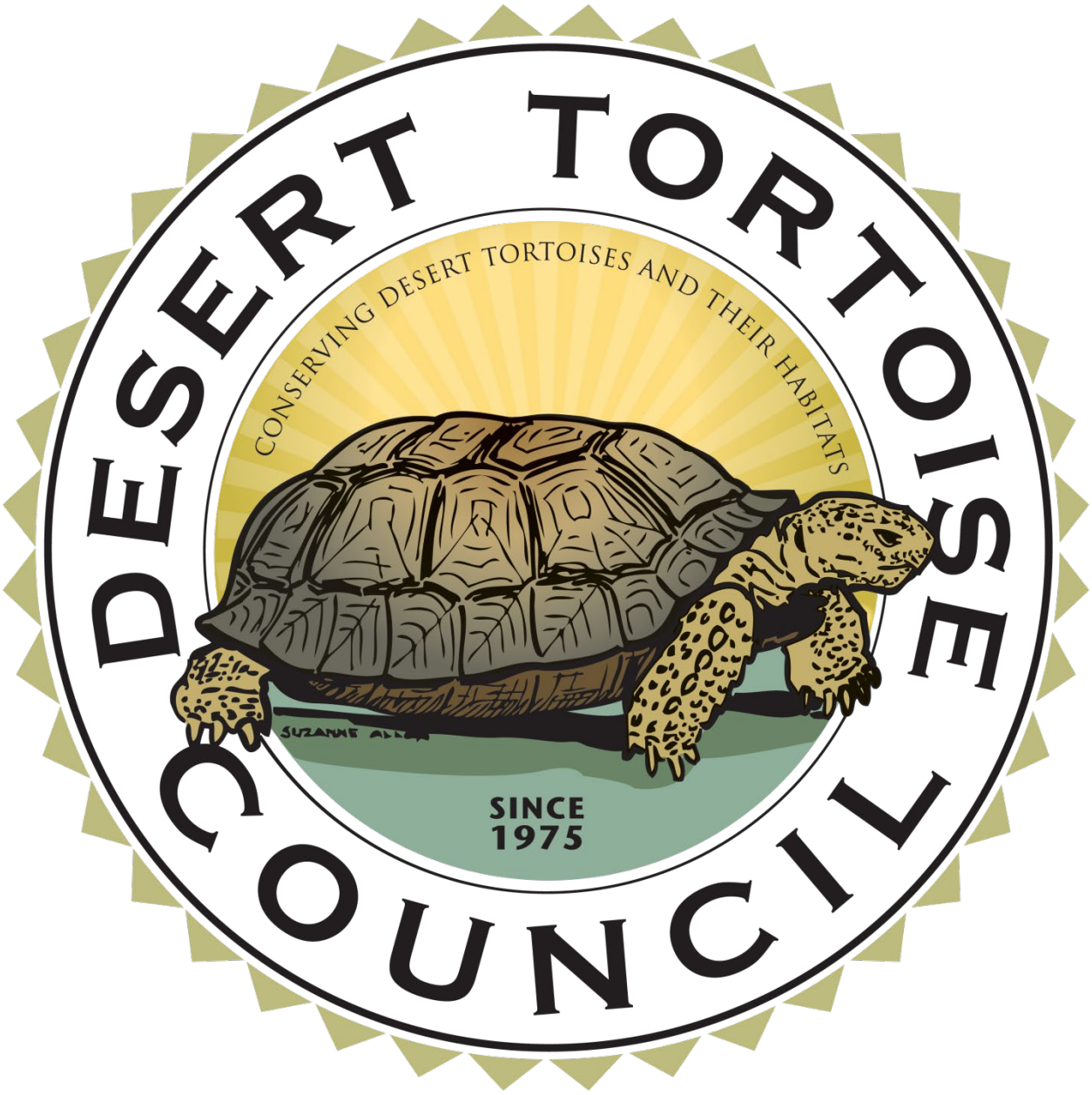

ABSTRACTS

45th Annual Meeting and Symposium

Las Vegas, Nevada

February 20–23, 2020

FORTY-FIFTH ANNUAL MEETING AND SYMPOSIUM
THE DESERT TORTOISE COUNCIL

LAS VEGAS, NEVADA
February 19–23, 2020

ABSTRACTS OF PAPERS AND POSTERS

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

Connectivity and the Framework for Recovery of the Mojave Desert Tortoise

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The U.S. Fish and Wildlife Service has standards for determining whether species should have federal protection. It also has standards for describing a viable species, couched in terms of representation, redundancy, and resilience. These characteristics were used in the 1994 Recovery Plan to design and evaluate the size and location of proposed critical habitat units for the Mojave desert tortoise. Regarding long-term representation and resilience, critical habitat units were designed to sustain a population of at least 5000 adult tortoises. In situations where the critical habitat unit was smaller than the threshold of 500 sqmi or if the number of tortoises was found to be fewer than 5000, it was expected that land management would result in connectivity to larger populations outside the critical habitat unit and to other critical habitat units. At the time the original recovery plan was developed, there were no estimates of the number of tortoises in any particular critical habitat unit and little information about how tortoise populations were connected for short-term viability. In the meantime, we are able to use population estimates to evaluate connectivity management needs for critical habitat units and to describe what long- and short-term connectivity entails for tortoise populations.

Survivorship of Resident and Translocated Tortoises from 2013-2018 in the Greater Trout Canyon Area, Nevada

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Population augmentation is one part of the recovery strategy outlined in the 2011 Recovery Plan for Mojave desert tortoises. The former Desert Tortoise Conservation Center (DTCC) housed thousands of tortoises that had been captive pets or (less commonly) were removed from areas where habitat destruction was imminent. When the DTCC was closed in 2014, several translocations were implemented with tortoises remaining there. In 2013 and 2014, 152 adult females and 173 adult males were moved from the DTCC to the greater Trout Canyon area, Nevada. Starting in 2013 and through 2016, 98 female and 91 male resident tortoises were

also marked in Trout Canyon. Recaptures during surveys in 2014, 2015, and 2018 allowed me to estimate annual survivorship of resident and translocated adult tortoises for the earliest period after translocation. Translocatees had slightly depressed survivorship (0.94, 95% CI: 0.905-0.966) during the first year after translocation, whether that was in 2013 or 2014, but annual survivorship thereafter was high and indistinguishable from resident survival (0.99, 95% CI: 0.981-0.999). Tortoises that were 100-179 mm MCL also had high annual survivorship whether translocatees or residents (0.99, 95% CI: 0.987-0.998). Survivorship within the first 5 years of translocation is one metric of success of translocations (Miller et al. 2014; Bell and Herbert 2017). Metrics that capture impacts to the population require longer evaluation to assess, for instance, evidence of breeding by translocated animals, growth and recruitment of translocated juveniles, and evidence of viable population dynamics, with original translocatees eventually replaced by younger animals. Research by others on animals at this site indicates relatively high survivorship before 100 mm MCL but also negative effects on growth (therefore, recruitment). When vital rates such as recruitment are reduced, higher adult survivorship is necessary to support stable or increasing population growth.

Protecting the Iconic Desert Tortoise

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For over two decades, the Center for Biological Diversity has worked to conserve and recovery the desert tortoise and its habitat in California, Nevada, Arizona, and Utah through science-based advocacy, participation in administrative processes, public information and litigation. The Center consistently supports increased protections for desert tortoise as the path to desperately needed recovery. Some challenges that the Center focused on in the past year include protecting and supporting current safeguards and programs that protect desert tortoise and other desert plants and animals from an environmentally hostile federal administration. In coalition with others, we have increased the drumbeat of support for desert conservation in California, Nevada and Utah which protect desert tortoise. In California, we have helped to assure proper implementation of the Desert Renewable Energy Conservation Plan (DRECP) and will defend it from any proposed rollbacks. We are also continuing to engage on poorly sited "grandfathered" solar projects that are not subject to the DRECP. We continue the struggle to limit ORV impacts in tortoise habitat from both authorized and unauthorized use and are anticipating challenging the rollbacks in the West Mojave Plan release in early 2020. We are pushing back on a proposal to legislatively amend Clark County's desert tortoise HCP, dramatically increasing the developable acreage limit without prior environmental impacts analysis, which would also expand the Las Vegas disposal boundary to undisturbed tortoise habitat outside of the Las Vegas Valley. We continue our decade-long fight against the Southern Nevada Water Authority's pipeline water

grab, in the courts and in the state legislature. We are fighting back against a massive military land grab, as the US Air Force seeks to expand the Nevada Test and Training Range into Desert National Wildlife Refuge.

Making Decisions Today: Putting Together Existing Information on Connectivity

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Connectivity of Mojave desert tortoise (*Gopherus agassizii*) populations has come under increased scrutiny due to current or proposed development of large tracts of occupied desert tortoise habitat between designated conservation areas, largely as a result of the recent renewable energy boom. Researchers have focused attention on the implications of isolating tortoise conservation areas and have developed models of past, current, and potential population connectivity across the desert tortoise's range. Managers have considered much of the available information in individual planning decisions, examples of which will be presented. However, general principles for maintaining functionally connected desert tortoise populations have not been synthesized to assist with decision making. Therefore, the contributors of this special session are developing a white paper that describes important vulnerabilities to desert tortoise population connectivity and the key considerations for maintaining functional connectivity, including the following points. (1) Narrow linkages do not allow for natural population dynamics. Linkages should be wide enough to accommodate overlapping home ranges along most of their widths so that tortoises can reside, find mates, and produce offspring that can disperse in the linkage. (2) Buffers $\geq$ 300 m, or farther where adjacent to high-volume roads, should be incorporated along disturbed habitat to maximize the area within linkages unaffected by edge effects. (3) Bottlenecks, such as highway crossings, should sum to no more than 10% of linkage length and should be mitigated by widening other parts of the linkage. (4) Given that most linkages include more multiple uses than within conservation areas, in largely intact, publicly owned landscapes, managing the entire matrix for permeability may be a better approach than delineating fixed corridors, especially given uncertainty about long-term quality of habitat under a changing climate. Ultimately, questions about "*what are the critical linkages that need to be protected?*" would be better framed as "*how can we manage the habitat matrix in ways that sustain ecological processes?*".

Space Use of Sonoran Desert Tortoises (*Gopherus morafkai*)

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Most studies of home ranges of North American *Gopherus* have occurred over durations of only 1–2 years with fewer than 30 individuals per population. In addition, tortoise researchers typically have estimated home ranges with minimum convex polygons (MCP) or kernel density estimators (KDE) due to common historical usage or perceived benefits in comparing studies. However, differential biases compromise the validity of traditional estimates and comparisons between studies. Recently developed autocorrelated kernel density estimation (AKDE) alleviates these problems, so we applied this methodology to describe space use of 43 individual Sonoran Desert Tortoises (*Gopherus morafkai*) monitored for up to 10 years relative to effects of age and sex on home-range size, fidelity, and range residency, and the effect of environmental condition on space use. Importantly, home-range estimation via AKDE resulted in less biased estimates than from traditional MCP and KDE methods. Immature tortoises were more likely to disperse during the study than were adults. Home ranges were highly variable, but range-resident immature females had smaller multi-year, cumulative home ranges than males and adult females, which were similar. Annual home ranges did not differ during drought, and male annual range areas exceeded those of females. The magnitude of annual home-range overlap did not differ by sex combination or drought condition, but drought decreased the chance of ranges overlapping. Study-site productivity and sex-specific behaviors may influence patterns of home-range overlap. Additional study of the use of permanent rock shelters will shed light on patterns of space use within and between individuals, and long-term study is needed to document survival, settlement, and contribution of dispersing tortoises to new populations, especially relative to anthropogenic habitat fragmentation.

An Overview of the Illicit Turtle Trade in Florida and Enforcement Efforts

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The illegal turtle trade has garnered increased attention in recent years due to the decline and decimation of wild turtle species trafficked around the world. Like other wildlife, turtles are susceptible to traditional threats such as: disease, nonnative competition, habitat alteration, and other concerns. Turtles exhibit a life history strategy characterized by slow growth and late reproductive age. Wild turtle populations sustain their greatest natural loss in the egg and juvenile stages but experience low natural adult mortality making illegal take especially adverse to this taxa. Wild turtles have an added threat from human exploitation and life history strategies that

make them vulnerable to subsequent declines. Additionally, as species become rarer in the wild, they become more coveted for illegal trafficking. Once depleted, a turtle population takes decades to recover, if recovery is even possible. There are many markets driving the international trade, primarily food trade, personal possession (pet trade), medicinal purposes, and as status symbols. While the motivations for the illegal trade of turtles vary, commercial profit is a major drive for rogue individuals and criminal networks.

The sale of Florida's wild freshwater turtles was prohibited by Florida Administrative Code 68A-25.002 in 2009. Prior to the 2009 rule change, global demand and out of state markets had the potential of negatively impacting and depleting Florida's wild turtle population. In recent years, international demand for native Florida turtles has significantly increased, driving up prices and creating lucrative illegal markets. Florida has tremendous biodiversity relative to turtle species and populations, which makes the state an attractive target for illegal harvest and sale. Currently, the most sought-after Florida turtle species are: box turtles, diamondback terrapins, mud and musk turtles, softshell turtles, and snapping turtles.

Wildlife trafficking is often difficult to uncover and track. As the demand for native Florida turtles increases, proactive enforcement efforts are essential to maintaining wild turtle populations. Partnerships with other state and federal entities, as well as the expertise and knowledge provided by biologists and researchers, allow for enhanced abilities to identify and track emerging trends to help focus enforcement efforts on the illicit trade of turtles. With collaboration from the public, as well as our state and federal partners, significant arrests and proactive enforcement of illegal collections have curbed the black-market trade of wild caught turtles.

Land Use Futures for the Mojave Desert, USA: Implications for the Mojave Desert Tortoise

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Population growth in the Mojave Desert, USA increased by 1.7 million people from 2000-2010, representing a 58% increase. Human population is expected to continue to increase over the next 5 decades with some researchers forecasting a slight decline beyond that point with others anticipating a lower growth rate. How the increase in human population manifests itself in regards to land use is speculative. Here we present four land use futures formulated around the representative concentration pathways (RCPs) created by the intergovernmental panel on climate change (IPCC). Scenarios are constructed based on likely policies introduced to achieve green house gas emission concentrations for each RCP. The narrative for each scenario assists in determining the support for a variety of land uses reflected in the type of development emphasized. Potential land conservation areas, housing density, energy generation facilities and transportation infrastructure all contribute in different ways within each scenario to create four land use futures which are spatially manifested across the Mojave Desert landscape. Each land use future is being

created for use in evaluating potential future species habitat and connectivity for the Mojave Desert tortoise. The overall process for creating land use futures will be described and preliminary results presented.

Fire and Fauna, Tales of a Life Untamed: Reflections and Readings from My Memoir

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I am frequently asked: "Why did you write a memoir?" The answer is as diverse as my career experiences and adventures. I have always been both a bibliophile and a storyteller. Whenever I would give professional talks, I would season my scientific presentations with anecdotes about colorful critters and humans. I continually heard: "You need to write a book!" But when one is afield seven days a week during various gopher tortoise studies and then generating scientific manuscripts, taking on the monumental task of writing a memoir isn't possible. So…I gave myself a year to settle into my New Mexico burrow after retiring from Florida Fish and Wildlife in 2014, and then I spent four years writing, editing, and publishing my book. I was extremely fortunate to have Texas A & M University Press as my publisher and to have my book be part of an Integrative Natural History series. My memoir covers the unusual evolution of this "wild biologist" and answers questions as to why I targeted the wildlife profession. I recount my exploits as a wildland firefighter and a wildlife researcher when women were not necessarily common in those fields. The paths that I traveled to become a wildlife scientist yielded misadventures that ranged from humorous to terrifying. I outran treetop flames as a helitack firefighter in New Mexico; spent a night in a small-town Georgia jail with an indigo snake; and survived a near disaster in rural Florida when a small plane's engine stalled as I searched for a wee, wandering gopher tortoise. My hope is that my passion and adventure stories will inspire young women and men to go into the wildlife field, and that my book will encourage folks to help conserve wildlife species and habitats. Additionally, it's my belief that we all have stories to tell, and those of you who work with animals in the wild will certainly have your own adventures to relate.

Revisiting Health and Disease at Sites in the Ivanpah and Fenner Valleys, California, after 18 to 23 Years

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From 1990 to 1995, desert tortoises (*Gopherus agassizii*) were evaluated for health and diseases to establish reference ranges for hematological and biochemical values at three sites, two of which are on the Mojave National Preserve. Also monitored during that period were clinical signs of upper respiratory tract disease, herpesvirus, cutaneous dyskeratosis (a disease of the shell and integument), and serology of *Mycoplasma*. In late summer and fall of 2018, data were collected

from two of the three sites, one each in Ivanpah and Fenner valleys, in the vicinity of the 1990-1995 research projects. We reviewed results of the 1990-1995 publications, necropsy data from salvaged tortoises from Fenner Valley in 2000, population data collected previously, and transect data compiled for the two valleys for 2015 and 2016 by the USFWS. In 2018, changes appear to have occurred in sizes and sexes of adult tortoises in both valleys. Moderate to severe clinical signs of upper respiratory tract disease were evident at both sites, but no tortoises tested positive for *Mycoplasma agassizii* or *M. testudineum*. Tests for herpesvirus were negative, but only two-thirds of tortoises were sampled. Positive tests for *Mycoplasma* spp. and observations of oral lesions had declined since the 1990–1995 health sampling. However, one tortoise had a black plaque in the oral cavity. In 2018, diseases of the shell and integument (cutaneous dyskeratosis, necrosis) and trauma were more common at Fenner Valley than at Ivanpah Valley. Overall, tortoises at Fenner Valley showed more clinical signs of disease than at Ivanpah Valley. Both sites have degraded habitats. This project would not have been possible without coordination, support, and assistance from the Mojave National Preserve team, Michael Tuma of USGS, and Kathy Simon and Corey Chan of Ironwood Consulting, Inc.

Recovery Progress at Mojave National Preserve

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Recovery efforts for the desert tortoise (*Gopherus agassizii*) at Mojave National Preserve in 2018-2019 included a health assessment conducted by the US Geological Survey (USGS), invasive weed control, raven management, monitoring of road maintenance projects, pre-project surveys for soils mapping, and habitat restoration. Drs. Berry and Tuma conducted a new health assessment in the Fenner and Ivanpah Valleys 23 years after earlier research. Preliminary results found older and larger size classes and more males compared to earlier work and noted moderate to severe clinical signs of Upper Respiratory Tract disease, but none tested positive for *Mycoplasma* spp. Surveys for Sahara mustard were conducted on 162 acres from which 19 acres were treated in tortoise habitat. Corvus Ecological Consulting found 13 recent juvenile tortoise mortalities associated with four raven nests out of a total of 36. At least four ravens were lethally removed by USDA Wildlife Services from two targeted nests. About 430 hours of tortoise monitoring to protect tortoises and their habitat from harm occurred on multiple road maintenance projects, but 17 tortoise mortalities from visitor vehicle collisions were documented. As part of the USDA-NRCS soils surveys for Mojave, some 186 locations, approximately 50 m X 50 m, have had pre-project surveys this past year. Three piospheres totaling ten acres in the Fenner Valley are undergoing restoration. We continue to support ongoing research in head starting at the Ivanpah Desert Tortoise Research Facility. Unfortunately, due to lack of funds, no land acquisitions have occurred since early 2017.

URTD: Lessons Learned at Individual and Population Levels and Future Approaches

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Mycoplasmal cause respiratory infections in a variety of animals, including food and fiber animals as well as wildlife. With few exceptions, the diseases are chronic and often clinically silent. While overt clinical disease expression is intermittent and pathogen shedding is intermittent, the damage and destruction to the epithelial surfaces can be extensive even in the absence of overt disease. The similarities and common features will be discussed. Recent studies have demonstrated that disease severity impacts key behaviors, impacting movement as well as feeding. Studies of controlled as well as natural populations suggest a number of scenarios for disease dynamics and transmission. Future research can capitalize on the expanding capabilities at the molecular level to offer new avenues to better understand the mechanisms, disease transmission, host resistance, and pathogenicity factors. Comparative genomic analysis of clinical isolates at different temporal stages of the disease within populations and linked with virulence studies can improve our understanding of the interactions within populations.

STUDENT PAPER

Mycoplasma in Review: ELISA Interpretation and 10-Year Seroprevalence in Free-Ranging and Captive Tortoise Populations

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In the early 1990s, an enzyme-linked immunosorbent assay (ELISA) was developed to detect the presence of antibodies to *Mycoplasma agassizii*, the confirmed etiological agent of upper respiratory tract disease (URTD), in the serum/plasma of free-ranging desert and gopher tortoises. Using a monoclonal antibody specific for the immunoglobulin light chain that detects both IgM and IgY, this presence of specific antibody had a high positive correlation with clinical signs and nasal lesions in both experimentally and naturally infected animals. *Mycoplasma testudineum* has been isolated from clinically ill, free-ranging desert and gopher tortoises. Although *M. testudineum* is a second etiological agent of URTD in desert and gopher tortoises, both experimental and natural infection studies suggest the pathogen is less virulent than *M. agassizii*, resulting in less severe tissue pathology. Seroprevalence is a hallmark tool for epidemiological studies at the population level. Exposure to both *M. agassizii* and *M. testudineum* in free-ranging, translocated and captive tortoises has been a valuable tool in characterizing URTD. Here we review in depth how to understand and interpret an ELISA and present data from the past decade. In tests on over 7,500 desert tortoises, >90% were seronegative in the *M. agassizii* ELISA with only 3% testing positive.

In contrast, high risk populations with confirmed URTD and positive PCR and/or culturally isolation of *M. agassizii* had >25% seropositive animals. Further the distribution of titers in seropositive animals differed. Titers ≥256 were seen in 70% of seropositive animals in high risk populations; in the low risk populations, only 25% of animals has high titers.

Utilizing Do-It-Yourself Open-Source Technologies to Make Easier the Life of the Turtle Biologist

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Turtle biologists are commonly required to fix, slice, hack, and modify field equipment to meet the needs of their research question. Not only does much of a turtle biologist's training lack formal introduction to such methods, the cost of commercially available technology may also preclude certain unique or informal approaches to answering biological questions. Here, I present a primer on ways one can learn to become more familiar with and skilled at modifying common electronic field equipment. More specifically, I will introduce how open-source hardware and software (e.g. Arduino, Raspberry Pi, and Python) and the thriving do-it-yourself (DIY) community can help facilitate such skills. With just a cursory understanding of electrical engineering, soldering, circuits, and coding, the turtle biologist can overcome many of the limitations of cost and even develop customized field equipment. I will briefly discuss few examples of open-source do-it-yourself equipment such as environmental loggers, GPS data loggers, and VHF systems (transmitters, receivers, and antennas).

Ranavirus, Research, and Rehabilitation; The Interconnectedness of Conservation Strategies

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The multiple anthropogenic threats facing turtles globally, require a multi-pronged approach for their mitigation. The Ontario Turtle Conservation Centre (OTCC; operating name of the Kawartha Turtle Trauma Centre) broadens its impact through this varied approach. Treatment, rehabilitation, and subsequent release, of turtles experiencing accidental injuries from roadways, boats and fishing by-catch can be shown to have a population impact, in essence 'buying time' for the underlying problem to be solved. Data-mining expands this impact; for example, the compilation of the sex ratio of turtles admitted, allowed us to revisit the hypothesis of sex-biased road mortality, and showed an equal number of males as females being impacted on roads, in painted turtles (*Chrysemys picta*), snapping turtles (*Chelydra serpentina*), and Blanding's turtles (*Emydoidea blandingii*). The impact of infectious disease on an already threatened

population, could be devastating. The OTCC can act as a convenient biomonitor for the health of the province's turtle populations through sampling of turtles from across the province; allowing concurrent studies on the prevalence of ranavirus and other diseases to be carried out. No turtles with clinical signs of disease have so far been found positive for ranavirus at OTCC, but we have shown that there exists a subclinical prevalence across the province, which could have far reaching impacts on turtles as well as other ectotherms sharing the water source. Headstarting, as a natural extension of the hospital, also not only allows for an additional means to augment populations, but also can add to knowledge of Best Practices of headstarting and offer an opportunity to quantify the results. Our post-release studies have shown that released headstarts exhibit comparable fitness to wild-hatched turtles, and accelerate subadult recruitment rates. Education is an essential piece to this conservation puzzle, and also must be addressed from all angles. Empowering the general public to carry out stewardship activities has far reaching positive effects; also, education of veterinary and rehabilitation professionals broadens the impact of the OTCC's hospital.

Addressing the Raven Food Subsidy Problem By Engaging Restaurants to Cover their Trash

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Ravens have benefitted by food subsidies provided to them by uncovered human trash so much that their populations have increased over 700% in the California desert over the last 30 years, and ravens have become year-round residents rather than migratory species. As predators, they are one of the greatest reasons for the decline of desert tortoise populations in this region. We sought to create and evaluate a behavioral change program among restaurants in Yucca Valley and Twentynine Palms, two areas where ravens are populous due to human resource subsidies. Half of the 60 restaurants in these two communities were part of a behavior change campaign to encourage them to cover their dumpsters and prevent ravens from consuming the trash, while the other half served as controls with no intervention. The intervention involved two visits to speak with managers, referencing the impacts on the natural world, the health code threats, benefits to rodents, litter problems, and harm to their reputation among possible diners that result from leaving dumpsters open. All treatment restaurants were given laminated information signs to hang near the employee bulletin board to extend the intervention. We also contacted city waste management to suggest repairs to damaged dumpster lids among treatment restaurants. We surveyed dumpsters for open/closed status five times prior to the intervention and then five times again two months after the intervention. We found an average 13% increase in lid closure among all treatment restaurants over that seen among the control restaurants. Management directives seemed to account for the majority of the impact and we will point out recommendations for improving the intervention here and elsewhere across the range of the tortoise. This campaign helps address one of the main threats to desert tortoise populations by reducing raven population sizes by reducing food subsidies for ravens.

Using Whole Genome Data to Understand Speciation of Desert Tortoises in Western Arizona

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Under many biological definitions, a speciation event is complete when the two diverged lineages no longer reproduce in the wild. The accumulation of differences on the molecular level between lineages facilitates this process. Yet, often even long-diverged species interbreed in narrow zones where the two species' ranges adjoin, resulting in genetically mixed individuals. Previous work has shown this to be true of tortoises in northwestern Arizona based on microsatellite markers and ecological variables. In addition, limited populations of Mojave desert tortoises occur just east of the Colorado River, which is an area excluded from the Endangered Species Act (ESA) listing decision of the species. We present new data from whole genome sequences of tortoises in western and northwestern Arizona in comparison to the core range populations of Mojave and Sonoran desert tortoises (*Gopherus agassizii* and *G. morafkai*, respectively). We estimate effective population sizes (Ne) based on the core range of each species to be 27,000-45,000 individuals for Mojave desert tortoises and 45,000-76,000 individuals for Sonoran desert tortoises based on different generation time assumptions. Additional comparative genomic analyses and the annotation of ~5,000 new genes as part of the gopAga2.0 genome project find that the Toll-Like Receptor 8 (*TLR8-1*) gene, which recognizes single-stranded RNA viruses, is truncated in the Mojave desert tortoise but remains full-length in the Sonoran desert tortoise. This finding suggests that the lineages may have evolved some molecular-encoded immunological differences, but more work is needed on this topic to contextualize its importance in lineage divergence and populational health.

Existing Desert Tortoise Spatial Models As A Foundation Toward Understanding Connectivity

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A variety of spatial habitat models have been developed for the management of desert tortoise habitats. We will compare and contrast several of these models describing habitat

suitability, genetic relationships, habitat linkages, connectivity, and habitat intactness across desert tortoise habitats. These models have been used for project proponent and regulatory planning, establishing survey requirements, evaluating reports on tortoise habitat, and as bases for subsequent spatial models. Furthermore, the natural resource layers developed for these models have been applied to understand habitats for many species of plants and animals. Issues related to the types and accuracy of data sources, the scale of models, and the uses and potential misuses of the models will be presented for discussion. Assumptions and caveats of using spatial models for habitat management will also be presented to highlight the benefits and limitations of their use.

Monitoring Use of Underpasses by Mojave Desert Tortoises (*Gopherus agassizii*) to Inform Culvert Design and Function

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Transportation infrastructure has fragmented previously contiguous habitat and reduced connectivity among populations of the Mojave desert tortoise (*Gopherus agassizii*). Over 55,312 km of roads exist throughout tortoise habitat. Tortoise road mortality is a significant issue relative to recovery of this species. Therefore, the U.S. Fish and Wildlife Service (USFWS) has identified installation of permanent exclusion fencing with culvert crossing structures as a significant priority for desert tortoise recovery. If crossing opportunities are inadequate or culvert structures are not conducive to movement of tortoises, connectivity among adjacent habitats may be permanently altered resulting in subdivision of desert tortoise populations and fragmentation of habitat. Identifying effective culvert designs that best facilitate tortoise movement is crucial for this species' survival and recovery. We used data from camera traps to evaluate the safety and functionality of culvert designs for desert tortoises. Tortoises were observed entering and crossing through both corrugated metal drainage culverts and concrete box culverts at various rates. Large openness factor does not appear to be a significant consideration for determining whether a tortoise will enter and cross through a culvert. In fact, tortoises appear to exhibit a preference for the smaller diameter corrugated metal culverts because of their similarity to burrows, which they use for shelter and thermoregulation. Adult tortoises were more likely to enter and cross through upon approach to the entrance of a culvert than juvenile tortoises. The USFWS and the Bureau of Land Management collaborated with the Nevada Department of Transportation to develop modifications to the concrete box culvert designs that would address safety issues for tortoises while allowing for hydrological functionality. We will continue to monitor these culverts with our camera traps to

evaluate the functionality of our modifications and effects of seasonal climate variation to tortoise use and movement.

POSTER

Road Warriors: Citizen Scientist Monitoring for Mojave Desert Tortoise Road Mortality and Live Encounters to Identify Priority Areas for Fence Installation

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Transportation infrastructure has fragmented previously contiguous habitat and reduced connectivity among populations. Tortoise road mortality has been identified as a significant issue relative to recovery of this species, and restricted movement of desert tortoises may limit or entirely prohibit access to suitable habitat, resources, and mates on either side of existing roads and highways. Therefore, the U.S. Fish and Wildlife Service has identified installation of permanent tortoise exclusion fencing and undercrossings along roads as a significant priority for desert tortoise recovery. Data regarding road mortality throughout the range of the tortoise are necessary to evaluate effects to recovery of the species and to prioritize areas for installation of fencing. We used citizen scientist volunteers trained and supervised by qualified biologists to conduct systematic road surveys to document tortoise mortalities and presence on or near roads in areas where permanent desert tortoise exclusion fencing has not been installed. Volunteers documented observations of tortoise road mortality, live tortoise encounters, carcasses, tortoise burrows, and tortoise sign on or near roads. Photos, GPS locations, and condition of carcasses or live tortoises were recorded and submitted for review. The citizen scientist volunteers also collected data regarding road mortality of other species observed during surveys and were trained to collect samples for genetic studies from all observed mortalities for submission to the Nevada Department of Wildlife (NDOW) for their monitoring programs and genetic databases. Species mortality data collected during road surveys conducted prior to and after installation of desert tortoise fencing

will provide information regarding potential benefits to other species monitored by the NDOW. The use of citizen scientists helps increase public awareness, outreach, and education and increase the level of participation in conservation by the general public.

The Discovery of a New Population of Pancake Tortoises on a Black Rhino Conservancy in Kenya

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The Pancake tortoise (*Malocochersus tornieri*) is a tortoise species that has seen its status decline from vulnerable to critically endangered (CITES Appendix 1) over the last ten years because of removal for the pet trade. Established in 1994, the Lewa Wildlife Conservancy is 25,000 ha, black rhino (*Diceros bicornis*) sanctuary in Kenya. Black rhino sanctuaries require high levels of safeguards to keep rhinos from wandering out of the reserves and to keep poachers out, such as electrical fences and 24-hrs a day armed patrol. The result of this level of security is that all of the local fauna benefits from habitat protection and Lewa hosts over 200 black and white rhinos, over 350 endangered Grevy's zebra and the full complement of Kenyan wildlife. Although no pancake tortoises had ever been documented on the Lewa conservancy, based on a fortuitous meeting in August 2019 and the discovery of an old photo shortly after, we embarked on a 3-day photographic survey of 14 high potential sites within Lewa in September 2019. The survey yielded 7 new specimens out of 4 of the 14 potential sites. These results extend the distribution range of the species in Kenya, as well as the only known occurrence above 1600 m. Armed with this information, we are now preparing a more comprehensive population survey in August 2020 that will cover the whole of the Lewa Wildlife Conservancy and two adjacent conservancies that have never been surveyed.

Connecting the Plots: The Relationship between Linear Barriers, Disturbance, and Habitat Linkages to Mojave Desert Tortoise Genetic Connectivity

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Anthropogenic disturbance in the Mojave Desert has been increasing, which can create barriers to movement and gene flow, potentially decreasing the persistence of native species. For the Mojave desert tortoise, habitat disturbance and degradation includes linear features (e.g. highways, railways, and dirt roads), urbanized areas, mining activities, and most recently, utility-scale solar facilities. To evaluate the spatial genetic structure of tortoises in an area experiencing rapid habitat loss, we genotyped 299 tortoises at 20 microsatellite loci from the Ivanpah Valley region along the California/Nevada border. We used a spatial principal components analysis to quantify population genetic patterns with isolation-by-distance. To explicitly consider landscape features (e.g. habitat and anthropogenic linear barriers), we used maximum likelihood population effects analyses. Our results support historical gene flow with isolation-by-environment, but also reveal reduced genetic connectivity across two parallel linear features bisecting our study area (a railway and a highway). We then applied spatially explicit forward-in-time simulations to predict genetic connectivity in no disturbance, current disturbance, and future disturbance landscape scenarios at 17 locations (525 – 625 km^2) across southern Nevada. As anthropogenic disturbance increased, genetic connectivity was predicted to decrease. However, connectivity improved when corridors allowed for movement across linear barriers, given moderate tortoise densities (14/km^2). Our work demonstrates that habitat loss and fragmentation limit connectivity and can have relatively rapid genetic consequences, potentially leading to progressively more isolated populations. We also find that genetic connectivity may be preserved by maintaining habitat linkages between protected areas.

BLM: Tortoise Management

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In 2019, BLM continued to work on restoring habitat for and minimizing impacts to desert tortoise. The Bureau continues to grapple with multiple use activities while preventing further declines in desert tortoise. There is progress in implementing the Department of Defense's Recovery and Sustainment Partnership Initiative. The desert tortoise is one of the top ten DOD species and BLM is working to assist DOD's RSPI, finding where recovery implementation

actions are best suited on BLM administered lands. We continue to look for efficiencies in permitting and regulatory requirements to increase the time staff can devote to recovery actions. Highlights from across all 4 BLM state offices will be presented.

Spatially-explicit population viability analysis for Mojave desert tortoises in the northeastern portion of their range

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Understanding Mojave desert tortoise (*Gopherus agassizii*) population trends across space and time is critical for prioritizing management and conservation actions. Further, data-based simulations can provide a useful tool for understanding how spatial differences in demographic rates contribute to long-term viability of local desert tortoise populations. We applied a hierarchical Bayesian spatially-explicit population viability analysis to desert tortoise populations in the northeast portion of their range (i.e., NV, UT, and AZ) to both develop understanding of spatial variation in demographic rates and to use these rates in stage-based projection models to estimate the long-term probability of local extirpation based on recent population performance. We found strong spatial variation in demographic rates. Annual population growth rates were highest ($\lambda > 1.10$) at the southernmost portion of our analysis area, were moderately positive ($1.00 < \lambda < 1.06$) in the northernmost portion, but were lowest at mid-latitude locations ($\lambda < 0.96$). Spatial variation in annual population growth rates were driven most strongly by higher spatial variation in juvenile survival rates ($0.581 < \phi < 0.983$) and corresponding juvenile-to-adult transition rates ($0.083 < \psi < 0.100$), and to a lesser degree by adult survival rates ($0.678 < \phi < 0.975$). Probability of quasi-extinction in 500 years was highest in the central and northwestern portions of the analysis area and lowest in the northeast and southwestern portions. These results provide useful spatially-explicit information on population trends based on nearly three decades of data and highlight the value of using spatially-explicit models to interpolate population trends in areas between established sample sites.

The 2017-2019 Tortoise Translocation by the Marine Corps Air Ground Combat Center (Combat Center)

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In April 2019, the Combat Center tra nslocated 38 Agassiz's Desert Tortoises (*Gopherus agassizii*) with carapace lengths >159 mm (i.e., large tortoises), bringing the translocation totals to 1270 tortoises (1017 large, 254 small). Radiotracking in 2019 identified 23 telemetered tortoises

died, 16 Controls (6.3%), 5 Residents (2.6%) and 2 Translocatees (1.0%). Seventeen died due to depredation by American Badger (n=12), Coyote (n=4) and raptor (n=1, likely eagle). Other deaths may have been associated with physiological or health conditions (2 hyperthermia, 1 urolithiasis), or had unclear causes of death (n=3). Since the initial translocation in 2017, 38 (15.0%) Controls, 13 (6.7%) Residents, and 31 (16.2%) Translocatees have died. This represents annualized survival rates of 93.7%, 97.3% and 93.2%, respectively, comparable to natural survival rates in moderate to good rainfall years. Small juveniles (n=527; carapace length <160mm) from the clearance surveys are protected, fed, irrigated and health-assessed in holding pens for future release and monitoring to help assess the effectiveness of headstarting. Monitoring via radiotelemetry continues and is being used to evaluate factors influencing survival, 'health', genetic assimilation, movements, and a soft release trial.

Current Trends in the Global Turtle Trade: Food, Pets, and the Rise of Investment Trading

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The Asian turtle crisis rose to notoriety in the early 1990s and has since resulted in the decimation of turtle populations across Asia. Fueled by the rise of China's global economy, the surge in international turtle trade to China started primarily as harvesting turtles for consumption and traditional medicine but then expanded to include pets. This boom, previously measured in tons of turtles traded per day, caused turtle species native to Southeast Asia to dominate the list of the World's Top 25 most endangered turtles and tortoises. Projected to rise from 25 million people in 1990 to over 300 million people by 2030, China's middle class' demand for turtles is undoubtedly only going to increase. With the depletion of wild turtles across Asia, there is evidence for a growing and diversifying market in China for more US species. While US species have long been exported legally for food and pets (e.g., *Apalone spinifera, Chelydra serpentina*, and *Trachemys scripta*), there has been a marked increase in smuggling species for the high-end pet trade. In addition to selling turtles to hobbyists, smugglers are marketing them as an investment opportunity, thereby further inflating their perceived market value within China, the US, and Europe. For example, fresh wild-caught highly colored eastern box turtles, *Terrapene carolina*, a species listed as CITES Appendix II - with a zero-export quota from the US, are openly sold at Chinese trade shows. They now command considerable sums (prices not given here as to not to spur additional illicit interest). Recent changes to laws within China that prohibit commerce in nonnative CITES Appendix I species have resulted in confiscations of sizeable numbers of US turtle species, as well as several arrests of key individuals at the center of this crime network. Yet, to increase the broad effectiveness of global counter wildlife trafficking actions and initiatives, species native to the Americas as well as Africa must garner more focused attention by law enforcement and regulatory agencies. While US State and Federal wildlife law enforcement agencies have recently made significant arrests within the US that have had a demonstrated effect on the number of US turtles being sold within China, they would benefit from active support by the turtle conservation community to prevent more US turtles from entering the illicit global market. Furthermore, the

repatriation of confiscated turtles would be greatly aided by the development and utilization of new molecular technologies. Due in part to the increasing concerns of the impacts of illegal and unsustainable collection of turtles in the US, Partners for Amphibian and Reptile Conservation formed a national turtle task team whose mission is to facilitate and guide action through public-private partnerships to conserve native, North American turtle populations. This team's priority will be assisting and supporting the much-needed coordination and communication between law enforcement and turtle conservation biologists. If the turtle community fails to engage now, the turtles of the US will surely be the next to be added to the growing list of the world's most endangered turtles.

STUDENT PAPER

Using Movement to Inform Conservation Corridors for Mojave Desert Tortoises

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Providing corridors for movement and gene flow between populations can assist in the recovery of threatened and endangered species. As human activity continues to fragment animal populations, characterizing natural corridors is important to establishing and maintaining suitable corridors within the anthropogenic development matrix. The Mojave desert tortoise (*Gopherus agassizii*) is a threatened species inhabiting a variety of habitats in the Mojave Desert. Urban expansion, incursion of recreation (e.g. OHV use), and utility scale solar facilities are all increasing in tortoise habitat. Desert tortoises are typically considered corridor-dwellers, and understanding how they use suitable habitat can be crucial to describing and identifying corridors. To elucidate how tortoises traverse available habitat and interact with potentially inhospitable terrain and human infrastructure, we used GPS dataloggers to infer fine-scale movement of individuals (~130) at ten 1-km^2 study sites centered in the greater Ivanpah Valley area, along the California/Nevada border. Our sites encompass a variety of habitats, including mountain passes that serve as important corridors connecting neighboring valleys, and have a variety of anthropogenic impacts (e.g. roads, fencing). We used path selection functions to quantify tortoise movements and develop resistance surfaces based on landscape characteristics and anthropogenic alterations. Our results indicate that both natural and human-created features shape tortoise movement patterns. Tortoises selected against movement through areas of high slope and low perennial vegetation cover, avoided crossing low-density roads, and often moved along linear barriers (fences and flood control berms). Using this model, we determine characteristics of known natural corridors and compare them to artificial corridors that have been integrated into land management decisions in the Ivanpah Valley. Understanding characteristics of functional corridors will help future land and conservation planning ensure that connectivity is maintained in the Mojave desert tortoise.

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

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Major activities within the Desert Tortoise Recovery Program in 2019 included: 1) Conducting range-wide monitoring surveys in 12 tortoise conservation areas in California, Nevada, Arizona, and Utah; 2) Coordinating with the Desert Tortoise Recovery Implementation Teams to fund and implement projects, such as habitat restoration, raven monitoring, reduction of predator subsidies, desert tortoise fencing installation, research, and public outreach/education, to address recovery priorities determined by the Desert Tortoise Management Oversight Group; 3) Coordinating with Federal and State agencies on range-wide efforts for raven management and desert tortoise exclusion fencing along roads; 4) Surveying desert tortoise habitat in Utah via satellite to evaluate habitat connectivity corridors, and to identify, protect, augment, and recover desert tortoise connectivity; 5) Refining and developing the Spatial Decision Support System with the assistance of Mountain View Business Group to establish recovery tools to assist with tracking and implementation of recovery actions for desert tortoise; and 6) Continuing to collaborate with our Federal, State, and local agencies, and non-governmental organization partners to increase efforts that benefit desert tortoise recovery.

POSTER

Ecologically Founded Intelligent and Aversive Decoy Device to Protect Vulnerable Species (e.g., Mojave Desert Tortoise) from Targeted Predation and Provide Data-Driven Insights

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Approximately 42% of threatened or endangered species are at risk due to invasive species (The National Wildlife Federation). Invasive species exacerbate threats on native species in a variety of ways, including habitat disruption, outcompeting native species for food and other resources, causing or carrying disease, and notably, preying on native species – particularly their young. For example, juvenile Mojave desert tortoises (*Gopherus agassizii*), currently listed as threatened under the Endangered Species Act (ESA), are experiencing predation from human-subsidized predators, predominantly ravens (*Corvus corax*) and coyotes (*Canis latrans*), at unprecedented and unnatural rates. While reducing human subsidies to these species would address the root of this specific issue, fusing the empirically established method of conditioned aversion with technological advancements in small form factor sensors, ruggedized electronics, and robotics, presents a novel opportunity to protect vulnerable species from unwanted predators in a

targeted, non-lethal, non-toxic, and self-sustaining way. To this end, Charles River Analytics has developed prototype technology to detect, identify, and train targeted predators from preying on vulnerable species through intelligent decoy devices. These devices are designed to cue predators through natural predation cues (e.g., looks and smells like a juvenile desert tortoise), detect predator interaction through onboard sensor processing, matching sensor data to biologically-informed predator profiles, and deploy repeatable, flexible, non-lethal, predator-specific aversion stimuli (e.g., light, sound, shock), which are randomized (e.g., by pattern, frequency, type) to reduce and/or mitigate habituation. Additionally, beyond predator aversion, these devices provide the ability to collect device interaction data and provide researchers with novel insights into predator prey ecology. This poster presentation will provide an overview of our ecologically-driven design and engineering approach, our results and key takeaways, plans for future IACUC-approved testing and design iteration, and recommendations for deployment in the field, additional species that could benefit from this technology, and future research pathways. Additionally, the presentation will include demonstrations of the prototype device.

This material is based upon work supported by the United States Air Force under Contract No. FA9302-19-P-1008. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the United States Air Force. DISTRIBUTION STATEMENT A. Approved for public release; Distribution is unlimited 412TW-PA-20014.

A Novel Application of the USFWS Line Distance Sampling Data: Estimating Range-wide Trends in Occupancy for Mojave Desert Tortoises

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Data from long-term monitoring programs, such as the 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 trends in the probability of occupancy as part of a larger effort to manage *G. agassizii* on BLM lands. We chose to develop dynamic occupancy models to answer fundamental questions posed by BLM personnel regarding how tortoises are distributed across the landscape over space and time. We transformed the LDS data into presence/absence data, and constructed a set of competing models using several time-varying (e.g., temperature, precipitation, NDVI) and static covariates (e.g., soil properties, topography, wash density, distance to roads, distance to urban areas) hypothesized to affect desert tortoise occupancy, and estimated trends in occupancy over an 18-year time period (2001-2018). We summarized trends in occupancy across 10 BLM field offices, and found that there was a wide range of variation in the probability of occupancy across field offices and over time. In general, the probability of occupancy was stable or increasing within critical habitat units for all field offices. However, we identified several areas with declining occupancy trends. We aim to further refine and validate our model in order to generate range-wide, 'wall-to-wall' trends in occupancy that will aid managers in identifying

habitat suitable for desert tortoises (e.g., for translocation efforts) and conversely, areas that have declined in occupancy and thus may be targets for restoration.

Zulu Nyala – A South African Wonderland!

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For the last several years at our annual symposia, the Desert Tortoise Council has provided two complete-package trips to Zulu Nyala Game Reserve, located in South Africa. Located about three hours east of Johannesburg and several hours west of the Indian Ocean, the 15,000-acre± fenced game preserve is home to cheetahs, elephants, rhinos, hippos, water buffalo, giraffes, warthogs, wildebeests, impala, and at the time of our visit in August 2019, a leopard that routinely jumped the 10-foot tall electric fence to hunt. Available only to nonprofit organizations, the participants are of a mind and spirit that made daily contact with them on safaris and at dinner a real joy. At daybreak and again in the late afternoon, there are three-hour safaris that allow up close wildlife encounters and exceptional photography opportunities. There are three banquet meals a day, and accommodations in motel-like facilities or canvas tents, the latter of which we stayed in and are highly recommended. We strongly recommend renting a car in Johannesburg so that you can make day trips to two nearby national parks, the Indian Ocean, and other day trips, a half-dozen of which are also chartered by Zulu Nyala. The six-night-seven day complete package was also a wonderful springboard for us into South Africa, where we spent 19 more days visiting national parks, and Kruger National Park in particular, where we rented a cab-over-camper and spent nine days, driving the entire length from north back south towards Johannesburg. The trip is available both in a silent auction and public auction at the Saturday evening banquet. After the base price is paid to the Zulu Nyala organization, the remaining proceeds remain with the Council for our normal operations expenses. Enjoy!

Does the Coachella Valley in southern California influence gene flow in Agassiz's desert tortoise (*Gopherus agassizii*) populations?

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Understanding the influence geographic features have on the evolutionary history and population structure of a species can assist wildlife managers in delimiting genetic units (GUs) for conservation and management. Landscape features including mountains, low elevation depressions, and even roads have been shown to influence connectivity and gene flow among Agassiz's desert tortoise (*Gopherus agassizii*) populations. Substantial changes in the landscape of the American Southwest occurred during the last six million years, including the formation of the Gulf of California and the modern Colorado River, that shaped the distribution and genetic structuring of tortoise populations. The area northwest of the Gulf of California is occupied by the Salton Trough, including the Coachella Valley at its northern end. Much of this area is below sea level and unsuitable as tortoise habitat, thus forming a potential barrier for gene flow. We assessed genetic differences among tortoise populations separated by the Coachella Valley. Two adjacent populations were on the east side of the valley in the foothills of the Cottonwood and Orocopia mountains separated by Interstate 10. The third population, Mesa, was located about 85 km away in the foothills of the San Bernardino Mountains at the far northwestern end of the valley. The Cottonwood and Orocopia localities showed genetic affiliation with the adjacent Colorado Desert GU immediately to the east, and the Mesa population was equidistant in relatedness between locations in the Southern Mojave and Colorado Desert GUs, despite having a greater geographic distance (0.5x–1.5x greater) to the Colorado Desert GU. Desert tortoise populations around the Coachella Valley, especially at the tip of the Salton Trough, represent an underappreciated portion of the species' range. Their genetic affiliation with the Colorado Desert GU suggests that the boundary for that GU needs to be substantially extended to the west.

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. The history of desert tortoise management in the California Desert Conservation Area has been one of increasing conservation through our land use planning decisions. In 2019, we monitored and controlled ravens, funded line distance sampling, 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 created the BLM Mojave Desert Working Group to better coordinate tortoise management across all the BLM offices within the range of the tortoise.

STUDENT PAPER

Using Spatial Information to Improve Methods for Estimating Density for the Desert Tortoise

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Accurate and precise population estimates are essential for monitoring the recovery of the federally listed Mojave desert tortoise (*Gopherus agassizii*), however, desert tortoise populations are difficult to accurately quantify due to a number of factors. Mark-recapture sampling methods have regularly been used to monitor this species, but the methods employed are often plagued by the violation of statistical assumptions, which have the potential to bias density estimates. By incorporating spatial information into conventional density estimation models, spatial capture-recapture (SCR) models can account for common assumption violations such as spatially heterogeneous detection probabilities and temporary emigration when animals leave plots during surveys. We conducted mark-recapture surveys separated by three years at 10 1-km^2 plots in and adjacent to the Ivanpah Valley of CA and NV from 2015-2019. Movement data were collected concurrently using radio-telemetry and GPS data loggers. GPS data demonstrated that desert tortoises frequently exhibited temporary emigration outside the plot during the three-day survey period; thereby, complicating standard approaches for closed-model density estimation. We

integrated mark-recapture survey data for adults (>160 mm MCL) at each plot with corresponding spatial capture locations and radio-telemetry data using a modified SCR model fitted in a Bayesian framework. We compared density estimates modeled with conventional non-spatial methods, standard SCR methods based on symmetrical usage areas, and a novel SCR model that integrates daily movement displacement quantified from fine-scale GPS data to define movement between sampling periods. The conventional models consistently resulted in inflated estimates of density while the SCR models allowed us to generate higher-precision estimates for a species where detectability and abundance are low. Our results demonstrate the importance of accounting for spatial information when estimating density for the desert tortoise and have the potential to enhance the efficacy of long-term efforts to monitor population trends and inform recovery efforts.

POSTER

Development of a Genotyping Protocol for Mojave Desert Tortoise Scat

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Non-invasive fecal genotyping can be used for population monitoring of elusive species. We tested extraction protocols on scat samples from the threatened Mojave desert tortoise, *Gopherus agassizii*, to evaluate the feasibility of scat-based mark-recapture and population genetic monitoring studies. We extracted DNA from *G. agassizii* scat samples using several extraction protocols, and evaluated the reliability of resulting genotypes using quality scores, maximum likelihood reliability estimates, and paired scat and blood genotypes from the same individuals. Finally, we assessed probabilities of identity (P_{ID}) and sibship (P_{SIB}), and locus amplification quality, and calculated genotyping error rates for nineteen microsatellite loci, to determine the best set of loci to use with *G. agassizii* scat extractions. We found that genotype quality depended more on the sample quality than the extraction method, and that the Qiagen DNeasy Plant Mini extraction kit is an efficient method for extracting DNA from tortoise scat. We identified six *G. agassizii* microsatellite loci that can be used to generate a unique molecular tag for individual tortoises. Of field collected scat, we matched three samples to blood genotypes from animals captured during population surveys within the study area, and discovered at least three new individuals, even after two years of extensive survey work in the same plots. These results suggest that genotyping of field collected scat can complement existing methods used in long term demographic and movement studies of *G. agassizii*, and other, closely related, tortoise species.

Captive Tortoise Management in the Mojave Desert

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The combination of federal protection and state laws create a unique niche for captive Mojave desert tortoises. Prior to their federal listing, residents collected desert tortoises from the wild and kept them as pets. Nevada and California state law permit citizens that collected animals prior to their listing to keep them as well as their progeny as pets or "captives". Tortoise Group receives thousands of requests annually regarding pet desert tortoises, many pertaining to households with multiple tortoises. Households with multiple tortoises have the potential to become a hoarding situation within a few years. Tortoises in captivity can be prolific breeders as they are given a regular supply of nutrition and their offspring are typically protected from predators. Las Vegas continues to rank in the top 10 fastest growing cities in the United States. National formulas used to estimate pet populations rely on the number of households or the human population in the community. These estimates infer that the growth of human population in an area directly correlates to growth of the pet population in that area. The burgeoning captive tortoise population will at some point adversely affect wild tortoise populations. Tortoise Group continuously explores strong partnerships that benefit wild tortoise populations.

Head-starting *Gopherus agassizii*: Some Lessons from the Twentynine Palms Marine Base Project

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We protected head-start tortoise eggs, hatchlings and juveniles from predation, via predator-resistant fenced and netted enclosures of natural habitat, and from droughts, by irrigating enclosures. Initially, we maintained enclosure conditions as natural as possible to minimize juveniles acclimatizing and learning poor habits. We anticipated that irrigation would supplement precipitation, foster annual wildflower production, and increase juvenile growth rates. Survival increased annually in each of eight cohorts (measured up to 11 years of age in the oldest cohort). Growth rates were lower than expected in the early years, apparently from low feeding rates. Although body condition indices suggested head-started tortoises were well-hydrated and had eaten well, even during two multi-year droughts between 2006 and 2013, head-start tortoises grew slower than free-living juveniles experiencing good wildflower years. Plant cover measured in an enclosure indicated that 1) initial irrigation schedules occasionally failed to stimulate wildflower production in drought years, and 2) selective feeding on favored plant species likely reduced the subsequent presence of those species and their seeds, changing plant species composition and cover over time. Subsequently, we provided nursery-grown wildflowers and green turf grass in springs when rain and irrigation amounts and timing failed to provide a substantial wildflower crop. Since 2013 we sowed seeds of favored wildflowers and irrigated regularly each fall and winter, provided Bermuda grass hay in summer and fall, and irrigated briefly in spring and summer

to support drinking, tortoise hydration and concomitant feeding. Modifying our original protocols, to include seeding, food supplementation and additional irrigation, nearly doubled annual growth rates.

Progress Toward Understanding the Impacts of Land Use and Climate Change on Desert Tortoise Structural Genetics and Corridor Functionality

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With increasing urbanization and land use, species must balance a complex suite of natural and anthropogenic factors to meet habitat needs. Pressures on populations as a result of habitat and climate change are likely to shift areas of suitable habitat, thus driving underlying species distributions. These pressures may be especially important for sensitive species living in desert ecosystems, where physiological tolerances are already challenged. The Desert Tortoise is a threatened [T&E] species listed under state and federal endangered species acts wherever it occurs. Climate change poses an imminent challenge to species persistence due to physiological constraints acting on individuals and populations. Our knowledge of habitat/environment relationships for desert tortoises are based largely on core habitat areas located within critical habitat, where most monitoring and research occurs, however, habitat change and the ability for species to shift their distributions are more likely to influence species near the edges of their range. Further, genetic differences and selective pressures in species are likely to occur near habitat edges, or where conditions change more rapidly. Thus, understanding species both in core areas, and at the limits of their distributions are important toward understanding their potential to adapt to habitat changes. Tortoises exists in a mosaic of inter-connected populations, exchanging of individuals among groups in the short-term, and genetically integrating individuals and populations over time. These connections are vital to maintaining genetic structure and genetic diversity, which allow populations to persist under new selective pressures. We are obtaining genetic samples and locality information for tortoises in under-sampled areas both well within and at the limits of their distribution. We are also generating data layers to model potential changes in land use by humans. We are working on multi-scale studies to understand the drivers of habitat for the entire range of the desert tortoise, and how habitat disturbances degrade habitat, population status, movements and population structure. Finally, we are using future climate forecasts to model potential changes in suitable habitat under future climates, and under associated land use scenarios.

We present preliminary results of our research, and how we intend to integrate our research toward a broader understanding of potential and realized tortoise habitat.

The Genome of *Testudinid herpesvirus* 2: Preliminary Data

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Testudinid herpesviruses (TeHVs) have surfaced as lethal pathogens of tortoises worldwide. Of the four distinct genotypes known to date, TeHV1 and -3 have been documented in several species of tortoises all over the world, whereas TeHV2 has been described in captive and free-ranging Agassiz's desert tortoise (*Gopherus agassizii*). The associated disease is characterized by stomatitis and glossitis together with other signs including ocular and nasal discharge, pneumonia and neurological signs and death. Most of what is known concerning TeHVs was derived by TeHV3, a Eurasian strain. The full genome of TeHV3 virus was recently sequenced and the data obtained were instrumental to better understand the biology of TeHVs and the basis of their pathogenicity. In the attempt of a better characterization of TeHV2 and of its virulence determinants, we considered critical to sequence its genome. Total DNA was obtained from a naturally infected desert tortoise. The DNA was submitted for Next generation Sequencing (NGS) using the "illumina" platform. We obtained a total of 47 Million reads which allowed to assemble a single preliminary contig 125 Kb long. The preliminary TeHV2 genome map contains at least 140 open reading frames (ORFs) with a minimum length of 270 nucleotides showing significant collinearity with those of TeHV3. The genomic data now available for TeHV2 will allow to investigate the association between TeHV2 infection, the associated-disease phenotype and the complementary molecular signature for a more thorough understanding of the basis of TeHV2 virulence and a better insight into TeHVs evolution and desert tortoise disease ecology.

POSTER

Progress Towards a New *Gopherus morafkai* Reference Genome to Identify Structural Genetic Differences Underlying Physiological Adaptations of Mojave and Sonoran Desert Tortoises

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Starting approximately 5.5 Ma, three *Gopherus* species are thought to have diverged and adapted to the diverse habitats of the Mojave and Sonoran deserts and the seasonal dry forest of Sinaloa. This divergence is preceded by a period of geological change that differentiated the habitats of these three species. The earlier rifting of the Baja California peninsula 14–12.5 Ma changed the coastline, and flooding of the Gulf of California about 6.3 Ma led to the emergence

of a monsoonal precipitation pattern indicative of the Sonoran Desert and absent in the Mojave Desert. The barrier effects of the Colorado River, which started its current flow 5.3–4.8 Ma, is thought to have reinforced the separation of the Mojave and Sonoran desert populations. As reported previously, Agassiz's/Mojave desert tortoise (*G. agassizii*) can be differentiated from Morafka's/Sonoran desert tortoise (*G. morafkai*) by differential adaptation to habitat, physiology, morphology, and behavior. *Gopherus agassizii* primarily occupies valleys and alluvial fans with Mojave creosote, saltbush, desert scrub, and yucca woodland, while *G. morafkai* occupies rocky hillsides and slopes of Sonoran Desert grasslands and upland thornscrub. Compared to *G. agassizii, G. morafkai* has a later oviposition time with fewer eggs in only a single clutch, less wide, flatter and more pear-shaped carapace, more adult activity to bask and drink during the winter, longer average lifespan, and reduced impact from *Mycoplasma* infections. Many of these adaptations are underlain by molecular changes in the genomes of *G. agassizii* and *G. morafkai*. Building on our whole genome sequencing of *G. agassizii*, we report progress towards generating a reference genome for *G. morafkai* using combined Dovetail Chicago, Hi-C, and PacBio long-read sequencing of an adult male from Pima County, Arizona. With this new reference genome, we can identify large-scale structural differences such as gene duplications, deletions, translocations, and inversions that may play an important role in reinforcing this lineage divergence. In addition, we can assess mutations in protein coding and regulatory sequences that may account for the adaptations to the Mojave versus Sonoran desert habitats. Information about the genetic origins of these adaptations, combined with the spatial localization of structural variation, will aid wildlife management of current populations as well as permit functionally informed predictive modeling for the effects of future climactic changes.

POSTER

Understanding the Role of the Adaptive Edge for the Desert Tortoise in a Changing Climate

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Understanding how long-lived species will respond to climate change is central to conservation management. In a changing climate, adaptation is likely to occur at the edge of a species' range, however, many species are primarily sampled in core areas of their range. Field surveys and monitoring efforts for Mojave Desert Tortoises have primarily focused on collection of population densities and genetic data in designated critical habitat units for the species, and thus interactions with climate and potential genetic differences at the adaptive front of their distribution have been understudied. These edge areas could be important in maintaining populations of tortoises under future climate scenarios that may result in spatial changes of core habitat and expansions along a warming front. We surveyed habitat edge areas in 2018 and 2019 and split the

resulting location data into various groups based on hierarchical K-means clustering algorithms using several metrics of climate data (minimum and maximum temperatures, winter precipitation, and periodic drought), and incorporated these data into a pooled habitat model. The residuals from this model were then used to produce multiscale geographically weighted regressions to examine differences between core and edge habitat. These models will help us understand the role edge areas play in maintaining tortoise populations now, and under future climate scenarios, as well as help understand connectivity of these areas to core regions. Future work will include combining genetic data with habitat models, and this combination of information on the adaptive edge will provide us with a multifaceted understanding of how the Desert Tortoise uses a changing landscape across the Mojave Desert.

On the Right Track: Understanding and Reducing the Impact of Railways on *Gopherus*

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Habitat fragmentation is one of the leading causes of biodiversity decline and most commonly results from urbanization and construction of transportation infrastructure. Roads are known to negatively impact species, but railways can often cause similar effects. Certain taxa, such as turtles and tortoises, are more vulnerable to railways than others due to limitations in mobility. We studied the impact of rails on the movement and behavior of Gopher Tortoises (*Gopherus polyphemus*), a threatened, highly terrestrial species likely in frequent contact with railways. First, we used radio-telemetry to determine the frequency of railway crossings and compared this to correlated random walk (CRW) simulations to assess if tortoises were crossing the rails less frequently than is expected by unconstrained movement. Second, we placed tortoises into the railway and measured behavior for one hour to assess crossing ability. Lastly, we tested whether trenches dug underneath the rails could allow safe passage for tortoises. We found that railways impacted the movement of Gopher Tortoises. Gopher Tortoises crossed the railway less often than what would be expected by unhindered movement for five of our ten tortoises tracked. During behavioral trials, 0 of 24 tortoises placed within the railways were capable of escaping from the rails. Using game cameras, we detected tortoises using trenches dug underneath the rails and between the ties 68 times over the course of a single summer. For minimal financial cost, the trenches facilitated tortoise movement across the railway, maintained full rail functionality, and

created an escape route for individuals that were trapped between the rails, and thus should be implemented as a mitigation strategy.

Desert Tortoises (*Gopherus sp.*) are likely similarly impacted by railways. Across the distributions of all four Desert Tortoise species, there is an estimated 19,865 km of railway. Proportional to the total area for each distribution, *Gopherus agassizii* is likely to be impacted the most. Given the thousands of km of railways impacted both *Gopherus* and turtles around the world, we recommend future studies focus on the new field of rail ecology.

The Eagletail Mountains: Returning to a Sonoran Desert Tortoise Long-term Monitoring Plot

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In Arizona, the Sonoran Desert Tortoise is a Species of Greatest Conservation Need and designated a tier 1A species by the state's wildlife action plan. With this designation, coordinated efforts with partner agencies have been made to ensure geographically and ecologically broad coverage of Sonoran Desert Tortoises in Arizona. Through a partnership between the Bureau of Land Management and the Arizona Game and Fish Department, a multi-decade long demographic monitoring program has been undertaken for this species. Information gathered from these monitoring efforts has been used to estimate abundance, density, annual survival, and other life history parameters for Sonoran Desert Tortoises. This information provides a better understanding of the Sonoran Desert Tortoise's status across its range and allows for any population changes to be identified. Between July and October 2019 we conducted surveys at the Eagletail Mountains long-term monitoring study plot. First established in 1987, a span of twelve years had elapsed since the last time this plot had been surveyed. We will provide an overview of our monitoring strategy, the long-term monitoring plots, and recent evaluations. Finally, we will highlight the outcome of the 2019 return to the Eagletail Mountains study plot. We will compare population estimates, sex ratios, age structure, and mortality in this population over its 32-year course of study. Recommendations regarding the monitoring strategy for Sonoran Desert Tortoises will be provided.

Washington County Habitat Conservation Plan - A Recent and Ongoing Project Summary

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Three recent and ongoing projects have highlighted Washington County HCP's tortoise conservation and public engagement efforts:

1. Raven monitoring – Washington County HCP has been monitoring tortoise predation within the Red Cliffs Desert reserve since 2015. Recent (2019) monitoring results suggest potentially increasing raven predation concerns.

2. Sahara mustard management – The very wet winter of 2018/2019 led to discovery of Sahara mustard in multiple locations within the Red Cliffs Desert Reserve. Through volunteer efforts and partnerships, Washington County is working to combat the spread of this invasive species into the core of the Reserve.

3. Citizen science – For the past several years, Washington County has been working to gain better tortoise distribution data in the Upper Virgin River Recovery Unit. Due to the success of preliminary citizen science efforts in 2017, we are launching a permanent and streamlined citizen science effort beginning in 2020. Our platform is designed to educate the public in addition to the valuable data that may be obtained.

Recent Applications of Technology to Desert Tortoise Conservation: Projects Underway

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This is a progress report on three projects underway by Hardshell Labs with applications to desert tortoise conservation interests. The presentation will include the roots of each project, funding sources used, and a description of work done with many collaborators.

Remotely Fired Laser- A project with the goal of creating a maximally flexible laser system for avian repulsion. The system will integrate multiple laser colors with adjustable power and flash pattern settings to be operable remotely in a semi-autonomous fashion. The use of artificial intelligence in the project will be described. Given the high sensitivity of ravens to laser light the system may have wide applications for desert tortoise conservation in repelling ravens from high quality tortoise habitat and from raven subsidy sites.

Semi-autonomous Rover- The project's goal is the creation of a rover capable of operating independently in tortoise habitat for recording the distribution of important sign of desert tortoise presence, principally live tortoises, burrows and carcasses. The rover will use robotics for navigation and camera-based image object recognition programming to filter out objects of interest in the desert environment and will record their location and environmental metadata.

Rainfall Concentrators- Working with Transition Habitat Conservancy on their privately-owned parcels, this project is an investigation of the potential to collect ambient rainfall from a larger area and deliver it to a smaller area that has been seeded with high value desert tortoise food species. In drought years these irrigated patches will receive an amount of water typical of an average or above average rainfall year. This work is a low-tech attempt to actively improve tortoise access to valuable food items in the face of the growing dominance of low-quality invasive plant species.

Novel Management Tools for Subsidized Avian Predators and a Case Study in the Conservation of a Threatened Species

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Wildlife managers face complex problems in attempting to achieve contemporary conservation goals while maintaining ecosystem function. As human development expands across the US, subsequent alteration of wildlife habitats can subsidize certain species, causing overabundance of those species better adapted to coexist with human infrastructures. Our team has been meshing practical field technologies with theoretical modeling to provide a complementary toolset aimed at ecological rebalancing despite anthropogenic expansion. Our field tool (Remote Fluid Application System; RFAS) is a novel technology that is used for the oiling of bird eggs, remotely from the ground, to reduce population growth of, and predation pressure by, anthropogenically subsidized and problematic pest bird species. To scale this application, we developed a theoretical tool (StallPOPd) which is an interactive software program used to prescribe the level of survival reduction necessary to counterbalance pest bird population expansion. Together, this toolset provides a novel and increasingly preferable alternative to managers seeking to combat bird damage in critical wildlife or human development areas. We demonstrate the use of this toolset in the case study of the common raven (*Corvus corax*) in Desert Tortoise Critical Habitat Units of the southwestern US. We highlight that the RFAS achieved the goal of reduced reproductive output on either artificial or natural nest substrates. We discuss the pragmatic scalability of these tools to remote egg oiling in larger geographic areas, plus the transferability of these tools to aid in avian pest management in other critical wildlife systems, or to minimize bird damage at other human-wildlife interfaces. We conclude that the combination of our RFAS technology and StallPOPd software are rapidly becoming an alternative of great interest for managers faced with increasing level of undesirable bird damage.

Assessing Critical Habitat Breadth for the Mojave Desert Tortoise

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Effective conservation planning in a non-stationary world requires accurate assessment of exposure to environmental changes and of the resiliency to weather those changes. To address these needs, we are advancing the concept of critical habitat breadth, defined as the range of environmental conditions capable of supporting viable populations, as the foundation for evidence-based vulnerability assessment tools. The Mojave desert tortoise (*Gopherus agassizii*) provides an excellent system for developing and applying the concept of critical habitat breadth because populations have been extensively studied, many occupied habitats exhibit steep environmental gradients, and many prior translocations have been conducted ("common garden" experiments that enable investigation into inherent resiliency). Our project aims to (1) understand the complex pathways through which environmental conditions influence population vital rates, (2) use this information to derive population growth rates, assess viability, and quantify critical habitat breadth, and (3) develop a conservation planning tool to aid managers in protecting metapopulations under global change scenarios. Although this work is ongoing, preliminary results from re-analyses of 'permanent study plot' data suggest that adult tortoise survival and recruitment are sensitive to environmental gradients such as soil depth and vegetation cover but are less sensitive to climate gradients. These efforts represent a critical first step in our broader assessment of climate resilience for Mojave Desert Tortoise populations.

Political Expediency, Career Security, and Status Quo Management Greatly Contribute to Rapid Declines of Desert Tortoise Populations

Richard Spotts, St. George, UT

An abstract excerpt from "Population trends in Mojave Desert Tortoises" (Allison/McLuckie 2018), *"Prevailing declines in the abundance of adults overall and in four of the five recovery units indicate the need for more aggressive implementation of recovery actions ...."* Despite many well-intended efforts, we have not stopped, much less reversed, these tortoise population declines. There are many increasing threats to tortoises, and many governmental factors that greatly reduce our ability to effectively address those threats. Several examples are provided during the presentation, including the following:

(1) The arbitrary and inconsistent planning decisions by the Bureau of Land Management relating to livestock grazing in tortoise habitat in Clark County, Nevada, vs. Mohave County, Arizona, and Washington County, Utah.
(2) During both Democratic and Republican Administrations, the pattern of profound incompetence and cowardice by the Bureau of Land Management, Fish and Wildlife Service, National Park Service, and Department of Justice in dealing with the chronic trespass livestock grazing by Cliven Bundy in tortoise habitat.
(3) The county-dominated administration of the Washington County Habitat Conservation Plan and obsession with building a northern corridor highway through the Habitat Conservation Plan which established Red Cliffs Desert Reserve and statutorily established the Bureau of Land Management Red Cliffs National Conservation Area.
(4) Nevada politicians reportedly may try to emulate Utah politicians (relating to previous Washington County legislation) with a draft Clark County lands bill that would take federal lands to greatly increase the size of Las Vegas, dictate land disposals without following the Endangered Species Act and National Environmental Policy Act processes, and destroy tortoise habitat.
(5) The Bureau of Land Management and Fish and Wildlife Service' apparent willingness to approve reportedly the nation's largest solar farm (Gemini Solar) in tortoise habitat, without analyzing distributed solar or other locations as much less damaging alternatives.
(6) The Trump administration and GOP leadership in Congress have consistently worked to circumvent, weaken, or repeal key Endangered Species Act and National Environmental Policy Act requirements that affect tortoise conservation.

To change the status quo and increase our ability to help tortoises, we must become stronger at speaking truth to power, at holding our elected and appointed officials accountable, and at supporting causes, groups, and candidates that are working to take us forward rather than backward.

Evaluating Techniques for Optimal Head-starting of the Mojave Desert Tortoise (*Gopherus agassizii*)

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Head-starting — the act of rearing juveniles through vulnerable life stages until they reach a larger size — requires careful evaluation before widespread implementation as a technique to increase population sizes of at-risk species. We began desert tortoise head-starting research in 2011 in the Mojave National Preserve in an adaptive management framework where results inform ongoing refinement of head-starting techniques. For instance, we found in early work that tortoises reared outdoors grew 10.7–12.7 mm carapace length per year with rain supplementation and would thus take many years to reach sizes associated with greater survival. We have since focused on

rearing hatchling tortoises indoors with food and water supplementation and recorded growth rates of 60 mm per year, greatly reducing the length of the rearing period. In a study of captive rearing over 7 months we found that although indoor-reared tortoises were much larger (87 mm) than outdoor-reared tortoises (52 mm) and free-ranging tortoises (49 mm), their survival after release in April was nevertheless low to November. Significant raven predation in spring and summer and within 1.6 km of roosting sites contributed to comparable annual survival that ranged from 37–50% among groups. In our most recent work, we have reared tortoises indoors for an entire year and then outdoors in protected enclosures for a second year. Tortoises reared in this manner were much larger (117 mm) than those reared entirely outdoors for two years (83 mm) and had greater annual survival of 88% compared with 71% one year after release. We also found that the odds of tortoises surviving one year after release increased with their size at release. It will be critical to determine the longer-term fate of head-started tortoises through successive years of monitoring but results to date are encouraging and suggest that head-starting may be a useful addition to the portfolio of strategies aimed at recovering the Mojave Desert Tortoise.

Desert Tortoise Council Activities in FY2019

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The Desert Tortoise Council's (Council) Board of Directors (Board) pursued and implemented strategies outlined in its 2015 5-year strategic plan and developed a new 5-year strategic plan for 2020-2024 in late 2019. We implemented the strategic plan through our existing committees and formulated new committees. Our Ecosystems Advisory Committee (EAC) submitted 27 letters to agencies in response to public comment requests. The Council's Grants Committee funded $2,500 each for the Morafka Memorial Research Award and Lockheed Martin Diversity Grant in early 2020. The Council received a grant in the amount of $10,000 from Southern California Edison to fund a restoration project grant. The 2019 Symposium was held in Tucson, Arizona, and featured 69 papers and posters from biologists, conservationists, and resource managers and was attended by more than 260 registrants. The Introductory and Advanced Training Committees provided training opportunities in 2019 through offering two training courses: the Introductory Course in Ridgecrest, California in November and the Health Assessment Procedures for Translocations of Mojave Desert Tortoises in April in Phoenix, Arizona. The Media Committee published one Newsletter and attracted more followers to our social media platforms. The Board established new committees in 2019, including the Training Program Committee and Fundraising Committee. By the end of 2018, total assets of the Council were $180,852, our active membership reached 295, and we implemented new membership categories and membership terms on a calendar year basis.

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 2.94M in 2018. 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 also an active participant in the Colorado Desert workgroup under the California Mojave RIT to guide future recovery efforts in the region.

Within the park, educational specialists provide desert tortoise educational presentations to many local schools. The park also has an active habitat restoration program that works to return degraded habitats to functional ecosystems for tortoises and other animals. Desert tortoise awareness talks are given to all NPS employees, construction workers and even researchers doing work in the park that may affect the desert tortoise. Since 2007, the park's wildlife staff has been tracking desert tortoises near roads as part of a study to understand the effect of roads on tortoise movement patterns. Currently, the park is analyzing the data with some interesting preliminary results. The park is heading into its fourth year of removing offending common ravens with some promise that the action is working to reduce predation on juvenile tortoises.

Recent Turtle Confiscations in the United States

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In the past five years, the U.S Fish and Wildlife Service (Service) has seen a marked increase in illegal turtle exports from the United States, to various Asian counties, mainly Hong Kong. All of the species exported were North American species, the majority being U.S. box turtles (*Terrapene spp*). The vast majority of the illegal shipments were exported via international mail. Traditionally, only import shipments were inspected by the Service. Most of the turtles were exported through New York (JFK), Los Angeles, and Chicago. Upon determining that turtles were being smuggled out of the U.S., the Wildlife Inspectors in those ports increased daily screenings of outbound mail shipments through x-ray and inspections and, in Los Angeles, trained a canine to detect turtles. These turtle shipments lead to investigations, which resulted in seizures of many more turtles and some arrests. As a result of our efforts, no turtle seizures have been found at the mail facilities in Los Angeles and Chicago in recent months, and New York is striving to get their turtle seizures under control. One of the obstacles in pursuing turtle cases is placement of animals. In Los Angeles, we have as many as 700 box turtles per year that require temporary placement, as the animals may have to be admitted to the court as evidence, if the case goes to trial. Investigations can take several years, during which time the animals remain as evidence until the Service gets forfeiture of the property. At that point, the animals can be permanently placed. Details of an open investigation must remain confidential. News releases by organizations and social media can sometimes compromise an investigation. Often times, we can find individuals or organizations that

can take groups of animals and provide immediate care, but to get a commitment to hold large numbers of animals for upwards of a half a decade is difficult. Animals that perish also remain as evidence and are often disposed, compromising a case against a smuggler. The Service, in conjunction with zoos, conservation groups and others are working on the development of a clearing house for large seizures of turtles and other live animals to reduce the burden on law enforcement in the future, and make it easier to pursue cases involving the smuggling of North American turtles.

Toward a Coherent, Range-wide Mojave Desert Tortoise Management Strategy for the Bureau of Land Management

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The Mojave desert tortoise (*Gopherus agassizii*) is listed as threatened under the U.S. Endangered Species Act due to several threats, including loss and degradation of habitat from human activities, increased predation subsidized by human development, and disease. Lands under the jurisdiction of the Bureau of Land Management (BLM) across Utah, Arizona, Nevada, and California account for approximately 20-million acres (~60%) of putative desert tortoise habitat. This means that BLM is a critical part of inter-agency species recovery efforts. In recognition of this responsibility, BLM personnel collectively identified the need for more effective coordination among field offices and for enhanced guidance on prioritizing desert tortoise management options. Since late-2018, we have been assisting BLM in developing a coherent, agency-wide approach to Mojave desert tortoise management. In particular, this effort has included three main objectives: 1) enhance coordination across BLM offices and staff; 2) establish a repository for all BLM data, reports, knowledge, etc., and; 3) develop a formal process for identifying gaps in the current knowledge base that hinder planning and decision-making in the management of the tortoise across its range. To achieve these objectives, we used a multi-method approach to gather information and resources, including regular communications with BLM personnel, a semi-structured questionnaire about habitat restoration planning and implementation, visits to BLM Field Offices, and quantitative analyses of available tortoise and land-use datasets. In this paper, we present themes and observations derived from our synthesis and review of collected information, as well as opportunities and recommendations for BLM to continue toward developing a coherent, rangewide approach for Mojave desert tortoise management.

Illegal Live Reptile Trade in the United States: An Overview of Topics and Trends

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The illegal trade in live reptiles in the United States does not have a long history; in general it is a dynamic which has evolved since the 1970s when more strict laws for the protection of wildlife came into existence at Federal and State levels. The vast majority of reptile species in the U.S. are not protected by Federal law or regulation, leaving the States as the principal regulators of domestic activities. Motivations for the illegal trade in live reptiles vary, although commercial profit, personal fulfillment, and professional scientific advancement are some of the motivators. Examining specific cases of illegal collection (poaching) and/or trade may help illustrate the reasons people engage in such activity. The illegal trade impacts all types of reptiles, including snakes, lizards, and chelonians, although native crocodilians and land tortoises (*Gopherus* spp.) appear to me minimally affected. U.S. turtle species impacted by illegal collection and/or trade include, but are not limited to: Spotted turtle (*Glyptemys guttata*), Wood turtle (*G. insculpta*), Bog turtle (*G. muhlenbergi*), Box turtles (*Terrapene* spp.), Map turtles (*Graptemys* spp.), Blanding's turtle (*Emydoidea* [=*Emys*] *blandingii*), Diamondback terrapin (*Malaclemys terrapin*), and the Alligator snapping turtle (*Macrochelys temnicki*). It is not known what proportion of the illegal trade services a purely domestic demand versus an international export market, although illegal trade for export may be a serious conservation, ethical, and legal problem. The North American Model of Wildlife Conservation can serve as a useful lens through which the U.S. live reptile trade may be viewed. Individuals and businesses involved in illegal trade often cite a conservation ethic as a motivation for their actions, although few recognized conservation protocols are followed in these circumstances. Laws for the protection of native reptiles vary across States, while Federal laws are uniform nationwide. Regulatory, law enforcement, and prosecutorial efforts to counter the illegal live reptile trade also vary as a result of differing resources, experience and training, normative values, and competing variables, such as violent and financial crime. While efforts have been made to synchronize State regulations on the collection, ownership, and trade of live reptiles, uniformity of requirements is likely an impossibility in the foreseeable future. The conservation impacts of the illegal trade vary. Such impacts are likely minimal for a variety of species, modest for others, and severe in some cases. The impacts of captive breeding subsequent to illegal collection may be cited as beneficial to conservation by reducing demand for additional wild-caught animals, although there is little peer-reviewed evidence to support such claims. As threats to wildlife populations continue – habitat destruction/alteration, climate change, disease, subsidized predators, pollution, etc. – the conservation impact of collection from the wild may have an increasingly deleterious impact on native reptiles.

Update of Activities and Concerns at the Desert Tortoise Research Natural Area

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For over 45 years the Desert Tortoise Research Natural Area has been protecting desert tortoises *(Gopherus agassizii)* and their habitat, documenting the population's health and studying the effect of the numerous observed threats. Over 56 research papers have been published regarding the Desert Tortoise, the Mohave Ground Squirrel, (*Xerospermophilus mohavensis*), and several rare and sensitive plants. Every year hundreds of visitors visit the preserve to enjoy the wildflowers and to see tortoises. During the spring months an on-site naturalist provides tours, educates the visitors and answers questions. The information panels at the visitor's kiosk have been updated with new ecosystem information and graphics. During 2019 the DTPC acquired new conservation properties, erected several miles of new fence to eliminate trespass by people and grazing animals, removed Sahara Mustard *(Brassica tournefortii)* and Russian Thistle *(Salsola tragus)* invasive plants. This year saw the roll out of a citizen science program providing volunteers with an application running on their cell phones allowing them to collect data on rodent burrows, invasive species, animals sighted. The application automatically maps the location of each data entry. This data is easily loaded on to the GIS assisting the DTPC with understanding the health of the habitat and prioritizing future management activities. The increase in the size and number of areas infested with invasive plant species and the continuing threat to all desert reptiles, birds, and other animals caused by the ravens has become a very significant concern, driving the DTPC to reevaluate the priority it has assigned in its strategic plan for managing these threats.

STUDENT PAPER

Common Raven Nesting Density and Success in California's Desert Tortoise Critical Habitat Units

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Common Ravens (*Corvus corvax*) are a native species in the Mojave Desert, but their populations have increased throughout the years due to resources provided by humans (ex. landfills, agriculture, standing water etc.). Increased densities of Ravens may have negative impacts on endangered or threatened species, such as the Desert Tortoise (*Gopherus agassizii*). We have developed statistical models to provide spatial context of raven nest density, nesting preferences, and nesting success throughout Desert Tortoise Critical Habitat Units (CHU) in the Mojave Desert of California. We analyzed nest survey data collected for nests on both anthropogenic and natural substrates using a variety of spatial methods to reduce autocorrelation bias, including spatial bootstrapping comparisons with null models, point process models, and geostatistical analyses. We found that natural substrate nests tend to be located in areas that are have high desert tortoise suitability values, closer to agriculture, and in rougher terrain. Anthropogenic substrate nests are more prominent in areas with high desert tortoise habitat suitability and closer to seasonal water resources. Fledgling success for both anthropogenic and natural nests was correlated with on lower temperatures at the beginning of breeding season. This work will increase our understanding on the potential influence of anthropogenic features and subsidies in the desert, provide a spatial context on

Common Raven threats to Desert Tortoise populations, and may have the potential to improve management tools and practices in managing the Common Raven populations, which may ultimately aid in recovering Desert Tortoise populations.
