Mojave Desert Tortoise Habitat Restoration Workshop

January 24-26, 2022 | Virtual

Workshop Summary

Contents

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Cover – Natalie Fronk

Note: In all places, "desert tortoise" refers to Mojave desert tortoise

Introduction

In January of 2022, the Clark County Desert Conservation Program convened a workshop focused on Mojave desert tortoise habitat restoration. The workshop brought together 79 partners from across the Mojave representing federal, state and local agencies, universities, and organizations. Partners met virtually over three days to: discuss and evaluate the current state of knowledge regarding desert tortoise habitat restoration; share current management actions and discuss successful methods; and identify critical management, monitoring and research needs (see Appendix A for the workshop agenda and Appendix B for participants).

In preparation for the workshop, Clark County contracted Dr. Scott Abella (Natural Resource Conservation LLC) to develop a comprehensive literature review of habitat restoration methods and research. Dr. Abella presented the findings of the literature review in a webinar before the workshop (Literature Review; webinar video).

The workshop was designed by a planning team including: Stefanie Ferrazzano and Scott Cambrin (Clark County), Flo Deffner (USFWS), Judy Perkins (BLM), Scott Abella (UNLV), and Julia Sittig and Colleen Whitaker (Southwest Decision Resources). The workshop was facilitated and documented by Southwest Decision Resources.

Habitat requirements and indicators of habitat quality – Panel Discussion

Panel moderator: Roy Averill-Murray, USFWS
Panelists:

- *Kristin Berry, USGS*
- *Ron Swaisgood, San Diego Zoo*
- *Melia Nafus, USGS*
- *Brian Todd, UC Davis*
- *Todd Esque, USGS*

Roy provided a brief overview presentation (link), and highlighted that the importance of habitat quality is emphasized in the Mojave Desert Tortoise Recovery Plan - particularly the need to demonstrate links between habitat characteristics and desert tortoise population survival, reproduction, and recruitment.

Panelists' current work relative to habitat quality and indicators
Brian Todd:

- Headstarting in captivity to prepare desert tortoises to survive in the wild. Getting a baseline for desert tortoises that were not headstarted so comparisons can be made with those that were.

Melia Nafus:

- Site fidelity work - exploring possible differences in habitats in which desert tortoise are seen/detected during monitoring versus where they are truly surviving.

Ron Swaisgood:

- Habitat preferences and desert tortoise health, behavior, and survival.

Todd Esque:

- Combining the Assessment, Inventory, and Monitoring (AIM) program with ancillary ways of monitoring habitat with near-remote and far-remote monitoring.
- Synthesis of cover and forage species utilized by desert tortoise (2021, Natural Areas Journal) by Esque and BLM.

Kristin Berry:

- Demographic plots in the Mojave and western Sonoran deserts to look at habitat characteristics and human impacts on desert tortoise populations.
- Exploring what factors affect survival of desert tortoises and their behavior (e.g., rejection and acceptance of habitat). Some cohorts date back to 2003.
- Studies on the natural recovery of habitat based on photos from up to 100 years ago.

General Findings

- Perennial plants are an important factor in where tortoises spend time.
- Large tortoises are very resilient to environmental challenges, juveniles are much more affected by habitat components.
- Juvenile tortoises grow more quickly when fed with native forage than invasive grasses.
- Juvenile tortoises spend time in burrows of mammals and in drainages/washes. Kangaroo rat burrows are very important for juveniles as they can't dig their own. (Translocation of squirrels in CA has been successful.)
- Kangaroo rat burrows have been found to be full of red brome seeds.
- Rocky substrates can reduce detection and predation rates.
- Larger home ranges indicate that fewer resources are available for desert tortoise.
- Red Brome is an important issue, specifically for diets of desert tortoise.
- No vegetation has been growing for the past two years; climate change is clearly affecting desert tortoise and habitat.

Potential indicators/characteristics of habitat quality

- Density of small mammal burrows is a great indicator of survival
- Large canopy cover that allows a coppice mound to be built
- Invasive species - red brome, schismus, and Sahara mustard
- Biomass of preferred forage - could look at ratio of good forage to invasive grasses
- Translocation information is a useful tool to measure desert tortoise response, including:
    - where they choose to settle

    - rejected habitat
    - micro-habitat use
    - tortoise growth and health - juvenile growth rates can be used as a barometer for habitat conditions (a baseline study on wild tortoise growth has not been published)
- Juveniles can provide better indications of habitat quality than adults; they are more sensitive to the environment
- Quantifying success of restoration could incorporate environmental metrics such as:
    - Burned landscapes that are still structurally sound but denuded of vegetation, versus those that have been leveled
    - Restoration areas lacking soil for kangaroo rats to burrow
- Indicators that are not as useful:
    - Population response is a slow and a delayed measure - numbers can lag for a decade or more
    - Occupancy modeling and presence/absence data may be less important now than it was before

Remaining questions

- How can we better use headstarting and translocation as probes to investigate questions about habitat?
- How do we know if habitats are of sufficient size?
- How quickly do kangaroo rats bounce back with restoration activities?
- Work on solar fields needs to be scaled up in a concerted way rather than on individual studies. As we deconstruct desert tortoise habitat on large solar fields, we can learn how to best reconstruct. Use juvenile tortoises to indicate what does and doesn't work

Advice for managers

- Selection of sites for restoration is critical and should consider:
    - Viability of soils - colonization can occur more rapidly with sufficient soils
    - Presence and density of predators - even if there is good forage, the site could end up being a population sink
    - Ability for desert tortoise to camouflage in substrate to avoid predation
- Do not prescribe methods to mitigate before we know the metrics that matter
- The community of desert tortoise practitioners have enough information on our hands to roll out restoration work on a larger-scale

Restoration Activities

Lightning talks

See video of lightning talks on current restoration work (link)

Speakers:

- *Stefanie Ferrazzano, Clark County Desert Conservation Program*
- *Dale Devitt, UNLV*
- *Derek Hall, Nevada National Security Site*
- *Curtis Deuser, NPS*
- *Lesley DeFalco, USGS - Western Ecological Research Center*
- *Judy Perkins, BLM*

Assessment of activities by disturbance type

Participants joined breakout groups on restoration activities to address the following disturbance types: roads, fire, renewable energy infrastructure, invasive species, and grazing/agriculture. Discussions focused on which activities are working or not, and why. A summary of each discussion is provided here. See complete breakout group notes in Appendix D.

Roads

- Overall, effective restoration methods are known. The biggest challenge is enforcement and public outreach/education.
- Challenges
    - Restoration activities discussed by the group: vertical mulch, post and cable barriers, seeding, signage, outreach, law enforcement.
    - This is a long-standing issue (e.g. US Government Accountability Office 2009: Public land-management officials across the US have identified that financial and staff resources were insufficient to meet the challenge of enforcing OHV regulations).
    - This is a critical issue. No tortoise conservation area with > 0.75 km of routes per square km had increasing tortoise populations between 2004 - 2014.
    - The issue of OHV recreation is expanding rapidly; current OHV impacts will likely get more intense as the number of OHV recreators continues to expand.
- Needs/Opportunities
    - Increase/improve outreach and education with the OHV community
    - Bring users into the conversations about routes
    - Long term engagement is essential
    - Education alone does not lead to behavioral change. We need to ask for direct actions and communicate clear accountability along those lines.
    - More law enforcement presence is needed, but law enforcement alone won't be successful.
    - Many partners agreed that a follow-up discussion on this topic would be beneficial
    - Resource - Todd Esque/USGS just published a protocol for route restoration: https://www.usgs.gov/publications/protocol-route-restoration-californias-desert-renewable-energy-conservation-plan-area

Fire

- Methods discussed by the group:
    - Broadcast seeding
    - Outplanting/transplanting
    - Fuel breaks
    - Green stripping
- Challenges/needs:
    - More research is needed on use of herbicides in desert tortoise habitat.
    - Availability of appropriate seeds. When it is not possible to use local seed sources exclusively, a result can be low species establishment.
    - Need information on managing areas with multiple burn scars and scaling up fuel breaks
- Careful site selection is the most important aspect of success and survivorship.

Renewable energy infrastructure

Overall, evidence for effective strategies is being developed. Now we need to share examples of successful implementation, scale up methods being used at individual project sites, and institutionalize best practices in environmental compliance processes.

- All restoration activities are new and an adaptive management approach is key in figuring out what will be most successful.
- Restoration activities discussed:
    - Clearing - using the drive and crush method instead of blading, etc.
    - Revegetation of temporary disturbance areas
    - Mowing
    - Dust abatement
- Needs
    - Maintain connection between washes/drainages and uplands/floodplains
    - Coordination with adjacent properties - how to keep updated on what is happening outside of your area of control
    - Scaling up and institutionalizing active restoration at renewable energy facilities
    - Wildlife-friendly security fencing - if we succeed in having healthy habitats in these areas, this fencing will allow animals to pass

Invasives

The group discussed 12 different methods for controlling invasive weeds and while many of them work, most come with challenges. There was agreement that many could use more research and adaptive management to hone the best methods for invasive weed management. The biggest challenge is scalability.

Methods discussed by the group:

- Removal of dry biomass
- Preventative spraying

- Herbicides
- Carbon addition to soils
- Firebreaks / fragment the fuelscape
- Controlled grazing
- Removal of dried Sahara mustard
- Strategic selection of sites for treatments
- Aerial herbicide deployment
- Ground-based herbicide deployment
- 5 acre islands that are soiled, seeded, and fenced post-burn

Needs/opportunities

- Main need: scaling up methods that work in one place.
- Prioritization is critical for species that are wide-spread and difficult to control. Threat analysis can be used to identify treatment locations.
- Focus efforts on "winnable" battles - think about what is best to put energy/resources into.
- There are many technical questions about the methods; more information sharing and training may be beneficial.
- There are some areas of fire-specific invasives where we could accomplish a lot; protect a relatively intact area, and tie a treatment in with other conditions or topography.

Grazing and agriculture

Overall, the discussion didn't focus on an evaluation of current activities, but rather gathered possible activities to trial in the future. The main issue is addressing overgrazing where it occurs.

Potential projects/methods discussed

- Targeted grazing (e.g. goats with specific plant species, camels with thistles)
- Spraying molasses for increased palatability
- Seeding with natives
- Planting native container stock near waters (guzzlers)
- Restoring natural water sources (springs and seeps) with native vegetation

Needs/opportunities

- Better oversight on grazing and range condition
- Coordination with BLM, FWS and local NGOs
- Solutions to control potential for spreading of non-native/invasives during targeted grazing
- The tortoise recovery plan recommends experimenting with grazing outside of tortoise conservation areas until grazing has been demonstrated to be compatible with tortoise occupancy.

Adaptive Management - Panel Discussion

Panel moderator: Scott Abella
Panelists:

- *Scott Cambrin, Clark County Desert Conservation Program*
- *JJ Smith, BLM*
- *Neal Darby, Mojave National Preserve*
- *Curt Deuser, NPS*
- *John Kellam, BLM*

Scott Cambrin of Clark County presented an overview of Adaptive Management (link).
A video of the panel discussion can be viewed here (link). Main points are summarized here.

Current agency/organization monitoring related to desert tortoise habitat

Clark County

- Restoration sites and easements, including desert tortoise occupancy at some sites.
- Adaptive management has informed management by showing which results are not occurring as expected or desired.

BLM Utah NCAs

- Adaptive management is used on habitat rehabilitation projects to address fire damage. The majority of 2005 and 2020 fires were in desert tortoise habitat. BLM is planting thousands of plants and monitoring how topography and other factors are affecting certain species. Recording and implementing lessons learned, which is increasing desert tortoise survivorship.

BLM Nevada

- Using BLM AIM data and fuel monitoring program to characterize habitat and burned area monitoring immediately post-fire to identify weeds and fuels.
- Early detection and rapid response (EDRR) is a critical component to invasive management on a district-wide basis.

Mojave National Preserve

- Monitoring is focused on invasives. Targeted monitoring on presence of salt cedar and Sahara mustard. Have successfully eradicated several stands of salt cedar.
- Monitoring restoration efforts in focal disturbance areas like livestock corrals/waters.
- Monitoring invasives (e.g., red brome) and Joshua Tree recovery after major fires. Have seen that the diversity of native annuals, perennial bunchgrasses, and shrubs have returned.
- ROW and grazing permit monitoring - disturbance impacts and invasives.

NPS

- NPS has a large Inventory and Monitoring (I&M) program comprising multiple parks that guides long-term decision making.

- Adaptive management is used to determine the effectiveness of treatment methods on smaller scales, which are then implemented on a larger scale.
- Spatial mapping of all treatments, with metadata is made available to external partners for the purpose of analyzing at larger geographic and temporal scales
- Effectiveness of control methods for invasives depends largely on environmental variables, especially for annuals. It is important to apply control methods even in years of low germination because the goal is to eradicate the seed bank.
- There may be an opportunity to connect large-scale information sources like NPS I&M, BAER data, etc. to inform future projects.

Examples of Adaptive Management programs for desert tortoise habitat restoration and to inform desert tortoise management

BLM UT

- Used biological data of where tortoises are, and observed habitat characteristics like rocky hills, to determine where to implement management actions. This is a combination of occupancy and habitat characteristics.

BLM Las Vegas

- Learning more as we attempt to scale-up projects. Developing remote sensing and modeling tools for monitoring. Need to be able to apply information in a timely manner.
- Developing effective monitoring methods and working with partners (e.g., FWS monitoring culverts and power lines, engaging in Transportation Ecology group) to address emerging issues. Need to identify the best places to implement management methods based on this information.

Clark County

- The adaptive management process was informal at first, but the County has begun to formalize it. Utilize desert tortoise occupancy data to identify locations for restoration actions.

Ways to deal with uncertainty and risk

- Bet-hedging - can be used to apply multiple treatment types under uncertain conditions (e.g., using a wide variety of species, combining biotic and abiotic methods). It is similar to formal adaptive management, and includes multiple strategies that can be compared with each other.
- Consider new technologies - such as using drones for desert tortoise surveys. Could incorporate techniques from other sectors and environments to our desert environment.
- Layering plant restoration with predator abatement – this may result in more success. Predation chance may also be considered in site selection for restoration actions (2012 Bioscience paper by Roy Averill-Murray et al. describes techniques and factors for restoration actions).
- Flexible and diverse funding mechanisms:

- Flexibility - Mojave NP contracts with USGS and CESUs so that money can be spent over a number of years and restoration actions can be done when they are most necessary.
- Cooperative Agreements can be useful mechanisms
- Having a diversity of funding sources

Invasive Treatments under Uncertainty

- Pre-emergent treatments of red brome or Sahara mustard usually occur before the growing season, and they can be ineffective if the species do not end up germinating. Is it better to wait for emergence to respond with a post emergent treatment? Should we prioritize certain desert tortoise habitat of critical value to use pre-emergents?
    - What are the effects of pre-emergent herbicides on native annual forb species? Thinking of Indaziflam - it is good at protecting against perennials, but what about annuals? What about *Bouteloua barbatus* and *aristoides*, threeawns?
        - Preliminarily, Indaziflam seems to be very selective for annual grasses.
        - Annual invasive exotic bromes are fueling most fires in the Mojave desert, and breaking that cycle is key. This is a reason not to apply methodologies across entire landscapes; larger acreages need to be protected and we don't know all the negative impacts to annual grasses.
        - Research on native annual tolerance to Indaziflam - UT State University is studying impacts on native annuals. Where there are invasives, natives already tend to be displaced. Preliminary observations are that desert marigold and filaree do not seem to be affected because the herbicide effects are only on the soil surface.
            - Indaziflam herbicide research reference: Derek Sebastian

Effectiveness Monitoring

Participants broke into small groups to discuss whether our monitoring efforts are successfully informing management, and ways to improve monitoring efficiency and effectiveness. A synthesis of main points from the discussions is provided here. For a list of partner organization/agency current monitoring see Appendix E.

Is current habitat restoration monitoring telling us what we need to know in order to effectively inform management?

- Don't have data on how tortoise are using habitat; all else is a proxy for this. For adaptive management to work we need direct feedback, not proxy.
- We don't have a good set of habitat quality indicators, which makes it difficult to determine which habitats are best.
- Lots of habitat restoration monitoring is related to plant survivability, but there is not much looking at whether the restoration is benefiting tortoise. There is some experimental work on this, but it is fairly limited.

- We're not getting what we need. We're getting enough to understand that restoration doesn't work in every place, every time.
- We have some sort of idea where good tortoise habitat is, but we don't have a clear sense of where large populations of tortoises are.
- Tortoise response lags behind vegetation response; monitoring does not necessarily capture this.

Recommendations for improving monitoring

- Clarify/agree on "what is good quality desert tortoise habitat?"
- Implement objectives-based management. Tie habitat restoration monitoring to tortoise outcomes. Connect habitat metrics to tortoise demography.
- The first step in site selection for developments, such as solar installations, should include a tortoise population survey.
- Develop standardized training protocols across agencies.
- Leverage existing agency/orgs efforts (i.e. BLM AIM).
    - Link AIM plot data to desert tortoise habitat areas; compare monitoring results and look for trigger points.
    - Add stratified random sampling for AIM plots.
- Develop new strategies to incorporate remote sensing data.
    - Use drones and satellite imagery, with more field work to validate and calibrate.
    - Link remote sensing data with ground data.
    - Explore use of NDVI to predict vegetation response after a treatment as a way to indicate forage quality.
- Improve current methods.
    - More use of camera traps with more sensitive triggers.
    - Translocation - encourage interdisciplinary approaches. Always include habitat based monitoring as part of translocation work.
    - Vegetation monitoring with blind intercept and quadrat monitoring
- Use tortoises to gather information.
    - Use juvenile tortoise as probes; introduce them to different areas and measure response to different habitat conditions.
    - Explore use of pet tortoises as "informants" – observe how they utilize habitat after restoration.
- OHV monitoring
    - Need more research on the impacts of OHV incursion on tortoise.
    - Monitor for compliance (closed route signs).
    - Need an automated method for monitoring the proliferation of unauthorized OHV routes .
    - Try a citizen science approach; help users gain a different perspective on the habitats they impact.

Suggested improvements to data collection, sharing and dissemination

- Coordination through workshops, forums, symposia are important for finding out what others are doing and sharing across the range.
- Need a shared geospatial data repository (i.e. Data Basin or Github).
    - Should be cross-jurisdictional
    - Include automatic data updates
    - Incorporate standardized data collection through an app that links to shared database
    - Include a repository for unpublished data
    - Data availability for longer and older studies is an issue
    - There have been many attempts in the past (i.e. BLM) – gather lessons learned from past efforts.
- More use of apps to improve data collection and dissemination.
    - Apps like FieldMaps can help consolidate data and keep it up to date; can use offline and sync later
    - Many use Survey 123. It is easy to share data within an agency, but outside of agency is harder
    - Apps for Mojave native plant identification would be useful
- Need a way to keep data consistent for multi-year projects that may have staff turnover
- Need a way for people without university library access to get access to articles, etc.
- Concerns/considerations about data sharing
    - Must be careful with sensitive information. In some cases cannot share specific occurrence points
    - Making data available outside of agencies is a concern due to nefarious objectives (e.g. illegal collection of desert tortoise for pet trade)
    - Sharing across agencies is key, but data needs to be declassified first
    - Publicly funded research/data should be made public, but there are barriers to sharing individual researchers' original data

Prioritization

Presentations:

- Availability of native plant material - *Judy Perkins, BLM* (link)
- Clark County prioritization examples - *Stefanie Ferrazzano, Clark County* (link)

Participants broke into small groups to discuss how they currently focus restoration efforts, and begin to identify criteria for prioritizing treatments at a regional scale. A synthesis of these discussions is presented here.

Considerations/criteria for desert tortoise restoration site selection

Habitat Characteristics

- Presence of desert tortoise, preferably with an increasing or stable population (33% minimum)
- Feasibility - areas where restoration activities are viable
- High vegetation species richness
- Minimal cover of invasive vegetation (e.g., cheatgrass)
- Connectivity with other desert tortoise habitat (can use desert tortoise suitability tools and connectivity model).
- Adequate water for plants
- Climate refugia – areas anticipated to be suitable for desert tortoise occupancy/movement into the future
- Density of nesting common ravens (predation)

Administration and Access

- Protected areas such as ACECs, Wilderness, Desert Tortoise Critical Habitat units, etc.
- Degree of access
- Little to no anticipated issues with environmental/cultural compliance
- Funding availability

Function within the larger system

- Areas where restoration activities would help prevent a future disturbance (e.g., fire, invasive infestation)
- Ability to help protect adjacent undisturbed habitat and/or other resource values
- Areas where disturbance has occurred and management would help restore ecological functions
- Areas on the edges of large disturbances where we can have a reasonable expectation of success
- Areas where modeling suggests high vulnerability

Applying criteria

- Develop a "rubric" with different weighting for different criteria
- Spatial analysis - develop maps overlaid with disturbances (solar farms, ROW, etc.)
- SWOT analysis is useful
- Habitat suitability/quality models:
    - The current (2009) habitat model is commonly used
    - Two new tortoise population tools are nearing completion: range-wide trends in occupancy and range-wide patterns of density (both at 1 sq km scale)
    - There is no substitute for actual field data from surveys.
    - There is an existing suitability model that is currently being updated (developed by Ken Nussear)

Moving Forward as a Community of Practice

Participants broke into small groups to discuss the most important needs/challenges to address in order to improve desert tortoise habitat restoration work, and what we need to do as a community of practice to address these needs. Plenary discussion following breakout groups helped to synthesize the outcomes. A summary of these discussions is presented here. More detail can be seen in breakout group notes in Appendix F.

Research

- How can we successfully scale up site-based treatments to landscape-scale?
- Need to connect habitat quality indicators to tortoise outcomes.
- More research on herbicides (for red brome, schismus) in desert tortoise habitat.
- Research on use of pet tortoises as informants and in translocations.
- Need more research on the impacts of OHV incursion on tortoise.
- Continue/enhance research on restoration activities that genuinely work in the Mojave.

Site maintenance

- Incorporate maintenance into restoration and site management plans up front. Build in funding for monitoring.
- Utilize techniques such as dry planting and vertical mulching to improve success of new plantings and decrease need for supplemental water (see USGS Common Gardens).
- Work to prevent negative impacts after restoration (e.g. from OHV use).
    - Improve communication with law enforcement and managers.
    - Increase public education and outreach focused on behavior change.

Native plant materials

- Increase access to, and use of, native plant materials.
- Use natives that are well-adapted to restoration sites.
- Need more growers for Mojave species; there is currently insufficient seed for the need.
- Plan ahead. Let seed growers know what you need for the next 5-10 years.
- Improve coordination on seed storage and dissemination.

Fire management

- Consider fire potential in site selection.
- Need more options, like herbicides, to protect restoration investments.
    - Develop thresholds for special approval/emergency application when appropriate.
    - Multiple agencies are working together to get Indaziflam approved for use. DCP has a small study coming up.
- Develop fire management plans that indicate risk and how to alleviate.

Prioritization - site selection for success

- Create a geospatial tool to support prioritization of management actions.
    - Build on the existing Eastern Mojave Conservation Collaborative (EMCC) tool; consider launching a desert tortoise specific tool linked to this.
    - Cross-check the prioritization criteria developed here with existing data on the Eastern Mojave Data Viewer.
    - Hire short term/seasonal GIS Technician to develop a comprehensive spatial map of tortoise habitat, fires, solar farms, urban development plan, ROW corridors, wilderness etc.
- Use prioritization as a way to scale-up treatments to larger landscape.

Renewable energy infrastructure impacts

- Develop effective mitigation strategies so that developers can offset impacts .
- Implement long-term policies that mandate money be put into a restoration "bank."
- Keep working to make these plans more tortoise and habitat friendly; keep an eye on plans and how they are implemented.

Project planning

- Long-term projects are needed to demonstrate successful restoration .
- Identify values at risk that resonate with people; what do people find compelling? This may help access funding (see the Sage Grouse Initiative as an example).
- Build in flexibility to allow time to acquire appropriate plant materials.

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Information sharing / Lessons learned

- Find and share stories of successful restoration. This is important for education, awareness raising and funding.
- Develop desert tortoise case studies with CCAST (Collaborative Conservation Adaptation Strategies Toolbox).
- Find ways to share non-published project data.

Climate change adaptation

- Use native species that are well-adapted to restoration sites.

Resources/Capacity

- Leverage partnerships to expand capacity.
- Prioritize staff capacity building.

Funding

- Think long-term: seek funding obligations on a longer horizon to increase sustainability; develop long-term plans; match funding timing to project timelines
- Design projects to address multiple needs simultaneously.

- Be prepared to take advantage of emerging opportunities (e.g. Federal Infrastructure Bill). Plan ahead with multiple sites ready to go when money is available; shelf stock projects.
- Explore development of a mitigation funding bank (related to renewable energy infrastructure).
- Raven management fund - developers put money into a fund to mitigate predation

Convenings

- There is value in this type of forum; evaluate the need for a follow-up workshop in the future.
- Coordinate with relevant existing groups - Mojave Desert Plant Network, desert tortoise Transportation Ecology Task Force, and others.
- The workshop planning team will discuss suggested field trips and follow up with participants.

Appendix A: Workshop Agenda

Mojave Desert Tortoise Habitat Restoration Workshop

January 24-26 , 2021 | Virtual

January 24 and 25: 9-11am and 12-2pm PST

January 26: 9-11am PST

Goals

- Understand and evaluate the current state of knowledge regarding the restoration of desert tortoise habitat
- Share current management actions and discuss successful methods
- Clarify critical management and monitoring needs
- Identify knowledge gaps and related research priorities

Day One: January 24 (9:00 - 11:00am and 12:00 - 2:00pm PST) Zoom Meeting: click here | Phone: 669-900-6833 | Meeting ID: 822 2029 4599	
9:00am PST	**Welcome and workshop overview** *Julia Sittig, Southwest Decision Resources*
9:15	**Current state of our knowledge** - *Scott Abella, Natural Resource Conservation, LLC* Key findings and highlights from literature review
9:45	**Partner work** *What are you working on that is relevant to this group?*
10:00	**Habitat requirements and indicators of habitat quality** **Panel Discussion** Moderator: *Roy Averill-Murray, US Fish & Wildlife Service* Panelists: ● *Kristin Berry, USGS* ● *Ron Swaisgood, San Diego Zoo* ● *Melia Nafus, USGS* ● *Brian Todd, UC Davis* ● *Todd Esque, USGS*
11:00-12:00	**Lunch Break**
12:00	**Restoration Activities - Lightning Talks** **Overview** - *Scott Abella, Natural Resource Conservation, LLC* **Lightning talks:** Current and recent restoration work ● *Stefanie Ferrazzano, Clark County Dept. of Environment and Sustainability* ● *Dale Devitt, UNLV* ● *Derek Hall, Nevada National Security Site* ● *Curtis Deuser, NPS* ● *Lesley DeFalco, USGS - Western Ecological Research Center*

	• *Judy Perkins, BLM*
1:00	**Restoration Activities - Group work** **Breakout group discussion:** What restoration activities are working for different disturbance types, which are not, and why? What are important challenges to address moving forward? Disturbance types: Invasives, Fire, Roads, Renewable Energy Infrastructure, Grazing and agriculture
2:00pm PST	**Adjourn**

Day Two: January 25 (9:00-11:00am and 12:00- 2:00pm PST) Zoom Meeting: click here | Phone: 669 900 6833 | Meeting ID: 886 7951 2963	
9:00am PST	**Welcome and overview of Day Two** *Julia Sittig, Southwest Decision Resources* **Desert Tortoise Photo Contest!**
9:15	**Synthesis and Discussion Habitat quality indicators and restoration activities** **Plenary discussion:** Synthesis and discussion of outcomes from day one
10:00	**Addressing uncertainty: Adaptive Management and monitoring** **Adaptive management overview** - *Scott Cambrin, Clark County* **Panel Discussion** Moderator: *Scott Abella, Natural Resource Conservation LLC* Panelists: *Scott Cambrin, Clark County Department of Environment and Sustainability* *JJ Smith, BLM* *Neal Darby, Mojave National Preserve* *Curt Deuser, NPS* *John Kellam, BLM*
11:00	**Adjourn for lunch**
11:00-12:00	**Lunch Break**
12:00	**Effectiveness Monitoring** **Breakout group discussion:** Is our monitoring telling us what we need to know? How can we make monitoring more effective and efficient?
1:00	**Prioritization: Strategic use of restoration resources** **Overview presentation** - *Scott Abella, Natural Resource Conservation LLC* **Considerations for prioritization and examples:**

	• Availability of native plant material - *Judy Perkins, BLM* • Clark County prioritization examples - *Stefanie Ferrazzano, Clark County* **Breakout group discussions:** How do you decide where to focus restoration activities? What are important considerations for prioritizing at a regional scale?
2:00pm PST	**Adjourn**

Day Three: January 26 (9:00-11:00 am PST) Zoom Meeting: click here | Phone: 253 215 8782 | Meeting ID: 849 3896 8017	
9:00am PST	**Welcome and overview of final day**
9:05	**Prioritization Criteria Discussion** **Plenary discussion:** Synthesizing and discussing criteria developed during Day 2 breakout group
9:25	**Challenges and Opportunities** **Breakout group discussion:** What are important remaining challenges? What opportunities do we have to address these, and what else is needed?
10:00	**Moving forward as a community practice** **Plenary Discussion**: What can we do as a community of practice to make progress on important needs and opportunities?
10:45	**Conclusion and next steps**
11:00am PST	**Adjourn**

Appendix B: Participants

During the workshop partners also shared a brief synopsis of their work relative to desert tortoise habitat restoration – see here.

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Appendix C: Resources

- Desert Tortoise Habitat Restoration Literature Review, *Scott Abella*
    - Document
    - Webinar
- Workshop presentation and panel discussion videos
- Mojave Desert Native Plant Strategy
- Transportation Ecology Report
- Climate Distance mapper
- Eastern Mojave Conservation Collaborative Geospatial Tools
- USGS Common Gardens
- Studies/papers referenced during workshop:
    - Averill-Murray, R.C., C.H. Fleming, and J.D. Riedle. 2020. Reptile home ranges revisited: a case study of space use of Sonoran Desert Tortoises (Gopherus morafkai). Herpetological Conservation and Biology 15:253–271.
    - Protocol for Documenting Disturbances, Prioritizing Restoration, and Evaluating Restoration Effectiveness for Vehicle Disturbances in Mojave Desert Uplands by USGS - https://meridian.allenpress.com/jfwm/article-supplement/210546/pdf/10_3996_052015-jfwm-046_s5/
    - Synthesis of cover and forage species utilized by desert tortoise (2021, Natural Areas Journal) by Esque and BLM
    - Protocol for route restoration, Todd Esque https://www.usgs.gov/publications/protocol-route-restoration-californias-desert-renewable-energy-conservation-plan-area
    - 2012 Bioscience paper by Roy Averill-Murray et al. describes techniques and factors for restoration actions

Appendix D: Restoration Activities Evaluation – Breakout group notes

Restoration activity	How well is this working? Why?	Challenges/needs	Anticipate working in the face of future changes?
Invasives			
Removal of dry biomass (e.g. Sahara mustard)	Most efforts over past decades have involved pulling and bagging. Mowing or weed-whipping spreads the seed further.	Labor intensive	
Herbicide – pre-emergent spraying	Utah State University is seeing a lot of success with the use of preemergence herbicides for red brome and Sahara mustard	Can destroy lots of species	
Herbicide - aerial deployment		Very few aerial contractors, hard to find them!	
Herbicide Ground-based deployment		Much more labor-intensive and expensive than aerial	
Carbon addition to soils		Hard to operationalize through large areas	

5 acre islands that are soiled, seeded, and fenced post-burn	Working well in 30 acre plots for MSTS (20 seedlings per m2)		
Controlled grazing		Grazing animals may eat same desirable plant species that tortoises want	
Firebreaks / fragment the fuelscape			
Strategic site selection			
Roads			
Vertical mulch	Good for masking that the road was there Works best at remote sites or low use sites Can scavenge for parts from standing dead plants	Can fail if the road was well-known; people will drive over vertical mulch Provide more information to the public so they are aware of alternate approved routes	Will continue to work if treatments are persistent
Post and cable barriers	Easier and more effective than outreach if there is a lot of non-compliance	People tend to cut them or drive around them creating more routes Need to make public aware of approved routes	
Seeding	Not used often for roads	Lack of required resources, time and personnel	Can work if climate change is

	Often not needed because roads are narrow and have seed sources on either side		considered as part of planning
Signage	Helps with outreach and information sharing	Doesn't work a lot of the time; people ignore	Not really
Outreach and education	Important to improve compliance Helps people to understand the reason for restoration Large groups can help "peer pressure" people into complying	Difficult to achieve true behavior change Especially difficult when there is a long history of using the landscape in a destructive way	Will not be the most successful method into the future
Law enforcement	Helps deal with issues immediately Most problems are to do with people not complying with regulations	Not available in all places Lack of resources to cover full landscape Hard to catch people in the act	Will work if it's available, but to varying degrees
Fire			
Broadcast seeding	Timing is very important depending on species Steep slopes raked in can be successful BAER teams don't think this works well, but earlier seral seedings may establish	Ants and rodents can be a problem. Need to use irrigation and cover the seed Large scale of need - unable to use all local seed sources which can lead to low establishment	Initial findings shows that the starting precipitation has most impact

Outplanting/transplanting	Most successful plant species in Utah: creosote, ephedra, white bursage and brittlebush (nursery plants a year old and planted in Nov) Plants that survived to one year in washes had a greater likelihood of making it to 4 years One project found that planting on slopes, base of rocky hills saw 1 year survivorship of 74.1% with no supplemental watering; another project had 65.3% survivorship with watering once, success due to careful site choice	More expensive than broadcast seeding for area coverage, but higher success of establishment (TNC report) at smaller scale Clustering outplanting for more effective management Target for small scale erosion concerns, etc. Need to time planting with peak soil moisture	
Fuel breaks	Apply herbicides every 1-2 years, followed by seeding Attempted patchy spread of low stature plants for fuel break but unable to achieve in study; worth attempting again	Challenge to control cheatgrass Lack of information for Mojave – can't compare to areas like Great Basin How to handle larger areas with multiple years of burn scars? Look at areas where brome and cheatgrass don't grow - research why	

Green stripping	Fluffgrass - low stature that covers large areas after a burn to hold ground		
Renewable Energy Infrastructure			
Revegetation of temporary disturbance areas	Local seed collections haven't been working	Scale up and institutionalize best practices established for active restoration Use USGS publications of seed transfer zones for getting good seed mixes. Monitor for 5 years and evaluate according to criteria	
Including a mowing alternative to EISs for new solar facilities	Plants that do well are along the dripline, with elongation rates of creosote larger than control. Two projects beginning soon that will attempt to leave 18-24" of vegetation	Security fencing is an issue for many renewable energy projects. 85% photosynthetic reduction under solar panels, but less freezing temperatures	
Addressing security fencing barriers (wildlife-friendly fencing)	The Valley Electric plant Pahrump has fencing that allows DT to move in and out. Most are still inside, and rabbits and coyotes enter the facility. The plants inside the fence look better than those outside. This has not happened yet in most projects	Need examples of how to design projects and monitoring data. (e.g. Ivanpah and Yellow Pines solar projects) Long-term monitoring being designed in Moapa by USFWS and USGS.	

	BLM has tried to get this alternative in EISs.		
Dust abatement	BLM has dust abatement as a BMP in their EISs, and is part of air quality analysis.	Dust abatement should be incorporated into overall budget. Limited resources for doing the work, and it involves driving on the roads. Problem when drainages are decoupled from uplands at solar facilities.	
Russian thistle control - mowing	Hopeful that mowing will be more effective than pulling, mechanical or spraying		
Coordination with adjacent properties (e.g. when recovery areas are near facilities)		Solar energy facilitates on private land may not need to notify neighbors of their activities. On federal land, notification is needed and there is a process for connected actions	
Scaling up and Institutionalizing active restoration at renewable energy facilities	Active management of solar energy facilities took a long time to do successfully; Valley Electric was the first good pilot. Little other scaling up has been done.	Need to coordinate across jurisdictions to scale up, standardize, and institutionalize best practices established.	

	USFWS is working with BLM and developers on tribal lands to answer questions and incorporate BMPs into NEPA and BOs.		
Grazing			
Targeted grazing (e.g. goats with specific plant species, camels with thistles)	Could work with cattle on lovegrass	Funding contractors and documentation Potential for spreading non-native/invasives with the use of goats/camels	
Seeding with natives		Longevity of establishment of grasses with increased utilization	
Plant native container stock near waters (guzzlers)	Planting container stock from local seed is working. With good access, supplemental watering is possible and makes for increased success.	Awareness and support from local organizations is needed Need better oversight on grazing and range condition (coordination with BLM, FWS and local NGOs)	
Restore natural water sources (springs and seeps) with natives		NEPA, agreements with permittees	

Appendix E: Partners' Monitoring

Kerry L. Holcomb, USFWS

- Common raven density and thus depredation potential

Roy Averill-Murray, USFWS

- Tortoise population density and trends at large scales within tortoise conservation areas
- Coordinating monitoring at a population augmentation site and at several solar sites.

James Danoff-Burg, The Living Desert Zoo

- Plant survivability, seed set, overall biodiversity pre and post planting, cover of invasives and natives
- The successful consumption of "tortoise supermarkets" by tortoises

Matthew D'Ambrosi, Lake Mead NRA

- Primarily focusing on sahara mustard populations around Lake Mead

Emily Lou Thomas, The Living Desert Zoo and Gardens

- Just started collecting transect data of presence & density of plant species found in our study site in the Chuckwalla Bench area

Ellie Baker, Desert Tortoise Preserve Committee

- Desert Tortoise Natural Area: Monitoring tortoise fencing for illegal incursions by the OHV rider community. Working with partners to restore fence damage and active habitat restoration.

Emily Lou Thomas, The Living Desert Zoo and Gardens

- separate project collecting data on dumpster closure to decrease food and water resources for ravens

Michael Vamstad

- Road mortality
- Line distance Sampling for population levels

Jeanette Perry, Dept. of Energy

- Road mortality, construction projects, juvenile tortoise translocation

Carrie Norman, NPS Lake Mead NRA

- Tortoise habitat on construction sites

Matt Flores, NDOW

- Take of desert tortoise using our permitting process
- Occurrences on the landscape of desert tortoise

Melissa Merrick, San Diego Zoo Wildlife Alliance

- Influence of fine scale habitat features (e.g. burrows, cover, substrate) on juvenile tortoise space use; how these features mediate mortality from predators

John Kellam, BLM UT NCA

- Tortoise distribution/abundance surveys, relying on the Utah Dept. of Wildlife resources for density data

Emily Hibbard, BLM

- Monitor during OHV events

Kathleen Brundige - Coachella Valley Conservation Commission

- Tracking of resident tortoises, searching for occupied habitat for any unknown populations, invasive species

Desert Conservation Program

- Desert tortoise occupancy and various habitat characteristics: shrub cover, species diversity, plant density, soil stability, vehicle incursions, weed presence, and probably more that I can't remember right now. We have transects and plots we visit on a regular basis. Protocol is similar to the USGS protocol for monitoring vehicle disturbances and restorations.

Flo Deffner, USFWS

- USFWS Desert Tortoise Recovery Office monitors:
    - population density and trends
    - suitable & critical habitat
    - disease status of desert tortoise populations

Chris Otahal, BLM, Barstow CA

- Range wide desert tortoise population surveys and range wide raven monitoring.
- At the Barstow FO we are engaged in effectiveness monitoring for restoration associated with route restoration.

Tali Hammond, San Diego Zoo Wildlife Alliance

- Monitoring movement, survival, and microhabitat use of juvenile tortoises after translocation using radiotelemetry tracking.
    - For habitat, we collect data on ocular estimates of plant/other ground covers, where possible species data on diet/forbs, invasives, and shrubs. Also information about substrate (e.g. rocky vs sandy; color of substrate), and about the number/density of small mammal burrows. We also have weather stations to collect weather data.
    - Working with FWS to collect data on predators, particularly ravens, in the region. This is using point count methods, camera traps, and recording any observations of predator scat/sign in the field.
- We also use Field Maps, Survey123, and other ESRI apps for consistency. Field maps makes it relatively straightforward for you to link data you collect in survey123 and put it into a field maps map, in which you can modify/edit records as you are in the field. But our field team still mainly uses Garmins rather than Field Maps for navigating.

Andre Delcalzo, BLM NV Caliente FO

- Habitat - Grazing allotments, some post-fire monitoring.
- Tortoise Populations - Project-specific surveys

Kim Field, USFWS Desert Tortoise Recovery Office

- FWS monitors populations within the recovery units. We work with others, including USGS, to develop habitat monitoring at specific sites.

Ann McLuckie

- UDWR - impacts of wildfires on tortoise populations (density, abundance, trends, growth, health, etc.) by surveying long term monitoring plots, updating translocation plan for recovery area
- UDWR - conducting lots of habitat monitoring following restoration projects.
- UDWR - joining with University of Utah on a capstone project to look at occupancy, habitat, wildfires, etc.
- Joshua Tree NP has a long-term vegetation monitoring project with Cam Barrows, with a 5-year return cycle. This has expanded to Santa Rosa-San Jacinto NM

Emily Presley - BLM Palm Springs South Coast Field Office

- Specific surveys for projects, monitoring vehicle incursions

Appendix F: Remaining Needs and Challenges - Breakout group notes

Need/Challenge	How to address?	Existing resources
Land use changes in the Southwest; large-scale development	Talk to eco-regional experts about patterns in land use change Learn about local drivers of economic growth, population growth, etc.	Local development plans US Census Bureau population projections Mitigation funds Federal infrastructure bill→ $ for fuels/fire management
Climate change	Take opportunities that accompany the changes (e.g. terrestrial/riparian habitat is formed when lake levels drop)	Mojave Rapid Ecological Assessment contained predictive climate modeling. Took a similar approach to the Great Basin REA.
Planning for climate change	Plan for hotter, drier conditions. Source seed so that it's adapted to restoration sites.	USGS climate distance mapper.
Increase proactive restoration work	Do not ignore the importance of immediate response to disturbances. Develop a way to analyze and prioritize focal areas/activities to best utilize available resources. Create a geospatial map to support prioritization of management actions Prepare to take advantage of upcoming resources (e.g. infrastructure bill funding)	Refer to efforts of Sagebrush Initiative - they are preparing to address challenges and utilize resources Geospatial files associated with potential Clark County lands bill 2009 Habitat Assessment model

	Consider launching a desert tortoise-specific tool from EMCC data explorer	USGS habitat connectivity model
Site selection for maximum success	Need a better way to prioritize/choose sites that have the highest likelihood of success	SWOT analysis
Prioritize site activities proactively	Proactively develop seed collection programs, such as taking advantage of locations within districts that have good rainfall in a particular year	Prioritize site activities proactively
Identify the “sustainable value” people consider tangible in the Mojave Desert		Refer to values described in desert tortoise Recovery Plan, Clark Co plan, DRECP. Older plans may have been on paper only.
Access to native plant materials	Partnerships to grow local seed Dry planting techniques	NV Forestry partnership USGS Common gardens
Fire management	More options like herbicide to protect restoration investments (decision thresholds) Research on herbicides in desert tortoise habitat	(Some) herbicide approvals in the works
Wildfire management	Consider resilience of the system in species selection Install fire breaks and barriers to fire Use maps of fire risk Control abundance of high fire risk species	
Maintenance of new plantings	Dry planting techniques	Vertical mulching
Subsidized predators (e.g. Ravens and Coyotes)	Placement of projects away from predators	

	Raven management fund - developers put money into a fund to mitigate predation	
Renewable energy development and habitat loss	Effective mitigation strategies so that developers can offset impacts Implement long-term policy that mandates money be put into a restoration “bank”	Example: Burrowing Owl Grassland Mitigation Fund (San Diego Foundation)
Loss of desert tortoise habitat to renewable energy development, such as solar	Work with solar proponents to improve conditions of the facilities for desert tortoise and other species after construction. Make sure the land is restructured and becomes functional to desert tortoise again.	
Disturbance from uses such as OHV	Change behavior that is affecting this system (i.e. OHV impacts)	
desert tortoise road mortalities (separate from OHV)	Fencing coupled with strategies that allow connectivity across roads (e.g. culverts) Signage on roads to announce desert tortoise crossing	
Lack of restoration funding	Establish mitigation funding “bank” - large pot of money with multi-year horizons that can be used strategically across the landscape	Example: Burrowing Owl Grassland Mitigation Fund (San Diego Foundation)
Hard to convince partners and funders to invest in desert tortoise restoration	Set realistic expectations for restoration Find ways to demonstrate/share success stories	
Short funding windows	Work with funders to extend funding windows	Have multiple projects ready to implement
Funding for monitoring	Build into project budgets as part of adaptive management	

Limited resources	Incorporate restoration into routine agency activities; meet multiple goals (e.g. fuels management for habitat restoration and archaeological resources preservation)	
Limited staff capacity	More staff Partnerships Capacity building	Existing staff NGO partners
Long-term projects are needed for successful restoration	Develop long term plans (20yrs) using formal (open standard) planning processes Incorporate adaptive management	Open Standard Planning Processes
Need longer-term restoration perspectives	Incorporate longer horizons in management planning; utilize CESU-type agreements	
Set realistic restoration targets	Restore ecological function instead of historical reference condition Utilize adaptive management Better communication with upper management	
Improve maintenance of restored sites (prevent further damage)	Enhance communication with law enforcement. Public outreach and information sharing Foster a sense of stewardship Invest in encouraging behavior changes	Examples of existing successes such as Tread Lightly
Site maintenance after treatment	Incorporate into new restoration and site management plans (irrigation, weed control, etc.)	
Excess of pet tortoises vs. dearth of wild tortoises	Explore use of pet juveniles for research and translocations.	Research by USGS (Todd Esque) and DCP

Information-sharing / Lessons learned	Share lessons learned	MSTS monitoring, presentations, annual reports

Appendix G: Photo Gallery

Photo Credits:
Panel One: 1 - J.Moore; 2 - E.Hibbard; 3 - F. Deffner; 4&5 - E. Hibbard
Panel Two and Three: K.Lalumiere