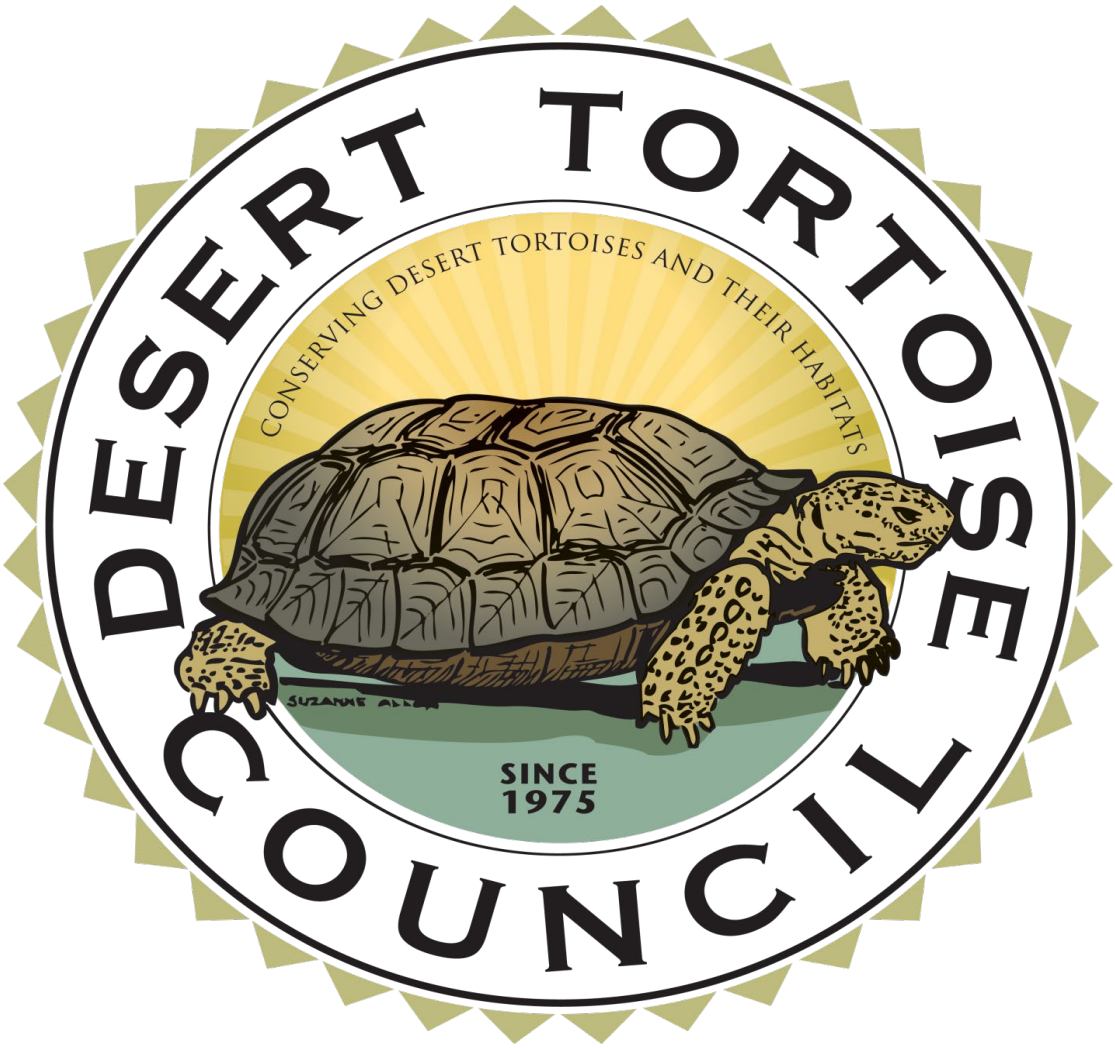

Symposium in honor of Founder
Dr. Glenn R. Stewart

ABSTRACTS

51rst Annual Meeting and Symposium

Hybrid and In-Person
February 25, 26, and 27, 2026

FIFTY-FIRST ANNUAL MEETING AND SYMPOSIUM
THE DESERT TORTOISE COUNCIL

Hybrid: in person and virtual by Zoom
Wednesday, Thursday, and Friday, February 25–27, 2026

ABSTRACTS OF PAPERS AND POSTERS

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

Recent Developments in Aerial Tortoise Surveys

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This paper will discuss recent developments in aerial methods for monitoring Mojave desert tortoise (*Gopherus agassizii*) populations. Methodological improvements related to sensor quality were introduced by Resi in 2024. In the 2025 season, these improvements were systematically tested through 1) data collection of tortoise surrogates at the USFWS training facility in Las Vegas, 2) large-scale systematic surveys on the Boulder City Conservation Easement, and 3) survey of Zone 6 of the Red Cliffs Desert Reserve in Washington County, UT. Relative to previous surveys, this improved methodology resulted in measurable improvements in detection efficacy and greatly increased rates of areal coverage. Taken together, these improvements made it possible to conduct efficient survey operations and to generate usable density and abundance estimates in an exceptionally challenging drought year.

Abundant Ticks but Limited *Borrelia* spp. Pathogens in Mojave Desert Tortoise Habitat

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Ornithodoros ticks, a genus of soft ticks in the family Argasidae, occur worldwide including throughout deserts in the Southwestern United States. In the Mojave Desert,

Ornithodoros parkeri and *O. turicata* are common ectoparasites of Mojave desert tortoises (*Gopherus agassizii*). These two tick species are vectors of *Borrelia* spp. that cause tick-borne relapsing fever (TBRF) in people, the distribution of *O. parkeri* and *O. turicata* and TBRF group *Borrelia* infection prevalence remain poorly known. These ticks are commonly found in desert tortoise burrows, and in this study, we collected ticks throughout Mojave desert tortoise habitat and used morphological characteristics and DNA sequencing to identify the species. All ticks were also tested for infection with TBRF *Borrelia*. We collected a total of 1,165 ticks and identified *O. parkeri* and *O. turicata*, with a single specimen of another soft tick, *Otobius megnini*, also found in a desert tortoise burrow. Only 22 of the 1,165 tick samples tested positive for TBRF group *Borrelia,* five of which could be sequenced and were identified as *Borrelia turicatae*. This study sheds light on the distributions of tick species and pathogens in an understudied ecosystem, the Mojave Desert, and provides insight for public health and TBRF group *Borrelia* as a risk factor in Mojave desert tortoise habitat.

Updates on Tortoise Protection and Recovery

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The Center for Biological Diversity continues our long-standing work to support survival and recovery of the desert tortoise and its habitat in California, Nevada, Arizona, and Utah, using science-based advocacy, administrative processes, public information, and litigation. Natural and man-made threats to desert tortoise from development of new roads and routes, off-road vehicle use, mines, transmission lines, expanded military training, and large-scale renewable energy projects are increasing. Direct habitat loss, increasing habitat fragmentation and loss of connectivity impair the tortoise's ability to seek more suitable habitat in a changing climate. In addition, the spread of non-native plants and increased fire and predation are pushing the desert tortoise farther from recovery. While some efforts have been made to protect and recover tortoise populations, including through headstarting programs and other translocations to salvage tortoises moved out of large swaths of habitat lost permanently due to other uses, overall desert tortoise populations continue to decline in most areas and the amount of high-value habitat is shrinking. We are awaiting a remedies order in our successful West Mojave litigation which we hope will reduce impacts of off-road vehicles in desert tortoise critical habitat. In coalition, the Center continues to oppose the road through Red Cliffs National Conservation Area in Utah that will undermine desert tortoise conservation. The Center is also engaged in commenting on the Castle Mountain Mine expansion which proposes to run a new waterline and powerlines in desert tortoise critical habitat, as well as in both the Castle Mountains and Avi Kwa Ame National Monuments and would drain desert aquifers critical to many species. The Center continues to oppose efforts to build or rebuild pipelines through desert tortoise critical habitat and occupied habitat that could allow Cadiz to drain the groundwater under public and private lands and destroy desert springs. The Center is monitoring new federal bills that could open up acres of tortoise habitat to development or further degrade desert tortoise habitat for new transmission lines, data centers and other industrial projects. The Center submitted comments in October 2025 on the Trump administration's Proposed Regulations for Eleven Species Treated as Listed Due to Similarity of

Appearance that included the Mojave desert tortoise and is submitting comments on changes to the ESA regulations as well as opposing efforts to further weaken NEPA and other bedrock federal environmental protections.

Fidelity to Site in a Tortoise Population in the Colorado Desert: 1977–2023

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In 1977 we established a long-term, demographic study of Agassiz's desert tortoise (*Gopherus agassizii*) in microphyll woodlands of the Colorado Desert, California, USA. We used mark-recapture techniques and conducted formal surveys in 1979, 1982, 1988, 1990, 1992, 1997, 2004, and 2023, and collected additional information in other years (1977–2024) relevant to site fidelity. As reported at the 2025 Desert Tortoise Council Symposium, this Colorado Desert population experienced substantial declines, likely related to disease, prolonged drought, and other factors, with adult females and immature tortoises experiencing greater losses than adult males. Short-term fidelity of a few years was previously described by Burge (1978) and Freilich et al. (2000). Here we discuss long-term fidelity at the Colorado Desert site. To evaluate fidelity to site, we identified subadult and adult male (N = 36) and female tortoises (N = 42) that were recaptured repeatedly over spans of 10 to 48 years. We then summarized locations in the 100-quadrat grid (quadrat = 2.59 ha) to determine whether the tortoise was found in the same quadrat or quadrats adjacent or connected to one another. The number of quadrats where tortoises occurred differed by sex, with females averaging 4.26 ± 1.67 SD quadrats (range, 2–8), compared to males at 6.28±2.71 SD quadrats (range, 2–14) quadrats. All 78 tortoises were observed to occur in two or more adjacent quadrats, often moving back and forth from one to another or more in different years, indicating long-term fidelity to site in spring. Our findings of fidelity have implications for expectations of tortoise behavior, such as time for a population to gradually fill in habitat adjacent to roads after roads are fenced with tortoise-proof fencing and for potential survival and success of long-distance translocation of adults.

Clark County Multiple Species Habitat Conservation Plan Update

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The Clark County Desert Conservation Program (DCP) continues to administer the Multiple Species Habitat Conservation Plan (MSHCP) on behalf of the Cities, Clark County, and Nevada Department of Transportation as mitigation for an Endangered Species Act Section 10 incidental take permit for desert tortoise and 77 other species of plants and animals. The DCP has

collected mitigation fees for 3,420 acres of take from January through September 2024, leaving 12,956 acres of take authorization remaining under the current permit. The 2023-2025 Implementation Plan and Budget allocated up to $18,431,842.00 for the funding of staff and projects starting in July 2025 and running through June 2027. Highlights of desert tortoise-related work conducted over the past year include occupancy surveys on the Boulder City Conservation Easement (BCCE) with associated drone flights for tortoises and burrows; have begun tortoise demography plot surveys across Clark County; completed year 11 of post-translocation monitoring of desert tortoises on the BCCE; continue to fund range-wide monitoring for Clark County and the surrounding areas; continue to work on predator management on the BCCE; continued to monitor autogenic restoration sites on the BCCE; and continued work on public information and education through the Mojave Max program.

Connectivity Counts: The Relationship between Population Genetic Structure, Barriers to Gene Flow, and Density for Mojave Desert Tortoise Connectivity

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The Ivanpah Valley, roughly 45 minutes southwest of Las Vegas, Nevada on the border of California and Nevada, is of central importance to Mojave desert tortoise connectivity range-wide. Recent anthropogenic developments have resulted in the loss of over 3,000 ha of desert tortoise habitat. Ten research plots were established in 2015 for the long-term study of desert tortoises in this complex environment. Data collected were analyzed using genetic techniques to better understand population genetic structure, barriers to gene flow, the potential role of culverts, and the future of connectivity across the landscape. We used Bayesian clustering and spatial principal components approaches to quantify population genetic patterns with isolation by distance. We used a maximum likelihood population effects analysis to determine the influence of landscape features on genetic patterns. We then applied spatially explicit forward-in-time simulations to predict genetic connectivity by landscape and at multiple population densities. We detected four genetic clusters with admixture that generally corresponded to valleys and one genetically distinguishable population in the McCullough Mountains. Patterns of emergent population fragmentation from Interstate-15 and the Southern Pacific Railroad suggested recent reductions of gene flow in the Ivanpah Valley. Accessible culverts were predicted to improve landscape-level connectivity provided population density was not low. However, anthropogenic disturbance was forecasted to reduce connectivity and population size over time. Our work demonstrates that habitat fragmentation limits connectivity and can have relatively rapid genetic consequences. We also found that genetic connectivity may be supported by hydrological culverts between habitat areas, provided population density and habitat amount does not decline.

Turning a Management Dilemma Into Conservation Research

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The Ivanpah Valley is widely considered a nexus of habitat connectivity for the Mojave desert tortoise while also providing excellent conditions for solar energy development – facts that spurred debate and intensive research for the past decade. Solar development proceeded under a biological opinion calling for research to address, "changes in demographic and genetic stability … related to the proposed solar projects". However, environmental groups replied, "…the Bi-Op fails to explain how the monitoring of Tortoises will allow the Service to discern whether changes in population stability are related to these solar projects, as distinct from any of the other myriad threats...". A decade ago, data and models to address this dilemma did not exist. In collaboration with other research groups we designed and implemented long-term, landscape scale research to address: 1) genetic and demographic connectivity; 2) changes in the health status of populations in response to habitat changes associated with development projects; and 3) the effects of climate, habitat suitability, and other factors on connectivity among populations. Our group presents results and syntheses on the influence of linear features on genetic structure and movements, spatial variation in density and demography, and environmental factors that influence these critical life history variables. Using newly adapted analytical models and field methods we present an adaptable way forward to inform Mojave desert tortoise population ecology across landscapes.

Notes from the Field: Ten Years of Conservation Corridors

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Beginning in 2015, ten demography plots were established by USGS and UNR in the greater Ivanpah Valley as part of a project designed to study the impact of solar development on Mojave desert tortoise connectivity. The objectives of this project are to study genetic connectivity, demographic connectivity, changes in health status of populations in response to habitat changes associated with development projects, and the effects of climate and between-site habitat suitability on connectivity between populations We will provide general information and some preliminary results on field activities for the Conservation Corridors for Ivanpah Valley project. Over the life of this project data has been collected on 813 tortoises over 27,701 encounters. The activities discussed in this talk include demographic plot surveys, year-round VHF telemetry, monthly GPS logger downloads during tortoise active season, and health assessments. After 10 years of focused research on demographic plots, the project is transitioning from individual tortoise monitoring toward work between the established plots to further address tortoise connectivity at the landscape scale.

Accelerometer-Enabled Trackers: a Promising Tool for Exploring the Hidden World of Desert Tortoise Nesting Ecology and Activity

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The Mojave desert tortoise (*Gopherus agassizii*) is an endangered species whose persistence is increasingly dependent upon conservation interventions. Head-starting, the process of raising hatchlings in managed care to reduce predation risk and increase survival, is one tool for bolstering declining populations and initiating new ones. Traditional head-starting practices are labor-intensive and may disrupt natural nesting behaviors and female nest choice with implications for resulting clutches. Sourcing headstarts from wild nests may offer a potential alternative and could be improved by the integration of new technology. Here, we test whether tri-axial accelerometers, paired with machine learning, can offer a lower-impact alternative to obtain individuals for headstarting while also contributing to our understanding of nesting in the wild. In 2025 we initiated a pilot study wherein we deployed solar-powered biologging devices on eight gravid females during the 2025 nesting season, recording acceleration, light, and GPS positions. During this deployment period, we also collected over 100 hours of video footage which we manually scored and used to train machine learning models to identify nesting behaviors, nesting events, and other key desert tortoise behaviors (walking, digging, resting, etc.). The machine

learning system achieved strong classification accuracy for nest cavity excavation and several other relevant behaviors and was able identify 14 of 15 successful nesting events. Battery longevity was variable, but often supported multi-month deployment, and on-board GPS precision located the nest within 4 meters of actual nest locations, on average. Our preliminary findings suggest that acceleration biologgers are a useful tool not just for identifying nests for the purposes of headstarting, but also for studying wild nests in situ, and for describing Mojave desert tortoise activity budgets more generally.

Origin of Translocated Animals is Associated with Time to Settlement and Post-Translocation Survival

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Translocation of animals is a widespread tool for resolving human-wildlife conflicts and augmenting struggling wild populations. However, expected time to settlement and survival (both measures of translocation success) are often unknown, particularly as a function of the origin of translocatees. We quantified settling times using Bayesian changepoint detection models on the variance in two derived movement metrics for Mojave desert tortoises (*Gopherus agassizii*) of two different origins: wild adults and adult waifs (i.e., former pets). We compared the annual home range sizes of translocated tortoises with residents, and we also compared survival of each origin group to tagged resident wild adults. We found that translocated tortoises from different origin groups took an average of 0.5-2.0 years, depending on origin group, to settle based on movement metrics. Waif tortoises took the longest to settle, on average, within 2 years. There was high individual heterogeneity in settling times among tortoises. Home range sizes were larger for translocated wild tortoises than for resident adults only in the year of translocation. Home range sizes of translocated waif females and males were larger than those of residents, but only for the first two years post-translocation. After accounting for a strong year effect, annual survival rates were not different between resident adults (0.91) and translocated wild adults (0.90); survival of waif adults was lower than residents, at an annual rate of 0.80 over the 11-year study. We provide results and discussion of using Bayesian models to identify fundamental changes in the variance of distance from release site and directional movement rate (e.g., erratic versus deliberate movements) to determine translocation success. We also provide guidance for managers of Mojave desert tortoise translocation projects and the translocation of animals in general.

Nine Years of Adult Survival in the Marine Corps Air Ground Combat Center's Desert Tortoise Translocation

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Adults survived at high rates (annualized, 88 to 98%) in the first nine years of the Combat Center's translocation (2017 to 2025), yet appeared to vary among sites, with winter rainfall, and probably among age groups in certain years (e.g., >90 mortality of juveniles released in April 2023 while adults typically survived greater than 88% in any year). Annualized adult survival during 2025 (91.1%) was similar to the rates of the first eight years, and followed another dry winter (October 2024 to March 2025). Survival of Control, Resident and Translocated animals varied considerably in 2025 (71.4, 88.6, and 92.7%, respectively), and continued the inconsistent fluctuation among groups from year to year (i.e., the group with the highest survival varied among years). Of the three intensely monitored sites in 2025, there are two recipient sites (residents and translocated tortoises) and one control site (having no translocated tortoises). The relatively low survival at the control site resulted primarily due to depredation by coyote (seven of eight mortalities), especially in September and October 2025. Of the 13 adult mortalities in 2025, 11 (84.6%) were due to depredation by coyotes and 1 was likely killed by a free-ranging dog. The highest annual survival occurred following wet winters (97, 96 and 98% in 2017, 2019 and 2020, respectively) while survival appeared lower in the relatively dry years (88.2 to 94.2%, mean ± SE= 92.6±1.13, n=6 [95% CL: 89.5 to 94.9%]), suggesting depredation is influenced by winter rainfall and concomitant effects on primary and secondary productivity, and on prey switching to tortoises when other prey are scarce, as suggested in other studies since the 1940's.

U.S. Fish and Wildlife Service Desert Tortoise Recovery Updates: An Ongoing Need for Integrated Recovery Actions and Future Collaboration

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The U.S. Fish and Wildlife Service Desert Tortoise Recovery Program collaborated with numerous partners during calendar year 2025, to implement Mojave desert tortoise (*Gopherus agassizii*, tortoise) recovery actions, monitoring, research and Endangered Species Act (Act) compliance. Notable updates include the following:

1. *We continued to leverage the best available science to identify draft tortoise population augmentation sites, intended to concentrate threats management within large, potentially contiguous habitat patches with a route density of ≤0.6 km/km^{-2}, a terrestrial development index of ≤5 percent, a forecast habitat suitability value of ≥0.5 under an uncontrolled emissions scenario (Representative Concentration Pathways 8.5), and are ≥10 km from the nearest*

unmanageable resource subsidies (e.g., standing water, landfills, trash, agriculture) that support unsustainable predator-prey conflicts (both ravens and coyotes). These sites will also typically include translocation recipient sites, designated wilderness, mitigation lands, and overlaps with other species of conservation concern.

2. *We continued range-wide desert tortoise surveys in six Tortoise Conservation Areas (TCAs) and established new demographic plots to improve our understanding of desert tortoise vital rates. Additionally, along with partners, we implemented a new spatially explicit survey design in southern Nevada, during the spring of 2025.*
3. *We continued to adaptively implement integrated raven management tools as well as research and monitoring in California, Nevada, and Utah. This includes expanding laser-based subsidy denial to several previously untreated subsidies located in the western Mojave Desert, with plans to expand further in 2026.*
4. *We contributed to several tortoise and desert ecosystem outreach events, including Earth Day, National Public Lands Day, and the seventh annual Desert Tortoise Week, to name few.*

We plan to resume tortoise Management Oversight Group (MOG) and Recovery Implementation Teams (RIT) meetings in 2026, as meetings were suspended during 2025 due to staff changes, travel restrictions, and uncertainty.

Nevada Department of Transportaton Desert Tortoise Program Update

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The Nevada Department of Transportation (NDOT) is committed to the protection of the Mojave desert tortoise. NDOT has installed 500 miles of tortoise exclusionary fence since the desert tortoise was listed under the Endangered Species Act, working closely with management agencies, and the Department continues efforts to protect and connect the desert tortoise and its habitat. In recent years, NDOT has explored innovative solutions for common infrastructure issues, such as modifying fence as it crosses washes and incorporating new ideas like tortoise turnarounds in place of tortoise guards. The Department has been working with hydraulic engineers and research firms to improve upon the common design of tortoise crossings using drainage culverts, with goals of sustaining hydraulic functionality and maintainability of the structures. Despite the challenges with design and maintenance, NDOT continues to push forward with retrofitting tortoise crossings to achieve permeability in tortoise fenced areas: 23 crossings have been added in the past 3 years and more than 90 are planned in the next 3 years. NDOT was recently awarded $16.8 million dollars from the FHWA Wildlife Crossings Pilot Program for the Coyote Springs Wildlife Crossings project focused on protecting the desert tortoise in the Coyote Springs critical habitat unit while maintaining habitat connectivity.

Tortoise Movement Ecology Informs Connectivity in the Ivanpah Region

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Maintaining connected populations of Mojave desert tortoise is a key management goal fundamental to the recovery of the species. Connectivity through the Ivanpah Valley region is vital to range-wide connectivity, yet this is likely impacted by current and future human development (e.g. highways, railways, utility-scale solar installations). We used VHF and GPS telemetry to track over 200 tortoises captured on mark-recapture plots in the Ivanpah Valley region over 10+ years. We used a variety of modeling approaches to understand how natural and anthropogenic features altered movement selection and behavior. Path selection analysis indicated that tortoises avoided areas of high slope and low perennial vegetation cover, avoided moving near low-traffic roads, and traveled along linear barriers (fences and flood control berms). Hidden Markov Movement Models suggested that tortoises would make faster movements when close to dirt, low-traffic paved roads, and fences while making slower movements near highways and in areas of high slope. We also determined that smaller tortoises are more likely to make dispersal movements and that seasonal precipitation is important in determining the likelihood that a tortoise would disperse. Our results suggest that the corridors left in place around the utility-scale solar installations likely serve to maintain connectivity across the Ivanpah Valley, though other human infrastructure is likely reducing the connectivity of the landscape.

From Exile to Entry: An Update on the Gemini Solar Project

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The Gemini Solar Project, northeast of Las Vegas, Nevada, is the model for the new Programmatic Environmental Impact Statement (EIS) for Utility Scale Solar Development in the west, wherein project conservation actions include maintaining as much original vegetation and hydrology as possible. In October 2021, after three years of baseline monitoring and population surveys, we removed 169 tortoises from the fenced solar fields. Tortoises presumed to have home ranges that included areas outside the solar fields were placed outside the fences; tortoises with home ranges internal to the project borders were temporarily held in captivity. In Winter 2023-4, following construction, tortoise exclusion fences were removed. In early April 2024, the temporarily held captives were actively placed back in the solar field; tortoises outside the solar fields could also passively re-enter the solar fields. In Spring 2024, 14 of 44 clutches from animals that had home ranges originally inside the solar fields, were laid in the solar fields. By brumation in Fall 2024, 30% of this group (N=66) brumated inside the fields, including 43% of those that had internal home ranges (N=28). Throughout 2025, roughly 35% of these tortoises consistently

occupied the solar fields and 47% of clutches were laid in the solar fields (N=43). Shrub and bunch grass vegetation at tortoise re-entry to the solar fields in April 2024 was ~44% of the original cover. As vegetation restores in the disturbed portions of the project, it is anticipated that tortoise occupation will also increase.

Disease- and Drought–Associated Reduction in Tortoise Growth in the Colorado Desert: Evidence from 46 Years of Mark-Recapture Data

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The disease, cutaneous dyskeratosis (CD), is prevalent in *Gopherus agassizii* populations in the Colorado Desert, yet its effects on growth remain poorly quantified. We analyzed 46 years of mark-recapture data (1977–2023) from 191 adult tortoises at Chuckwalla Bench, California, to test whether CD reduces growth rates after controlling for body size, sex, and rainfall. We used linear mixed-effects models with AICc-based model selection. We also compared growth before and after CD onset within 21 individuals that transitioned from CD-absent to CD-present status during the study. Overall, growth rates had a negative relationship with tortoise size (larger animals grew slower than smaller ones). Male tortoises tended to exhibit a higher growth rate than female tortoises across all sizes. CD was present in 82% of the growth intervals we measured. Winter-spring precipitation promoted growth (+2.1 mm/year per SD in males, +0.9 mm/year in females). CD effects were sex-specific: females with CD grew 1.6 mm/year slower than CD-free females (*95% CI: −3.1 to −0.1, P = 0.037*), whereas males showed no significant effect (−0.8 mm/year, *P = 0.33*). Within-individual analysis of tortoises that transitioned from CD-absent to CD-present status revealed a significant reduction in growth following CD onset in 71% of individuals. These findings demonstrate that CD measurably reduces growth in female desert tortoises. Because body size influences clutch size in this species, sustained growth reductions could affect reproductive output over time. Given CD's high prevalence, incorporating disease effects into demographic models may improve population projections for this species.

Specialized Wildlife Cameras Used to Evaluate Desert Tortoise: Case Studies with Crossing Structures and Dry Washes

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Desert tortoise populations are often studied using telemetry and visual surveys along walking transects. Although highly effective, these methods can be challenging to implement to study desert tortoise due to their life history, living in remote and rugged areas, and spending much of their time in shelters. Other methods might also be used to evaluate some types of research questions. For example, wildlife cameras have been widely applied to study small to large sized animals, and can be effective for detecting secretive wildlife in remote locations over relatively long periods of time. However, the use of wildlife cameras to study desert tortoise is somewhat limited. Here, we present on the use of specialized wildlife cameras to study small wildlife populations, with an emphasis on Sonoran desert tortoise (*Gopherus morafkai*), across three systems: (1) underpass crossing structures along the CAP canal in Arizona, (2) dry washes from foothills to valleys, and (3) dry washes and uplands in relation to fire. We demonstrate that specialized wildlife cameras can be effective in detecting Sonoran desert tortoise using underpass crossing structures and dry washes. We also present on the limitations of using wildlife cameras to study tortoises. For example, it can be challenging to deploy wildlife cameras throughout tortoise habitat. In addition, although multiple types of wildlife cameras may be effective at detecting adult tortoise, some camera models may be more effective at detecting juvenile tortoises. We also share insights about deploying specialized wildlife cameras in the field to maximize species detections and withstand the rigors of water movement through canal culverts and dry washes. In addition, we summarize detections of other small wildlife species using specialized wildlife cameras. Ultimately, wildlife cameras provide another method to consider for studying desert tortoise and small wildlife populations to answer research questions and help manage and conserve populations.

Chasing Catastrophes Slowly: Changes in Turtle Population Patterns Over Time

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Population catastrophes are widespread, unpredictable phenomena occurring in natural populations that have important, yet frequently underappreciated, consequences for persistence. As human impacts on ecosystems increase globally, the frequency of catastrophes is likely to rise

as increasingly fragmented and depleted populations become more vulnerable. Species with slow life histories, such as chelonians, are expected to recover slowly from catastrophes because of their long generation times, and assessing their population recovery requires data spanning long periods. I will present case studies on three at-risk freshwater turtle species (Snapping Turtles, Spotted Turtles, Blanding's Turtles) in which catastrophes, including mass mortality events, have impacted their population ecology, and assess outcomes using modeling, observational data, and speculative musings. In the case of Snapping Turtles, despite high post-catastrophe survivorship and connectivity with other populations, the population failed to recover, displaying consistently reduced abundance and reduced recruitment for more than two decades after a mass mortality event caused by otter depredation. For Blanding's Turtles, the catastrophe also appears to have been a large-scale depredation event, but for Spotted Turtles, the cause of the missing turtles remains elusive. I will discuss the relationship between life history attributes and the causes and consequences of local catastrophes and their conservation implications. Finally, I will weave in a brief personal narrative about navigating "catastrophes" in one's life and career, and the importance of staying the course with a view to the long game.

El Pitayal, Sonora Biodiversity Expedition

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There are threatened, unique habitats that need immediate protection. Non-governmental organizations often lead the process to get these areas protected. An integral component is creating technical files to support the proposed legal protection process. Limited funding or capacity to identify species that occur within these habitats can limit the success of legal protection. Recruiting a team of volunteer field biologists with the necessary expertise, equipment, and legal permits can offer valuable support to the protection process. El Pitayal in southern Sonora is in urgent need of protection. A local non-profit has taken the lead to acquire legal support to declare this 192,742-acre area a state reserve. This new reserve seeks to protect one of the last fragments of coastal scrubland in southern Sonora, Mexico, an area of great ecological and cultural importance. This region, known for its dense population of *pitayas* (*Stenocereus thurberi*), is not only vital for local biodiversity, but also supports the way of life of the Yoreme-Mayo people, who depend on its resources for the local economy, such as natural medicines, construction materials, firewood and food. A group of 80 field biologists, led by a woman only crew (The Crazy Biologists que aman el monte) came together on a biodiversity expedition in November 2024 to document the presence of all species encountered/captured including small and large mammals, birds, reptiles and amphibians, plants, fish, and insects. Focused searches were conducted for the Sinaloan Thornscrub tortoise (*Gopherus evgoodei*). The data were shared with the Sonora State Government and Nature and Culture International, the two entities leading the conservation effort and new declaration of Reserva El Pitayal.

Overview of Recovery Priorities and 2025 Spring Monitoring

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The Utah Division of Wildlife Resources (UDWR), has been committed to the protection and recovery of the Mojave Desert Tortoise (*Gopherus agassizii*) focusing on habitat restoration, translocation, fencing and population monitoring. Two Recovery Units, based on unique morphological, ecological and genetic characteristics, are identified in Utah, the Northeastern Mojave and the Upper Virgin River, with the latter existing entirely in Utah and significantly smaller than other recovery units. The accomplishments and conservation actions to help recover the Desert Tortoise are due to UDWR's continued partnerships with local and federal agencies. To address the threat of wildfire, UDWR is actively engaged in habitat restoration. We continue to work collaboratively with our agency partners to apply pre-emergent herbicide along roadsides and previous wildland fire perimeters to reduce fine fuels created from invasive annual grasses in the Beaver Dam Wash and Red Cliffs National Conservation Areas. The overall project goal is to build wildland fire resilience by removing invasive annual grasses. To mitigate the impacts of roads and reduce negative impacts on tortoises and their habitat, we have identified and secured funding to upgrade fencing to USFWS fencing standards and repair old and compromised fencing undercut by erosion and general wear. We have updated and amended our Translocation Management Plan, identifying how displaced desert tortoises from developed areas are to be used to enhance desert tortoise recovery efforts in southwest Utah. Finally, UDWR has been conducting long-term monitoring on Desert Tortoise populations for over 40 years, both on the Beaver Dam Slope (BDS) and Red Cliffs National Conservation Areas as well as the Red Cliffs Desert Reserve to assess population status and trends in Utah. We report findings from our 2025 spring monitoring efforts and compare those results to previous years. Working with our agency partners, UDWR will continue to help protect Desert Tortoise populations in the face of continued population growth.

Walking the Line Toward New Methods to Inform and Improve Range-wide Monitoring for the Mojave Desert Tortoise

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Accurate estimates of demographic parameters for the federally threatened Mojave desert tortoise (*Gopherus agassizii*; tortoise), including population density and growth rate, are essential

to informing range-wide tortoise management, effective implementation of recovery strategies, and Endangered Species Act status review. In 1999, the Desert Tortoise Management Oversight Group endorsed line-distance sampling as the method that would be used on public lands to monitor tortoise populations. Distance sampling, which accounts for imperfect detection rates and is repeatable and comparable between years, has been used by the U.S. Fish and Wildlife Service for range-wide tortoise population monitoring since 2001. However, distance sampling provides only coarse-scale estimates of adult tortoise density, is subject to bias due to tortoise behaviors that violate statistical assumptions, can be strongly influenced by spatiotemporal and environmental conditions, and requires a targeted number of detections to produce meaningful estimates. As tortoise populations decline or sampling areas are reduced, distance sampling and other traditional survey approaches may not produce reliable density estimates or provide accurate information on population status and trends. Additionally, in recent years, the capacity of range-wide monitoring has been limited by inadequate funding necessary to sufficiently survey suitable tortoise habitat throughout the contemporary range. To address these challenges, we propose a spatially explicit approach to tortoise monitoring that will build on the foundation established by distance sampling and the range-wide monitoring program, while promoting statistically robust density estimates for multiple size classes, as well as direct estimates of other critical demographic parameters. This approach will also serve as a sustainable program opportunity by providing potential cost savings relative to current practices. In 2025, the first tortoise-specific spatially explicit survey design was employed in southern Nevada with considerable success. We plan to continue expanding these methods, including larger geographical scale implementation in 2026 within the Western Mojave in California.

UnifyKeeping the Baby Without the Bathwater:
Unification of Distance Sampling and Capture-Recapture Facilitates Spatially Explicit Desert Tortoise Demographic Monitoring

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Obtaining accurate and reliable demographic parameter estimates at predefined intervals is critical for informing effective conservation and management actions that promote recovery of the federally threatened Mojave desert tortoise (*Gopherus agassizii*). For more than 20 years, two disparate approaches have been used to estimate and monitor desert tortoise demographics: Line-distance sampling to estimate spatially averaged adult desert tortoise densities at the larger landscape scale (i.e., Tortoise Conservation Areas), and traditional nonspatial capture-recapture to estimate vital rates (e.g., survival and recruitment) at the smaller local scale (i.e., Demographic Study Areas, Long-term Study Plots). However, behavioral and biological characteristics of desert tortoises often violate statistical assumptions of both standalone methods, resulting in biased and potentially unreliable demographic parameter estimates. Further, inferences cannot be transferred among spatial scales, thereby limiting the usefulness of each method on its own to inform conservation and management or provide reliable assessments of population trajectories. We show

how spatial capture-recapture (SCR) models represent a unification of distance sampling and capture-recapture in a cohesive model-based framework, which can overcome said issues to produce unbiased, spatially explicit estimates of demographic parameters important for directly addressing desert tortoise recovery criteria. We also provide a detailed presentation of our stepwise approach to implementing and advancing SCR applications to desert tortoises over the last 5 years. Lastly, we demonstrate the major advantages provided by SCR for desert tortoise demographic monitoring across space and through time based on results from multiple empirical studies we have completed, and we briefly discuss planned future studies and directions.

Update on the Recovery and Sustainment Partnership (RASP), a Collaborative Tortoise Recovery Effort in the Western Mojave

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The Recovery and Sustainment Partnership (RASP) is an joint initiative between DOD and DOI to accelerate the recovery of priority species while providing DOD greater mission flexibility. In 2020 the Mojave desert tortoise (*Gopherus agassizii*) was selected as a RASP priority species, establishing a partnership between the National Fish and Wildlife Foundation (NFWF), the U.S. Marine Corps, U.S. Army, DOD, USFWS and BLM. A key part of the RASP strategy is concentrating resources in focal areas within Tortoise Conservation Areas in the western Mojave (Fremont-Kramer, Superior-Cronese and Ord-Rodman). Priority RASP strategies are drawn directly from the 2011 USFWS Revised Recovery Plan. These strategies include habitat protection (acquisitions), habitat restoration, highway exclusion fencing and crossings, community outreach (particularly to recreational off highway vehicle users), population augmentation through head-starting and improved population monitoring. Organizations apply for funds on an annual cycle. There are multiple metrics for evaluating RASP's success, with the most important being improved population vital rates. As of late 2025, RASP funding has totaled ~8.4 million dollars. These funds have supported work by 6 non-profits, two agencies (FWS, USGS), and one for-profit company. Strategies funded to date include acquisitions, habitat restoration, community outreach, head-starting, tortoise fencing and population monitoring. Progress towards interim RASP goals is mixed. The RASP program has the potential to meaningfully contribute to desert tortoise recovery. Challenges include securing proper funding levels, environmental and cultural clearances, broadening the applicant and grantee pool, coordinating strategies and maintaining programmatic focus on appropriate measures of success (improved tortoise vital rates). Science needs include linking conservation actions to tortoise demographics, evaluating the impact of RASP at the species level and determining the appropriate spatial scale for conservation efforts

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From Scats to Satellites: Multi-Scale Approaches to Desert Tortoise Connectivity

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Habitat fragmentation and utility-scale solar development continue to consume, degrade, and fragment desert tortoise habitat, eroding movement pathways that provide critical connectivity for desert tortoises. Focusing on the Ivanpah Valley (NV/CA), we integrated geospatial analyses, genetic capture-recapture, and demographic surveys to quantify functional connectivity and identify corridors most at risk. Spatially explicit resistance modeling paired with movement ecology highlighted how roads, railroads, and solar facilities pinch off connectivity. Genetic samples—including microsatellite DNA isolated from scat—were used to estimate relatedness, effective population size, and dispersal, providing a non-invasive way to detect animals and refine density estimates. Telemetry and mark-recapture data, analyzed with Bayesian models that leverage spatially explicit capture recapture models (SECR) have been developes, and we are now adding juvenile detectability, influences of habitat characteristics, to calculations of demographics and vital rates. Collectively this information is being used to produce updated population density estimates that align demographic signals with genetic structure. High-resolution UAS imagery linked to Landsat/Sentinel data is being used to track recent habitat changes, allowing us to connect disturbance patterns with observed gaps in movement and gene flow. Results from our research point to corridor segments where connectivity is most vulnerable and can be used to recommend where targeted easements, crossing structures, and vegetation restoration would yield the largest gains. Our findings inform conservation corridor design and management strategies, supporting the persistence of desert tortoise populations in increasingly fragmented habitats. This integrated approach offers a practical application to pair relatively non-invasive genetic sampling with telemetry to locate functional bottlenecks, monitor disturbance with repeat UAS imagery, and to recommend prioritized mitigation where both genetic and demographic signals converge. Ultimately these actions can be implemented alongside ongoing solar planning and transportation upgrades to recommend practices that sustain population persistence in an increasingly fragmented desert landscape.

STUDENT PAPER

Dispersal Mechanisms and Demographics of the Mojave Desert Tortoise – Who's New Here?

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The Mojave desert tortoise (*Gopherus agassizii*) is currently listed as threatened due to population losses from predation, disease, rapid urbanization, and increased infrastructure development such as installation of solar facilities resulting in habitat loss, degradation and fragmentation. Collectively, these impacts encroach on and disrupt the habitats vital to desert tortoise survival, jeopardizing the species' long-term persistence across the landscape. Population connectivity is a key concern given these impacts to habitat, and crucial to understanding connectivity is understanding dispersal mechanisms. However, dispersal is difficult to detect in a long lived, but relatively slowly moving species with characteristically stable home ranges. One of our aims is to comprehend the dispersal mechanisms for these species which may be important to our understanding of demographics and population connectivity. We studied the dynamics of dispersal and demography in these species by analyzing ten years of spatial and biological data collected during field surveys by the University of Nevada, Reno (UNR) in collaboration with the United States Geological Survey (USGS) among ten monitoring sites. Tortoises were monitored during repeated capture-recapture surveys and fitted with VHF and GPS trackers to garner data on their movement parameters, health status, body mass, sex (adult, subadult or juvenile) over a period of ten years. Over these ten years of monitoring – with as many as four capture-recapture sessions on each plot – we continued to accumulate tortoises during surveys with no sign of saturation or leveling off. This generated questions about why we might continue to discover new individuals over these extended periods, and how this might inform which animals seem to be dispersing into and out of the plots to achieve these results. We hypothesized that new tortoises that show up in the plots could be of smaller size classes (e.g. juveniles or subadults) compared to the average size of animals already on the plots. This could manifest itself in several ways. For example, smaller animals may be more likely to be undetected during previous surveys due to their small size – or some of these animals (e.g. subadults) are more likely to disperse onto the plot, or alternatively these animals have home ranges in the interstitial spaces around the plot and they are located at edges of the plot boundaries during surveys as they are not always contained within the survey boundaries. We analyzed these questions by examining the relationship between sexes (juveniles, subadult, male, female) and capture status (new or previously known tortoises) and calculated distances of tortoises within the plot boundaries. Our findings reveal an influx of tortoises significantly smaller than the average residents on the plot with indications that they may be found closer to plot edges than residents. This highlights the potential that newly encountered animals in our study may be "dispersers" rather than undetected animals and emphasizes the need for spatial capture-recapture models that incorporate open population models in understanding tortoise demographics.

Evaluating Early Post-Release Behavior and Growth of Bolson Tortoises (*Gopherus flavomarignatus*) on Federal Lands

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The U.S. Fish and Wildlife Service, in partnership with the U.S. Geological Survey and the Turner Endangered Species Fund, is evaluating the feasibility of establishing a conservation population of the endangered Bolson tortoise (*Gopherus flavomarginatus*) at the Sevilleta National Wildlife Refuge in central New Mexico. As part of this effort, a 3.4-hectare (8.5-acre) soft-release enclosure was constructed on the refuge. Juvenile tortoises equipped with VHF transmitters were introduced in three cohorts on 26 September 2024, 26 April 2025, and 8 May 2025. The enclosure currently houses 30 tortoises. We monitored all individuals to assess acclimation, movement behavior, and growth. Movement activity was quantified using mean movement rate (m/day) and mean step length (m). The September and May cohorts moved significantly more and made significantly longer movements than the April cohort. These behavioral differences likely reflect differences in rearing environments, as the September and May cohorts were raised in semi-wild conditions, whereas the April cohort originated from a zoo setting. Growth assessments showed that the Fall cohort increased in midline carapace length by an average of 2.16% over one year, while the Spring cohorts grew an average of 3.28% during their first six months in the enclosure. We attribute the slower growth of the Fall cohort to the harsh overwinter period they experienced immediately after release, a challenge the Spring cohorts avoided. Overall, these results have provided crucial insight into ensuring the success of these relocation efforts in the future and establishing self-sustaining populations of this endangered species on federal lands.

STUDENT PAPER

Advancing Population Models for the Mojave Desert Tortoise (*Gopherus agassizii*) through Expanded SECR and CJS Models.

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The accurate assessment of population processes such as density, survival, and recruitment is essential for evaluating the effectiveness of conservation efforts for at-risk species like the

Mojave desert tortoise (*Gopherus agassizii*). Mark-recapture sampling remains widely used for wildlife monitoring and has been especially useful for desert tortoise demographic studies. We conducted mark–recapture surveys from 2015 to 2025 across ten 1-km² plots in and around the Ivanpah Valley of California and Nevada, paired with radio-telemetry and high-resolution GPS tracking. However, model assumptions and tortoise detectability make the application of mark-recapture challenging, leading to biased density and survival estimates due to low detection probabilities, routine exclusion of juveniles, and limited knowledge of temporary emigration and immigration. To address these challenges, we expand previously developed spatially explicit capture recapture (SECR) models to incorporate juveniles and environmentally driven variation in detection and density estimation using a modified Bayesian framework. These modifications yield more realistic estimates of density and life-stage distributions. In addition, future work will bring together SECR and Cormack-Jolly-Seber (CJS) models using multiple data sources to expand our understanding of demographic parameters in our research. Collectively, these methods offer powerful tools for ecological inference by accounting for imperfect detection, incorporating spatial structure, and estimating demographic rates through repeated encounters over time. While these statistical approaches have improved the monitoring of this species, critical limitations remain. Advancing these modeling approaches is essential to improving demographic inference, refining conservation strategies, and supporting the management of the Mojave desert tortoise. Ultimately, this work contributes to both the statistical development of mark-recapture methodology and the long-term conservation of this threatened species.

Desert Tortoise Council Activities - 2025

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The Board of Directors (BOD) of the Desert Tortoise Council (Council) conducted an in-person business meeting at the 2025 Annual Symposium and held six online BOD meetings in 2025. The BOD now consists of 15 members with two open officer positions, Treasurer and Membership Coordinator, and three open Member-At-Large positions. Dr. Debra Hughson, formerly of the National Park Service, joined the BOD in March of 2024. In 2025, the Council's Operations Manager continued to implement duties associated with fundraising, assisting the BOD and Committee Chairs, implementing robust social media efforts, assisting with the Annual Symposium and training course implementation, and conducting outreach to the membership, the public, and other relevant organizations. At the end of 2025, the membership of the Council included 414 active members with 3,945 contacts on the contact list. The Ecosystem Advisory Committee commented on 55 (100%) of the notices received for projects or actions potentially affecting tortoises and their habitats in CA, NV, UT, and AZ and for interstate or national issues. The Council held the Introductory Course/Workshop with the virtual lecture in late October followed by two field workshops in early November. A total of 190 people completed the entire course and 55 people audited the lectures. The Council held a"Drink Beer Save Tortoises" fundraising event in November in conjunction with the Introductory Course. More than 300 people attended the 50th Annual Symposium in Las Vegas, Nevada. Peter Woodman conducted a field

trip and SNEI, Inc. and Playa Environmental sponsored the pre-conference mixer. Vita Sheehy sponsored an elaborate Western Soiree mixer for all attendees that included food, drinks, music, and fun activities. Thirty-one companies, organizations, and individuals sponsored the Symposium at various levels, and twenty-one exhibitor tables lined the halls outside of the meeting room. The Symposium program included 58 oral presentations, including two plenary speakers and a banquet address, and six posters. Three travel grants were awarded to students so they could attend the symposium. Eleven individuals were honored with awards during the banquet. Dr. Kristin H. Berry was awarded a Lifetime Achievement Award for her amazing contributions to the Council since its inception. Planning for an Advanced Training Course began in mid-2025 and the Mexican Tortoise Conservation Committee and Agency Coordination Committee continue to be in the process of being re-energized. Representatives from our Education and Outreach Committee attended The Wildlife Society Western Section and Turtle Survival Alliance conferences to educate attendees about the mission of the Council, to sign up new members, and to sell SWAG as a fundraiser. The Fundraising Committee implemented fundraising events through Amazon and social media platforms and near the end of 2025, the Council was notified of a grant award of $308,416 from the National Fish and Wildlife Foundation. The grant will fund the construction of tortoise road crossings and exclusion fencing in California. In addition, the Council was notified in December of 2025 that it would again be awarded the $15,000 Edison International Grant. The Council assisted with health assessments, attaching transmitters, and releasing Bolson tortoises at the Sevilleta National Wildlife Refuge in New Mexico and provided a small grant to the Turner Endangered Species Fund to monitor the Bolson tortoise enclosure at the Armendaris Ranch. The Council also continues to monitor transmittered tortoises at the long-term study site. The BOD spent a significant amount of time in the last quarter of the year planning for the 51st Annual Symposium.

Improving Sex-ratio Predictions in Desert Tortoises Using a Mechanistic Temperature-Sensitive Period Model

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Accurately predicting sex ratios in wild turtle nests requires identifying when embryos enter the temperature-sensitive period (TSP), yet most field studies rely on fixed periods or relative chronological windows (e.g., the middle 30% of incubation). Using three years of nest temperature data and testosterone assays from Mojave desert tortoise (*Gopherus agassizii*) nests on Edwards Air Force Base, CA, we evaluated a developmental model approach for estimating TSP timing based on early-incubation temperatures. This mechanistic approach outperformed fixed or chronological TSP windows at predicting sex ratios and identified biologically important variation in TSP timing among nests and years. Applying this framework to a warming scenario indicated substantial feminization risk and demonstrated systematic bias in sex-ratio predictions relying on traditional fixed or chronological windows. Our findings have direct implications for identifying locations capable of supporting viable tortoise populations into the future.

And Now, Where Will We Take Refuge? Climate Change Effect on *Gopherus flavomarginatus* and its Accompanying Vertebrates

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Bolson Tortoises (*Gopherus flavomarginatus*) are a keystone species whose burrows are a unique microhabitat for a large number of vertebrates in the Chihuahuan Desert. Through the construction of burrows, Bolson Tortoises modify the habitat, resulting in greater structural complexity. This in turn results in a greater number of niches and therefore in greater biodiversity, providing not only shelter from predators, adverse climatic conditions, and fires, but ideal conditions for reproduction, socialization and feeding of various species. The potential distribution of Bolson Tortoises, eight mammal, four bird, and seven reptile species that use Bolson Tortoise burrows was modeled for the present, as well as for 2050 and 2070. The maximum entropy model (Maxent) included 19 bioclimatic layers and altitude. The models suggest a decrease in the potential distribution of *G. flavomarginatus* (its distribution was reduced by 85.95% from the present scenario to 2070) and 17 out of the 19 species of vertebrates that use their burrows, in both projected scenarios. This indicates climate change would negatively affect not only species with restricted or micro-endemic distributions, such as Bolson Tortoises, but also those of wide distribution, such as Coyotes (*Canis latrans*), Striped Skunks (*Mephitis mephitis*), and Scaled Quail (*Callipepla squamata*). The models also indicate that the percentage of geographical overlap of ≥12 of vertebrate species with *G. flavomarginatus* will decrease drastically by 2070, thereby reducing the availability of microhabitat (*G. flavomarginatus* burrows) for these species. Reduced availability of microhabitats could affect the ability of these accompanying vertebrates to hide from predators or adverse weather conditions, as well as to find sites for reproduction or feeding (*Lepus californicus*, *Athene cunicularia*, *C. latrans*, *Lynx rufus*, *Vulpes macrotis*, and *M. mephitis*). This work emphasizes the importance of conservation actions to help Bolson Tortoises (*G. flavomarginatus*), which in turn will benefit other species of mammals, birds, and reptiles that require the presence of tortoise burrows as microhabitats.

Lessons from *Gopherus* Genomes: Current Progress Towards Conservation Efforts Using a Genomic Toolkit

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Genomic toolkits offer myriad methods for estimating genetic parameters within and among species that can be applied to conservation efforts. Among the six tortoise species in the genus *Gopherus*, five are now listed by the International Union for Conservation of Nature Red

List as Vulnerable or Critically Endangered, with only the Texas Tortoise (*G. berlandieri*) being classified as Least Concern. Therefore, much conservation effort is being applied across the genus, and a growing number of genomic resources are being used to investigate how each species is adapted to its environment to inform management plans. For example, five *Gopherus* species (all but *G. polyphemus*, to our knowledge) now have reference genomes assembled and annotated. This allows for in-depth investigations into evolutionary divergence among species, as well as species- and population-level variation that results from local adaptation. Leveraging these resources from *G. agassizii*, *G. berlandieri*, and *G. morafkai*, we investigate species-level adaptation, population sub-structure, and areas of hybridization. We describe methods used for population genetic analysis of the Texas Tortoises, with diagnostic SNPs used to develop cost effective genotyping assays for repatriation efforts by the Texas Parks and Wildlife Department. Further, we apply similar methods to develop high-resolution markers for investigating hybridization in western Arizona between the Mojave and Sonoran desert tortoises. This effort is focused on identifying diagnostic alleles to confidently assign genetic status to hybrid individuals, providing a critical molecular management tool for state agencies. Finally, we discuss challenges in translating genomic results into well-informed conservation strategies. Overall, we illustrate how genomics can be used to develop actionable assays for the imperiled *Gopherus* tortoises to address conservation challenges.

POSTER

Variation in Desert Tortoise Burrow Structure and Overwinter Microclimates Across Life Stages

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Burrows are critical refugia for desert tortoises (*Gopherus agassizii*), buffering individuals from extreme temperatures and desiccation. This buffering is crucial over winter when surface temperatures can fall below freezing and tortoises remain largely inactive, surviving on limited energy and water reserves. While burrow use is well documented, less is known about how burrow structure and microclimate vary across life stages during overwintering. We compared burrow structure and microclimate used by adult and juvenile tortoises over two winters in the Mojave Desert. Microclimate data were collected using temperature and humidity loggers affixed to tortoises, representing the conditions experienced during brumation, spent primarily in their chosen winter burrow. On average, juveniles used shorter, narrower burrows and experienced lower temperatures, higher relative humidity, and lower vapor pressure deficits than adults. This suggests the narrower burrow structure and associated microclimate experienced by juveniles partially compensate for the greater water-loss susceptibility of juveniles due to their higher surface area-to-volume ratios. These results reveal ontogenetic differences in burrow structure and highlight that juvenile tortoises can access hydric microclimates equal to or more favorable than those available to adults. Juveniles may possess greater resilience to dry conditions than would be expected based solely on their physiological vulnerability.

Three Decades Without Change: Revisiting Desert Tortoise Exclusion Fence Standards and Opportunities for Innovation

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Since the first Desert Tortoise exclusion fence specification was published in 1995, design standards have remained effectively unchanged. Later codified in the 2009 U.S. Fish and Wildlife Service *Desert Tortoise Field Manual*, the prescribed welded-wire mesh buried at least 12 inches continues to be the benchmark design. While effective in restricting tortoise movement, this specification has seen little innovation despite widespread adoption and decades of field experience. This presentation evaluates the limitations of the existing standard and considers opportunities for updating fencing technology to reflect modern material science and project management needs. Traditional wire-mesh fencing is labor-intensive to install, susceptible to climbing and damage, and requires extensive trenching. In contrast, ERTEC's E-Fence, a high-density polyethylene exclusion system, can be installed up to three times faster, substantially reducing labor costs and project timelines. The smooth, vertical surface combined with smaller apertures improves climbing resistance and minimizes breach potential. Additionally, reduced open area creates localized shade along fence lines, offering incidental thermal refuge in an increasingly hot and arid climate. The implications of adopting improved exclusion fencing are significant: faster deployment during construction mobilization, lower maintenance costs, enhanced protection of tortoises, and the potential to deliver ecological co-benefits not envisioned when the original standards were drafted. After nearly thirty years of reliance on a static specification, it is time to reassess whether current regulatory requirements optimize both conservation outcomes and construction efficiency.

Using Community Engagement and Behavior Change Strategies to Promote Desert Tortoise Conservation

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The desert tortoise (*Gopherus agassizii*) population in the Western Mojave Desert has experienced a steep and sustained decline over the past several decades. This decline is driven by various interconnected threats from different human activities and behaviors, including increased raven predation due to human-provided food subsidies, habitat degradation from non-compliant off-highway vehicle (OHV) use, the spread of disease, and other human disturbances. The Living Desert has been conducting an outreach, education, and behavior change campaign in areas near critical habitat units in the Western Mojave to mitigate the impacts of these anthropogenic threats to the desert tortoise. We incorporate social influence approaches into our education and outreach efforts, which is more effective at producing behavior change than just information sharing. We

have engaged directly with OHV users and recreation groups to build trust and promote responsible riding practices that reduce habitat damage and tortoise mortality. Additionally, we have delivered presentations at schools near critical habitat units to teach students about ways they can contribute to desert tortoise conservation, using the Norm Activation Model to promote behavior change. Pre- and post-surveys conducted with students demonstrate significantly increased positive attitudes towards desert tortoises, an increased sense of personal responsibility to protect tortoises, and an improved understanding of actionable conservation practices. Theseresults suggest that targeted community-based interventions can meaningfully influence public behavior and support a future generation of desert tortoise advocates. Our findings from this campaign highlight the importance of incorporating social science strategies, in addition to biological and ecological conservation efforts, to address the root causes of species decline. By fostering a conservation ethic through relationship-building and outreach designed to promote behavior change, we aim to create lasting changes that benefit both the desert tortoise and the broader Mojave Desert ecosystem.

Practical Raven Predation Reduction in and Around the Desert Tortoise Research Natural Area, Kern County, California

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The Desert Tortoise Research Natural Area (DTRNA) is the most valuable piece of desert tortoise habitat in the west Mojave Desert. However, proximity to the cities of California City and Ridgecrest, unincorporated communities such as Cantil, Mojave and Rosamond, and China Lake Naval Weapon Station and Edwards Air Force Base exposes tortoises to predation by elevated densities of Common Raven (*Corvus corax*). Unaddressed, this predation may inhibit recovery of tortoise populations in and around the DTRNA. Application of practical raven management measures in the region offers the promise of realizing the full value of this high quality desert tortoise habitat. To address the raven threat, numerous entities (Desert Tortoise Preserve Committee, US Fish and Wildlife Service, Southern California Edison, Pacific Gas and Electric and the Electric Power Research Institute) have worked with OrniLogic, LLC, to apply methods to map raven nests, monitor their breeding season status, reduce human subsidies, and inhibit raven reproductive success. We describe efforts to find raven nests, tools used to record information on their status, implementation of community-based outreach campaigns, and future opportunities to reduce or eliminate loss of small tortoises to raven predation. Remote egg oiling (REO), applied to both natural substrate nests and those built on utility structures, has proven effective in significantly reducing egg hatching in raven nests in the area. We describe the various ways to apply oil to these eggs and the system used to direct this effort effectively. In addition, the recently developed Nest Abandonment Induction Laser (NAIL), a device designed by OrniLogic to repel ravens from desirable nest substrate, was tested successfully in the California City area in 2025. We discuss these results and plans to expand the use of NAILs to further thwart raven nesting.

Investigating Online Sentiment Toward the Mojave Desert Tortoise and Outreach Efficacy Using Natural Language Processing

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Outreach events can increase public awareness of threatened species, help garner support for conservation actions, and can lead to behavioral change that aids recovery efforts. Social media plays a key role in outreach and can be used to assess public awareness, attitudes, and engagement. Conservation Science Partners and The Living Desert Zoo and Gardens partnered to conduct a sentiment analysis of social media data (i.e., Twitter/X) related to the Mojave desert tortoise (hereafter, tortoise) and to quantify the impacts of tortoise-focused outreach programs on social media engagement from 2012–2024. We scraped Twitter/X to collect >18,000 relevant 'tweets' and deployed an online survey to solicit information on tortoise-focused outreach events. We leveraged a natural language processing model to conduct sentiment and thematic analyses of tweets to assess trends in public perception and engagement and identify salient topics and narratives related to the tortoise. Over the study period, average sentiment of relevant tweets was positive, and there were significant positive trends in sentiment and user engagement (i.e., number of unique users, tweet frequencies) over time. The three main themes that emerged from analyzed tweets were conservation and protection, appreciation for the species, and tortoise humor and analogies. We then conducted inferential analyses on our tweet and outreach program data to assess the impact of outreach events. We found that tweet frequency was significantly higher in the weeks an outreach program occurred, and that tweet frequency and the number of unique users tweeting were significantly higher in the week after an outreach event than in the week before. Our results suggest that outreach programs have a positive effect on social media engagement, with sustained and increased engagement up to five weeks following an outreach event. We interpret our findings to inform outreach design and tracking of outreach success.

Mojave Desert Tortoise Population Response to Multiple Stressors Across its Range

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Despite decades of monitoring data, the impacts of multiple interacting stressors on Mojave desert tortoise (*Gopherus agassizii*, hereafter tortoise) distribution and demography remain largely unquantified over extensive temporal and spatial scales. Guided by early and iterative engagement of natural resource managers, we sought to quantify the cumulative impacts of environmental and anthropogenic stressors and produce statistically robust, rangewide models of historical, current, and future tortoise survival. We employed a knowledge co-production approach and machine learning methods to identify and generate hundreds of spatial data layers representing priority stressors. We then developed an integrated, spatially explicit Bayesian model that leverages demographic data from both capture-mark-recapture (n = 3,923 individuals) and telemetry (n = 2,849) studies spanning 1970–2020 to identify key drivers of tortoise declines, estimate spatial and temporal variation in tortoise survival, and generate rangewide estimates of tortoise survival under historical, current, and future exposure scenarios. Our results revealed that average precipitation over the previous two winter seasons had a significant positive impact on survival probability, while coyote distribution, raven population density, and invasive plants had significant negative effects on rangewide survival. When we focused our modeling efforts on areas that experienced high magnitudes of change in off-highway vehicle (OHV) route networks, we found a significant negative effect of OHV routes on survival of adult males and juvenile tortoises. Our results revealed a significant negative trend in survival probability over time across the range of the tortoise, with probability of survival being lowest in the Western Mojave and highest in the Upper

Virgin River recovery units. Our project represents the most extensive spatiotemporal analysis of the impacts of multiple stressors on tortoise survival. Results from our rangewide, historical analyses underscore findings from local and shorter-term studies and provide insights into the impacts of multiple stressors on tortoise survival.

The Past, Present, and Future of Drought and Aridification in Southwestern North America

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Southwestern North America is warming and aridifying due to human-caused climate change. These persistent and accelerating changes are happening on top of naturally large swings in moisture availability in the region, much of which is caused by far afield factors such as sea surface temperatures in the tropical Pacific Ocean. These combined factors are changing the risks of droughts in southwestern North America, as well as compound events like droughts and heatwaves. For instance, human-caused warming made the megadrought conditions in southwestern North America 42% more severe and likely 6 years longer over the 2000-2021 period. The interval also comprised the driest consecutive 22 years in the region since at least 800 CE. Similarly, the co-occurence of hot and dry conditions during the 21st century are likely unprecedented since at least the 16th century. These paleoclimate perspectives indicate conditions in southwestern North America are already extreme by historical standards, but continued warming and drying trends in the region will perpetuate even more extreme conditions over the remainder of the 21st century and beyond. This talk will review what we know about the climate conditions in southwestern North America over the last millennium, what we understand about current conditions and their causes, and what to expect as we move further into the 21st century and human sources of greenhouse gas emissions continue to rise.

Investigation Online Sentiment Toward the Mojave Desert Tortoise and Outreach Efficacy Using Natural Language Processing

Madeline Standen [1], *Mae Lacey* [1,3*], *Alexander Robillard* [1], *James Danoff-Burg* [2], *Katie Shaw* [2], *Justin Suraci* [1], *Elissa Olimpi* [1], *and Brett Dickson* [1][1]Conservation Science Partners, Inc., 11050 Pioneer Trail, Suite 202, Truckee, CA 96161, USA[2]The Living Desert Zoo and Gardens, 47900 Portola Ave, Palm Desert, CA 92260, USA[3]Email: mae@csp-inc.org

Outreach events can increase public awareness of threatened species, help garner support for conservation actions, and can lead to behavioral change that aids recovery efforts. Social media plays a key role in outreach and can be used to assess public awareness, attitudes, and engagement. Conservation Science Partners and The Living Desert Zoo and Gardens partnered to conduct a sentiment analysis of social media data (i.e., Twitter/X) related to the Mojave desert tortoise (hereafter, tortoise) and to quantify the impacts of tortoise-focused outreach programs on social media engagement from 2012–2024. We scraped Twitter/X to collect >18,000 relevant 'tweets' and deployed an online survey to solicit information on tortoise-focused outreach events. We

leveraged a natural language processing model to conduct sentiment and thematic analyses of tweets to assess trends in public perception and engagement and identify salient topics and narratives related to the tortoise. Over the study period, average sentiment of relevant tweets was positive, and there were significant positive trends in sentiment and user engagement (i.e., number of unique users, tweet frequencies) over time. The three main themes that emerged from analyzed tweets were conservation and protection, appreciation for the species, and tortoise humor and analogies. We then conducted inferential analyses on our tweet and outreach program data to assess the impact of outreach events. We found that tweet frequency was significantly higher in the weeks an outreach program occurred, and that tweet frequency and the number of unique users tweeting were significantly higher in the week after an outreach event than in the week before. Our results suggest that outreach programs have a positive effect on social media engagement, with sustained and increased engagement up to five weeks following an outreach event. We interpret our findings to inform outreach design and tracking of outreach success.

POSTER

Desert Tortoise Headstarting: Multi-year Comparison of Desert Tortoise Hatchling Growth Rates

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Desert tortoises (*Gopherus agassizii*) are most susceptible to predation as hatchlings when their shells are soft and they are at their smallest size. Headstarting, a technique shown to improve the survivability of desert tortoises, has been conducted in a variety of ways across studies with mixtures of indoor and outdoor rearing periods. For purely indoor reared hatchlings, a mixture of warm temperatures and appropriate humidity, hydration, and feeding methods, can produce expedited growth speeds. From the past four cohorts, hatchlings upon emerging form their eggs weighed an average of 23.3g and had midline carapace lengths of 44.8mm on average. After seven months of indoor rearing, headstarted tortoises weighed an average of 83.6g and had an average midline carapace length of 71.4mm. Although both mass and volume increased, shell hardiness was not studied or recorded. Survival for the first cohort at one year is 78.3% with some individuals undergoing behavior trials in predator avoidance. The second cohort has a 53.1% after one year and for the third cohort, released October of 2025, 36 of 72 hatchlings had transmitters with one mortality leading to a 97% survival rate of tracked tortoises within 45 days. Cohort number four is still indoors receiving care at The Living Desert Zoo and Gardens. Given that daily husbandry can be intensive and costly and that funding can prove difficult to obtain, it is advantageous for tortoises to grow as quickly as is safe for conservation initiatives. In this way, more hatchlings can be headstarted and released each year to allow for a greater number of hatchlings to benefit from this technique.

Update on Survival of Head-started Mojave Desert Tortoises and Releases in Climate Refugia at Mojave National Preserve

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Climate change is expected to affect biological communities as organisms track preferred climate and habitat. The predicted increases in the severity, frequency, and prevalence of droughts that will accompany climate change in parts of the Mojave Desert, for example, may lower the value of some areas for tortoises while turning others into climate refugia. We have shown that annual survival of head-started tortoises in the wild dipped to 60% in lower Ivanpah Valley during an Extreme Drought from 2020–2021, irrespective of tortoise size, before returning to >85% after the drought relented. We attributed the decrease in survival during the drought to predation by coyotes that turned their attention to tortoises when jackrabbit prey grew scarce. Areas that maintain cooler temperatures and adequate moisture, such as those at higher elevations, may be spared the worst of drought impacts and instead serve as areas of "climate refugia". In Fall 2024, we released 15 head-started tortoises in lower Ivanpah Valley in the Mojave National Preserve (1050 m elevation) and an additional 15 slightly upslope (1250 m elevation) to examine the possibility of directing future releases to "climate refugia". Drought conditions in the region worsened again from October 2024 to October 2025 after tortoises were released. One year later, just five of the 15 tortoises released at the lower elevation site were alive, in contrast to 11 of 15 at the higher elevation site. We released an additional 15 tortoises at each of the two sites in Fall 2025 and we continue to radio-track them and monitor their survival. We discuss the possible value of targeting future population augmentation to areas that may continue to increase in value as habitats for desert tortoises given expected climate change.

Tortoise Genetics and Family Structure: From Plots to Populations

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Since 2015 we have gathered genetic data for Mojave desert tortoises (*Gopherus agassizii*) encountered during biannual surveys on long term study plots throughout the Ivanpah Valley to aid in demographic and connectivity studies. While traditional population genetic methods are useful for defining broad-scale population units and gene flow at multi-generational and evolutionary timescales, genetic data can also be used to reconstruct pedigrees to infer recent (within a generation) dispersal, and assess diversity at the neighborhood scale. Here we analyze

the family relationships of ~700 tortoises using maximum likelihood pedigree analysis. We inferred 331 parent/offspring and 163 full-sibling relationships. Most close relatives were located within 1 km of each other, with a maximum distance of 9 km. The distances between close relatives were of similar scale to individual dispersal distances observed with telemetry (range 0.2 km - 13.65 km). Analysis of genetic diversity data of adult and subadult age classes suggests intergenerational declines in the effective population size (Ne) at the genetic neighborhood scale, most prominently in plots in the center of the valley, where land development and disturbance are concentrated. Integrating these results can assist managers in habitat restoration and recovery efforts in multi-use landscapes.

Return to Tiburón Island-Land of the Comcaac People, After Twenty-Four Years. A Desert Tortoise (*Gopherus morafkai*) and Biocultural Expedition

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In 2001, we traveled to Isla Tiburón in the Gulf of California in response to reports from the Comcaac community of a high number of Morafka's desert tortoise (*Gopherus morafkai*), (formerly *Gopherus agassizii*) shell-skeletal remains being observed. We established a one square kilometer study plot near the center of the island in an area known as Caracol. During that survey we confirmed and quantified the Comcaac's observations while working alongside them and training them on survey methodologies. In November 2025, a team of 37 volunteer skilled tortoise biologists returned to repeat the Caracol study plot to determine if the island tortoise population had undergone any recovery, further decline, or remained the same. With the logistical and collaborative support of Prescott College Kino Bay Center personnel, we, again, worked alongside a team of 10 young Comcaac paraecologists providing them training on standardized methodologies. We found indications of recovery on the Caracol plot, with a tortoise population density estimate of 26.5/km². Additionally, we were tasked with establishing a study area on the mainland for long-term tortoise monitoring near the Comcaac village of Punta Chueca. The results of the Punta Chueca plot survey were discouraging, as a high number of recently dead tortoises were found, and only three live tortoises were observed. Discussions are underway to determine additional potential sites for long-term monitoring. Concurrently with conducting the tortoise study plots we participated in lessons on the biocultural diversity of the region. Ongoing progress for long-term tortoise monitoring will require collaboration with the Comcaac community, Prescott College Kino Bay Center, and tortoise researchers from the U.S. and Mexico.

POSTER

A Predation Event Unlike Any Other: Large-scale Predation on Large Juvenile and Subadult Bolson Tortoises (*Gopherus flavomarginatus*) in July of 2025

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Twenty-six adult Bolson Tortoises (*Gopherus flavomarginatus*) were moved to Ted Turner's Armendaris Ranch in New Mexico in the fall of 2006, where they are housed in the ~18.5 acre 'Cedar Tank' (CT) pen that encloses Chihuahuan Desert grassland and is designed to keep tortoises from walking away but otherwise live like their wild counterparts. Starting with ten individuals in the fall of 2012, we also began adding juveniles (>100 mm MCL) outfitted with VHF transmitters to the enclosure to develop release protocols and study predation pressures and survivorship in anticipation of obtaining permits to release tortoises outside of the enclosures (granted in 2021). In summer of 2025, 23 adults and ~140 juvenile tortoises were housed at CT.

Over the years, camera traps have documented the presence of various predators in or near CT (regular visits by coyotes and occasional visits by predators like birds of prey, foxes, badgers, skunks, and bobcats, and very rare visits by a mountain lion), but only about a dozen juvenile tortoise deaths (and no adult tortoise mortalities) could be attributed to probable predation. However, in July of 2025, we discovered an unprecedented predation event: the remains (consisting of mostly the carapace and gut piles) of at least 21 large juvenile tortoises (average: MCL, 171.3 mm; mass, 1.141 kg; age, 13.1 yrs) were found outside the enclosure. This suggests that the predator had to be large and strong enough to be able to jump over the 2 ft fence with a 0.5 - 2 kg tortoise in its mouth. Recent rains had obliterated any tracks or scat at the scene. Our best current hypothesis is that the tortoises were predated by a mountain lion.