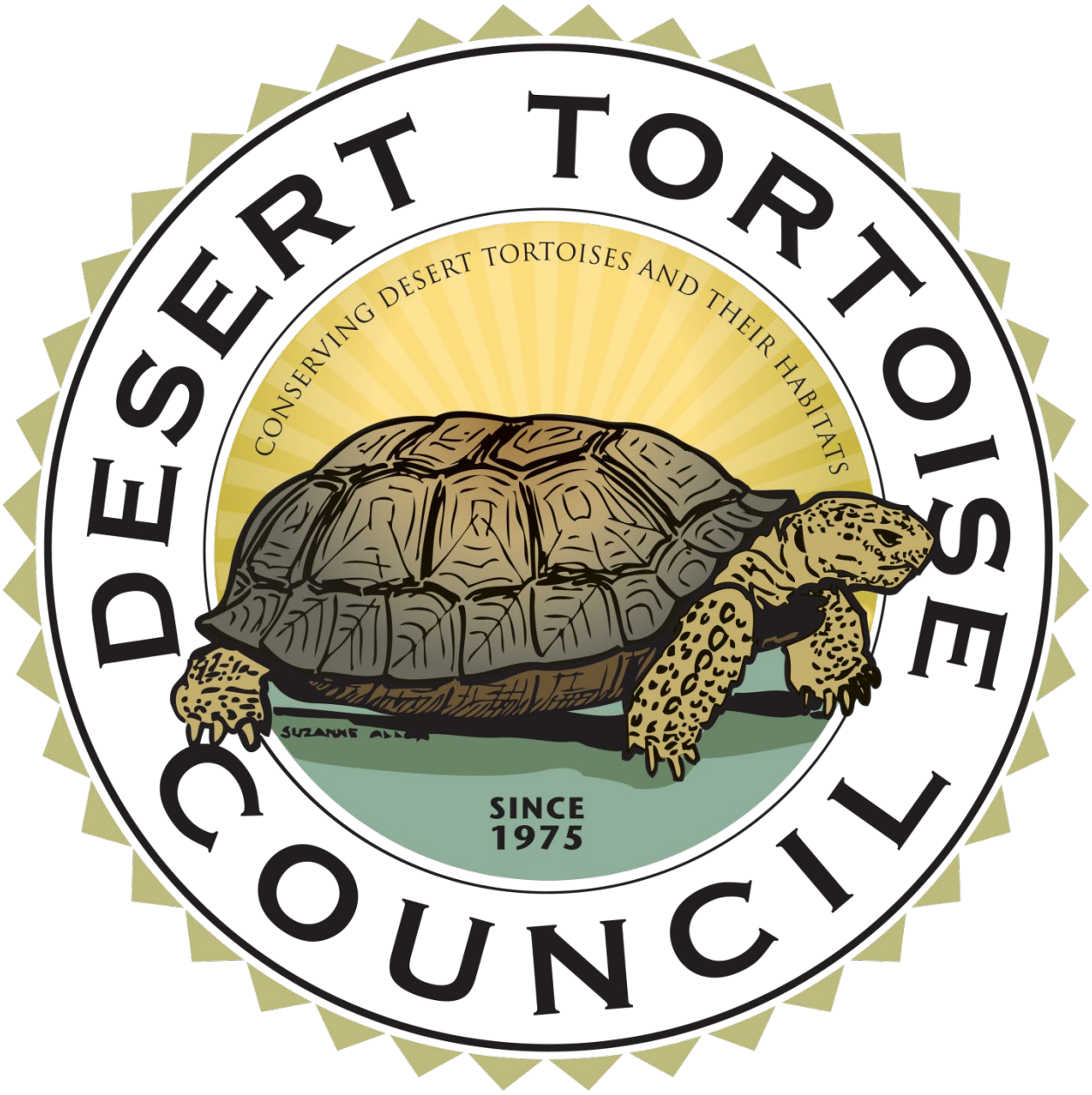

ABSTRACTS

46th Annual Meeting and Symposium

Virtual

February 9, 11, 16, 18, 23, and 25, 2021

FORTY-SIXTH ANNUAL MEETING AND SYMPOSIUM
THE DESERT TORTOISE COUNCIL

Virtual by Zoom
Tuesday and Thursday Mornings February 9–25, 2021

ABSTRACTS OF PAPERS AND POSTERS

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

Developing a Population Augmentation Strategy for the Mojave Desert Tortoise

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Because desert tortoises have low reproductive rates, the U.S Fish and Wildlife Service (2011) *Revised recovery plan for the Mojave population of the desert tortoise (Gopherus agassizii)* outlined a role for population augmentation to accelerate the rate of recovery in targeted areas. Mojave desert tortoises have been shown to have a survival rate comparable to that of residents during the first years after translocation, and this tactic has been used for years to move tortoises from impending project sites. Translocation guidance to date has focused on enhancing survival of individual tortoises and of minimizing risk of mortality to both resident and translocated tortoises after translocation. Population augmentation called for in the revised recovery plan builds on these principles by using the translocation tactic strategically to enhance populations by increasing the resilience, resistance, or replication of populations in each designated recovery unit. Population augmentation is one type of conservation translocation covered by guidelines of the International Union for the Conservation of Nature (IUCN). The guidelines call for a focus on achieving defined conservation goals by assessing feasibility and risk, addressing threats to the population, laying out a release strategy in advance, and monitoring as part of an adaptive strategy. This process necessarily requires management involvement to ensure more than short-term survival of translocatees but also should have an exit strategy. The Desert Tortoise Recovery Office has been developing population augmentation guidelines specific to *Gopherus agassizii* by drawing on the IUCN (2013) guidelines so that the ongoing and isolated translocations from project sites can be targeted to achieve recovery goals in addition to allowing for survival of individual tortoises.

Advancing Desert Tortoise Protection and Recovery

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The Center for Biological Diversity continues its work to protect and aid in the recovery of the desert tortoise and its habitat in California, Nevada, Arizona, and Utah. Using science-based advocacy, participation in administrative processes, public information and litigation, the Center focuses our efforts on increasing protections for desert tortoise as the path to desperately needed recovery. Some challenges that the Center focused on in the past year include opposing the weakening of ESA and NEPA regulations that help protect desert tortoise and other desert plants and animals from environmentally harmful activities and ensure adequate consideration of alternatives and mitigation. In various coalitions, we have increased the drumbeat of support for desert conservation in California, Nevada and Utah to protect desert tortoise. In California, we have helped to assure proper implementation of the Desert Renewable Energy Conservation Plan (DRECP) while continuing to engage on poorly sited "grandfathered" solar and transmission projects that are not bound to DRECP requirements. Relying on the available science showing that ORV impacts significantly undermine desert tortoise survival and recovery, we continue the struggle to limit ORV impacts in tortoise habitat from both authorized and unauthorized use and anticipate challenging the expansion of ORV use authorized in the West Mojave Plan in early 2021. We are pushing back on the proposed Clark County Lands Bill, which would expand the public lands disposal boundary into undisturbed desert tortoise habitat outside the Las Vegas Valley, allowing new sprawl development which will exacerbate climate change. We celebrate our decade-long fight against the Southern Nevada Water Authority's pipeline water grab, in the courts and in the state legislature, finally prevailing with our coalition partners in 2020. We successfully derailed the massive military land grab, as the US Air Force sought to expand the Nevada Test and Training Range into Desert National Wildlife Refuge, which includes hundreds of thousands of acres of tortoise habitat. We are actively involved in the strong coalition defending the Red Cliffs National Conservation Area from the destructive "northern corridor" in Washington County and improving the County's HCP. Unfortunately these projects appear to be headed to a legal challenge.

Lessons Learned from Twenty Years of Egyptian Tortoise Conservation and Research in Egypt

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The Egyptian tortoise, *Testudo kleinmanni,* is one of the smallest and most endangered tortoise species in the world and has the most restricted range of all tortoises in the Mediterranean Basin. The main threats to the Egyptian tortoise are habitat loss as a result of overgrazing, largescale development, and the pet trade. The first Egyptian tortoise population was rediscovered in North Sinai, Egypt in 2000 and now at least 5 small populations are known to occur in North Sinai. We discuss the lessons we have learned from over twenty years of conservation and research on the Egyptian tortoise. These lessons include approaches to working with the local community, translocations and reintroductions, and habitat restoration in areas grazed by livestock, to name a few. One of the greatest achievements of this local community approach is that Egyptian tortoise conservation has proceeded for the past twenty years without any major problems.

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

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The Desert Tortoise Recovery Program collaborated with numerous partners on several large-scale recovery projects in 2020:

1) We conducted range-wide monitoring surveys of desert tortoises in six strata in California. Surveys in Nevada and Arizona were cancelled due to the coronavirus pandemic.
2) We finalized revision of translocation guidance and developed an overarching strategy for population augmentation, as recommended in the recovery plan.
3) We wrote a white paper on desert tortoise population connectivity.
4) We coordinated on transportation infrastructure-related projects and effects on recovery, including a programmatic NEPA analysis of the installation of tortoise barrier fencing along highways, a transportation ecology webinar series and workshop, and the "Road Warriors" project documenting roadkills and fence maintenance issues in southern Nevada.
5) We led the expansion of range-wide monitoring of raven populations and predation risk.
6) We coordinated on the design of a new Desert Tortoise Recovery Center as legislated in the 2019 Dingell Conservation Management Recreation Act.
7) We coordinated on the Recovery and Sustainment Partnership Initiative, which will provide new resources for recovery efforts in Tortoise Conservation Areas.

8) We led the 2nd Annual Desert Tortoise Week. Despite the necessity of making the event a primarily virtual experience, we expanded the focus from the Coachella Valley and Colorado Desert area of California to the full range of the species.
9) We coordinated efforts to change how several utility-scale solar developments will be constructed so that vegetation will remain and allowed to regrow and so that tortoises will be allowed to reoccupy the sites.
10) We published 4 papers with collaborators on topics including post-translocation survival, degree of development vs. tortoise presence, and home-range estimation.

STUDENT PAPER

Borreliosis Transmission from Ticks to Humans Associated with Desert Tortoise Burrows – Examples of Tick-borne Relapsing Fever in the Mojave Desert

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Ticks interact with wildlife and harbor agents involved in zoonotic diseases throughout many ecosystems. Argasid ticks, such as *Ornithodoros* spp., harbor and transmit *Borrelia* spp. resulting in tick-borne relapsing fever (TBRF) in people. Tick-borne relapsing fever is endemic in the western United States, yet cases can be misdiagnosed. Tick-borne relapsing fever is mostly described as occurring in higher elevations and was not previously confirmed in the Mojave Desert. We describe the first documented TBRF cases in the Mojave Desert (Clark County, Nevada, USA) with individuals exposed to *Ornithodoros* ticks during excavation of soil burrows associated with Mojave desert tortoises (*Gopherus agassizii*). Our findings should serve as a precaution to individuals working with tortoises or animal burrows, or those in contact with *Ornithodoros* ticks in this region and will contribute to enhanced education and surveillance of this disease.

Factors Affecting Survival of Adult Desert Tortoises During the 10 Years Following Long-distance Translocation

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In spring of 2008, several hundred desert tortoises (*Gopherus agassizii*) were translocated from the National Training Center, Fort Irwin, in the central Mojave Desert of California. Several principal investigators and multiple projects were involved with the translocated tortoises, and we previously reported progress to the Desert Tortoise Council on this project. We translocated 158 healthy adult desert tortoises to four 2.58 km^2 plots, moving tortoises 7.4 to 42.5 km, an average distance of 23.0 0 ± 10.2 km from their original capture sites on Fort Irwin. By 2018, the tenth year following translocation, 28 tortoises (18%) were alive, 103 (65%) were dead, and 27 (17%) were either missing or had been removed from the project. To better understand factors contributing to survival, we prepared models of survival for each year post translocation. Initially we considered nine variables but eliminated four to avoid collinearity. Final models contained five variables: plot, sex, size (midline carapace length), average distance traveled between observations, and numbers of repeat locations during periods of temperature extremes, a potential measure of settling. Factors affecting survival differed by year; numbers of repeat location were important in each annual model, indicating that tortoises with more repeat locations were more likely to survive. Other factors of importance, depending on year, were size, average distance traveled per observation, and plot.

Three-D Printed Tortoise Models Used to Measure Predation Risk by Common Ravens

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Juvenile Desert Tortoises (*Gopherus agasizii)* experience high rates of predation by Common Ravens (*Corvus corax*). We developed a 3-D printed juvenile tortoise (Techno-Tort™) intended to simulate real tortoises to measure predation risk, monitor the effectiveness of management actions at reducing raven predation, and deliver aversive experiences to train ravens not to attack tortoises. In 2017-2018 in Eldorado Valley, Nevada, we performed a proof-of-concept test to see how ravens responded to the Techno-

Torts™ (TT) and to construct raven predation risk maps. Ravens investigated and sometimes attacked the models causing damage similar to that found on tortoise shells beneath raven nests. Motion-triggered cameras focused on cat food cans were placed at 84 randomly selected points for one year; ravens were photographed at 21% of those cameras. TTs coupled with motion-triggered cameras were employed at 37 points, 13 (37%) of the cameras recorded ravens at the TTs. Using these data and raven pellets containing raven DNA, predation risk maps were generated that could help direct future management actions. In 2019, we placed Techno-Torts™ coupled with motion-triggered cameras for up to 15 weeks at 273 locations in a 654 km^2 area in Kramer Valley, California. Techno-Torts™ and cameras were placed at mostly randomly selected locations to determine best placement, design, time, and habituation. We measured the number of events with ravens, the most intense type of action performed, and latency to respond. Ravens were recorded at over 30% of the Techno-Torts™ within one week of placement. Responses declined with time, but that pattern was overwhelmed by temporal changes in raven breeding cycle. Techno-torts™ show promise for effectiveness monitoring and taste aversion tools, both of which we are developing further.

Modeling and Mapping Predation Risk to Desert Tortoise Populations

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Subsidized predators, such as common ravens (*Corvus corax*) and coyotes (*Canis latrans*), are a threat to the recovery of desert tortoise (*Gopherus agassizii*) populations. Understanding the spatial and temporal extent of predation is essential to managing the recovery of threatened and endangered populations. We investigated the distribution of raven, coyote, and kit fox (*Vulpes macrotis*) populations in Eldorado Valley, Clark County, Nevada, for two years to measure temporal-spatial characteristics of predation risk. We conducted surveys, used motion-triggered infrared cameras, collected scat, and deployed 3-d printed tortoise models over a 1035-km^2 study area including the Boulder City Conservation Easement. Data from these efforts (including genetic analysis of scat contents), habitat characteristics, and proximity to human developments were used to model predation risk and develop a series of predation risk maps to help direct management efforts to areas where they may be most fruitful at recovering tortoise populations. As anticipated, relative abundance coyote and raven populations were positively associated with human developments. We propose a comprehensive, multi-faceted species-specific predator management program that could be implemented in a phased manner depending on the monitored results of the first (and subsequent) steps taken.

Historical Perspective on the Desert Tortoise: Field and Conservation Efforts in the Late Holocene up to Its Listing

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Many today lack an appreciation of the substantial early efforts to understand the ecology of and conservation for the Desert Tortoise (then *Gopherus agassizii*). Here, I provide a historical perspective on the contributions of several biologists and programs to better archive that earlier information and, hopefully, indicate how they served as a springboard for many current efforts. In 1969, I submitted any account to include the species for the U.S. Red List but it was not accepted. By 1975. the Desert Tortoise Council was created (due in large part to efforts by KH Berry). Early on, almost all efforts were minimally funded. For example, in 1974 the World Wildlife Fund funded my first tortoise project for $10,000 (=$46,000 today) and that was split among all four species of North American tortoises. Still, it served as vital leverage that lead to publication of an edited book (Bury 1982) that had a review of the ecology of the Desert Tortoise by RA Luckenbach and it remains a classic. Later, we released a companion volume with 17 chapters (Bury and Germano 1994). Both were government publications (US Dept. Interior) and widely distributed at no cost. Specific research projects included field surveys at large scale (e.g., Mojave Desert) or regional (e.g., Sonora, Mexico). Other studies examined gene flow and connectivity, assessed impact of grazing and ORVs, and uncovered key life history traits. Some of the early field warriors included those above as well as Steve Busack, Steve Corn, David Germano, Ron Marlow, and Phil Medica. Post-listing (1990), few of these investigators remained focused on tortoise issues. Still, they merit our appreciation because of establishing the beach head for the larger, more integrated studies of today.

Diet Influences Growth, Survival, and Microbiome Composition in the Mojave Desert Tortoise

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Access to high-quality nutritional resources is a critical requirement for individual health and population persistence, yet is often understudied in wild systems. As humans alter and fragment existing habitat areas invasive plants have become more abundant, displacing native foraging resources . For the Mojave desert tortoise (*Gopherus agassizii*), encroachment of invasive grasses such as red brome (*Bromus rubens*) has detrimental impacts on growth and survival of juveniles. However, little is known about how invasive grasses impact the composition of the gut microbiome of tortoises. We conducted an

experiment with Mojave desert tortoises where juveniles were housed in enclosures and fed diets of either invasive red brome, native forbs, or commercial tortoise food for comparison. By collecting scat samples throughout the experiment, we were able to pair data on growth and survival with high-throughput sequencing of the gut microbiome. Tortoises fed the brome diet had higher mortality rates, suggesting that shifts in nutritional quality associated with invasive grasses have individual- and population-level fitness effects. Diet, growth, and survival status were all associated with microbial community composition, indicating that the gut microbiome may be a mediating factor driving variation in survival and growth across diet groups. Our high-resolution microbial dataset also allowed for identification of 33 microbiome representatives across nine phyla that were significantly differentiated across diet groups, pointing to a subset of bacterial lineages ultimately responsible for community-level differences. These results highlight the role of the microbiome in mediating individual health and survival and indicate that assessments of the gut microbiome in free-ranging tortoises may serve as a useful monitoring tool for indirectly assessing fitness and health.

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 907 acres of take during the period of January to November 2020, leaving 54,945 acres of take authorization remaining under the current permit. The 2021-2023 Implementation Plan and Budget will allocate up to $19,617,877.05 for the funding of staff and projects starting in July 2021. Highlights of desert tortoise-related work conducted over the past two years include: reinitiation of occupancy surveys on the Boulder City Conservation Easement (BCCE); restoration of nine kilometers of linear disturbance on the BCCE; commenced year 7 of post-translocation monitoring of desert tortoises on the BCCE; initiated development of models to determine ways to maintain and/or increase connectivity in areas where connectivity is expected to decline in the future; launched a multi-agency collaborative effort with USFWS, BLM, and others to better understand how tortoises utilize culverts on the landscape; began development of a desert tortoise connectivity literature review and management plan that should be available in the summer of 2022; and kicked off a literature review of desert tortoise habitat restoration methods and best practices that will culminate in a two-day workshop in January 2022 and development of a synthesis review document.

STUDENT PAPER

The Role of Physiological Stress in Head-starting Success for Mojave Desert Tortoises (*Gopherus agassizii*)

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Turtle head-starting involves the protection of eggs and rearing of hatchlings in captivity until they reach a size less vulnerable to predation, at which point they are released to augment diminished wild populations. Outdoor head-starting has been studied as a recovery tool for desert tortoises (*Gopherus agassizii*), but may require 5–9 years for tortoises to reach recommended release sizes. We evaluated combination head-starting that included both indoor and outdoor rearing as a means of reducing the duration of captivity. Animal stress under different captive rearing strategies and its role in post-release behavior and survival have not been evaluated for desert tortoises. We reared 72 hatchling desert tortoises under three head-start treatments for release: (1) one year indoor rearing followed by one year outdoor rearing in predator-proof enclosures ("combination" rearing group), (2) two years of solely outdoor rearing ("SOR" group), and (3) 6–7 years of solely outdoor rearing ("Six-plus" group). We collected blood and fecal samples to measure baseline stress-related parameters, including corticosterone, testosterone, lactate, and lymphocyte profiles prior to release. We radio-tracked tortoises for one year to determine survival and dispersal from the release site. Treatment groups differed in mean movement displacement between their release location and their location at the end of the study (LME; p=0.002), with "Six-plus" tortoises moving 4x farther (mean: 423.1±104.8 m) compared with combination (mean: 118.3±24.5 m) and SOR tortoises (mean: 102.7±16.2 m). Survival was 86.4% for all tortoises with confirmed fate and did not differ significantly among treatment groups (GLM; p=0.693). While our results suggest that combination rearing reduces captive duration with no significant detriment to survival or site fidelity, further analysis of stress metrics is needed. We hypothesize that acute and chronic stress influence individual post-release movement and survival. The emerging field of stress physiology emphasizes the need to consider animal welfare in captive conditions.

Tracing the Legacy of Anthropogenic Radionuclides from 20th Century Nuclear Testing in Desert Tortoises (*Gopherus agassizii*) at the Nevada Test Site

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Between 1951 and 1962, the United States tested 100 above-ground nuclear weapons at the Nevada Test Site (now the Nevada National Security Site) northwest of Las Vegas. During this era there was a significant release of anthropogenic radionuclides into the environment through direct contamination of soil/vegetation at testing sites and indirect contamination through fallout. An important component of these nuclear tests and subsequent fallout and contamination is that many locations of testing coincided with areas of known desert tortoise (*Gopherus agassizii*) habitat within southern Nevada (e.g., Frenchman Flats). Furthermore, while fundamental research by Singh and colleagues in 1984 helped established that desert tortoise scute and shell are potential 'sinks' for records of these anthropogenic radionuclides in the environment, little additional work has focused

on the historic and modern record of tortoise radionuclide assimilation at the Nevada Test Site and elsewhere. Here, we present our recently funded Laboratory Directed Research and Development, Exploratory Research project, from Los Alamos National Laboratory, focused on investigating this legacy record of radionuclides in tortoise and turtle scute keratin tissue. Our collaborative research project aims to answer several questions: 1) are radionuclides present and measureable in annual growth layers within tortoise/turtle keratin, 2) do desert tortoises from the Nevada Test Site record the legacy of anthropogenic release of radionuclides from above-ground nuclear testing, and 3) can modern scute sampling provide a technique for radionuclide monitoring and potential contamination in desert tortoises and other tortoises/turtles from nuclear sites around the globe. Here, we overview our research methodology, approach, and current and future sampling strategies.

POSTER

Activity Patterns of the Spur-thighed Tortoise in the Central Mediterranean

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The Spur-thighed Tortoise *Testudo graeca* Linnaeus, 1758 has a wide distribution including North Africa, Europe and Asia. In Italy, viable populations of *T. graeca*, originating from North Africa, are present in central-western Sardinia where they occur in both coastal and hilly areas. Classified as Near Threatened in the IUCN Italian Red List assessment, this species is increasingly menaced by human-induced land use changes (in particular intensive agriculture) and by illegal collection, translocations, and related consequences (e.g., possible dissemination of infectious diseases). Less is known about the ecology of the Italian *T. graeca* populations.

Here we report some ecological notes based on over 500 field observations recorded from 2001 to date, on an Italian population of *Testudo graeca* mainly inhabiting a coastal zones characterized by open uncultivated areas, dune vegetation and Mediterranean maquis. *T. graeca* seems to be active throughout the year but with a decreased/null activity in the hottest summer days, when very high temperatures can be recorded and food and water availability is minimal due to scarce precipitation. In fall, characterized by relatively mild temperatures, more frequent falls and presence of herbaceous vegetation, an intense activity was recorded, especially when compared with the Italian peninsular populations of the congeneric *Testudo hermanni*. In particular, in the Spur-thighed Tortoise, courtship and mating were observed more frequently in fall (September-November) than in spring (February-March). Assessing the actual pattern of activity of a species is key to implement effective conservation actions, including possible relocations.

Mojave Desert Grasslands: 40 Years of Collecting Historical Ecological Evidence of Past and Present Native Plant Community Diversity

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Through extensive examination of reference sites across the Mojave Desert of California and Nevada since the 1980s, supplemented with historical record searches, and

the study of herbaria collections, a diversity of native arid grassland components can be reconstructed among current native plant communities. Grassland communities may have been a more common part of deserts, intermixing with Mojave desert scrub, Joshua tree savannas, and wetlands. Distinct desert grassland communities are evidenced in the West Mojave Desert region, southern Mojave lowland and upland areas, uplands in the Mojave National Preserve and southern Nevada ranges, and a distinctive desert grassland type in the northern Mojave. Details of the native grass species diversity in these geographic regions are reviewed. Cool season grasses dominate western Mojave Desert regions, transitioning to warm season grasses in eastern Mojave regions. Warm-season grasses are known as C4 plants, as they use the four-carbon compound PEP carboxylase in photosynthesis. PEP carboxylase is a photosynthetic enzyme that can "attract" CO2 more efficiently than C3 plants, and allows the stomates of the plant to be closed more often—an adaptation to drought. Historic and ongoing impacts such as livestock grazing, invasive non-native grasses and forbs, habitat development and disturbance, and climate change have greatly reduced native grasses. Given the importance of high-quality grass forage to adult Agassiz desert tortoise (*Gopherus agassizii*), a better understanding of this component of Mojave Desert plant communities is recommended, especially when considering mitigation measures and restoration activities of desert habitats.

Recovery Progress at Mojave National Preserve

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The Dome Fire burned 43,273 acres on Cima Dome, which included almost 42,000 acres of the Ivanpah/Shadow Valley desert tortoise (*Gopherus agassizii*) Critical Habitat Unit. However, impacts to desert tortoises were minor. Limited surveys found no tortoises or burrows in the burned area. Habitat values based on the USGS regionwide habitat model (Nussear et al. 2009) were 0.4 or less while 82 percent was valued at less than 0.2. Line-distance sampling and general observations also suggest limited tortoise presence. Recovery efforts across the Preserve included; invasive weed control, raven management, monitoring of road maintenance projects, pre-project surveys for soils mapping, and habitat restoration. Time and quantities of projects were limited this past year due to pandemic restrictions but surveys and control of Sahara mustard (*Brassica tournefforti*) were conducted near Goffs and Kelso. Raven (*Corvus corax*) management continued, documenting and monitoring 100 raven nests in and around the Preserve. Thirty nests containing 136 eggs were oiled while Wildlife Services removed several ravens from offending nests. About 250 hours of tortoise monitoring to protect tortoises and their habitat from harm occurred on multiple road maintenance projects and ongoing soils mapping, but tortoise mortalities from visitor vehicle strikes remain concerning. Extensive planning was started to address road mortalities investigating fencing, road closures and enforcement as solutions. We continue to support the University of Georgia and University of California, Davis in ongoing research on head starting at the Ivanpah Desert Tortoise Research Facility.

Analysis of Captive Desert Tortoise Health Data

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Desert tortoises held in captivity as pets may be exposed to a wide range of diseases. The population of captive tortoises may have exceeded 100,000 within Clark County, according to a recent survey. Unwanted captives may be released into the desert habitat and potentially expose wild tortoise populations to the diseases they carry. Captive tortoise health data, along with anonymous demographic data, collected from their custodians may assist with evaluation of the current threat to wild tortoise populations and identify geographic hotspots within Clark County that should be targeted for public education and outreach. Health and demographic data was collected from 475 captive desert tortoises during ten clinics hosted by the Tortoise Group in collaboration with the U.S. Fish and Wildlife Service from 2015 to 2019. We used this data to evaluate the health status of captive tortoises within Clark County relative to zip code location, number of tortoises per household, and density of custodian households within a zip code. We identified several zip code locations with both high densities of custodian households and intensity of clinical symptom scores among tortoises examined. The results of this analysis will allow the Tortoise Group to focus educational outreach efforts within specific locations to help minimize the potential threat to wild tortoise populations from captive tortoises released by their custodians.

Desert Tortoise Transportation Ecology Workshop

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Desert tortoise road mortality is a significant threat relative to recovery of this species. Construction of over 60,000 kilometers of major roads throughout the range of the desert tortoise has permanently fragmented previously contiguous habitat, reducing connectivity among populations. Installation of tortoise fencing and culverts to limit

mortality, encourage re-colonization of habitat, and ensure connectivity has been identified as a high priority for desert tortoise recovery, yet many miles of roads throughout desert tortoise habitat remain unfenced. Technical, financial, and administrative obstacles to fencing installation are common, and can present significant barriers to implementation of this high priority recovery action. The Service partnered with the Center for Large Landscape Conservation (CLLC), the Western Transportation Institute (WTI), and other local, state and Federal agencies to develop and organize a series of virtual Desert Tortoise Transportation Ecology workshops, with the final workshop scheduled for March 2021. The primary objective of the workshops is establishment of a Task Force to address issues regarding effects of roads to desert tortoise populations, and implementation of conservation actions intended to minimize these effects. The Task Force will collaborate, under the guidance of the Service, CLLC, and WTI, to develop technical solutions and best management practices, which will be published as a guide for transportation and natural resources/wildlife agencies. In addition to the workshop, the CLLC developed and analyzed a survey intended to identify key issues and inform development of the final agenda for the March 2021 workshop. In lieu of an in-person field trip, a documentary featuring a rangewide tour of study sites, interviews, and presentation of relevant issues was filmed, and will be presented during the March Workshop. This project is an excellent example of interagency collaboration with non-governmental organizations to better inform and increase implementation of actions to benefit recovery of the desert tortoise.

Interspecific differences in the genome and historical effective population size: Insight for future management of the Mojave and Sonoran desert tortoises

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As a lineage splits into separate species, genetic and phenotypic differences accrue that may require the use of different management practices if conservation efforts are needed to preserve the integrity and health of both species. Here, we summarize differences between Mojave and Sonoran Desert tortoises (*Gopherus agassizii* and *G. morafkai*, respectively) across the whole genome and relate how these genetic differences may account for key phenotypic differences. Results show that genes in diverged parts of the genome are statistically enriched for chemosensory processes, including detection of stimuli involved in sensory perception, sensory perception of smell, and sensory perception of chemical stimuli. Diverged categories also include circadian rhythm, telomere maintenance associated with aging, and osmoregulatory processes including renin secretion into the blood, response to osmotic stress, and kidney development. Several genes involved in the formation, maintenance, and transportation of solutes across the blood-brain barrier have also diverged between the two species, which can affect how an organism perceives thirst and regulates its hydration state. We also summarize whole-genome data of populations to delineate the identification of Mojave Desert tortoises and Mojave-Sonoran hybrids within Arizona. Specifically, individuals in the Lake Mead

National Recreation Area match the genotype of Mojave Desert tortoises, expanding the range of this species further into Arizona. Finally, we show that the changes in historical effective population sizes of these two species differ, indicating that they have responded differently to past environmental changes and may respond differently to future climate changes.

Comprehensive Evaluation of Immune and Physiological Dysregulation in Mojave Desert Tortoises using Altered Diet as a Natural Stressor

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Immune function and physiological responses in reptiles are not well understood, as their responses are complex and influenced by many factors. Previous studies on chelonians and other taxa have provided insights on the types and magnitudes of responses wild animals have to stressful stimuli or altered environments. Yet, comprehensive and directed diagnostic approaches are needed to evaluate immune reactions and physiological conditions in tortoises. We conducted an experiment with captive juvenile Mojave desert tortoises (*Gopherus agassizii*) using altered diet. Tortoises were fed a diet of invasive red brome grass (*Bromus rubens*), a mixture of native forbs, or commercial tortoise food for comparison from April through September. Tortoises were evaluated monthly for clinical health conditions, growth, and survivorship. Blood samples were used to evaluate a comprehensive laboratory panel for analytes involved in oxidative stress and antioxidant defense, immune function, and physiological stress. Not surprisingly, laboratory results were mixed, and analytes varied temporally especially between June and July. Cellular stress metrics (e.g. alanine and aspartate aminotransferases) generally decreased throughout the study for all animals; however, they were lower for tortoises consuming *Bromus* than other diets. Interestingly, metrics often used to evaluate systemic stress (e.g. alpha 2-macroglobulin) and generalized tissue damage (e.g. lactate dehydrogenase) in other vertebrates were higher in tortoises that grew more, appeared clinically normal, and consumed subsidized commercial diet. We found immune indicators such as the production of proinflammatory cytokines (interleukin 6), stress-induced chaperone proteins (heat shock proteins -70, -90), and metrics of toxic cellular stress from lipid peroxidation and reactive oxygen species (ROS) damage increased in individuals consuming native diets. These results were informative toward understanding how tortoises respond physiologically to stressful stimuli and may enhance the effectiveness of health surveillance and management programs for this species.

Tribute to Philip A. Medica: Herpetologist, Conservationist, Mentor and Friend

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Our friend and mentor Phillip Anthony Medica spent much of his 79 years committed to the study and conservation of reptiles. Sadly, he passed away on May 3, 2020. Phil enjoyed sharing life's experiences by telling captivating stories. As a budding herpetologist in new York, Phil made lifelong friends at the American Museum of Natural History. Phil moved to Las Cruces, NM for college and also met his wife, Gloria. He graduated from New Mexico State University with Bachelor and Master's degrees. Next, Phil studied at Brigham Young University, Utah, with Wilmer Tanner and worked at the Nevada Test Site (NTS). Later he conducted extensive research on the life history of side-blotched lizards (*Uta stansburiana*), and eventually completed the longest longitudinal study of the Mojave desert tortoise (*Gopherus agassizii*) growth and longevity yet published. Phil's professional experiences at the NTS from 1987 –1992 included the International Biome Project, Research Associate with the University of California Los Angeles, and consulting positions in nuclear safety and research for national defense. When the Mojave desert tortoise received Endangered Species Act protection (1991), Phil was drafted as a senior scientist to build research programs at the Bureau of Land Management – NV; National Biological Survey, US Geological Survey, and US Fish and Wildlife Service where he was the first Mojave Desert Tortoise Recovery Coordinator, establishing range-wide population monitoring across the Mojave. From 2005–2011, Phil was a Wildlife Biologist at USGS and co-principal investigator of a large project at the Ft Irwin National Training Center developing several procedures used in tortoise translocation actions today. Phil became a Scientist *Emeritus* with USGS where he continued to do science. Phil was our treasured friend and mentor, and he shared his vast knowledge of herpetology and deserts with all those who had the good sense to listen.

Philip A. Medica's full professional history is available in the online journal Herpetological Conservation and Biology:

http://www.herpconbio.org/Volume_15/Issue_2/Esque_etal_2020.pdf

STUDENT PAPER

Characterization of Texas Tortoise (*Gopherus berlandieri*) Home Ranges and Habitat Use in Cameron County, Texas

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Species habitat use is valuable information in conservation planning, especially in species with restricted home ranges such as *Gopherus* tortoises. The Texas Tortoise (*Gopherus berlanderi*) inhabits Tamaulipan scrublands throughout south Texas, and coastal populations have been associated with low relief clay ridges filled with mesquital scrub known as *lomas*. *Lomas* are typically surrounded by salt prairie grasslands. Our study examines *G. berlandieri* habitat use at Palo Alto Battlefield National Historical Park, a protected natural area in Cameron County, Texas. Eleven tortoises were outfitted with GPS loggers which took locations once an hour. GPS loggers were replaced monthly after tortoises were relocated using radio telemetry. We used three different metrics to delineate home ranges of individual tortoises: 100% Minimum Convex Polygon, 95%, and 50% Kernel Density Estimate. We conducted a χ^2-analysis for each individual tortoise for each home range metric to compare tortoise use of *loma* and prairie habitats to the amount of each habitat type available for use. A χ^2-analysis was also performed for the entire study population for each home range metric. No individual tortoise showed patterns of habitat use that were different from availability of the two habitat types, regardless of home range metric. However, the study population as a single entity exhibited habitat use that was significantly similar to the availability of *loma* and prairie habitat types when home ranges were estimated as 100% MCPs and 95% KDEs. These results are counter to previous studies which strongly associate *G. berlandieri* with *loma* habitat in coastal populations of south Texas. Future research will focus on differences in *G. berlandieri* behavior when located on *lomas* or in the surrounding matrix as well as possible differences in *G. berlandieri* home range size and habitat use when comparing tortoises inhabiting *lomas* and coastal populations inhabiting surrounding grasslands and scrubland.

Translocation and Headstart Advances of the Marine Corps Air Ground Combat Center (Combat Center)

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In April 2020, the Combat Center translocated 167 small tortoises, those with carapace lengths < 160 mm. The translocation totals are now 1017 large (carapace length > 159 mm) and 421 small tortoises. Radiotracking in 2020 identified nine mortalities (3 Controls, 4 Residents & 2 Translocatees), for totals of 41 Controls, 17 Residents and 35 Translocatees (16.1%, 8.8% & 18.3%, respectively). The annualized mortality rates from April 2017 to October 2020 were 4.9%, 2.6% and 5.6%, respectively (annualized survival: 95.1%, 97.4% and 94.4%, respectively). These rates are comparable to natural survival in wild populations during good rainfall and primary production years. The nine mortalities were spread among sites, included 8 adults (5 females, 3 males) and 1 juvenile, and resulted from predation (5: 4 coyote, 1 raven), vehicle strike (n=1), hyperthermia (overturned, n=1) and unidentified causes (n=2). The Combat Center's Headstart Program published a multi-year, multi-cohort growth rate and survival study in 2020 (doi.org/10.3354/esr01067), documenting strong effects of year, age and cohort on juvenile growth. Annual effects were likely due food availability associated with winter rainfall (natural effects), and program management (e.g., food and water supplementation). Program management in headstart enclosures resulted in 11-year survival rates that were ten times that of a remote wild population.

Margaretha Delina Hofmeyr, In Memoriam, 1950-2020

Brian T. Henen

Among the rich, diverse wildlife of the Mother Continent, South Africa's tortoise diversity reigns king. In Africa's vast landscape and lore of lions, leopards and elephants, Margaretha Delina Hofmeyr (Retha) heartily embraced the tremendous challenge to understand and conserve the world's richest diversity of tortoises.

Retha was born in Kimberly, South Africa, and studied springbok and sheep physiology for her Master of Science degree at Stellenbosch University, with renowned Professor Gideon Louw conferring Retha her degree on the majestic sand dunes of Gobabeb. While lecturing full-time at the University of the Western Cape (UWC), Retha completed her PhD on ungulate thermoregulation at the University of Cape Town.

Continuing at UWC, a historically black university, Retha persevered as young woman in a primarily male faculty, during socially turbulent times in South Africa. Dedicated and determined, Retha lectured numerous zoology courses in two languages, and supervised post-graduates researching marine species and small mammals. As an

exemplary champion of merit, Retha became Head of UWC's Department of Zoology in 1990.

Retha's commitment to fairness, discipline and equity in mentoring students consistently brought her high praise, with many students referring to her as 'mom'. She compassionately challenged students to strive, perform their best, and achieve beyond expectation while adhering to integrity. Her students have become prominent academics, government officials and renowned biologists. Retha had an intense understanding, respect and dedication to diversity, cultural and biological.

In the mid-1990s, encouraged by tortoise expert Ernst Baard, Retha launched an intense program investigating southern Africa's tortoise diversity and conservation. With Ernst, Gerald Kuchling, Uwe Fritz and a slew of post-graduate students and other colleagues, Retha significantly broadened worldwide understanding of chelonian (turtle and tortoise) evolution, ecology and physiology.

Within genetic, morphological, paleontological, climate and habitat constructs, these insights help us understand the deep evolutionary path and forces leading to southern Africa's rich chelonian diversity. The findings also broadened worldwide perspectives of turtle and tortoise reproduction, nutrition and life-history strategies.

As an indefatigably loving wife to Theunis and mother to Michael, Isabella and Lize, Retha inspired them all to love and be ambassadors of skilpadjies (little tortoises). She also inspired Theunis and Lize to become superb tortoise field biologists, Isabella's passion for biodiversity and conservation legal services, and Lize's art and scientific illustrations of tortoises and flora. In matching Retha's keen sense of humor, her children often jokingly complained about feeling they needed to compete with tortoise favourites, such as #253, for Retha's affection.

Retha's drive and compassion infused her desire for nature conservation, propelling her to be the pillar of Chelonian Biodiversity and Conservation in southern Africa. The geometric tortoise (*Psammobates geometricus*), a Critically Endangered species, was always Retha's central focus. Its dire status compelled Retha to establish the first headstart program for geometric tortoises. When Retha died, only 800 wild geometric tortoises remained, yet she had headstarted more than 100 juveniles for release.

Retha, Theunis, Isabella and Lize worked tirelessly with the Turtle Conservancy to protect one of the last geometric tortoise populations from land development. Retha was instrumental in helping the Turtle Conservancy establish the Southern Africa Tortoise Conservation Trust, of which Retha was founder Trustee. In 2014, she earned the Sabin Turtle Conservation Prize. Through painstaking efforts, Retha orchestrated the tortoise component of South Africa's Atlas and Red List for Reptiles and led the recent IUCN Red List Assessments of all tortoises of southern Africa.

On the Mother Continent, Retha mothered her children and her students. Retha was also the mother of turtle and tortoise conservation in southern Africa. As a person of

exemplary standards, productivity and compassion, Margaretha Delina Hofmeyr is a brilliant star that will continue to shine and guide us.

Tiered Management of Common Raven Density within California's Tortoise Conservation Areas

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Since 1970, common raven (*Corvus corax,* hereinafter raven) abundance has skyrocketed throughout the arid and semi-arid ecosystems of North America, fueled by an ever increasing supply of anthropogenic subsidies to carrying capacity (i.e., water, food, and substrates). Unsurprisingly, the raven is now implicated in the decline of both avian and reptilian species of conservation concern—including the threatened Mojave desert tortoise (*Gopherus agassizii*, hereinafter tortoise). During the spring of 2020, 536 variable radius point counts were conducted, and 3,372 twelve-hour tortoise decoy depredation-trials were analyzed. These data were collected at randomly places locations throughout tortoise conservation areas found in both the Mojave and Sonoran desert of California. Ravens were observed at 53.39% of points, counts ranged from zero to twenty-nine ravens, and raven density among all sampled conservation areas was estimated to be approximately 1.15 ravens per square kilometer. Average weekly tortoise survival probability was estimated to be approximately 90.52% and ranged from approximately 74.49% in the Fremont-Kramer Critical Habitat Unit to near 100% along California's south eastern border. Coarse area-by-area estimates of raven density explained approximately 38.37% of observed variation in weekly survival probability estimates and, did so, in a negative, linear fashion. This relationship, however, was not statistically significant at an *alpha* of 0.05. This coarse relationship, plus observations from the Great Basin Desert, involving greater sage-grouse (*Centrocercus urophasianus*) nest success, support the preliminary acceptance of 0.4 ravens per square kilometer as the first, of at least two, predator density thresholds important to the recovery of the tortoise. Raven management in California will now lavage StallPOPd V3 to restore raven densities to less than 0.4 ravens per square kilometer, with 95% confidence. Once achieved, lethal removal will cease, but subsidy and habitat management will continue until raven densities reach to-be-determined thresholds relevant to subsidy and habitat management.

STUDENT PAPER

Intrinsic and Extrinsic Factors Regulate Dispersal in Mojave Desert Tortoise

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Dispersal is a key process in an organism's life history. An individual may make a dispersal movement to reduce competition with conspecifics, escape unsuitable conditions, and find mating partners. Discerning the processes that drive dispersal movements is key to understanding how connectivity functions both between and within populations. Factors, both intrinsic, such as life stage and health, and extrinsic, such as weather, are known to be important in determining if an individual will make a dispersal movement. Drivers of dispersal in *Gopherus agassizii* are poorly known, and modeling dispersal patterns will lead to better predictions of how habitat development and climate change may influence connectivity. We used long-term telemetry datasets (> 3 years) from the Ivanpah Valley CA/NV region to understand patterns in Mojave desert tortoise dispersal and how they relate to connectivity in the region. We defined a dispersal movement as a year where a tortoise left its prior home range for a new area and did not return to the prior home range in the next year. Based on 1074 tortoise-years of 208 subadult and adult (> 150 mm MCL) tortoises we found dispersal movements in roughly 3% of tortoise-years. Dispersal distances ranged from 0.2 to 3.2 km. We compared mixed-effects logistic regression models to determine which covariates, both intrinsic and extrinsic, were important in determining if a tortoise would make a dispersal movement. Top-ranked models suggest that higher levels of spring and summer precipitation and lower levels of winter precipitation increase the odds of a dispersal event. The relationship between dispersal probability and size were less clear, but suggest that smaller tortoises are more likely to disperse.

Chelonian Health Issues: Past, Present, and Future

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Emerging and recently emerged infectious diseases coupled with environmental degradation and exploitation of animals and their parts are significant threats to global biodiversity. Regarding chelonians and other reptiles, it is not surprising that health issues

were under-appreciated until the end of World War II when some of these animals became popular as pets. In the 1950s, traveling circuses offered American anoles (*Anolis carolinen*sis) and red-eared sliders (*Trachemys scripta elegans*) for sale. Starting in the 1960s, several animal dealers in Florida began importing and offering a great variety of reptiles, many of which would be sold in pet stores in northern cities. The Greek Tortoises (*Testudo graeca*) was the first tortoise the author recalls being sold in pet stores in the New York City area. It would take another 30 years for the reptile business to take a major leap forward, when the first reptile expo (or show) had its grand opening in Florida. Throughout this period of time, the demand for chelonians as pets remained high or increased. At the same time, over-exploitation of chelonians in the pet and food trade resulted in numerous species in southeast Asia approaching extinction. Chelonian medicine and disease was an outcome of the health care needs of chelonians kept as pets, displayed and used for educational and conservation programs in the wild and in zoological parks and aquariums, used for captive breeding and sale in the pet trade, and studied in both the laboratory and field. It is interesting to note that fibropapillomatosis, a world-wide disease of wild marine turtles, was first reported in the 1930s in turtles arriving at the New York Aquarium from the Florida Keys, with anecdotal reports by fisherman around 1900. It would take another 60 years before progress was made to better understand the breadth of this disease in marine turtles around the world and its ultimate cause. Starting in the 1980s, numerous pathogens were identified in chelonians, with most reports simply being descriptive. Although respiratory disease had been seen in captive Mojave Desert Tortoise (*Gopherus aggasizii*) in the 1970s, it wasn't until 1989 when an upper respiratory tract disease was reported in wild Mojave Desert Tortoises, and 1991 when a mycoplasma identified as a potential causative agent. Much has been done since that first report to better understand the nature of this disease in *Gopherus* spp. in the US and Mexico, and in other species of tortoises in Europe. Other pathogens such as *Ranavirus, Testudines* intranuclear coccidiosis, and multiple herpesviruses have all emerged as significant pathogens of chelonians. Molecular and serological tools have been responsible for much of the advances that have been made. Added upon disease issues, exploitation in the food and pet trade, climate change resulting in fires, drought and temperature fluctuations, cold-stunning events in marine turtles, dumping of plastics in aquatic systems, and habitat loss and degradation will push many species to the brink of extinction over the next 20 years unless these issues are adequately addressed. A challenging future awaits us given all the threats that continue to affect biodiversity and new threats yet to emerge.

Celebrating Desert Tortoise Week 2019-2020

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Establishing and sustaining an environmental education program is a high priority as described in the Mojave Desert Tortoise Recovery Plan. The goal of the education program is to build public support for, and involvement in, desert tortoise (*Gopherus agassizii*) recovery. The U. S. Fish and Wildlife Service (Service) organized and hosted a public outreach campaign to inform the public about desert tortoise conservation issues,

change learned behavior, and encourage responsibility for public actions that affect the species. The campaign called 'Desert Tortoise Week 2020' occurred from October 5 through October 11, 2020. The Service encouraged conservation partners to develop and host educational events to promote conservation and recovery actions for desert tortoises. Due to the global pandemic, the Service employed existing resources to ensure that this education campaign was effective through socially distanced events and advertised through social media. Conservation partners hosted a series of desert tortoise talks and coordinated with local businesses to show desert tortoise informational videos. The Service also developed social media presence that challenged the public to engage in desert tortoise awareness activities such posting photos of desert tortoise habitat during recreational activities. Conservation partners also developed educational virtual lesson plans, hosted online presentations, and established wildlife biologist panel discussions for the public to enjoy and learn more about the species. After Desert Tortoise Week 2020, our conservation partners reported public participation resulting in attendance of over 2,400 people at socially distanced events and over 1.2 million social media impressions. Overall, Desert Tortoise Week 2020 was a successful education recovery action. The Service is currently planning Desert Tortoise Week 2021 for April or October 2021, depending on the status of the pandemic.

STUDENT PAPER

Thermal Ecology and Activity Patterns of Adult and Juvenile Bolson Tortoises (*G. flavomarginatus*)

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Desert-adapted tortoises face challenges due to climate change as arid environments are expected to become even drier and warmer in the coming decades. To better predict and mitigate the impact of rising temperatures on tortoises, we first need to determine how activity patterns and physiological processes of tortoises are affected by variations in the thermal environment. In this study we evaluated whether thermoregulatory strategies during the summer differed between male and female Bolson tortoises as well as adults and juveniles. We obtained data on temporal patterns in body temperatures by affixing temperature loggers onto 11 juvenile and 12 adult Bolson tortoises. Temperature loggers were attached on either the anterior or posterior part of the carapace for juveniles ($n_{♀}$=5, $n_{♂}$=6) and in both locations for adults ($n_{♀}$=6, $n_{♂}$=6) to capture temperature variation within individuals. Temperatures were recorded every 30 minutes for 6 weeks during periods of high tortoise activity (06/14/2019 – 07/27/2019). Preliminary results showed a similar unimodal distribution of carapace temperatures for all tortoises over a 24-hour period ($\bar{x}_{Day}$=29.9±3.9°C, $Range_{Day}$=16.5-47°C, $\bar{x}_{Night}$=26.7±2.5°C, $Range_{Night}$=14.5-35.5°C).

Mean temperature ranges, while similar during the day, showed significant differences between adults and juveniles and between males and females at night ($p < 0.05$). Adult males occupied larger temperature ranges at night (14.5-35.5°C) than adult females (16.5-34.7°C) or juvenile males (17.5-34.3°C) and females (16.9-33.5°C) which could indicate that males spend more time outside the burrow at night than females or juveniles. We also compared the frequency and duration of emergences per day among adults and juveniles of both sexes and investigated the association between body size and heating and cooling rates. These results indicate that adults and juveniles use different strategies to thermoregulate, and that the exact strategy depends on the sex of the individual.

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Range-wide Occupancy Trends for Mojave Desert Tortoises

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Data from long-term monitoring programs, such as the US Fish and Wildlife Service (USFWS) line distance sampling (LDS) program for Mojave desert tortoises (*Gopherus agassizii),* are increasingly being used in new ways to elucidate trends in population dynamics. Here, we use the USFWS LDS data in a novel way to generate range-wide predictions of occupancy, colonization, and localized extinction rates from 2001-2018. We chose to develop a dynamic occupancy model to answer fundamental questions posed by BLM personnel regarding how *G. agassizii* are distributed across the landscape over space and time. We transformed the LDS data into presence/absence data, and constructed a Bayesian dynamic occupancy model using several time-varying (e.g., temperature, precipitation, NDVI, fire, and a proxy for invasive grasses) and static covariates (e.g., soil properties, topography, wash density, distance to roads, distance to urban areas) hypothesized to influence *G. agassizii* occupancy dynamics. Drawing on these model outputs, we developed an interactive, web-based tool for exploring trends in dynamic occupancy across the species range, allowing users to hone in on areas of management interest or concern. For example, this tool can be used to support National Environmental Policy Act (NEPA) reports, identify potential 'sink' habitat (i.e., where occupancy has declined or extinction rates are high), and areas that may be suitable for translocation (i.e., areas where the probability of occupancy has increased).

Management of Desert Tortoise Habitat on Bureau of Land Management Lands in California

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The CA BLM administers 2 million acres of desert tortoise critical habitat within 8 critical habitat units across 5 BLM field offices. In 2020, we monitored and controlled ravens, funded line distance sampling, funded a study on connectivity in the California Desert, participated in regional planning efforts like the Desert Tortoise Recovery Implementation Team and the West Mojave Working Group, expanded the BLM Mojave Desert Native Plant program for habitat restoration, closed washes in "washes closed zones", restored and signed routes of travel, acquired lands within priority areas, funded a naturalist at the Desert Tortoise Natural Area, reported on our multiple biological opinions to track the types of projects/ surface disturbance authorized by BLM each year, and continued the BLM Mojave Desert Working Group to better coordinate tortoise management across all the BLM offices within the range of the tortoise.

STUDENT PAPER

Use of Survey Data to Identify Key Issues and Insights Regarding Implementation of Conservation Actions to Address Effects of Roads on Mojave Desert Tortoise *(Gopherus agassizii)* Recovery

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Conservation actions intended to benefit the survival and recovery of at-risk species can be complicated by a myriad of technical, financial, and administrative issues, which can delay or entirely preclude effective implementation. Social science tools, such as surveys, can be an effective approach to identifying key issues and insights for navigation towards resolution and subsequent successful implementation of conservation measures. Over 60,000 kilometers of major roads occur throughout the range of the Mojave desert tortoise (*Gopherus agassizii*), resulting in unsustainable levels of mortality and habitat fragmentation, posing a major threat to the recovery of this species. Yet, conservation actions, such as installation of fencing and culverts, have not been effectively implemented along hundreds of miles of priority road segments as a result of numerous roadblocks presented by overlapping technical and administrative issues. In an effort to effectively disentangle and resolve these issues, we developed an anonymous survey to inform the architecture of a Desert Tortoise Transportation Ecology workshop and establish an interagency task force that would collaborate on development of guidelines for implementing recovery actions to address road mortality and increase connectivity. Responses were collected from representatives of local, state, and Federal agencies, tribal entities, non-governmental organizations, and academic institutions that may have a role in recovery of the desert tortoise. The results of the survey were analyzed and compiled into a summary report, which was provided to the planning team. Key findings and insights

gained from this survey highlighted critical issues that will be addressed through the workshop and task force.

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Fire Mortality within the Red Cliffs Desert Reserve

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In the last two decades, wildfires within the Red Cliffs Desert Reserve (Reserve) have increased in size and frequency, due primarily to the proliferation of nonnative grasses, specifically cheatgrass (*Bromus tectorum*) and red brome (*Bromus rubens*). We estimated the total number of tortoises that died from the 2005 wildfires and compared mortality among four fires that varied in size and intensity. Wildfires killed 687 tortoises, including 380 adults and 307 juveniles. We observed a pattern of mortality, with significantly more shells observed in the large, intense Plateau Fire than in the small Red Cliffs Fire. Further, more remains than expected were observed in the Rock Land and Rock Outcrop soil types, characterized by dense nonnative vegetation and supporting high densities of tortoises.

Recent fires in July 2020 burned over 11,000 acres of tortoise habitat within the Reserve, primarily in areas that previously burned in the summer of 2005. Wildfires killed 25 tortoises, including 17 adults, with a higher density of shells observed in the Cottonwood Trail Fire. In spring 2021, we will assess latent mortality as well as estimate densities of live animals within burned areas. Wildfires can have different impacts on tortoises depending on various factors, including soil type, fuel load, fire intensity, timing (e.g., season, time of day, weather conditions), shelter availability, and tortoise density. Large-scale wildfires can have significant population impacts on size-structure and survivorship, particularly for a long-lived species with low reproductive potential such as the desert tortoise.

STUDENT PAPER

"Unscrambling" the Drivers of Egg Production in Agassiz's Desert Tortoise: Climate and Individual Attributes Predict Reproductive Output

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The 'bet hedging' life history strategy of long-lived iteroparous species reduces short-term reproductive output to minimize the risk of reproductive failure over a lifetime. For desert-dwelling ectotherms living in variable and unpredictable environments, reproductive output is further influenced by precipitation and temperature via effects on food availability and limits on activity. We assembled multiple (n = 12) datasets on egg production for the threatened Agassiz's desert tortoise (*Gopherus agassizii*) across its range and used these data to build a range-wide predictive model of annual reproductive output as a function of annual weather variation and individual-level attributes (body size and prior-year reproductive status). Climate variables were more robust predictors of reproductive output than individual-level attributes, with overall reproductive output positively related to prior-year precipitation and an earlier start to the spring activity season, and negatively related to spring temperature extremes (monthly temperature range in March-April). Reproductive output was highest for individuals with larger body sizes that reproduced in the previous year. Expected annual reproductive output from 1990-2018 varied from 2-5 eggs per female per year to 6-12 eggs, with a weak decline in expected reproductive output over this time (P = 0.02). Climate-driven environmental variation in expected reproductive output was highly correlated across all 5 Recovery Units for this species (*Pearson's r* > 0.9). Overall, our model suggests that climate change could strongly impact Agassiz's desert tortoise reproductive output, and could have a negative population-level effect if precipitation is significantly reduced across the species' range as predicted under some climate models.

STUDENT PAPER and Invited Paper

Hyperpredation of Tortoises and Freshwater Turtles by Subsidized Corvids: Global Case Studies of a Conservation Conundrum

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Subsidized predators are animals, native or introduced, whose populations proliferate through association with humans. Resource subsidies facilitate rapid increases in subsidized predator populations, their geographic range expansion, and prey overexploitation. Corvids (Aves: Corvidae), such as ravens and crows (Corvinae: *Corvus* spp.), are intelligent, highly social, long-lived, and widespread generalist predators that have undergone explosive regional population increases in response to anthropogenic subsidies. Freshwater turtles and tortoises (Chelonia) are among the most imperilled vertebrates globally, and elevated mortality caused by subsidized predators is identified as a leading threat. As subsidized predators, corvids pose a considerable additive mortality threat to turtle eggs, juveniles, and, in some cases, adults. The objectives of this presentation are to: (1) Examine regional population trends for corvids and chelonians; (2) review global case studies of corvids as chelonian predators; (3) evaluate our current understanding of subsidized corvids as threats to chelonians; and (4) discuss corvid management strategies where they threaten the persistence of chelonian populations. The hyperpredatory interactions of corvids with chelonians have been largely discussed in isolation, yet the case studies share many commonalities across northeastern and southwestern North America, Mediterranean regions, South Africa, and Australia. Corvid predation of chelonians is: Geographically widespread but patchy in occurrence; can be severe where and when predation occurs; supported by anthropogenic subsidies and linear anthropogenic corridors; and co-occurs with often drastic corvid population increases. Substantial increases in corvid populations as well as the broad geographic areas over which chelonian hyperpredation events have occurred suggest that this threat is more common than currently recognized, warranting action from the conservation community.

Habitat Characteristics of Contact Zones using Network Modeling on Desert Tortoise Populations

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There has been an increasing research focus on connectivity as it relates to desert tortoise populations. Connectivity has implications at many scales, and recent research has

investigated range wide movement potential, regional landscape genetics, and fine scale movements of desert tortoises, all of which are influenced by natural as well as anthropogenic features at the scale of inquiry. Localized influences on connectivity can also have implications on population social structure and function, and habitat where tortoises interact may have a unique subset of environmental characteristics and requirements. We use tortoises from several populations and habitat types (e.g. valleys, upper bajadas, and mountain passes). tracked using radio-telemetry GPS position recorders. We examine contact networks created at several scales of temporal overlap to look at network characteristics, and to identify the subset of localities that comprise contacts among individuals. We analyze the nature of contacts (e.g. male-male, or male-female) relative to seasonal, as well as fine scale habitat attributes enumerated using fine scale imagery. We employ point process modeling to compare the habitat associated with social contacts to that of "available habitat" as indicated by the totality of tortoise observations. To adequately conserve tortoise populations, and the connectivity within and among them, we must have a good understanding of their habitat needs, not only for movement, but also for interactions of animals with one another. Our research will contribute to our knowledge of what constitutes "habitat quality", and how tortoises use features of the desert landscape differently to achieve population structure and function

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Innovative Partnerships & Stakeholder Outreach Opportunities Facilitating Desert Tortoise Conservation During COVID-19

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Community outreach and public education are fundamental components of wildlife conservation strategies since public support of and engagement with conservation efforts is often required for successful implementation. Institutions with high and condensed visitation, such as zoos, aquariums, museums, and some state or national parks, often utilize in-person education and interpretation techniques to maximize memorable and effective learning experiences for visitors. However, in March of 2020 the global COVID-19 pandemic required radical changes to human behavior, including social pressures and policies to cease all in-person gatherings or close interactions. Herein we elaborate on new partnerships The Living Desert Zoo and Gardens has established in the time of COVID-19 to create innovate opportunities for public engagement to support desert tortoise (*Gopherus agassizii)* conservation. Although these partnerships were established under undesirable circumstances, they yielded the opportunity to reach new audiences in creative ways. We particularly highlight our online webinars with partner agencies, socially-distanced events on grounds and at a local drive-in theater. At the drive-in we provided tortoise visits with guests in vehicles, short presentations, and memorable films to create enriching and effective engagement with local community members to encourage their support of desert tortoise conservation efforts. We encourage other conservation organizations to explore unique partnerships with unexpected collaborators that are arising during COVID-19 to access untapped audiences. During a time when visitation to normal outreach events and

venues is low to non-existent, potential partners have been interested in accessing audiences typically belonging to conservation organizations, thereby increasing the likelihood of confirmed partnership and creating mutually beneficial opportunities.

Facing the Pathogen Cold-blooded

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Tortoises, similarly to all the other reptiles are poikilotherms. Accordingly, their body temperature is largely influenced by that of the environment. This is a common physiological trait to all the other vertebrate poikilotherms, specifically fish and amphibians. Temperature impacts the entire physiology of poikilotherms and the efficiency of the immune response to pathogen is notoriously significantly dependent on temperature. However, it would be reductive to limit the impact of the environment on poikilotherms considering temperature only. Accordingly, seasonality, together with specific hormonal changes is another major player contributing to modulate the host immune response in the wild. Interesting, temperature and seasonality is not only relevant for the poikilotherm host, but also for the pathogen itself. It is consequential that host-pathogen interaction is not a two-players game only, but a three-player game, where the environment is a critical element, significantly impacting the emergence and the outcome of the disease in the poiklotherm host, including reptiles. In this presentation we will provide specific examples of how host-pathogen and environment interplay in the context of infectious diseases in poikilotherms with the goal of trying to emphasize the complexity of host and pathogen disease ecology in free ranging conditions.

STUDENT PAPER

Comparative Analysis of Immune Gene Family Evolution Based on a *De Novo* Genome for the Sonoran Desert Tortoise, *Gopherus morafkai*

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Compared to extensive molecular and cellular analysis of the innate and adaptive immune systems in mammals and birds, only limited investigation has been carried out in reptilian species, despite impacts of pathogens on wild populations. The Mojave desert tortoise, *Gopherus agassizii*, have been severely impacted by respiratory infections from *Mycoplasma agassizii*, and this pathogen has been identified at lower rates in wild Sonoran desert tortoise populations (*G. morafkai*). One question is whether there are differences

between the Mojave and Sonoran desert tortoise immune systems that underlie different rates of *Mycoplasma* spp. infectivity, or whether it is completely environmentally based. Based on our *G. agassizii* whole genome assembly, we have used RNA-Seq analysis to identify genes expressed in the immune response to *Mycoplasma* infection in the Mojave desert tortoise (Xu et al., 2020).

To advance comparative studies between the Sonoran and Mojave desert tortoises, we used a combination of high throughput short-read and long-read sequencing to generate a genome assembly and annotation, gopMor1.0, from a male *G. morafkai* specimen from Pima County, Arizona. The N50 and L50 of the assembly are 5 scaffolds and 141 Mega-basepairs (Mbp), respectively, with the longest scaffold being 366 Mbp. Through annotation, we identified 22,130 protein-coding genes. Our previous comparative genomic analysis of the *G. agassizii* genome (Dolby et al., 2020) identified changes in the Toll-like receptor (TLR) gene families that may underlie immune response differences. With this new assembly we are carrying out comparative analysis of gene families from *G. morafkai* and *G. agassizii* with other chelonian and vertebrate immune gene families. The innate immune system allows individuals to rapidly respond to pathogens such as *Mycoplasma,* and gene families that play a role in response include: toll-like receptors (TLRs), classic, lectin, and alternative complement pathway genes, scavenger receptors, gram-negative-binding proteins (GNBPs), peptidoglycan-recognition proteins (PGRPs), lactins, and caspase pathways. Genes of the adaptive response being analyzed include: T-cell receptor genes, antigen receptor proteins (IgM, IgD, IgY/G+E, IgA), and the major histocompatibility complex class I and II genes. This new genome resource and expanded analyses will help characterize the immune system of desert tortoises relative to other vertebrates, as well as identify differences between the desert tortoise species.

STUDENT PAPER

Determining current and future drivers of habitat suitability for the Mojave Desert Tortoise, *Gopherus agassizii*, across its range in the Mojave Desert

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Field surveys and monitoring efforts for the Mojave Desert Tortoise (*Gopherus agassizii*) have largely focused on quantification of population densities in designated critical habitat units that are centrally located within their range. As a result, interactions with climate and potential habitat differences at the adaptive front of their distribution have been understudied. Under future climate scenarios, these edge areas could become important in maintaining populations of tortoises as spatial changes of core habitat may

increase extirpation risk in these areas. Understanding the spatial variation in climate conditions that influence differences between edge and core regions of the range, as well as connectivity between these regions, will help delineate areas that are important for conservation and management purposes. We attempted to identify abiotic factors that drive regional habitat differences in the tortoise's range under current and future forecasted climate scenarios. We built an updated rangewide habitat suitability model for the tortoise using a dataset of over 200,000 points, updated predictor variables, and ensemble modeling methods. We also built regional habitat models based on climatic clusters to compare to our rangewide global model and projected these regional models to future climate scenarios using a climatically-weighted approach. Our preliminary results show that regional models may predict areas of suitability for the tortoise better than the global rangewide model. We also found that, under future climate scenarios, our climate clusters begin to shift northward. Finally, our results show that edge areas need to be thoroughly surveyed to understand habitat drivers in these areas. Future work will combine these data with landscape genetics analyses to gain a multidisciplinary understanding of how the tortoise uses the landscape across the Mojave Desert.

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Non-invasive Genetics Reveals Higher Frequencies of Canid Predation on the Mojave Desert Tortoise (*Gopherus agassizii*) than Estimates Based on Morphological Analysis

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The field of non-invasive genetics provides scientists and conservation practitioners highly sensitive tools to study rare or elusive species without needing to trap or directly observe animals in the wild. Using DNA extracted from fecal samples allows researchers to investigate food web dynamics by identifying hosts and prey species. Here, we apply non-invasive genetics techniques to determine the frequency of canid predation on Mojave desert tortoises (*Gopherus agassizii*, MDTs) in the Boulder City Conservation Easement Area (BCCEA) in the northeastern Mojave Desert, and compare the sensitivity of these techniques to morphological analysis. We extracted DNA from 380 scat samples collected between September 2015 and April 2018 and amplified a region of the mitochondrial control region gene (CR) with diagnostic length differences in sympatric canid species. We identified 87 coyote (*Canis latrans*), 209 kit fox (*Vulpes macrotis*), 5 grey fox (*Urocyon cinereoargenteus*), one dog (*Canis lupus familiaris*), and 10 mixed-

species scats. We then designed primers to amplify a short fragment of the CR specific to MDTs. Using a qPCR assay to test for the presence of MDT DNA in the 312 canid scat samples, we detected MDT DNA in 16% of coyote and 13% of kit fox samples. In addition, we detected MDTs in 31% (12/39) of raven pellets. Our qPCR assay was more sensitive than our morphological analysis on the same samples, which detected MDTs in only 1.9% of coyote scats, 0% of kit fox scats, and 2.6% of raven pellets. Similarly, previous reports based on morphological analysis found MDT remains in <6% of coyote scats across a period of 5 years, with peaks up to 8.8% during years following MDT translocation events. Our results suggest that previous studies may have underestimated the true rates of canid predation on MDTs. Although we cannot determine whether the consumption rates we observed are the result of predation or scavenging, our findings indicate that managers may need to pay more attention to resource subsidies and activities that attract and support predator populations.

PLENARY ADDRESS

Turtles in Trouble: Tortoise and Freshwater Turtle Conservation Priorities in the 21st Century

Craig Stanford, Chair

Tortoise and Freshwater Turtle Specialist Group, IUCN Species Survival Commission

More than half of the world's 360+ species and 480 taxa of tortoise and freshwater turtles are threatened with extinction. Chelonians are among the vertebrate groups with the highest extinction risk. Turtle populations are declining worldwide, and many taxa could become extinct before 2100. I examine the major threats to their survival, highlight some reasons for hope and notable success stories, and discuss the work of the IUCN SSC Tortoise and Freshwater Turtle Specialist Group.

POSTER

Estimating Reductions in Landscape Connectivity for Sonoran Desert Tortoise (*Gopherus morafkai*) in the United States-Mexico Border Region

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Intensive anthropogenic activity in the border region between the US and Mexico has changed the natural connectivity of the landscape for desert species. Activities such as land-cover conversion and road building degrade habitat and may constrain connectivity, leading to a reduction in important ecological and evolutionary processes such as gene

flow, dispersal, demographic rescue, and response to climate change. Such constraints on movement may have a particularly strong effect on low-motility species that exist in small, isolated populations, such as the Sonoran desert tortoise, *Gopherus morafkai*, a species already faced with navigating through a harsh matrix. It is likely that barriers in the rapidly changing border region have reduced connectivity among populations of Sonoran desert tortoises, the effects of which have not been studied. We are reporting preliminary estimations of reduction in structural connectivity caused by landscape alterations as part of a project involving the identification of barriers to tortoise movement and the potential impact of barriers on landscape connectivity. We quantified structural connectivity of a network of desert tortoise habitat patches to identify the role of individual patches in providing connectivity through the network. We identified areas where major anthropogenic barriers intersect patch linkages and estimated reductions in connectivity based on four hypothetical scenarios of barrier permeability. Future work will involve estimating landscape functional resistance to tortoise movement to be used in estimating potential reductions in connectivity caused by barriers and to identify opportunities to protect, restore, or enhance connectivity.

Building Community Around Desert Tortoise Conservation in Southwest Utah:
Advocacy, Outreach and Stewardship with Conserve Southwest Utah

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Conserve Southwest Utah's work to protect quality of life for Washington County residents is directly linked to conservation of desert tortoise critical habitat in the Upper Virgin River Recovery Unit. Protecting habitat essential for desert tortoise survival benefits human communities by conserving the scenic, recreational, health and economic values that enhance quality of life in a fast-growing, sprawling desert city like St. George. Unfortunately, efforts under the Trump administration to weaken key Endangered Species Act and National Environmental Policy Act requirements created an ideal political atmosphere for Washington County to pursue the Northern Corridor Highway through a rushed, biased, and incomplete National Environmental Policy Act review in 2020. CSU continued its work to prevent construction of this highway through the Red Cliffs NCA and what "may be the most important high-density cluster of desert tortoises in the [Upper Virgin River] recovery unit (USFWS 2020a)" by participating in NEPA with the Red Cliffs Conservation Coalition. CSU's efforts to engage Washington County residents in NEPA commenting led to the creation of community centered around desert tortoise conservation and the understanding that efforts to protect desert tortoise must be grounded in clear communication of the peripheral benefits to people. The human community that is subtly built around conserving desert tortoise habitat is rather like the desert tortoise itself- enduring, charismatic and resilient, leading to high levels of participation in advocacy, outreach and stewardship activities- and several examples are provided during the presentation. Community support for habitat protection is necessary for stopping, and reversing, range wide tortoise population declines. Southwest Utah can be seen as a

microcosm for the benefits of creating community centered on desert tortoise conservation *because* of the value to human residents and their quality of life.

PLENARY ADDRESS

The Value of Head-Starting in Desert Tortoise Conservation and Recovery

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Head-starting turtles—the protecting of juveniles until they reach a larger size with higher survival—has been treated with much skepticism. Because juveniles have naturally low survival and can take 15 years or more to reach sexual maturity, they have been viewed as less important than adults to conservation efforts. Conservation practitioners, however, are increasingly realizing that management intervention like head-starting may be required to produce meaningful recovery, especially if juveniles can be reared to larger sizes in a safe and timely manner. Here, I summarize a decade of our research head-starting the Mojave Desert Tortoise (*Gopherus agassizii*). We reared tortoises after hatching both in predator-proof outdoor enclosures and using a combination of indoor- and outdoor-rearing. We also radio-tracked tortoises after hatching or head-starting to estimate survival and identify causes of mortality. Annual survival in the wild averaged 48±9% after hatching, compared with 94±1% in outdoor enclosures and 99±1% indoors. Tortoises averaged 11–13 mm/year growth outdoors, compared with 55 mm/year indoors; hatchling tortoises reared indoors reached the size of six–ten-year old tortoises in just one year. Survival of head-started tortoises increased with their size at release and averaged approximately 85% annually, ranging from 68–100% depending on the year and their size at release. Head-started tortoises typically remained within 100–300 m of their release sites. Desiccation was a common cause of juvenile morality early in the study, whereas predation by ravens became more prominent recently. Most predation by ravens was on tortoises <90mm midline carapace length. Our work shows that tortoises can be safely head-started to large sizes in a timely fashion, exhibit intended high rates of survival and site fidelity after release, and thus provides encouraging support for the use of head-starting as a tool to recover desert tortoise populations. A longer-term view is nevertheless needed to know whether head-started tortoises ultimately reach sexual maturity and contribute to wild populations.

The Sonoran Desert Tortoise's Long Slow Journey to Endangered Species Act Protection

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Western Watersheds Project first petitioned for Endangered Species Act (ESA) protection for the Sonoran desert tortoise (*Gopherus morafkai*) in 2008, with partner group WildEarth Guardians. The U.S. Fish and Wildlife Service (Service) made an initial 90-day finding that the tortoise warranted legal protection, and in 2010 determined protection under the ESA was warranted but precluded by higher priority species. In 2014 the Service conducted a species status assessment and recognized the Sonoran desert tortoise as a distinct species from the Mojave desert tortoise (*Gopherus agassizii*) and reaffirmed the Sonoran species warranted protection under the ESA. A decision to conduct another species status assessment and new population viability analysis just five months later, in May 2015, resulted in an about-face by the Service. Despite increased pressure from known threats to the tortoise, the Service issued a determination the Sonoran desert tortoise did not warrant the protection of the ESA. The Service has since then relied on a Candidate Conservation Agreement that largely relies upon voluntary actions by federal land managers to protect the tortoise and monitoring of populations that has not materialized. Western Watersheds Project and WildEarth Guardians challenged the Service's unexplained change of heart in court on September 5, 2019. The Service and the Court agreed that it would be prudent to reconsider the 2015 not-warranted decision, placing the Sonoran desert tortoise back on the list as a candidate for protection under the ESA. On December 2, 2020, the Service notified the public it was seeking information about new threats, scientific or monitoring information, conservation efforts, and habitat information. The Service will make a new 12-month finding decision by February 3, 2022. While the Service requested information by January 16, 2021, there is still time to provide any relevant information for consideration.

Desert Tortoise Management and Research in Joshua Tree National Park

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Joshua Tree National Park protects nearly 800,000 acres of public land of which 240,000 is considered high quality desert tortoise habitat. Annual visitation to the Park grew from just over 1.4M in 2013 to 3M in 2019 which has posed challenges to all aspects of management. The park has supported the recovery of the tortoise through participation of region wide planning efforts, management of habitat, educational outreach and scientific research. The park is an active participant in the Colorado Desert workgroup within the California Mojave RIT to guide future recovery efforts in the region. Within the Park, educational specialists provide desert tortoise educational presentations (now virtual) to many local schools. The Park also has an active habitat restoration program that removes

exotic plants and outplants native species. Desert tortoise awareness trainings are given to all NPS employees, construction workers and even researchers doing work in the Park that may affect the desert tortoise. Since 2007, wildlife staff have been tracking desert tortoises near roads as part of a study to understand the effect of roads on tortoise movement patterns. Additionally, the Park is heading into its fifth year of removing common ravens with some indication that the action is working to reduce predation on juvenile tortoises.

PLENARY ADDRESS

Multi-year, Comprehensive Monitoring of Tortoise Translocations in the Ivanpah Valley: lessons Learned for Research, Management, and Conservation

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Translocations have been implemented in several locations to mitigate potentially harmful impacts of anthropogenic activities on federally threatened Mojave desert tortoises (*Gopherus agassizii*). However, factors that have influenced the success of translocation efforts require careful analysis and interpretation. In this context, we designed and implemented a multi-year (2011 through 2018) 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 were monitored over nearly five years to understand the effects of short-distance translocation on tortoise survival and other demographic parameters. Here, we review the methodological approach and results of comprehensive monitoring of tortoise movements and space use patterns associated with several individual, local-, and landscape-level variables. We then present lessons learned from this comprehensive, multi-year monitoring of tortoise translocation outcomes conducted under the ISEGS EMP for (1) new and improved ways of approaching the science of translocation to enhance survival of the individuals translocated, and 2) improving recovery efforts and mitigation measures to increase survival of tortoises.

A Novel Herpesvirus Detected in Three Different Species of Chelonians

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Herpesviruses are significant pathogens in both wild and captive chelonian populations due to their association with morbidity and mortality. Currently, all chelonian herpesviruses have been identified as closely related alphaherpesviruses within a clade of their own. In the present report, we detected a novel herpesvirus related to other alphaherpesviruses in three species of the Emydidae family: a captive leopard tortoise (*Stigmochelys pardalis*) in West Texas, a Steppe tortoise (*Testudo* [*Agrionemys*] *horsfieldii*) found in the Fort Irwin Western Expansion Translocation Area project in San Bernardino County, California, and two free-ranging, three-toed box turtles (*Terrapene mexicana triunguis*) found in Forest Park, St. Louis, Missouri. The leopard tortoise was also coinfected with the tortoise intranuclear coccidian and displayed clinical signs of severe mucoid/diphtheric stomatitis, rhinitis, glossitis, and conjunctivitis. The Steppe tortoise was ELISA-positive for exposure to *Mycoplasma agassizii* and exhibited mucopurulent nasal discharge, severe dehydration, and poor body condition. One of the three-toed box turtles displayed no clinical signs at the time of detection, whereas the other free-living turtle was found dead after a chronic course of severe blepharedema, limb wounds, lethargy, dehydration, and edema of the neck and both tympanic membranes. Based on phylogenetic analysis, we suggest the name Terrapene herpesvirus-3 (TerHV-3) for the novel herpesvirus. The branching order of the turtle herpesviruses mirror the divergence patterns of their hosts, consistent with codivergence. This virus appears to have the ability to host-jump and potentially be associated with significant morbidity in aberrant hosts. Future screening for this herpesvirus may be useful in determining its role in chelonian upper respiratory tract disease.
