource planning to an emphasis on public-private partnerships. The policy environment for conserving lands has undergone dynamic changes. In the past, federal and state funding were the fundamental drivers determining land acquisition priorities. With increasing constraints on government budgets, nonprofit conservation organizations have created new mechanisms to subsidize land acquisition and management. Along with innovations in land acquisition funding, nonprofit organizations have experienced a significant increase in stewardship responsibilities and associated costs. The Desert Tortoise Preserve Committee's land acquisition and stewardship programs at the Desert Tortoise Research Natural Area and other preserve areas in the California's deserts highlight the evolution of land conservation practices in the region.

Current Status of the Mohave Ground Squirrel

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The Mohave ground squirrel (*Xerospermophilus mohavensis*) is endemic to a restricted area in the western Mojave Desert of California. This species has been listed under the California Endangered Species Act (CESA) since 1971, first as "Rare" and then as "Threatened" when CESA was re-authorized in 1984. A conservation plan is likely to be published by the California Department of Fish and Wildlife in 2018, almost 50 years after the initial listing. Two petitions for federal listing have been rejected by the U.S. Fish and Wildlife Service, the latest rejection occurring in 2011. The Mohave ground squirrel is closely related to the round-tailed ground squirrel (*Xerospermophilus tereticaudus*), which is widely distributed throughout the eastern desert regions of California, into Arizona and southern Nevada, and south into the Mexican state of Sonora. There is evidence of occasional hybridization where their ranges meet on Fort Irwin and west of Barstow, especially in areas of habitat disturbance. Taken together, the overall distribution of these 2 ground squirrel species closely matches the combined geographic ranges of *Gopherus agassizii* and *G. morafkai*. The two *Xerospermophilus* species probably differentiated in the early Pleistocene, with the Mohave ground squirrel becoming highly adapted to the winter rainfall regime of the western Mojave Desert. Reproductive success in the Mohave ground squirrel is strongly dependent on sufficient winter rainfall to support growth of native forbs. The active season is short, with emergence from hibernation in February, birth of young in late March-early April, and entry into dormancy again in July and August. The first Mohave ground squirrel specimens were collected in 1886 in Lucerne Valley. However, the full extent of the range was

not established until 1977, when surveys found Mohave ground squirrels on Fort Irwin. Occurrence records up to 1986 show that the species was distributed from Lucerne Valley in the southeast to Owens Lake in the northwest and from Palmdale in the southwest to the Avawatz Mountains in the northeast. In the 1970s and 1980s there were many Mohave ground squirrel observations in the southern portion of its range, from Palmdale east to Victorville. However, there is now clear evidence that the species has been extirpated from almost all of its southern range for the past 25 years. The last record from Los Angeles County was a visual observation in 1991. The cause of this extensive extirpation is not clear, but it seems to be correlated with the severe 1989-91 drought. Many of the threats to the desert tortoise also impact the Mohave ground squirrel. There has been extensive habitat loss due to urbanization, agriculture, and transportation infrastructure in the western Mojave Desert, along with habitat degradation due to livestock grazing, OHV recreation, and military training. The current status of the species where it still occurs is uncertain. Live-trapping and trail camera surveys in the central and northern portions of the range showed widespread presence of Mohave ground squirrels in 2011-12, after several years of high winter rainfall. However, current BLM-funded monitoring shows a remarkable lack of detections even in areas that have supported good populations over recent decades, very likely a result of the recent multi-year drought. This raises the question of long-term viability for the species, as climate change brings hotter and drier conditions to the western Mojave. Can Mohave ground squirrels retreat upslope and to the north? Will they be replaced by round-tailed ground squirrels? Can standard conservation measures like protecting the best existing habitat and maintaining connections between population centers make a difference?

The Effects of Drought and Fire in the Extirpation of an Abundant Semi-aquatic Turtle from a Lacustrine Environment in the Southwestern USA

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Fire and drought are naturally occurring disturbances that have profound impacts on ecosystems and ecological processes, either singly or in synergy. Semi-aquatic turtles are useful

organisms to study the effects of drought and fire because their "dual citizenship" in terrestrial and aquatic habitats makes them susceptible to impacts that affect both environments. During the summer of 2014, we documented a significant mortality event affecting a southwestern pond turtle (*Actinemys pallida*) population living in Elizabeth Lake in Los Angeles County, California. The area around the lake was severely affected by a large wildland fire in 2013 that occurred during a protracted and ongoing drought that extended from 2012-2016. As the mortality event was still unfolding, we collected data in August and September of 2014 on water quality, demographic structure, and short-term survivorship of the population. Causes of mortality were investigated through necropsies of recently dead turtles. Water quality was poor with low levels of dissolved oxygen and high levels of salinity ranging from 12.40 to 45.90 ppt. We marked ninety-two turtles with a total of 218 captures and recaptures. Many turtles were severely emaciated and coated with a pale, friable to firm, mineralized layer (to 2.7 mm) on their shells and skin. The initial population size was estimated at 170 and the daily survival rate was estimated at 0.983. At the end of the 24-day study, the population was estimated to be 114. These survival rates would result in an estimated 90% decline in 134 days and a high probability of extirpation or near extirpation over the course of a year, a forecast that was confirmed in 2015 when the lake dried up. Necropsies suggested death by starvation but some turtles had mild to severe bacterial pneumonia. Fire and drought can have profound negative effects on populations of *A. pallida*.

POSTER

Modeling as a Tool to Guide Head-Starting, Translocation and Monitoring Decisions for the Mojave Desert Tortoise

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Supplementations of Mojave desert tortoise (*Gopherus agassizii*) populations have frequently been used to augment tortoise populations. The source of tortoises for these supplementations is either translocation, which involves removing tortoises from at-risk habitats and relocating them to protected areas, or head-starting, which aims to increase survival rates of juveniles by temporarily raising them in captivity before release. We created a matrix-based simulation model using demographic rates and uncertainty bounds drawn from the literature to address multiple questions that are relevant to decision-making when using these conservation strategies. We aimed to identify 1) the population conditions (e.g., vital rates, initial population size) under which supplementation will improve population persistence, 2) how long positive effects of supplementation on populations persist after supplementation has ended, 3) whether declining populations would benefit more from head-starting programs or translocations, and 4) the intensity and duration of monitoring effort needed before the benefits of supplementation are detectable in simulated populations. The benefits of supplementation may not be discernible for some time, and knowing how long to wait after supplementation to monitor for its effects could be of use to managers. Knowing the ideal frequency of monitoring effort could also help to reduce costs relating to labor-intensive tortoise surveys. Our initial results indicated that head-starting will

only be beneficial when the recipient population is at a low initial density and has high survival rates, but that translocation can be beneficial under a wider range of conditions (particularly with larger translocations). By modeling across a range of actual demographic and field detection rates together with a range of simulated starting population sizes, release numbers, and durations, we will provide useful insights into which populations will most benefit from supplementation in the future and how best to monitor for these benefits.

Road Mortality Mitigation: The Effectiveness of Animex Fencing vs. Mesh Fencing

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It is important to understand the impact from human development and infrastructure, such as roads in wildlife populations. Road-kill could be contributing to the global amphibian and reptile decline. To reduce this, many types of exclusion structures exist; fencing is the most efficient mitigation measure, however little research is known about what fencing types work best to exclude herpetofauna from roads and there are a lot of concerns with the safety and effectiveness of mesh fencing. Hence, this research tries to fill that gap of knowledge and evaluate the effectiveness of mesh fencing and solid hard plastic Animex fencing and its application for conservation of the herpetofauna.

The study was undertaken in Ontario, Canada. Each trial period was comprised of placing an individual animal in an enclosure with two sides composed of steel mesh fence (1/4 inch), and two sides composed of black Animex fence. This paper reviewed any relation between the different studied variables, which were monitored and recorded along the trial.

The results showed that all the studied animals spent a greater proportion of time along the mesh fence or trying to escape it, possibly because they were able to see or smell through the mesh fence. All the groups attempted to escape the mesh fence during more than twice as many trials as the Animex fence. All species except Midland Painted Turtles successfully escaped the mesh fence; however none escaped the Animex fence. Based on behaviours exhibited by animals during the trials, mesh fencing could result in injury to some herpetofauna. This study recommends using plastic solid barrier fence as the most appropriate road mitigation measure for the species studied, as the goal of exclusion fencing is not only to keep animals off the road, but also to funnel animals

safely to wildlife crossing structures. Mesh fence will not direct as easily animals towards the wildlife crossings due to additional risk of injury, escape and delay, causing as well an increase of the potential risks from roads.

KEYNOTE ADDRESS: WINNER, ROBERT C. STEBBINS RESEARCH AWARD

No Paternal Genetic Integration in Agassiz Desert Tortoises Following Translocation into an Existing Population

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Translocations are a tool widely used by wildlife managers, yet their impact is often insufficiently evaluated. Most translocation studies only assess the initial establishment phase, and the majority of long-term persistence studies to date have only tracked female fecundity. Male genetic integration for mitigative translocations have as of yet not been assessed and could greatly undermine the validity of translocation evaluations. To test for successful male integration, we determined genetic paternity of 92 desert tortoise hatchlings (*Gopherus agassizii*), from both resident and translocated females, four years after the initial translocation event and found that all 35 hatchlings with a match in our genotype database were sired by residents. Given that translocated males constitute 46% of the genotyped males found in the home ranges of the females, they produce significantly fewer offspring than resident males in the same area (G-test, p value < 0.0001). This is the first study assessing paternal genetic integration following a translocation of a wild sourced population into a native resident population. We hypothesize that male condition following the translocation, female mate preference for prior residents and competitive exclusion by resident males may contribute to the lower reproductive output of translocated males. We advocate the use of genetic paternity testing in other species to determine the generality of male translocation success across taxa given this unexpected and alarming result.

Coyote Cues Elicit Behavioral Responses in the Desert Tortoise

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Individual animals should minimize their risk of predation through the decision they make, which can result in non-lethal predator effects on behavior and spatial use. Coyotes, *Canis latrans,* are one of the primary predators for adult desert tortoises and have experienced large population increases in some locations due to human activity. In order to determine if coyote presence may have indirect, non-lethal effects on Mojave desert tortoises, *Gopherus agassizii,* we exposed captive animals to visual and olfactory coyote cues. We also measured risk of coyote depredation by wild radio telemetered adult (>180 mm midline carapace length) desert tortoises that were part of a large-scale translocation to Trout Canyon (Clark County, NV) based on burrow use. We found that captive tortoises exposed to coyote urine were equally willing to approach their food dish and fed for the same period of time as when they were exposed to rabbit urine. However, chronic exposure to coyote urine resulted in a significant increase in the amount of time animals spent in burrows, compared to when they were exposed to rabbit urine. The presence of a coyote decoy in their pens resulted in increased anti-predator behaviors, such as freezing, tucking or retreating into their burrows compared to the presence of a deer decoy. Wild tortoises that were found in burrows more often were also less likely to show signs of canid depredation in the first season after a translocation. Thus captive tortoises were able to recognize coyote cues as a potential threat and responded by reducing the time they spent on the surface as well as by displaying anti-predator behaviors. Furthermore, behaviors such as increased burrow use by tortoises in the presence of coyote cues may function to reduce the risk of coyote depredation.

The Power of Collaboration: A Case Study of How to do More with Less

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Habitat restoration to benefit the Agassiz's desert tortoise is widely recognized as critical to tortoise recovery, particularly in the West Mojave. Despite this, no examples of implementing a comprehensive suite of habitat enhancements currently exist. The Desert Tortoise Council's (Council's) 5-Year Strategic Plan aimed to correct this situation, but there was a problem: as an overburdened, all-volunteer Board, we could not do it on our own.

In January 2016, we enlisted the help of a team of master's students from the Bren School of Environmental Science and Management at U.C. Santa Barbara. Within the first three months, we selected a 460-acre site at the southeastern corner of the Desert Tortoise Research Natural Area's Eastern Expansion Area as the restoration study site. Over the next six academic months, the students worked with experts from the Desert Tortoise Preserve Committee, the Council, and others to develop the site-specific, integrated, and phased restoration plan.

From its inception, the restoration plan was designed to be strategic, by maximizing the conservation benefit while minimizing its financial costs. In this regard, the plan truly excels: Phase 1 calls for restoring more habitat (nearly 200 acres) at less cost (roughly $50,000-$60,000) than any other project under consideration by the California Recovery Implementation Team (RIT) in 2016.

The Council is currently working to fund the project and has successfully sought $7,500 from the California Community Forests Foundation, submitted an application to the West Mojave Workgroup of the California RIT, and is actively seeking other funding options. Meanwhile, the Council is also exploring several opportunities to put the many lessons learned to use on a new project. It was a daunting, yearlong project that required tremendous effort from all involved, but the Council's Board of Directors agree: the project has been a huge success, and would not have been possible without the power of collaboration.

STUDENT PAPER

Use of Modified GPS Loggers to Monitor Resident and Translocated Gopher tortoises (*Gopherus polyphemus*) in Southeastern Georgia

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Gopher tortoises (*Gopherus polyphemus*) are frequently translocated to avoid mortality from various development practices. In many cases, minimal monitoring is performed to confirm translocated individuals are integrating successfully into an existing gopher tortoise population at recipient sites. The resident-translocated tortoise social structure dynamic at the Penholoway Swamp Wildlife Management Area in Wayne County, Georgia is the result of two relocation cohorts totaling 138 tortoises which were relocated in March and September 2016 from Southern Ionics Minerals LLC. Mission Mine in Charlton County, Georgia. Modified recreational GPS logger units (i-gotU GT-120) and VHF radio transmitters are currently deployed on 20 resident and 20 translocated adult tortoises (~13-20 months to date). Here, I present burrow-use and home range spatial results obtained using modified GPS logger units. Our configuration of these GPS units allows an average battery life of 3-6mo.+ using an attempted logging interval of every 30-60min. from 0800-2100hrs. Stationary testing revealed that these units acquire satellite fixes with variable mean accuracy up to the tested maximum depth of 2m inside tortoise burrows. While the amount of spatial data obtained is substantially greater than traditional radio-telemetry methods, a considerable amount of trapping time and effort is required for this species. Additionally, care must be taken to use an appropriate spatial analysis method which overwhelms any error in logging

accuracy by prioritizing areas of high use. High use burrows and home ranges were identified using k-LoCoH (50%, 75%, and 95% isopleths) analyses in R via the ZoaTrack.org cloud-based platform and post-processed in Arcmap 10.3.1.

Desert Tortoise Council Activities – 2017

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The year 2017 was a productive year for the Desert Tortoise Council (Council) and Board of Directors (BOD). We continue to follow strategies identified in the 2015 5-year strategic plan with the goal for the Council to be a leader in desert tortoise recovery. But, tortoise populations are in decline, and more than half of the tortoise populations monitored by US Fish and Wildlife Service (USFWS) do not meet viability standards. These alarming statistics has motivated the BOD to continue to increase efforts. The Council is represented on each of the USFWS Recovery Implementation Teams, and attends the interagency meetings of the tortoise Management Oversite Group. We reviewed 30 projects in CA, AZ, UT, and NV, commenting on six; and a letter was sent to the NV Board of Wildlife Commissioners to ban commercial collecting of reptiles (which they did). To facilitate more consistent implementation of tortoise conservation measures, the Council developed a document providing "A Compilation of Best Management Practices to Protect the Mojave Tortoise" (available on our website). Of particular concern to the BOD is inadequate tortoise exclusion fencing along highways in California.

Total assets of the Council are $279,286. Workshops and symposium raffles are our primary source of funds used to advance the mission of the Council, support the annual symposia, and provide grants and awards. This year ASU received a grant to conduct genetics studies of tortoises from the Colorado River corridor ($11,970); the Tortoise Group received a grant in support of their "Keep Wild Tortoises Wild and Captive Tortoises Captive" initiative ($5,000); and a grant was awarded to California State Parks studying tortoises in Anza-Borrego Desert State Park ($9,587). Two awards were given students to attend the symposium. The Council received a grant of $7,500 from California Community Forests Foundation to initiate a habitat restoration project at the Desert Tortoise Natural Area identified and planned as part of a Bren School project sponsored by the Council. A very generous donation of $5,000 was provided by California Turtle and Tortoise Club, and we received a donation of $250 in the memory of Eleanor Benes. We did not receive applications for the $1,000 grant sponsored by Lockheed Martin to support minority students. For the second year there were no applicants for the Morafka award.

There were 90 participants in the Introductory Tortoise Workshop, and the Council sponsored three local (Ridgecrest) school teachers. A new week-long Authorized Desert Tortoise Biologist Training course was developed and provided instruction on advanced skills to 27 participants. The Council has signed a Memorandum of Understanding with the USFWS and Nevada Department of Wildlife to monitor radio-tracked tortoises on the Large Scale Translocation Site (LSTS), using these animals for workshop participants to gain field experience. It takes people to keep the Council functioning. There are 428 members, including 13 students.

The BOD continues to seek ways to reach out to students and young professionals. There are 15 members on the BOD, including two new members: Judy Hohman and Dr. Greer Dolby. The BOD continues to seek persons willing to serve on committees or be a BOD member. We particularly are looking for persons with a background in fund raising, social media, newsletter editor, or academia/education. The 2019 symposium will be held in Tucson, February 21-23 (Thursday through Saturday) and include a special session and field trips featuring the Gila monster.

Update on Desert Tortoise Head-starting Studies at the Mojave National Preserve

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Because of the severity of desert tortoise population declines, nontraditional management interventions are being explored as potential conservation tools to help recover remaining populations. Head-starting may provide a unique opportunity to "jump-start" depleted populations toward recovery while concurrent threats are addressed or mitigated. In 2011, we began a long-term study to 1) evaluate the effectiveness of head-starting to increase juvenile survivorship and 2) subsequently increase recruitment and overall population size of resident tortoise populations in the Mojave National Preserve, CA. To date, we have produced 396 hatchling desert tortoises for our objectives designed to compare growth, survivorship, and post-release spatial ecology of juvenile tortoises from 3 main experimental treatments: 1) "direct-release" hatchlings, 2) "low rain supplemented" head-starts reared in outdoor enclosures receiving low levels of rain supplementation, and 3) "high rain supplemented" head-starts reared in outdoor enclosures receiving higher levels of rain supplementation. In 2015, we initiated an additional treatment that involved rearing hatchlings indoors for their first year of life and comparing their growth and survivorship with siblings raised in the outdoor enclosures. Tortoises reared in the outdoor enclosures require 5–9 years to attain carapace lengths of > 100 mm MCL, but do not attain the shell hardness of similar-sized but older outdoor-reared juveniles. Initial indoor head-starting, followed by transition to outdoor enclosures for a second year may help reduce head-starting duration while assuring size-appropriate shell-hardness. Here, we provide an update on the status of the project, with results on growth and survival of all animals and movement of released animals, as well as discuss challenges encountered over the course of our long-term study.

Reproductive Ecology of Desert Tortoises (*Gopherus agassizii*) in the Sonoran Desert Region of Joshua Tree National Park and the Nearby Orocopia Mountains

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Agassiz's desert tortoise (*Gopherus agassizii*) is a long-lived species that is slow to reach maturity, making it difficult to study multiple generations. However, building knowledge of life history traits and demographic structure of populations is imperative to successful conservation. *G. agassizii* has a wide geographic range in California, inhabiting both the Mojave and Sonoran Deserts. The reproductive ecology (e.g. clutch size, clutch frequency, clutch phenology) of the species is expected to be influenced by climatic differences between the two deserts. The ecology of *G. agassizii* inhabiting the Sonoran Desert, where the species reaches the southern edge of its distribution, is understudied in comparison to populations inhabiting the Mojave Desert. We studied fecundity and reproductive phenology of *G. agassizii* at multiple locations in the Sonoran Desert, including within Joshua Tree National Park (1997–1999 at Pinto Basin, 2015–2016 at Cottonwood Canyon) and just south of the Park boundary on the northern versant of the Orocopia Mountains (2017). In each year of the study, female *G. agassizii* outfitted with radio transmitters were X-rayed from April to July to determine reproductive output. Overall means for annual clutch frequency (1.8 ± 0.1 clutches/female/year), clutch size (4.3 ± 0.24 eggs/clutch), and X-ray egg width (36.8 ± 0.13 mm) were comparable to data published for Mojave Desert populations. However, desert tortoises in this area of the Sonoran Desert produced shelled eggs approximately two weeks earlier (April 6) than the earliest dates reported for populations in the Mojave Desert which is likely an effect of a regionally warmer climate. Triple clutches, reported elsewhere in the western Sonoran Desert of California and rarely in the Mojave, were not observed.

Monitoring Movements of Sonoran Desert Tortoises in Relation to Wildlife Crossing Structures in Southern Arizona

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As with most wildlife species, roads are a nearly impermeable barrier to Sonoran Desert Tortoises (SDT; *Gopherus morafkai*). Sonoran Desert Tortoises rarely cross roads due to their lack of mobility but they suffer high rates of mortality when they do attempt to cross. There is speculation

that wildlife crossings can facilitate movement of SDTs across roads, however opportunities to evaluate the effectiveness of crossing structures for this species have been limited. The SDT population in the vicinity of the State Route 77 (SR77) northeast of Tucson, Arizona provides a unique opportunity to determine the combined effectiveness of an overpass, underpass, and multiple culverts linked with funnel fencing in minimizing road mortality while allowing for habitat connectivity for SDTs. To evaluate SDT movements along SR77 we conducted visual surveys for the presence of SDTs adjacent to SR77. Upon detecting a live SDT, we fitted the animal with a Very High-Frequency (VHF) radio-transmitter and Global Positioning System (GPS) tracking unit. GPS tracking units were replaced monthly and data was downloaded so that we may estimate home range size, activity patterns, and movement corridors for each individual. After 15 months of tracking, a total of 34 SDTs have been detected while GPS locations have been collected from 21 unique individuals. To date, no crossings by SDTs have been documented, however recent detections place radio-tagged SDTs within their closest proximity yet to the crossing structures.

New Genome-level Analyses of Genetic Structure Reveal Important Differences in Agassiz's Desert Tortoise Populations on a Landscape Scale

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Distance and landscape heterogeneity can strongly influence population structure and connectivity. Understanding how these factors shape the genomic architecture of threatened species is a major goal in conservation genomics, which can help robustly inform wildlife management. In this study, we used thousands of single nucleotide polymorphism markers and spatial data to re-evaluate the population structure of Agassiz's desert tortoises (*Gopherus agassizii*). Based on 6,859 markers, we found from 4 to 8 well-supported clusters across the range. All clusters were well-defined spatially. Western, central, and southern populations within the Western Mojave Recovery Unit were consistent throughout, while other recovery units were sometimes merged depending on the level of clustering. Based on 11 environmental features and a species distribution model, we tested the null hypothesis of isolation-by-distance by comparing least-cost and circuit-based resistance distance models. Statistical methods based on maximum-likelihood population effects and reciprocal causal modeling consistently supported least-cost distance with elevation, predicted habitat, and winter precipitation as better predictors than Euclidean distance, of genetic connectivity. Mountain chains, deep valleys, and local precipitation during winter, have had a strong

evolutionary role restricting gene flow between populations. Together, these findings have important repercussions for conservation initiatives, such as translocations and reproduction in captivity, opening new venues for conservation genomics in desert tortoises.

Bird Population Change in the United States Range of the Desert Tortoise: Results from the North American Breeding Bird Survey, 1968 – 2015

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The North American Breeding Bird Survey (BBS) is the primary source of information regarding population change in North American birds. It is multinational, jointly coordinated by biologists in the United States, Canadian, and Mexican governments. The survey is composed of >5,000 roadside survey routes, each of which contains 50 points at which an observer conducts a 3-min count and records birds heard or seen. The BBS was started in 1966 in the eastern US. Coverage started in the western US in 1968. Coverage of survey routes varies regionally, and a log-linear hierarchical model is used to control for differences in route coverage and observers over time. Analyses are conducted using Bird Conservation Regions (BCRs) within states and provinces as primary strata, and results for larger regions are aggregated from stratum results. . Here, we present results from the Sonoran and Mojave Desert BCR, a physiographic region that contains portions of California (with 42 routes), Nevada (6 routes), and Arizona (34 routes) coincident with the desert tortoise range in the United States. The BCR extends into northern Mexico, but the Mexican BBS is still under development and is not included in summaries. Trends could be estimated for 155 bird species encountered on $\geq$3 BBS routes in the region. Although trends tended to be imprecisely estimated for the region (average half-width of CI is 3.4 %/yr), 80 of the species (51.6%) had positive estimates of population change over the interval 1968-2015. Trends for species within the BCR tended to be slightly higher (average = 0.52 %/yr) than trends for the species estimated at a range-wide scale. Most species are more widely distributed than the BCR; on average, only 8% of the species range within the BBS survey area occurred within the BCR. In recent State of the Birds reports, Aridland species (i.e., that breed in desert, chaparral, and sagebrush habitats) were viewed as being of particular conservation concern (North American Bird Conservation Initiative, U.S. Committee. 2014. The State of the Birds 2014 Report. U.S. Department of Interior, Washington, D.C. 16 pages.). Forty-four of those species occur in the BCR; 24 of them (55%) have negative estimates of trend, but the slight declines indicated mean estimate of trend (-0.06%/year) does not suggest disproportionate declines in population within the BCR Bird species with >50% of their US ranges within the BCR include Le Conte's Thrasher (*Toxostoma lecontei*, Trend= -2.5 %/yr [95% CI: -4.0, -0.5], N = 48 routes, 89% of range in BCR); Abert's Towhee (*Melozone aberti*, 1.4 %/yr [-0.6, 3.6], N = 27, 75%); Gilded Flicker (*Colaptes chrysoides*, -2.1 %/yr [-2.9, -0.3], N = 27, 73%); Gila Woodpecker (*Melanerpes uropygialis*, -0.5 %/yr [-2.1, 0.5], N = 32, 69%); Lucy's Warbler (*Oreothlypis luciae*, 1.4 %/yr [-0.6, 3.3], N = 35, 54%); and Black-tailed Gnatcatcher (*Polioptila melanura*, -0.2 %/yr [-2.1, 1.7], N = 59, 50%).

Tortoise Abundance on SITLA & BLM Lands West of St. George, Utah

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Washington County HCP staff and Utah Division of Wildlife Resources (UDWR) conducted a desert tortoise survey on 5,150 acres of state School Institutional Trust Lands (SITLA) and BLM lands west of St. George, Utah during April and May, 2017. We found 78 live tortoises (56 adults and 22 juveniles), and 4 carcasses. The total estimated abundance for the survey area is 468 adult tortoises with a density of 22.5 tortoises per sq/km. We found a very high percentage (30%) of juvenile tortoises (not factored into the abundance or density estimates) which likely indicates a young population with excellent recruitment. We also started a citizen science project soliciting tortoise observations from trail users in and beyond our survey area. So far we have received over 80 tortoise observations from the public, greatly expanding our knowledge of the tortoise's distribution in the Upper Virgin River Recovery Unit. This area also contains many endangered dwarf bear-poppies, and other listed and state sensitive species. Based on these findings, this area has a high conservation value, and would be a valuable addition to the Red Cliffs Desert Reserve as we look to renew our HCP.

Doing More with Less: NGO Partnerships and the Preservation of Desert Tortoises

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Tortoise Group has been advocating and educating for the protection and well-being of the desert tortoise since 1982. Our founder, Betty Burge, was one of the first biologists to begin tracking data from local tortoises in southern NV and was a critical voice in getting the species listed in the late 1980's. Tortoise Group is recognized as one of the leading NGO's in captive tortoise management. Our emergency habitat, free microchipping and sterilization clinics, and re-homing services are some of the services Tortoise Group offers to residents of the state of Nevada. However, our largest impact comes from Tortoise Group's volunteer corps. We partner with numerous local and federal government agencies in order to augment their workload. Our partnerships with BLM, USGS, and NDOW (to name a few) enable our volunteers to use their time to their liking in assisting with current on-going agency projects. This allows the agencies to plan for larger scale projects where budgets would not previously permit. Recently, BLM needed to move several thousand seedlings into burned areas in the Mojave and the weight of the seedlings prohibited a large-scale planting (each of the bundles must be transported by hand in the field at some point). Tortoise Group utilized volunteers to help "jelly-roll" the seedlings throughout 3rd and 4th quarter 2017, as a result BLM planted well over 1,200 seedlings in December 2017. Tortoise Group receives no funding from the state or the county, and federal funding accounts for less than 20% of our budget. We are a small agency, but Tortoise Group is a thriving example of NGO partnership into 2018 and beyond.

Life History of *Mycoplasma agassizii*: Implications for Conservation Desert Tortoise

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Traditional models of disease processes (e.g., SIR models) do not work for desert tortoise and mycoplasmosis-caused URTD. Epidemiology theory and empirical evidence indicates that *Mycoplasma agassizii* is normally a commensal, and only turns into a pathogen when the tortoise is stressed causing its normal immune strategies to fail. Surveys for the presence of *Mycoplasma* in Mojave desert tortoise throughout the Mojave Desert, showed that the existence of *Mycoplasma* in tortoises was far more common than was disease in the tortoises. This is what would be predicted if *Mycoplasma* is normally a commensal. Moreover, epidemiology theory indicates that transmission of *Mycoplasma* among tortoises has to occur at rates far greater than are possible if *Mycoplasma* persists in populations where individuals clear their pathogen between incidences of disease. This additionally indicates that mycoplasmas do not leave their hosts, but instead persist as a commensal in the body of the host. We conducted a semi-natural factorial-design experiment to quantify dynamics of disease and pathogen in desert tortoises. We found no evidence of long-term immune protection against *M. agassizii*, or of immunological memory in tortoises. The results of our experiments indicate that recrudescence is as significant as transmission in causing manifestation of disease in tortoises. Results from our experiments and theory have led us to propose a new model of the host-pathogen system causing URTD due to *M. agassizii*.

Movements, Growth, and Survival of Head-started, Juvenile Tortoises at Edwards Air Force Base

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We monitored three groups of head started, juvenile Agassiz's desert tortoises (*Gopherus agassizii*) released onto two sites (Leuhman Ridge and Baker-Nunn) at Edwards Air Force Base. The release groups (Fall 2013, Spring 2014, and Fall 2014) were composed of cohorts produced in head start pens between 2003 and 2010. We used radio telemetry to track the tortoises, determined home range size using the minimum convex polygon (MCP), and assessed patterns in movements and burrow use. We determined annual growth rates in terms of mm/year and percent increase/year and survival trends using Kaplan-Meier survival curves. Thirty-seven tortoises died, attributed to predation by coyote (N=2), canid (N=4), "consistent with canid" (N=6), raven (N=13), "consistent with raven" (N=2), and dehydration/exposure (N=10). The Kaplan-Meier survival curve for all release groups combined indicated a steady decline, with cumulative annual survival rates ranging from 97.1% to 53.1%. No significant differences in survival existed between the release groups. The Fall 2013 group exhibited higher growth rates (6.5 mm/year) than Fall

2014 (5.8 mm/year) and Spring 2014 (4.3 mm/year) groups. Lower growth rates of the Spring 2014 group (Baker-Nunn release site) suggest their nutritional requirements are not being met as sufficiently as those released at Leuhman Ridge. Mean home range for all tortoises for which home range could be determined was 6,672.1 m^2, and total distances moved ranged from 18.3 to 2,524.8 m. Tortoises were tracked to between two and 28 discrete locations, and by release group they re-used a mean of between 1.1 and 2.6 burrows. Tortoises in the Fall 2013 release group exhibited significantly greater home range areas, used more burrows, travelled greater distances, and exhibited greater site fidelity than tortoises in the other release cohorts; these activities were likely a function of their larger body sizes and longer time being tracked.

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 degraded 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 affect 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. The park is heading into its third year of removing offending common ravens with some promise that the action is working to reduce predation on juvenile tortoises.

Inferences and Lessons Learned from Comprehensive Monitoring of Tortoise Translocations in the Ivanpah Valley

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Translocations have been implemented in several locations to mitigate potentially harmful impacts of anthropogenic activities (e.g., energy development, military exercises) on federally threatened Mojave desert tortoises (*Gopherus agassizii*). However, factors that have influenced the success of translocation efforts have been poorly understood. In this context, we designed and implemented a multi-year (2011 through 2017) study of translocated and resident Mojave desert tortoises at the Ivanpah Solar Electric Generating System (ISEGS) project site in the Ivanpah Valley of southern California. As required and described in the Revised Biological Opinion (2011) and the associated Effectiveness Management Plan (EMP), Mojave desert tortoises that were translocated from within ISEGS project boundaries to an adjacent area in the Ivanpah Valley have been monitored over nearly five years to understand the effects of short-distance translocation on tortoise survival and other demographic parameters. Here, we present the results of comprehensive monitoring of tortoise movements and space use patterns associated with several individual (e.g., body size, sex, translocated vs. non-translocated), local- (e.g., weather, soil properties) and landscape-level (e.g., shrub and wash density, metals concentrations, anthropogenic barriers to movement) variables. The comprehensive, multi-year monitoring of tortoise translocation outcomes conducted under the ISEGS EMP has provided numerous insights for developing effective translocation protocols, for detecting and interpreting translocation effects, and for identifying drivers of tortoise habitat use across the Ivanpah Valley, which provides high-quality habitat to an apparently healthy population of desert tortoises.

A Genomic View of Adaptation and Population History in Desert Tortoises

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Since their initial divergence, populations of *Gopherus agassizii* and *G. morafkai* have been shaped by an array of biotic and abiotic factors that have resulted in differences between the species. However, while the characterization of these factors in a historical context is critical for

understanding the biology of modern desert tortoises and informing their conservation management, they are not evident in the fossil record. Fortunately, both natural selection and demography leave detectable signals in the genome. Here, we discuss our ongoing efforts to investigate the evolutionary history of *Gopherus* in the desert southwest using a population genomics approach. Specifically, we focus on three evolutionary processes that have played a primary role in shaping both species since their initial divergence. First, using scans across the genome, we are identifying genomic regions exhibiting signatures of natural selection. Next, using broad geographic sampling, we are working towards evaluating evidence for historical and ongoing admixture between *G. agassizii* and *G. morafkai* in northwestern Arizona. Finally, we are reconstructing past changes in population size. By integrating these lines of evidence with detailed biological and geological information, we aim to provide a detailed picture of the adaptations and demographic phenomena that have been important throughout the evolutionary history of these two species.
