Conserving Climate Change Refugia for the Mojave Ecosystem

WORKSHOP REPORT

Presentations Available at **https://www.climaterefugia.org/mojave**

> *Climate Change Refugia: Areas that remain relatively buffered from contemporary climate change over time and enable persistence of valued physical, ecological, and socio-cultural resources. Morelli et al. 2016 PLOS ONE*

The Conserving Climate Change Refugia for the Mojave Ecosystem workshop was held virtually via zoom on Wednesday, December 9, 2019, using funding from the Southwest Climate and the Northeast Climate Adaptation Science Centers (SW and NE CASCs).

The objectives of this workshop were to bring together natural resource managers and researchers to 1) learn about current work in the Mojave ecoregion related to climate adaptation, 2) prioritize focal species/ecosystems for climate change refugia conservation/funding, and 3) identify research gaps, all in service of operationalizing climate change adaptation strategies in the Mojave ecoregion.

The meeting began with presentations by researchers and resource managers who have been working on key resources in the Mojave ecoregion. The function of these presentations was to provide background on climate change refugia conservation and existing data and projects relevant to climate change adaptation in the Mojave ecoregion (see Appendix 1).

Prior to the meeting, workshop participants were polled for their opinions about which Mojave ecoregion resources should be conserved using a climate change refugia strategy. Based on participant responses, workshop facilitators arranged several potential discussion groups around proposed priority resources. These results were shared with the workshop group during the meeting, and participants provided feedback to refine the priority resources. The group settled on the following 4 resources for further discussion (riparian systems, desert dry wash woodland, and birds were also proposed as categories but ultimately not pursued for focused discussion during the workshop):

Priority Resources for Climate Change Refugia Conservation in the Mojave Ecoregion:

- Springs (including pupfish, spring snails)
- Desert scrub (including Joshua Tree, Black Brush)
- Desert tortoise
- Bighorn sheep

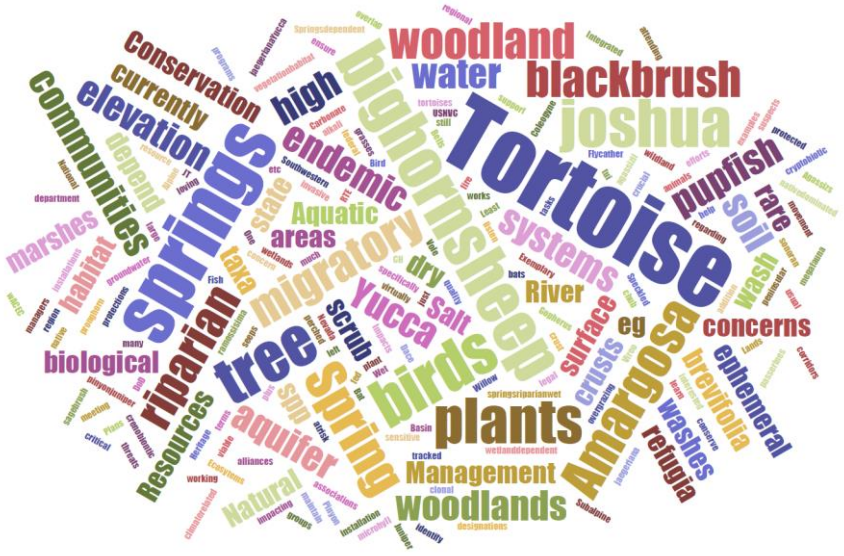


Figure 1: Participants response to *What resources (e.g., species, ecosystems) would you like to see refugia conserved for in the Mojave?*

After defining the priority resources, workshop participants signed up for their first or second-choice resource and split into Zoom breakout groups (Appendix 3) to answer the following questions:

1. *What is your specific resource focus? How do you define refugia for it?*
2. *How to apply climate change refugia results to ongoing or future management actions?*
3. *What data and partnerships are a) available and b) needed?*

Breakout room groups then reunited to report their major discussion points. To wrap up the day, workshop participants discussed the needs and next steps for climate change refugia conservation.

Workshop participants refined several priority focal resources for which climate change refugia should be conserved, described projects and data that might be used to identify refugia, and brainstormed potential management actions to conserve refugia.

Follow-Up Survey

The meeting facilitators then sent a follow-up survey to assess whether meeting objectives were met and gauge interest in additional work toward operationalizing climate change refugia conservation in the Mojave, which might involve working groups, additional videoconference meetings, and the development of federal and state grant proposals.

Most participants felt the workshop was very useful, with building collaborations and discussions of current research highlighted as the most valuable aspects.

Identified Research Gaps/Management Opportunities

The following research gaps and management opportunities were identified either through discussions in the workshop or through the follow-up survey:

Most survey participants prioritized the following next steps for climate change refugia conservation in the Mojave Ecoregion:

1. *Use the information currently available to collaboratively identify short-term/immediate management actions for preserving or enhancing climate refugia in the Mojave Desert.*
2. *Compile information on climate change refugia in the Mojave Desert and summarize/report the state of this information.*
3. *Create a Springs Working Group for collecting information on and coordinating management of springs in the Mojave Desert.*
4. *Gather more information on the movement and future viability of plant species such as Joshua tree, blackbrush, and/or vegetation that supports wildlife.*

Overall

- Centralized location of data on climate refugia for the Mojave
- Map refugia for important species/ecosystems, strategies for managers to better conserve these areas.
- Model validation.
- Map water availability and trends.
- Baseline data (distribution and threats) on plant communities, springs/wetlands, rare species.
- Population surveys showing extant population and the edges that occur near areas with projected suitable future climates.
- High resolution future climate data, especially with soil moisture variables.
- Better resolution to soil data, or a newer compilation of what is available.
- Restoration of interior department documents and datasets, it was taken offline during the last four years.
- Better information on invasive species presence and density, particularly of annual grass species including red brome and *Schismus sp*. as an indicator of fire risk and native plant community degradation.
- Data is needed to determine what is happening on the ground.
- Engage/connect with leaders of state climate initiatives.
- Continue to bring climate change researchers together with those who have data on species at risk.
- Creation of a springs working group for the Mojave.
- How agencies, including regulatory agencies, want others to comply with their climate change requirements when in consultation (e.g., Section 7 of ESA).

Springs (including pupfish, spring snails)

- Working group on springs of the Mojave
- Landscape-scale data combined with ground truthing of springs.
- Baseline data in Mojave.
- Distribution of invasive and native species.

- Link spring data with other data, such as upland associations or topography.
- Incorporate legacy data into modern databases.

Desert scrub (including Joshua Tree, blackbrush)

- For Joshua tree, there are at least two varieties/species, so any work should be specific to the type of tree and habitat (see below for approximate delineation of *Y. brevifolia* and *Y. jaegeriana*).
- Blackbrush also ranges into the Great Basin Desert, and co-occurs with a variety of other vegetation.
- On the whole, refugia information can be used for fire management prioritization (fuel breaks, reduction of invasive grasses). Both occur where there is some natural occurrence of lightning and wildfire naturally can occur, particularly during monsoonal events, but into the future, information on refugia will be necessary to preserve the already reduced stands of both species.
- There also could be some value to studying conditions necessary for upper (leading edge) refugia areas to recruit and support the species there, but neither community is known for rapid dispersal and colonization into new areas.
- More information is needed about how land use historically impacted desert shrub.
- Research needs to be conducted on how to reestablish black brush after fire.
- Need to develop restoration prescriptions for blackbrush (why do they naturally recover in flat bottom borrow pits created in 1957 along US89A north of Page, AZ?)

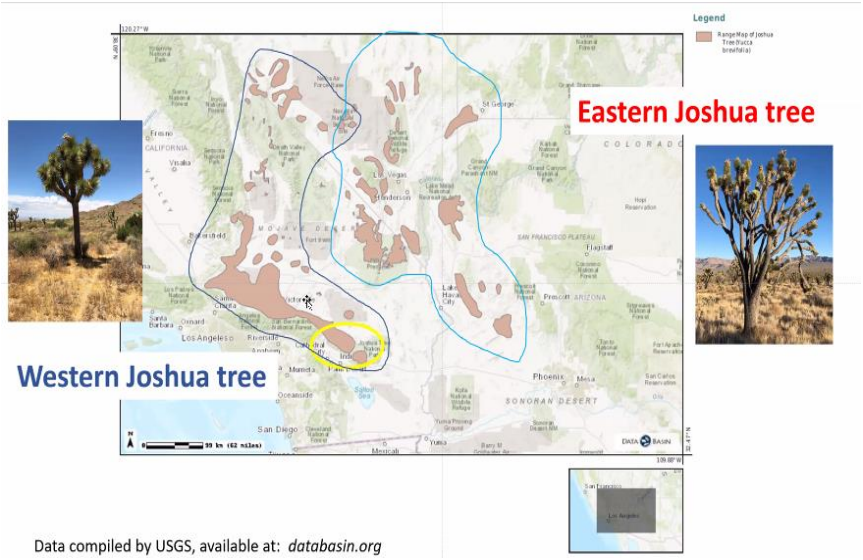


Figure 2: ***Excerpt from Lynn Sweet's Presentation***

Desert tortoise

- Genetics vs. behavioral plasticity in reproductive timing.
- Determine if tortoises in refugia areas would be successful in reproduction/survival.
- More important is ratio of native vs. non-native annual forage -- where are species locations currently vs where they might be in the future.
    - Tortoises need species diversity for nutritional needs.
    - Seedbanks in soils -- what is the quality?

    - Overall forage quantity/primary productivity (winter rainfall a big factor).
    - Some available modeling for this but maybe hasn't been leveraged yet in tortoise science.
    - Invasive Bromus distribution and projection in the future -- maybe places where tortoise & Bromus projections overlap under climate change could be a good indicator.
    - Current known tortoise distribution vs. capacity based on range wide sampling (areas they could occupy but don't yet)
    - Habitat adjacency (i.e., connectivity) (so that tortoises have capacity to move into nearby quality habitat)
- Potential study:
    - Black brush not typically associated with desert tortoise, but on their site (DOE Nevada National Security Site) desert tortoise use black brush quite a bit.
    - Southern portion of their site is in desert tortoise habitat, north is not; if can get permission from FWS to get transmitters on the tortoise, could be uniquely situated to understand range shifts/climate change impacts on desert tortoise.

Bighorn sheep

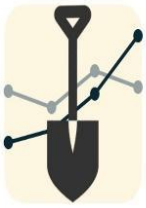
- Understanding of how each metapopulation will be affected.
    - Some populations have some protections, but others are facing anthropogenic disturbances. Climate change exacerbates these existing stressors. One effective strategy would be to eliminate other threats.
    - Some populations are more vulnerable than others in national parks based on higher elevation and vegetation (Clint Epps work)
- Need NDVI data to look at biomass during springtime for lamb survival/recruitment.
- How green up is being impacted among populations across the region, especially in the Southern Sierra Nevada.
- Currently have an index of vulnerability, but there is need for better data on thresholds.
    - What is the threshold for temperature and precipitation for low elevation populations?
    - What levels of climate change will affect populations?
- Disease dynamics and climate change
    - How climate change affects outbreaks of pneumonia
- Identifying areas of concern, maintaining connectivity where roads are in place.
- Maximize what sheep need to allow for adaptation.

Summary and next steps

From the working groups, 4 research priorities arose:

- Start a working group on springs of the Mojave Ecoregion.
- Develop prescriptions for reestablishing blackbrush after fire disturbances.
- Map distribution and vulnerability of forage.
- Analyze how each metapopulation of Bighorn sheep will be affected.

Appendix 1: Workshop Agenda



REFUGIA RESEARCH COALITION
RRC
connecting science to actions

USGS
science for a changing world

Southwest Climate Adaptation Science Center

NECASC
Northeast Climate Adaptation Science Center

Conserving Climate Change Refugia for the Mojave Ecosystem

December 9, 2020

https://umass-amherst.zoom.us/j/876697350

1-646-876-9923; Meeting ID: 876 697 350

Workshop Objectives:

-Learn about current work in the Mojave ecoregion related to climate adaptation
-Prioritize focal species/ecosystems for climate change refugia conservation/funding
-Identify research gaps

> ***Climate Change Refugia*** *= Areas that remain relatively buffered from contemporary climate change over time and enable persistence of valued physical, ecological, and socio-cultural resources.*
>
> *(Morelli et al. 2016, PLOS ONE)*

9:00-10:00 PT Introductions
Background on climate change refugia conservation – Toni Lyn Morelli (USGS)
Background on Mojave Conservation – Julia Sittig (Southwest Decision Resources)
Choose a breakout group

10:00-11:00 PT Presentations by researchers and managers on Mojave refugia maps and data:

- Springs/Seeps – Larry Stevens (Spring Stewardship Institute)
- Joshua Tree – Lynn Sweet (UC Riverside)
- Desert Tortoise – Roy Averill-Murray (USFWS)
- Bighorn Sheep – Kathy Longshore (USGS)
- Case Study, Amargosa River – Michael Clifford (TNC)

11:20-12:00 (Virtual) Breakout groups – Focal Resource
Address the following questions:

1. *What is your specific resource focus? How do you define refugia for it?*
2. *How to apply climate change refugia results to ongoing or future management actions?*
3. *What data and partnerships are a) available and b) needed?*

12:00-12:45 Report out and Next Steps

Appendix 2: Participant List

Name	Organization
Kim Marsden	BLM CA
Judy Perkins	BLM CA
Chris Otahal	BLM CA Barstow Field Office
Kristen Lalumiere	BLM CA Palm Springs South Coast Field Office
Janyne Pringle	BLM Las Vegas
Boris Poff	BLM Southern Nevada
Marla Steele	Center for Environmental Management Military Lands (CEMML)
Khishigbayar Jamiyansharav	Center for Environmental Management Military Lands (CEMML)
Kay Hankins	Chicago Botanic Gardens
Theresa Galhouse	Chicago Botanic Gardens
Abbie Zastawny	Chicago Botanic Gardens
James McAuliffe	Chicago Botanic Gardens
Scott Cambrin	Clark County Desert Conservation Program
Sally Miller	Consultant to CA NGOs, CA Desert & Eastern Sierra
Maggie Fusari	Desert Tortoise Council
Terry Christopher	Great Basin Institute
Brian Henen	Marine Corps Air Ground Combat Center
Derek Hall	Mission Support and Test Services
Chris Clarke	National Parks Conservation Association
Anna Johnson	Nellis Air Force Base
Olivia Baez	Nellis Air Force Base
Gary Reese	Nevada Division of Forestry
Kristin Szabo	Nevada Division of Natural Heritage
Neil Frakes	NPS Joshua Tree National Park
Neal Darby	NPS Mojave National Preserve
Kevin Wilson	NPS Death Valley National Park
Ali Ainsworth	NPS Death Valley National Park
Allen Calvert	NPS Mojave Desert Inventory and Monitoring Network
Joseph Ladd	NPS Mojave Desert Inventory and Monitoring Network
Drew Kaiser	NPS Mojave National Preserve
Bill Lamb	Quadstate
Andres Mendoza	RRC Intern (meeting facilitation support)
Julia Sittig	Southwest Decision Resources / EMCC Facilitator
Larry Stevens	Springs Stewardship Institute
James Danoff-Burg	The Living Desert Zoo and Gardens
Michael Clifford	The Nature Conservancy
Lynn Sweet	UC Riverside
Cathleen Balantic	UMass/NECASC (meeting facilitation support)
Sara Wisner	UMass/NECASC (meeting facilitation support)
Jim Malusa	University of Arizona
Jim Hurja	USDA FS Humboldt-Toyaibe National Forest
Katy Gulley	USDA FS Humboldt-Toiyabe National Forest
Roy Averill-Murray	USFWS Desert Tortoise Recovery Office
Nifer Wilkening	USFWS National Wildlife Refuge System

Toni Lyn Morelli	USGS, NE CASC (Meeting Facilitator)
Kathryn Thomas	USGS
Kathy Longshore	USGS
Carolyn Enquist	USGS, SWCASC

Appendix 3: Priority Resource Breakout Groups

Springs
Larry Stevens
Michael Clifford
Andres Mendoza
Allen Calvert
Jim Hurja
Kristin Szabo
Kevin Wilson
Boris Poff
Abbie Zastawny
Olivia Baez
Theresa Galhouse
Chris Otahal

Desert Scrub
Lynn Sweet
Sara Wisner
Chris Clarke
Neil Frakes
Gary Reese
Joseph Ladd
Derek Hall
Anna Johnson
Drew Kaiser
Judy Perkins
Sally Miller

Desert Tortoise
Roy Averill-Murray
Cathleen Balantic
Julia Sittig
Brian Henen
James Danoff-Burg
Scott Cambrin
Maggie Fusari
Terry Christopher
Khishigbayar Jamiyansharav
Neal Darby

Bighorn Sheep
Kathy Longshore
Nifer Wilkening

Appendix 4: Breakout Group Notes

Springs (including pupfish, spring snails)

Address the following questions:

1. What is your specific resource focus? How do you define refugia for it?

Geographically, mostly Eastern Mojave.
Springs
Seeps-ephemeral
Spatial scope: across elevation
Spring classification is a great debate. The water resources, so water exits the ground but has an outsized impact on the environment. Springs not only function internally but have a broader role on the landscape.

2. How to apply climate change refugia results to ongoing or future management Actions?

Important to consider the species that require the water and use water
Keystone ecosystem concept -- small spatially, large impact ecologically
Montane springs may be more greatly impacted by climate change as they depend on precipitation at shorter-scales.
Lower elevation springs may be more buffered as water can be 10,000 years old, but groundwater pumping/use may be greater threat than climate change
Groundwater pumping increases 2-5 times during drought and reliance on groundwater becomes greater. Will then have greater influence on springs and water resources. Will require a societal discussion.
Groundwater modeling is more small-scale.
Groundwater modelling and drilling is expensive and requires a collaborative effort.
Still a lot of uncertainty around the impact of groundwater pumping on groundwater dynamics and impacts to springs.
High resolution modelling is likely the most useful for understanding springs.
Springs are usually highly sustainable and can have water removed and still remain viable, however water laws are not often conducive for conservation.
Need to keep ecological functionality in mind.
Data security is an important factor.
Policy needs changed to better conserve springs.

3. What data and partnerships are a) available and b) needed?

Available data and resources:
Need landscape scale data combined with groundtruthing of springs. Still need baseline data in Mojave. Need to understand distribution of invasives and native species
SSI database integrates data from multiple partners and agencies.
CA is not contributing data to spring snail
NTTR monitors most species on the Range. Species are reported to FWS, NDOW and other agencies.
Nevada and Utah Springsnail Conservation Agreement and Strategy http://heritage.nv.gov/zoology

NPS monitors springs in Mojave Desert and working to upload data into SSI database. Data collected on three-year rotation.
Important to be able to link spring data with other data, such as upland associations or topography
TNC groundwater dependent ecosystems publication (L. Saito)
Some Data shared via the Survey that could be relevant:
NNHP has database in NV on at risk species. Database is species focused.
National Wetland Inventory
potential to use data from the NABat monitoring program to try and see if there's enough data in the future to get a Mojave regional analysis. In addition, we are using NABat in Mojave region national park units and most of our locations are at springs so there's potential to try and glean some info specific to springs and of course I welcome others that may be doing bat work to try and find overlap in monitoring locations that would benefit broader research like climate change (Allen Calvert)

Needs:
Don't have good data on interaction between spring and surrounding landscape.
Develop research agenda to better understand springs
Find legacy data and incorporate into modern databases
Working group on springs of the Mojave would be useful

Desert scrub (including Joshua Tree, Black Brush)

Address the following questions:

1. What is your specific resource focus? How do you define refugia for it?

- Joshua tree communities -Focus on taxa -2 species, 2 varieties
- Blackbrush communities

Geographic focus:

Initial workshop focus is Eastern Mojave region, or Mojave as a whole? Expand to the entire region where species will be or transition to? This would include the Colorado Plateau and Great Basin Ecosystems. Needs to be addressed to focus.

Might come down to feasibility in terms of dialing in management use/goals and data availability

2. How to apply climate change refugia results to ongoing or future management Actions?

Creating refugia by identifying the most plant diverse black brush and implementing management prescriptions to protect them from wildfires.

- Fuel breaks
- Remove invasive grasses

Nevada Security Site (?) - early response to deal with lightning strike caused fires

Brush crews on site, look for smoke plumes and look for fires, following monsoons - limited in huge fire years though

Joshua Tree National park most fires start from lighting strikes, they also have fire crews to look out for fires.

3. What data and partnerships are a) available and b) needed?

Biodiversity rankings on classification plots of both blackbrush and joshua tree dominated alliances within Spring Mountains National Recreation Area

Nevada Division of Forestry: Priority Landscape Area in 2020 Forest Range & Watershed Action Plan

- Future focus of future management actions on the NW Las Vegas area wildlands
- Do we need to reduce competition at upper altitudes where Joshua trees are migrating to, such as thinning Utah juniper and big sagebrush (would also help in wildfire protection of refugia)?

Todd Esque current mapping of Joshua trees based on satellite data

Presence / absence

Not a model

Also some distributed plots in several National Park units (JOTR, DEVA, others)

Joshua Tree genome mapping project - Chris Smith, Jeffrey Yoder + Todd Esque et al.

- Reach out to them
- Data for both western and eastern trees

Need more information about how land use historically impacted
Research needs to be conducted on how to reestablish black brush after fire

Gary Reese

- created 30 permanent plots in Clark Co., NV, discovered 16 associations. They require more protections
- Mapped Joshua tree density and height to 1 km resolution, or better, throughout Clark Co., NV, provided this shapefile to USFWS for data call on T/E listing

Need to develop restoration prescriptions for blackbrush (why do they naturally recover in flat bottom borrow pits created in 1957 along US89A north of Page, AZ?

Desert tortoise

Address the following questions:

1. What is your specific resource focus? How do you define refugia for it?

- Mojave Desert Tortoise
- Habitat quality matters too; but not defined quantitatively, often relies on expert opinion ⇒ current work to translate that expert knowledge into more specific metrics
    - What variables define quality habitat? (e.g., shrub cover, native vs non-native annuals, perennials, soil substrate, precipitation, winter & summer temperatures, other climate variables, human centered aspects of habitat quality: proximity to roads, OHV use, visitation)
    - Todd Esque (USGS, Western Ecological Research Center (WERC))
    - Kerry's models with roads and habitat fragmentation
- Geography:
    - Patchiness in knowledge

    - Should look at full range, not just Eastern Mojave
    - Need to be practical about prioritizing which refugial areas can actually be managed

2. How to apply climate change refugia results to ongoing or future management actions?

- NRCS soil surveys ⇒ use for modeling? Past work has run into sample size issues and continuity.
    - Geomorphology critical for burrowing.
    - Will have a third order soil survey completed at Mojave National Preserve -- could tie in burrow substrates with soils to map that way
    - What is mechanistic link between tortoise and distance to bedrock (https://databasin.org/datasets/7977bbcc26d548228106dd25b2ca042d)
- Genetics vs. behavioral plasticity in reproductive timing
- Would tortoises in refugia also be the ones who are successful in reproduction/survival?
- Known characteristics of climate change refugia for tortoise?
    - It's a generalist, so don't need to worry about individual forage species
    - More important is ratio of native vs. non-native annual forage -- where are species locations currently vs where they might be in the future
        - Tortoises need species diversity for nutritional needs
        - Seedbanks in soils -- what is the quality?
        - Overall forage quantity/primary productivity (winter rainfall a big factor)
        - Some available modeling for this but maybe hasn't been leveraged yet in tortoise science
        - Invasive *Bromus* distribution and projection in the future -- maybe places where tortoise & *Bromus* projections overlap under climate change could be a good indicator
    - Current known tortoise distribution vs. capacity based on rangewide sampling (areas they could occupy but don't yet)
        - Habitat adjacency (i.e., connectivity) (so that tortoises have capacity to move into nearby quality habitat)
- What organizational infrastructure do we have for operationalizing climate change refugia. Could current working groups/orgs take this info and use it, or would we need new groups / tools to get there?
    - Many entities involved; challenging but improving at info-sharing & concerted directions; still not clear on a roadmap across large landscapes
    - Agencies often driven by legal mandates (e.g., Endangered Species Act, Integrated Natural Resource Management Plan, NEPA); mandates provide the focal framework; military climate change responsibilities/guidance are obscure at the moment
    - Tortoise already has a working group so could be an asset for this effort

3. What data and partnerships are a) available and b) needed?

- Several items mentioned above
- Available: Two large-scale SERDP projects mentioned in Roy's presentation -- anxiously awaiting the results, will undoubtedly identify needs for future work. Looking at the project timelines of the two SERDP tortoise projects, map products should be produced in early to mid-2021 (assuming that things are relatively on track).
- RE: Desert tortoise partnerships, the range-wide DT Management Oversight Group has recently bitten off large-scale issues such as population connectivity and addressing highway impacts, so this group should be poised to take on related issues to climate change.

Other comments on DT during report out:

Derek Hall (Mission Support and Test Services)

- Black brush not typically assoc'd with DT, but on their site (DOE Nevada National Security Site) DT use black brush quite a bit
- Southern portion of their site is in DT habitat, north is not; if can get permission from FWS to get transmitters on the tortoise, could be uniquely situated to understand range shifts/climate change impacts on DT

Bighorn sheep

Address the following questions:

1. What is your specific resource focus? How do you define refugia for it?

Bighorn Sheep and related habitat and movement corridors. Metapops need connectivity. Mountain ranges, high elevation habitats with appropriate vegetation and water availability and forage. For all mountain ranges with/without natural water sources, we need NDVI data to look at biomass during springtime because that is important for lamb survival/recruitment. The timing and amount of green up is really important for lamb survival.

2. How to apply climate change refugia results to ongoing or future management Actions?

Each metapopulation has its own issues. Some pops are somewhat protected, but others are facing other anthropogenic disturbances. Climate change exacerbates these existing stressors. One effective strategy would be to eliminate other threats.

We know some pops are more vulnerable than others in national parks based on higher elevation and vegetation (Clint Epps work). But managers need to make decisions about which pops to focus on, and what the implications are if certain pops are negatively affected (ie, how does this affect metapop overall).

We have an index of vulnerability, but we need better data about thresholds (eg, what is the threshold for temp and precip for low elevation pops). What levels of climate change will affect pops? We need to monitor CC to better determine how changes directly affect pops (eg, how many drought years in a row can pops take before they are pushed over the edge, etc.). Also synergistic relationships, how does this tie in to disease.

Other than identifying these needs, the other question becomes what do we do?

3. What data and partnerships are a) available and b) needed?

Available partnerships and data include:
Partnerships that provide data that can be useful (phenotypic or NDVI, etc.)
Partnerships include land management agencies and Dept of Wildlife; Desert Bighorn Council; local groups that help take care of water needs such as providing water sources at refuges; interagency management team that works on long term planning and conservation efforts; several iterations of management plans include current threats and these could be could starting point for incorporating climate change;
A better understanding of how each metapop will be affected.
Southern nevada pops, we need more information about how green up is being impacted among pops across the region.
Managers are providing water because it is a game animal and the state manages for sheep because they translocate animals around the state to improve pop condition, etc.
We don't know how CC affects outbreak of pneumonia, we need more info about disease dynamics and CC.
Identifying areas of concern, maintain connectivity where roads are in place.
Maximize what sheep need to allow for adaptation.
High degree of behavioral plasticity may have high levels of adaptive capacity.
Bighorn sheep are a great umbrella species for mountain communities.