GOLDEN CURRANT SOLAR PROJECT

INPUT SUMMARY REPORT

Bureau of Land Management
Southern Nevada District Office
Las Vegas Field Office
4701 North Torrey Pines Drive
Las Vegas, NV 89130

August 2022

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1.0 INTRODUCTION

Noble Solar, LLC (Applicant) proposes to construct, own, operate, and decommission the Golden Currant Solar Project (Project), consisting of up to a nominal 400-megawatt (MW) alternating current (MWac) solar photovoltaic (PV) power generating facility and 400-MW Battery Energy Storage System on BLM-administered land located in Clark County, Nevada, approximately 5 miles southeast of Pahrump and 26 miles west of Las Vegas. State Route 160 is less than 2 miles northeast of the site.

In 2012, BLM and the United States Department of Energy released the Final Programmatic Environmental Impact Statement for Solar Energy Development (Solar PEIS) in six southwestern states (Arizona, California, Colorado, Nevada, New Mexico, and Utah) and a Record of Decision was approved October 2012 (amending the Las Vegas Resource Management Plan). The comprehensive Solar PEIS facilitated the permitting of solar energy development projects on federal public land in a more efficient, standardized, and environmentally responsible manner. The Solar PEIS designated Solar Energy Zones that are well suited for utility-scale production of solar energy and also designated variance areas on BLM-administered lands that are outside of the Solar Energy Zones and not otherwise excluded by the Solar PEIS. Variance areas are available for utility-scale solar energy development on a case-by-case basis and are evaluated through the BLM's established variance process. As part of the variance process, the applicant must demonstrate that the proposed project would avoid, minimize, and/or mitigate the impacts to sensitive resources, according to standards set out by the Solar PEIS.

The BLM considers right-of-way applications for utility-scale solar energy development in variance areas on a case-by-case basis based on environmental considerations; coordination with appropriate federal, state, and local agencies, and Tribes; and public outreach. Information gathered during the public input period will inform the variance process as well as the BLM determination on whether to continue to process or to deny the right-of-way application (application evaluation determination). The application evaluation determination, including the variance process determination, is separate and comes before the National Environmental Policy Act (NEPA) process. More information about the application evaluation process is included on the website: https://www.blm.gov/sites/blm.gov/files/docs/2021-11/Nevada%20-%20SNDO%20-%20Solar%20Application%20Eval%20Process%20Fact%20Sheet_0.pdf

The purpose of this report is to summarize input provided by individuals, organizations, Tribes, and agencies during the public input period for the Project. This report also describes methods used for soliciting input.

PROJECT DESCRIPTION

The Project would be constructed using PV solar modules mounted on single-axis, horizontal tracker structures. The Project will be located on approximately 4,364 acres of BLM administered land. The ROW application contains a larger area than required for the solar field to allow for adjustments in the facility layout to minimize environmental impacts, based on the National Environmental Policy Act (NEPA) analysis.

The power produced by the Project would be conveyed to the NV Energy ("NVE") transmission system or the California ISO transmission system ("CAISO") via a 2.1 mile long 230 kV overhead Gen-Tie to the Trout Canyon 230 kV substation where the Project holds an interconnection queue position. Average annual energy production from a 400 MWac project equates to the annual daytime electricity needs of approximately 230,000 households. Solar electric power is produced during daylight hours when electricity demand is highest which will be coupled with battery energy storage technology in order to improve the customer's energy product.

The Project would generate greenhouse gas-free electricity that would offset approximately 860,000 metric tons of carbon dioxide and other emissions that would result from producing an equivalent amount of electricity from fossil fuel-fired electric generators.

2.0 NOTIFICATION AND SOLICITATION OF INPUT

During the public input period, the BLM informed the public, landowners, federal, state, and local government agencies, Tribes, and interested stakeholders about the proposed Golden Currant Solar Project and solicited their input. The BLM announced the Project and the initiation of the public input process, held public information forums, and invited the public to comment and ask questions. The public information forums were publicized on the Project website and BLM social media accounts, in letters mailed to interested stakeholders, and through public notices/news releases. These outreach and notification activities are described in more detail in the following subsections.

TRIBAL CONSULTATION AND COORDINATION WITH NATIVE AMERICAN TRIBES

Thirteen Indian tribes have been identified and invited to consult on this undertaking and include: Chemehuevi Indian Tribe, Colorado River Indian Tribes, Fort Independence Band of Paiute Indians, Fort Mojave Indian Tribe, Hopi Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, Las Vegas Paiute Tribe, Moapa Band of Paiutes, Paiute Indian Tribe of Utah, San Juan Southern Paiute Tribe, Twenty-Nine Palms Band of Mission Indians, and Utu Utu Gwaitu Paiute Tribe (Owens Valley Paiute Benton Reservation). The tribes were notified, and formal Government-to-Government consultation was requested in the early stages of project planning by letter dated May 2, 2022. The BLM has also identified the Big Pine Paiute Tribe as having ties to the proposed Project area and will formally invite the Tribe's participation.

The BLM has received a formal response from the Moapa Band of Paiutes and discussed the Project in a Government-to-Government meeting on July 21, 2022. Tribe expressed concerns about the status of various surveys and how tribal input would be included the overall project review, tortoise treatment during various stages of the project, vegetation treatments, and a request for a site visit. The BLM is working to coordinate the site visit request from the Moapa Band of Paiutes. The BLM is gathering information from the tribes regarding the identification of any additional KOPs for the visual resources analysis, cultural resources that should be included in the Section 106 of the NHPA and NEPA analysis, and other concerns the tribes may have with the proposed Project. Government-to-Government consultation for the proposed Project is ongoing.

PROJECT WEBSITE

The BLM issued a press release on July 1, 2022. The press release included information about the proposed Project and variance process; registration information for the virtual public information forums; instructions for providing written input; and contact phone numbers—one for the media and the other for general questions. After the two virtual public information forums, the website was updated to include links to video recordings of the forums in addition to the lists of questions and answers from each of the forums. The website will remain active for the duration of the application evaluation process and can be accessed at www.blm.gov/press-release/land-segregation-announced-golden-currant-solar-project

NOTICE OF VIRTUAL PUBLIC INFORMATION FORUMS

Notice of the virtual public information forums for the Golden Currant Solar Project was distributed via postcards, emails, and BLM social media accounts. Postcards were sent by the BLM to government agencies, elected officials, property owners near the proposed Project, various non- governmental organizations, Native American Tribes, individual members of the public, and other interested stakeholders. The postcards briefly explained the Project, identified the application evaluation and variance processes, announced the virtual public information forums, and described how to access additional information. Included on the postcard was a map displaying the Project location. Over 4700 postcards were mailed on July 6, 2022. The postcard can be found in **Appendix A**. In addition to postcards, notifications of the virtual public information forums were distributed via email to interested publics, agencies, and Native American Tribes.

METHODS FOR SUBMITTING INPUT

The BLM publicized that public input would be accepted until August 5, 2022, and encouraged interested parties to submit input through a variety of methods:

- Written input could be submitted via email to: BLM_NV_SND_EnergyProjects@blm.gov.
- Letters could be mailed to: BLM SNDO, Attn: Golden Currant Solar Project Variance, 4701 N. Torrey Pines Drive, Las Vegas, NV 89130.
- Input could be provided verbally at the virtual public information forums. A link to the recording for each virtual public information forum can be found below: https://www.blm.gov/press-release/land-segregation-announced-golden-currant-solar-project

3.0 VIRTUAL PUBLIC INFORMATION FORUMS

The BLM hosted two virtual public information forums using the Zoom online platform. These forums provided a description of the application evaluation and variance processes, information on the proposed Project, and the opportunity to ask questions and provide public input. The two virtual public information forums were held at the times listed below.

DATE	REGISTERED	ATTENDED
July 19, 2022 6:00 p.m. to 8:00 p.m. PST	39	36
July 20, 2022 6:00 p.m. to 8:00 p.m. PST	45	23
Total	**84**	**59**

Registration for the virtual public information forums opened July 1, 2022 and was announced via the press release and postcard. Registration was required in order to attend the meeting and participants were able to register at any time, including during the forum. The virtual public information forums were open for participation for the duration of the announced time from 6:00 p.m. to 8:00 p.m. PST. Those without access to a computer were still able to register and participate via phone. Those who were not able to join the live forum could access a recording of the meeting in addition to the lists of questions and answers from each of the forums on the Project website.

PRESENTATION

A formal presentation was included as part of the forum. The presentation opened with a welcome and overview by Kenda Pollio, a consultant for the BLM. The Field Manager, Shonna Dooman, provided introductions for the meeting. Then the Project Manager, Jessica Headen provided information about the proposed Project and application evaluation process. The presentation included maps and information about the Project location; descriptions of the major Project components; information about the application evaluation process in solar variance areas; and resources for additional information.

After the formal presentation, Kenda Pollio facilitated the live question and answer section with Jessica Headen before moving into the verbal input portion and then a closeout by Shonna Dooman. Throughout the meeting, participants were reminded that the public input period would close on August 5, 2022, and that additional comments could be sent in via email or mail. Additional information about the question and answer and verbal input portions of the virtual public information forums is provided below.

The PowerPoint presentation provided a visual aid for the virtual public information forums and is provided in **Appendix B**. As previously mentioned, the entirety of each virtual public information forum was recorded and posted to the Project website.

QUESTION AND ANSWER

Written questions could be submitted throughout the meeting using the online platform's Q&A feature. Questions were either responded to in writing or answered verbally by the Project Manager, Jessica Headen. A total of 112 questions were asked and answered over the two nights of virtual public information forums, 73 on the first forum and 39 on the second forum. Copies of the questions that were asked and answered foreach forum are provided in **Appendix C**.

VERBAL INPUT

Verbal input could be provided during the verbal input portion of the virtual public information forums. Verbal input was accepted in the order of participant registration online. Input was limited to two minutes to ensure that every participant had a chance to provide input. After going through the registrants who signed up before the meeting to provide input, verbal input was opened to anyone who had not yet spoken. After that, the verbal input portion was opened to any additional input, and participants were able to provide as much input as the remaining time in the virtual public information forums allowed.

Input and questions were not responded to verbally; however, participants were encouraged to continue submitting their questions in writing using the aforementioned Q&A feature. A total of 42 verbal comments were provided over the two forums, 24 on the first forum and 18 on the second forum. A summary of the input provided each night is included in **Appendix D.**

A link to the recording for each virtual public information forum, which include the verbal public input portion, is below:
July 19 - https://youtu.be/gp0oBzRT7k8
July 20 - https://youtu.be/wCQVrj6jZ5Y

AGENCY INPUT

The BLM conducted a meeting for federal, state, local governments, and Tribes to provide information on multiple proposed solar projects in the Pahrump Valley, including the Golden Currant Solar Project, and to gatheragency input. The virtualmeeting was held on July 19, 2022, from 1:00 pm to 2:00 pm PST. The virtual meeting was attended by 14 individuals from 7 agencies, including:

- Chemehuevi Indian Tribe
- National Park Service

- Nevada Department of Wildlife
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- Clark County Department of Aviation
- Environmental Protection Agency

The agency input period concluded August 5, 2022 and 4 letters/emails were submitted with agency input. The agency submissions are included in **Appendix E.**

<u>Summary of Agency Input</u>

- Concerns with topography and facilitating vegetation recovery and requests to try targeted native plant/seed during operation, particularly relative to potential rainfall collection below the solar panels.
- Concerns overall about protection of the plants and animals that will be displaced.
- Potential water impacts to the basin from the proposed Projects.
- Dust concerns associated with the Project.
- Acknowledgment of the potential contribution to renewable energy portfolios and job creation. Requests a reevaluation of potential number of them.
- The Paiute Tribe has felt left out of discussions in the past.
- Suggestion of mowing as a design element that will minimize environmental effects.
- Replace disk-and-roll manner with drive-and crush whenever feasible.
- Minimal impact on military operations conducted in the area.
- Request to correct numbering errors within the POD.

4.0 COMMENT EVALUATION

The public input period began on July 1, 2022, the date the press release was published. In addition to verbal comments received during the virtual public information forums, there were 32 comment emails received. Each comment document was read to identify key concerns/topics. In some cases, a single comment document contained multiple comments that were identified by resource/concerns/ topic categories. All comments were evaluated, and copies are contained in **Appendix F.**

This report summarizes concerns/topic areas identified from the input received throughout the public input period. For the purposes of this summary, all concerns/topics were given equal weight, regardless of whether they were mentioned once or mentioned several times. This report does not prioritize concerns/topic areas, but it provides tracking for the number of comments each concern/topic category received. The identified topics and areas of concern will be used to guide the application evaluation determination and variance process for the Project.

5.0 COMMENT SUMMARY

This section provides a summary of the key concerns/topics identified during the public input period for the Golden Currant Solar Project. The Project received public input in a variety of ways and the public input table below summarizes the topics that were raised.

At the Public Input Forum on July 19, 2022, there were 24 comments. At the Public Input Forum on July 20, 2022, there were 18 comments. In addition to comments received during the Public Input Forums, BLM received emails and letters. There were 32 emails received from the public. Therefore, in total, the BLM received a total of 74 public input submissions. Some of the submissions focused on one subject or topic, while other submissions mentioned several topics. The attached table shows the topics or areas of concern that were included in the submissions received. Each individual mention of a specific topic or area of concern provided in the submissions was included in the table below.

GOLDEN CURRANT SOLAR PROJECT COMMENTS BY TOPIC CATEGORY

Topic Category	Total Comments Submitted	Percentage of Total
Variance Process		
Public Outreach	2	.51
Range of Alternatives/New Proposals	25	6.3
Other Regulations, Policies, Surveys, or Permitting	32	8.1
Monitoring (including Mitigation)	6	1.5
Other Issues, Concerns	14	3.5
Public Access/Traffic/New Construction		
Recreation		
Off-highway Vehicle (OHV) Use	4	1
Access to Public Lands	21	5.3
Cultural and Historical Resources	34	8.6
Environmental Justice	4	1
Wildlife and Vegetation		
Threatened, Endangered, and Sensitive Species	52	13.1
Sensitive Vegetation and Soils	71	18
Socioeconomics/Property Values	17	4.3
Quality of Life	11	2.8
Air Quality and Climate	40	10.1
Public Health and Safety	16	4
Water Resources	28	7.1
Other Resources	19	4.8
Total	**396**	**100**

Variance Process

- From public comments and input received, there was a generalized tone of opposition to solar projects within the Pahrump Valley area.
- The BLM should add local people, entities, or groups to the list of planning partners and consult with businesses and local entities.
- Questions on how BLM is reviewing the projects in the Pahrump Valley area, reviewing case by case or looking at all the projects together in the area.
- Input submitted suggested the Project should be placed on private rooftops and parking areas.

Recreation

- The BLM should engage and partner with local experts in the OHV community, local tourism, and chambers of commerce during this process.
- The BLM needs to consider the loss of area hiking trails, dispersed camping sites, horseback riding, and non-motorized vehicle trails as well as impacts to national park land.
- The BLM needs to consider visual impacts to the area and local communities from the proposed Project solar panels.
- The BLM needs to take into account how the proposed Project will impact the peaceful nature and enjoyment of the proposed Project area by the local communities.
- Concerns were expressed about access being restricted to trails that are currently being used for recreation and business purposes. Access restrictions to trails in the area may impact organized events for trails rides and races, and in turn impact economics of the local communities.

Cultural and Historical Resources

- The BLM needs to ensure adequate tribal consultation and consider impacts to spiritual land.
- The BLM should consider impacts to the Old Spanish National Historic Trail, the grave of Quehoe, and Cathedral Canyon.

Wildlife and Vegetation

- The BLM should consider the loss of sensitive desert soil crust, deterioration of biologically diverse vegetation such as buckwheat, Mojave Yucca, Joshua trees, Parish club cholla, and other rare plants, including how the potential impacts to Joshua trees would be mitigated. Comments about the removal of vegetation in the area impacting carbon-sequestration and global climate change.
- The BLM should be aware of the prior desert tortoise relocation efforts.
- The BLM should consider the loss of habitat and general harm to all area wildlife, including desert tortoises, kit fox, desert iguana, burrowing owl, bird species, and coyote.

- The Project proponent needs to resurvey the Project area for desert tortoise based on the conditions in which the previous surveys were completed.
- The proposed Project will impact 100,000-year-old biological soil crusts and desert pavement within the area.

Socioeconomics/Property Values

- The BLM should consider the public's concern about loss of property values.
- Comments expressed concern that the local communities will not benefit from the solar projects which are located very close to homes and residences, and schools.
- Comments were received that suggested proposed job creation from the Project will not offset impacts to the environment.

Public Health and Safety

- The BLM needs to consider impacts from dust pollution, fine particulate matter, and climate change issues. Comments were made on the removal of the desert surface which would result in uncontrollable fugitive dust.
- The BLM needs to consider impacts to temperature in the valley from the construction of solar panels.

Water Resources

- The BLM should engage and partner with local experts to ensure water resources are adequate for this Project without detrimental impacts to the community of Pahrump and that water resources will not be affected.

6.0 NEXT STEPS

As part of the solar application evaluation process, the BLM will continue agency coordination and evaluation of the information gathered during the public input period. The BLM will then determine whether to process or deny the right-of-way application for the Golden Currant Solar Project. The variance determination is made by the BLM Nevada State Director, with concurrence from the BLM Director. If the BLM determines to process the application, then the NEPA process will be initiated which involves NEPA analysis and further public involvement.

The BLM will post documents related to the variance process for the Project at the Project website. https://www.blm.gov/press-release/land-segregation-announced-golden-currant-solar-project

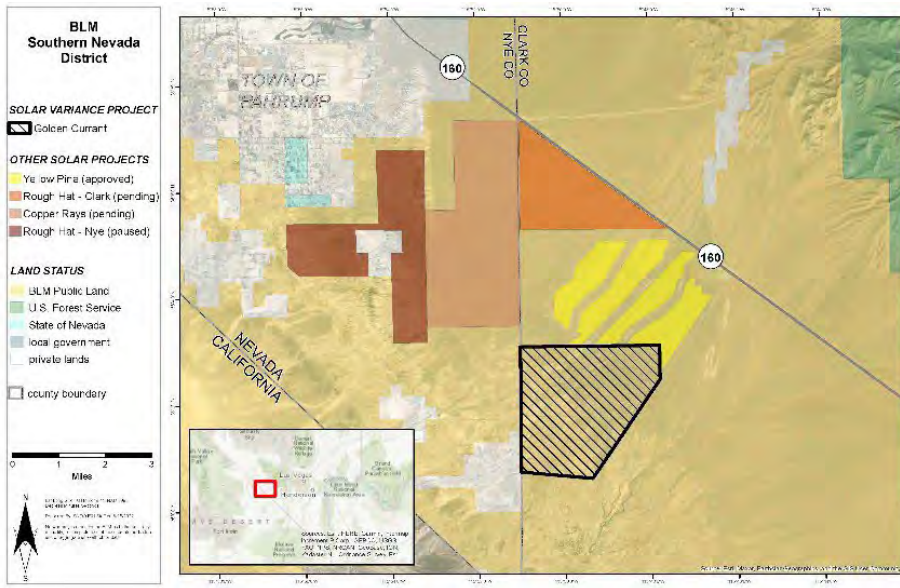
Appendix A - Post Card

In 2012, the Bureau of Land Management (BLM) and the United States Department of Energy issued the Final Programmatic Environmental Impact Statement for Solar Energy Development (Solar PEIS) in six Southwestern States. The Solar PEIS designated Solar Energy Zones that are well suited for utility-scale production of solar energy.

Outside of those zones, the PEIS designated variance areas on BLM-administered lands that are not otherwise excluded by the Solar PEIS. Solar energy development within variance areas is considered on a case-by-case basis through the BLM's established variance process, which includes coordination with appropriate federal, state, and local agencies and tribes, and public outreach.

Noble Solar LLC proposes to construct, own, operate, and decommission the Golden Currant Solar Project, consisting of up to 400 MW alternating current solar facility and Battery Energy Storage System on BLM administered land. The information forums are being held as part of solar variance process and information gathered during the public input period will inform BLM's determination on whether to continue to process or to deny the Project right-of- way application.

NOTICE OF VIRTUAL PUBLIC INFORMATION FORUM



BLM Southern Nevada District Office
Attn: Golden Currant Solar Project Variance
4701 N Torrey Pines Drive
Las Vegas, NV 89130

As part of the variance process, the BLM will hold virtual public information forums for the Golden Currant Solar Project on July 19 and 20 from 6 p.m. to 8 p.m.

To register for a virtual public information forum, please use the following links:
July 19:
https://us06web.zoom.us/webinar/register/WN_qaB2qpcz Tf28jypNVfO3Aw
July 20:
https://us06web.zoom.us/webinar/register/WN_zWRpyve TQSyACdaZBP3l1A

If you have any questions or technical issues trying to register, please call 864-901-3832 for assistance. More information on the Project and the virtual public information forums can be found at www.blm.gov/ press-release/bureau-land-management-hold-variance-process-virtual- public-information-forums-golden. The forums will be recorded and posted at that website. The information forums will include a presentation on the Project and BLM's variance process, a question-and-answer portion, and a public input period. Public input will be accepted until August 5, 2022.

Appendix B - PowerPoint Presentation-
Visual Aid

U.S. Department of the Interior
Bureau of Land Management

Golden Currant Solar Project

Variance and Application Evaluation Virtual Public Information Forum

Agenda

- Field Manager Introduction
- Presentation
- Question & Answer Session
- Public Input
- Close out

This meeting will be recorded, and the video will be posted for 30 days on the project website

Introductions

Presenters

- Shonna Dooman, BLM Field Manager
- Jessica Headen, BLM Project Manager
- Kenda Pollio, Principal, KP Environmental, Inc.

Additional Participants

- Steve Leslie, BLM
- Beth Ransel, BLM
- Mark Slaughter, BLM
- Whitney Wirthlin, BLM
- Matt Klein, BLM
- Dagmar Galvan, BLM
- Mary Ann Vinson, BLM
- Curtis Walker, BLM
- Ernie Johnson, BLM
- John Asselin, BLM

Questions and Input

Tonight's meeting will provide opportunities to ask questions and provide public input

- Question & Answer portion: written questions can be submitted throughout meeting
- Verbal Public Input: after the presentations and Q&A portion

Want to provide input or questions after the meeting?

Input or questions can also be submitted after the meeting, until August 5, 2022, via:

EMAIL: BLM_NV_SND_EnergyProjects@blm.gov

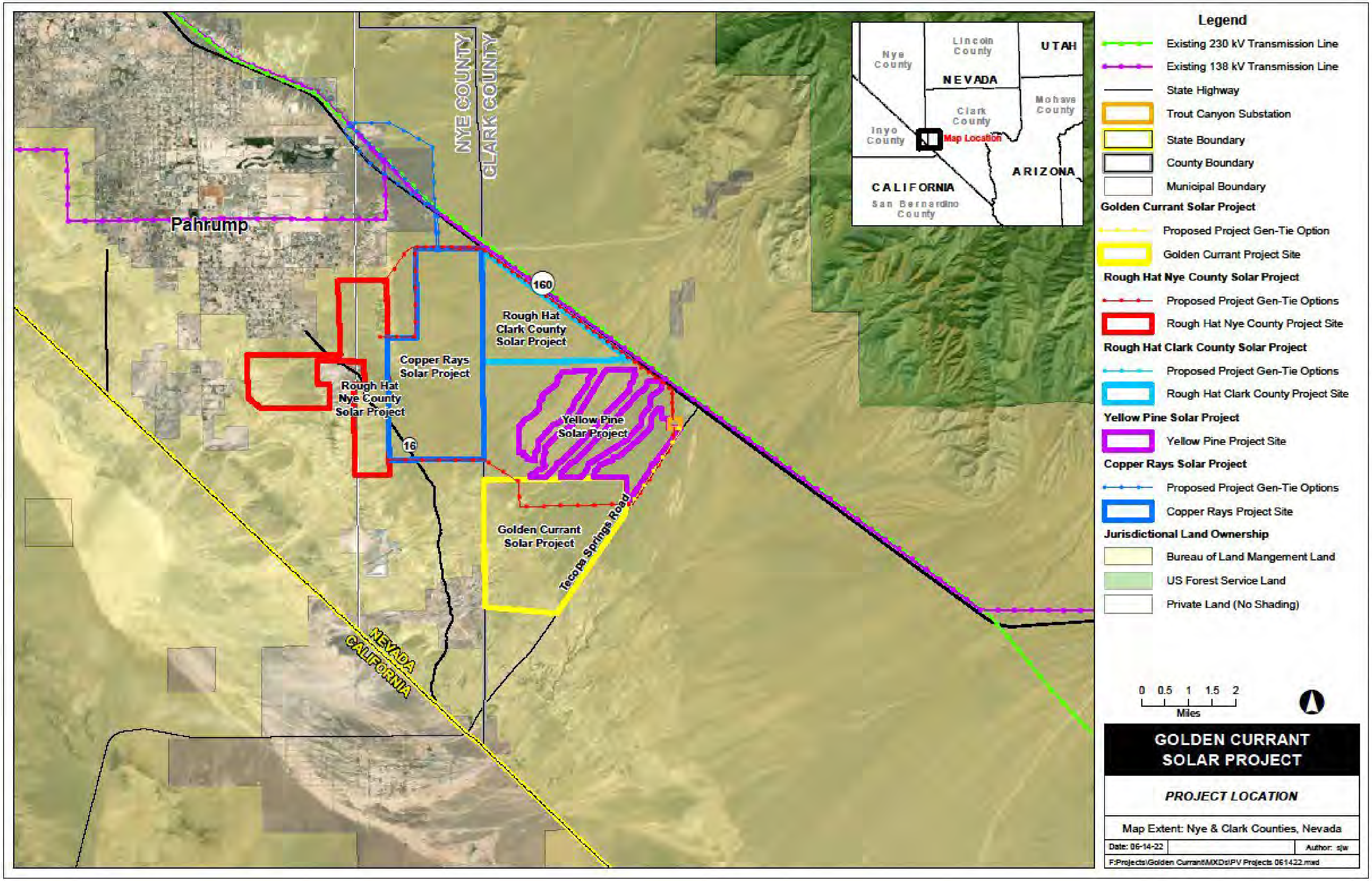
MAIL: BLM Southern Nevada District Office,
Attn: Golden Currant Solar Project Variance
4701 N. Torrey Pines Drive
Las Vegas, NV 89130

Questions and Input

Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment, including your personal identifying information, may be publicly available at any time.

While you can ask that your personal identifying information be withheld from public review, BLM cannot guarantee that they'll be able to do so. Anonymity is not allowed for submissions from organizations or businesses and from individuals identifying themselves as representatives or officials of organizations or businesses.

Solar Projects within the Pahrump Valley



Golden Currant Solar Project

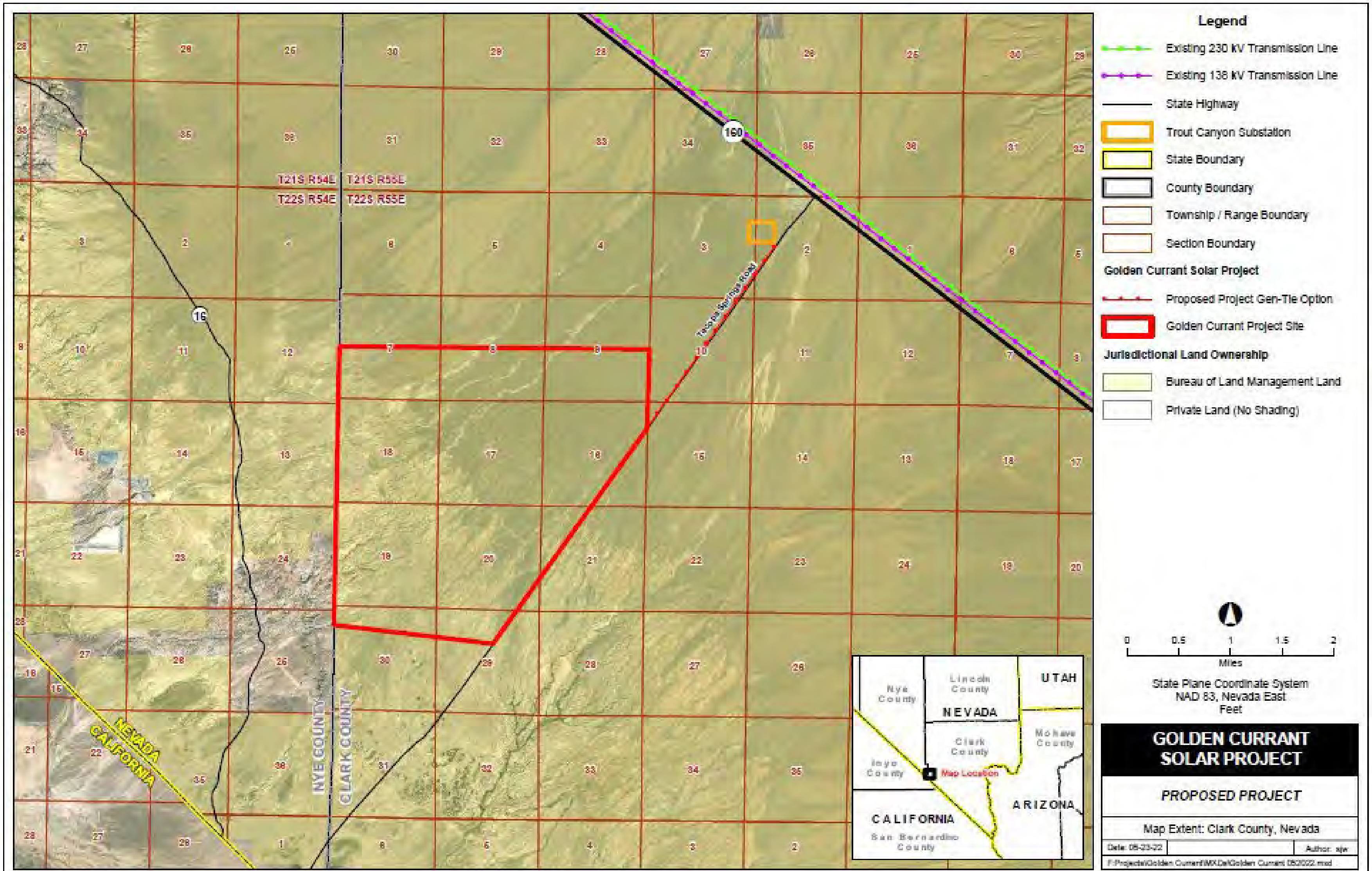
- Noble Solar, LLC applied for a right-of-way grant requesting to utilize public land for the construction and operation of a proposed solar facility with interconnection to the regional transmission system.

- The project consists of up to a nominal 400-megawatt (MW) alternating current (MWac) solar photovoltaic (PV) power generating facility and 400-megawatt (MW) Battery Energy Storage System.

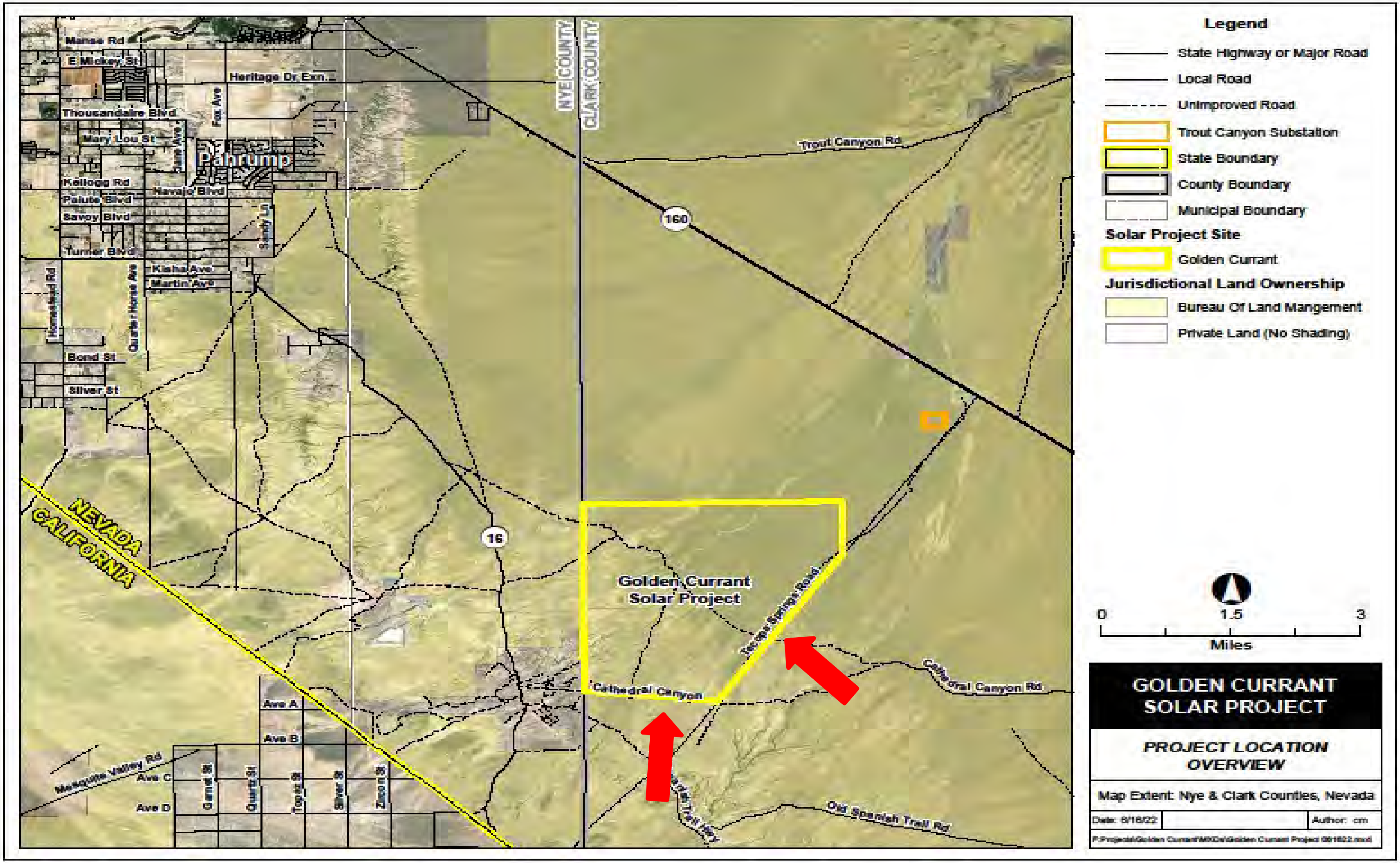
- The request is to use approximately 4,364-acres of public land managed by the BLM Southern Nevada District, located in Clark County, Nevada, approximately 5 miles southeast of Pahrump and 26 miles west of Las Vegas. State Route 160 is less than 2 miles northeast of the site.

U.S. Department of the Interior
Bureau of Land Management

Golden Currant Solar Project



Golden Currant Solar Project



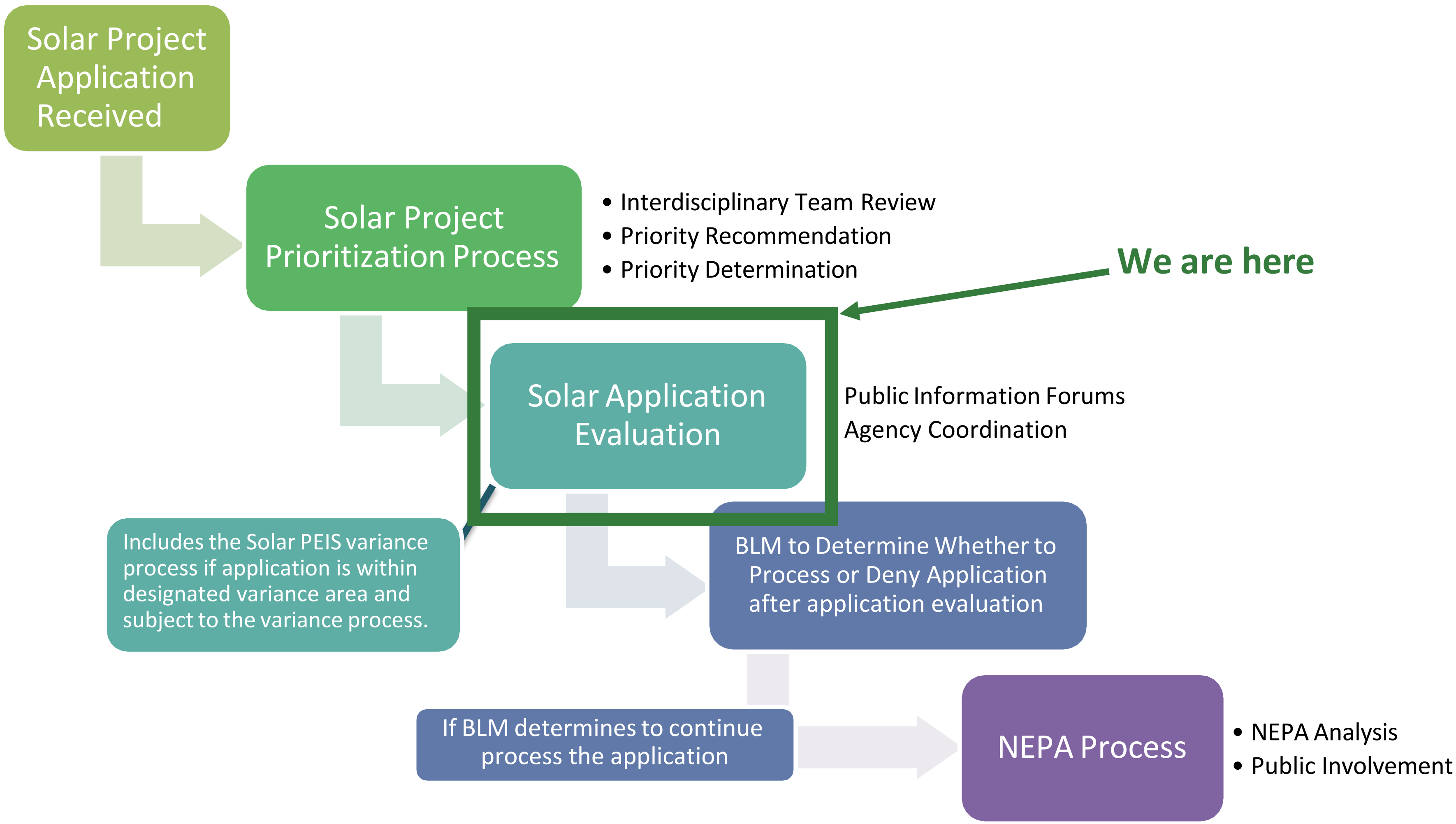
Additional Project Information

- Direct current electricity is collected and converted to alternating current electricity through a system of inverters.

- Energy would be delivered to the Trout Canyon 230 kV substation, consisting of a 230 kV transmission line (Gen-Tie) with 150 foot right-of-way width.

- The power produced by the Project would be conveyed to the NV Energy (“NVE”) transmission system or the California ISO transmission system (“CAISO”) via a 2.1 mile long 230 kV overhead Gen-Tie to the Trout Canyon 230 kV substation where the project holds an interconnection queue position.

Golden Currant Application Review Process



Application Evaluation Process in Solar Variance Areas

- In 2012, BLM and DOE issued the Final Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States.
- The PEIS designated Solar Energy Zones that are suited for utility-scale production of solar energy.
- Public land is available on a case-by-case basis, outside of the Solar Energy Zones. Variance areas require a separate process prior to initiating analysis under the National Environmental Policy Act. The Golden Currant Solar Project is located in a variance area.

Application Evaluation Process in Solar Variance Areas (cont)

- The variance process is included in the application evaluation determination process, as described in the right-of-way regulations.

- The focus of the variance process is to review the project in relation to the variance factors identified in the Solar PEIS and gather input from Tribes, and Federal, State, and local governments to assess the appropriateness of the proposal.

Public Input as Part of Application Evaluation

- These scheduled public information forums and public input period for the Golden Currant Solar Project provide opportunities for public outreach and input.

- Information gathered during the public input period will inform the application evaluation/variance process including the BLM determination on whether to continue to process, or to deny, the right-of-way application.

Next Steps

- Public input on the Golden Currant Solar Project will be accepted until August 5, 2022.

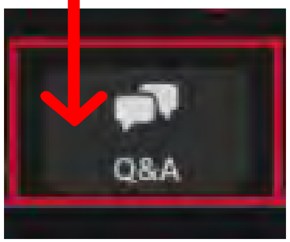
- The information gathered will be presented to the BLM Nevada State Director. The Nevada State Director, with concurrence from the BLM Director, will make the determination of whether the project will move forward and be analyzed under the NEPA process. Determination expected in the Fall of 2022.

What Types of Input Would be Most Helpful Now

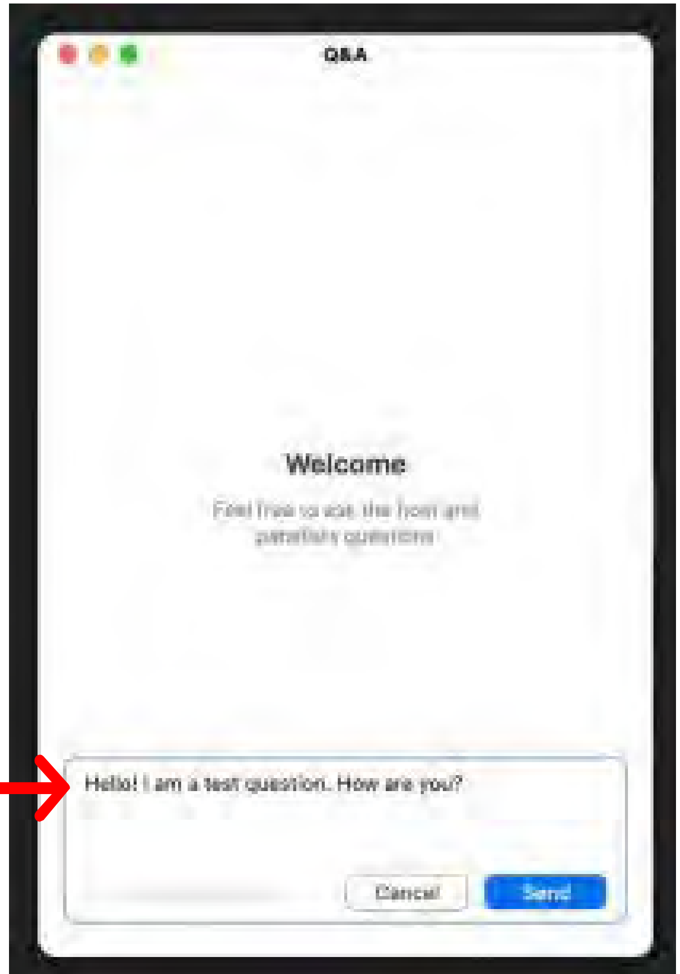
- Helpful public input at this point would include potential local concerns, barriers, and/or opportunities related to the proposed project.
- Input about types of use or resource concerns within the proposed area, like recreational activities and opportunities, wildlife, vegetation, visual resources, and other factors, would also be helpful at this time.
- Information related to the variance factors found at the following link: https://blmsolar.anl.gov/variance/process/factors/

Question and Answer Section

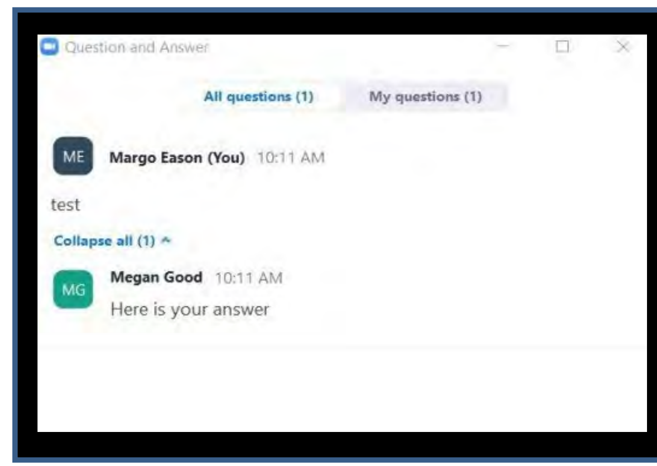
1. Click "Q&A" button at bottom of screen



2. Type your question



BLM will answer your question in Zoom or live



More information is available at the website https://www.blm.gov/press-release/bureau-land-management-hold-variance-process-virtual-public-information-forums-golden

How to Provide Verbal Input

- Input will be accepted in order of registration.
- Once your name is called, use the 'Raise Hand' feature and the meeting facilitator will open your microphone.

- If you are on the phone, you can raise your hand with *9 and then unmute/mute using *6.
- A timer will be displayed on your screen to show the time remaining for your input.
- Your input will be included in the project record.

Public Input Section

BLM wants to hear from all members of the public. Out of respect for everyone's participation and input, we will be using the following guidelines:

- Stay within your allotted time so that everyone can speak
- Please be respectful of others
- Refrain from profanity

If guidelines are not followed, your microphone will be muted, and we will move to the next person

Next 10 commenters

1. Chris Mazlo
2. Joyce Barishman
3. Kevin Emmerich
4. Kim Hover
5. Robert Adams
6. Mike Garabedian
7. Judy Branfman
8. Christina Sanchez
9. Debra Savitt
10. Patrick Donnelly

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Next 10 commenters

1. Shannon Salter
2. Theresa Bartoldus
3. Susie Hertz
4. Don Hertz
5. Carl van Warmerdam
6. Cali Anderson

How to Submit Further Input

More information is available at the website:

https://www.blm.gov/press-release/bureau-land-management-hold-variance-process-virtual-public-information-forums-golden

Want to provide comment?

EMAIL: BLM_NV_SND_EnergyProjects@blm.gov

MAIL:

BLM Southern Nevada District Office,
Attn: Golden Currant Solar Project Variance
4701 N. Torrey Pines Drive
Las Vegas, NV 89130

**Public input period closes
August 5, 2022**

Appendix C - Q&A From Virtual Public Information Forums

7/19/22

Question	Asker	Answer
Is this project in the same area that the endangered Tortoise were released from the Yellow Pine project? What are the plans for protecting them?	Joni Hawley	live answered- No, Golden Currant is not located within the translocation area for the Yellow Pine Project. The BLM and Fish and Wildlife Service work in coordination to reduce those impacts by requiring the tortoise to be translocated prior to construction of the solar facility. The BLM and Fish and Wildlife Service designated the Trout Canyon and Stump Springs translocation areas that can potentially be used as recipient sites for the tortoises from the Golden Currant Solar Project. Measures to reduce impacts could include post construction work for 12 months, health assessment, and treatment, if needed. Specific measures would be developed in a desert tortoise translocation plan during the environmental review process.
I can't hear. I can see Jessica and the slides. Any help?	Sharon Minsch	
I got sound. Sorry.	Sharon Minsch	Great!
What would happen to the mesquite woodlands around Cathedral Canyon	Shannon Salter	live answered- Within the project area, there are approximately 14 acres of mesquite. This is from preliminary botanical data survey, and we do not have a good estimate at this time of how many mesquite trees are within the project area. If the project receives a favorable application evaluation determination, then environmental review/ national environmental policy and process is initiated. Relevant measures to avoid ,minimize, and/or mitigate potential impacts to mesquite trees would be considered.
How much water will be needed to complete the Golden Currant Solar project?	David Perlman	live answered- The plan of development indicates 1000-acre feet of use during construction and approximately 225-acre feet per year for operation and maintenance.
Are we being asked to sell our portion of the land?	Tiffany Hill	live answered- The Golden Currant Solar Project is sited entirely on public lands managed by the Bureau of Land Management, there is no sale of public lands proposed for this project.

7/19/22

Question	Asker	Answer
Hello, you said that both the Copper Rays and Rough Hat Clark projects would have plan amendments. Is that over visual resources? Will there not be a plan amendment for Golden Currant? Thank You.	Kevin Emmerich	live answered- As part of the solar variance process, one of the variance factors that the BLM will consider is whether the proposed project is in conformance with decisions in the current land use plans, including visual resource management and class designations. The BLM is still reviewing the Golden Currant Solar Project through the variance process to determine confirmation with the applicable resource management plan and amendments. If the BLM determines a land use plan amendment is needed for the proposed project, the BLM land use planning processes, including public involvement requirements would be utilized. Information on the land use planning process can be found at the BLM website.
What would happen to the solar panels at the end of their lives? Solar panels contain lead and cadmium, a hazardous waste, and they contaminate groundwater when put in landfills. Would Noble Solar have to pay for the panels to be safely recycled?	Shannon Salter	If the project is approved, the developer will be required to provide a bond that will ensure that the site is reclaimed after the useful life of the project. At the time of decommissioning, the most appropriate methods for disposal will be utilized. The applicant will be required to develop a decommissioning plan, which would identify the methods of removal of the solar panels.
We have hiked in the proposed project site, and it appears that half the site is deeply incised badlands and washes. How can a solar project be built here? It is not flat.	Kevin Emmerich	The Applicant is studying the project site to develop a more refined project design. If the project receives a favorable variance determination, this will be considered during the environmental review process.

7/19/22

Question	Asker	Answer
How close is the project to the Stump Springs ACEC?	Shannon Salter	live answered- Stump Springs ACEC is adjacent to the Golden Currant project area south of Tecopa Road.
How were the variance areas determined in the Solar PEIS of 2012? Were areas surveyed on the ground, what was the level of detail of analysis?	William Helmer	live answered- The solar PEIS designated solar energy zones that are well suited for utility scale production of solar energy and designated variance areas on BLM administered lands that are outside of solar energy zones and not otherwise excluded by PEIS. Various areas are available for utility scale solar energy development and are evaluated through the BLM's establish variance process on a case-by-case basis. Pahrump Valley is designated as a variance area, the lands being requested in the application were identified as variance lands. The BLM is currently considering the appropriateness of the application utilizing the variance process that was identified in the solar PEIS. The current public input meetings and public input period are a critical piece of the variance process and will inform BLM's decision on whether to continue processing the application by initiating the environmental review/NEPA process.

7/19/22

Question	Asker	Answer
I used to be under the assumption that BLM is supposed to be a good steward of conserving lands managed by it. Seeing the devastation that the Yellow Pine project did to the area, what are the reasons for which BLM even consider this second project that would add to the natural destruction that is already happening?	Erik Ven	live answered- Although the proposed projects are located in a similar area, BLM received individual applications for the five standalone projects, each has potential site-specific resource concerns. Since the applications are standalone projects, once the application evaluation process is complete, including completion of the public information forums for each project, the BLM will make individual determinations for each application. In addition to the public information forums each project will have public input period that will provide time before and after the public forums for additional public input for the Golden Currant Solar Project. The public input period will end on August 5.
How many wild horses and burros will be impacted by all projects current and future in all these areas?	Kim Hover	The proposed Golden Currant Solar Project is not within a herd management area. Thank you for your question. We strive to provide the best information and at this moment we do not have an immediate response. If there is a favorable Variance Determination made for the project, the BLM would continue processing the application by initiating an environmental review/National Environmental Policy Act process. This question could be further considered during that process.
Can you explain the mitigation funds that Noble Solar would need to pay into?	Shannon Salter	Mitigation measures have not been developed at this time. Currently, we are requesting information about potential impacts within the site. If the project receives a favorable application evaluation determination and the environmental review/National Environmental Policy Act process is initiated, relevant mitigation, including mitigation fees, would be identified, and addressed as part of the environmental review process.

Question	7/19/22 Asker	Answer
Stump Springs is where the last batch of tortoises were killed. Waiting for the environment process is not acceptable. What plans are there to save the desert tortoise. What new plans are coming into play?	Sharon Minsch	live answered- The BLM and Fish and Wildlife Service works in coordination to develop translocation plans prior to construction of the proposed facility. Translocation plans are developed based on current site-specific information. Predator surveys will be conducted in translocation areas prior to the translocation of tortoises to assess predator diversity abundance and the likelihood of predation. Additionally, the BLM and Fish and Wildlife Service are considering multiple protective measures, including the release of tortoises into preexisting burrows within translocation areas during the late fall prior to winter dormant season, where they will be temporarily tent pinning to protect desert tortoises from predation through their winter dormant cycle and allowed the individuals to acclimate to their new environment ahead of underpinning in the following spring, when they become active.
What would happen to the graves on the Golden Currant site?	Shannon Salter	If the project receives a favorable application evaluation determination and the environmental review/National Environmental Policy Act process is initiated, relevant mitigation would be identified and addressed as part of the environmental review process and cultural surveys.
How will the site be "reclaimed"?	Heather Gang	live answered- If the project receives a favorable application evaluation determination, the project will proceed to the environmental review/NEPA process. A draft decommissioning plan is typically included as an appendix in the NEPA document and analysis, and the final would be posted to the planning if the project is approved.

7/19/22

Question	Asker	Answer
Since many desert tortoise died as a result of the Yellow Pine move, what is the plan to make sure this doesn't happen again?	Teresa Skye	The BLM and Fish and Wildlife Service work in coordination to develop translocation plans prior to construction of the proposed solar facility. Translocation plans are developed based on current, site-specific information. Predator surveys will be conducted in translocation areas prior to the translocation of tortoises to assess predator diversity, abundance, and the likelihood of predation. Additionally, the BLM and Fish and Wildlife Service are considering multiple protective measures including the release of tortoises into pre-existing burrows within translocation areas during late fall, prior to the winter dormant season where they will be temporarily penned. Penning will serve to protect desert tortoises from predation through their winter brumation cycle and allow for individuals to acclimate to their new environment ahead of unpenning in the following spring when they become active.
I don't believe she answered the questions. WILL THEY BE MADE TO RECYCLE THE SOLAR PANELS AFTER THEY ARE OF NO USE? Or we have a landfill full of them like other countries?	Bond-Kuglin Tina L	If the project is approved, the developer will be required to provide a bond that will ensure that the site is reclaimed after the useful life of the project. At the time of decommissioning, the most appropriate methods for disposal will be utilized. The applicant will be required to develop a decommissioning plan, which would identify the methods of removal of the solar panels.

7/19/22

Question	Asker	Answer
I'm concerned about visual and proximate impacts on the Old Spanish National Historic Trail. The project's SW corner is only a mile from Stump Spring, a major feature of the OSNHT. What figure is BLM using for the width, or breadth, of the OSNHT for assessment of impact? The official route of the OSNHT is on the Nat 'l Park Service's web site.	Jack Prichett	live answered- The official route of the OSNHT is on National Park Service's website. If the project receives this variance determination, potential impacts, to the OSNHT corridor would be analyzed during the environmental review/ NEPA process. This could include preparation of an inventory and impact analysis report in compliance with the National Trail System Act and with the guidelines in the BLM manual 6280. The management corridor for the Old Spanish National Historic Trail has not been designated. The BLM has established an interim corridor for the Old Spanish National Historic Trail that is five miles from the center line of either side of the trail.
Will this project be sold to another operator after it is built?	Susan Sorrells	live answered- The BLM has no knowledge at this time regarding their current applicant's future ownership plans for the Golden Currant project.

7/19/22

Question	Asker	Answer
It appears that about 40 percent of the project site is eroded badlands topography and I see some canyons would be avoided. Are the paleo sites on the badlands? Are you worried that crushing up that topography will create even more intense dust issues than Yellow Pine?	Kevin Emmerich	live answered- The construction of solar energy facilities may cause surface disturbances and soil compaction resulting in increased erosion run off, dust and sedimentation. The solar PEIS has required design features for air quality and soil, which would be incorporated into the project. Construction related impacts are mitigated by implementing best management practices, specific mitigation measures and standard operating procedures that would reduce soil erosion potentially. If the project receives a favorable application evaluation, determination mediations would be determined during the environmental review/ NEPA phase of the project. The project would also have to comply with Clark County permit requirements such as an air quality permit. Paleontology of the project area would be evaluated, based on the potential of significant paleontology resources. If the project is given favorable variance determination, potential for significant paleontological resources will be evaluated during the NEPA process.
What herbicides would be permitted to be sprayed on the site and would they pose a harm to insects and animals around the site and at the nearby Stump Springs ACEC?	Shannon Salter	live answered- Only those approved in the record of decision in the PEIS for the vegetation treatment in the 17 western states and the southern Nevada district office programmatic biological opinion.

7/19/22

Question	Asker	Answer
How much carbon is being naturally sequestered on the 4300-acre site?	Shannon Salter	We strive to provide the best information and at this moment we do not have an immediate response. Currently the BLM is reviewing the project through the variance process. If there is a favorable Variance Determination made for the project, the BLM would continue processing the application by initiating an environmental review/National Environmental Policy Act process. Carbon sequestration and greenhouse gases would be analyzed during that process.
What other plant species occur in the area of the proposed development project site?	Christina Sanchez	live answered- Rock valley buckwheat, which is a BLM sensitive species has potential habitat within the project area during the 2022 botanical surveys. The botanical surveys have not yet been finalized, but there were skeletons of past season plants that were tentatively identified as Pahrump valley buckwheat in one area within the project site. Botanical reports have not been finalized at this time.
Have other sites been considered which do not destroy undeveloped desert?	Theresa Bartoldus	The applicant, Noble Solar, LLC, identified and applied for the proposed project site. The lands being requested in the application were identified in the Solar PEIS as Variance lands, where solar energy development applications can be considered on a case-by-case basis. The BLM is currently considering the appropriateness of the application utilizing the Variance process that was identified in the Solar PEIS. The current public input meetings and public input period are a critical piece of the Variance process and will inform BLM's decision on whether to continue processing the application (initiate the environmental review/National Environmental Policy Act process).

7/19/22

Question	Asker	Answer
How do we protect the tortoises and prevent them from being killed?	Sharon Minsch	The BLM and Fish and Wildlife Service work in coordination to reduce those impacts by requiring that tortoises be translocated prior to construction of the solar facility. The BLM and Fish and Wildlife Service designated the Trout Canyon and Stump Springs Translocation Areas that can potentially be used as recipient sites for the tortoises from the Golden Currant Solar Project. Measures to reduce impacts could include post construction monitoring for 12 months, health assessments, treatment if needed. Specific measures would be developed in a desert tortoise translocation plan during the environmental review process.
How will this project impact the sacred Salt Song Trail as well as the Old Spanish Trail?	Susan Sorrells	live answered- If the project receives a favorable application evaluation determination and the environmental review/ National Environmental Policy Act process is initiated, types and alternatives of replanting of vegetation species within the project area would be analyzed. During the environmental review process the BLM would make efforts to avoid. minimize, and mitigate impacts to vegetation. Mitigation measures have not been developed at this time, currently we're requesting information about potential impacts within the site. If the project receives a favorable application evaluation determination and then environmental review/ National Environmental Policy Act process is initiated relevant mitigation would be identified and addressed as part of the environmental review process.

7/19/22

Question	Asker	Answer
How much would Noble Solar pay to lease the land	Shannon Salter	live answered- The BLM will calculate acreage rent on or before the date of issuance of a right-of-way grant. The BLM will charge acreage rent on an annual basis by calculating the annual acreage rent by multiplying the entire number of acres authorized in the right-of-way grant or leased by the appropriate per acre rate. The BLM will charge a (garbled) once generation of electricity starts on an annual basis, based on megawatt capacity fee by multiplying the proved megawatt capacity by the appropriate megawatt capacity fee. BLM recently updated the rent guidance and rates.
What is the max megawatts the Trout Canyon Substation can carry?	Kevin Emmerich	The BLM approved the Yellow Pine Solar, including the Trout Canyon Substation. For the substation, the BLM approved the facilities and equipment for the substation. The right-of-way grant Holder, GridLiance, is the best contact for providing information about their planned capacity for the substation.
If I own property near there, will it increase or decrease the value of the property? How many jobs would this provide to people?	Janet Keesee	The BLM is currently in the application evaluation phase for the project and has not yet determined what resource impacts would be considered during an environmental review. If there is a favorable application evaluation determination made for the project, the BLM would continue processing the application by initiating an environmental review/National Environmental Policy Act process. Based on input during this current public input period (including your comment) and scoping input gathered when the environmental review process is initiated, the BLM would determine what resource impacts were appropriate for analysis. Noble Solar, LLC provided estimated workforce numbers for construction of the proposed Golden Currant Solar project in their preliminary Plan of Development. The BLM has posted the preliminary Plan of Development for the project online at the following link: https://www.blm.gov/press-release/bureau-land-management-hold-variance-process-virtual-public-information-forums-golden.

7/19/22

Question	Asker	Answer
How many Mojave Yucca do you anticipate being on this site? How many creosotes do you estimate?	Shannon Salter	live answered- On the preliminary botanical survey results, an estimated 13,085 yucca are present within the survey area with cacti and yucca densities increasing as elevation increases up. The predominant species of cacti and yucca found within the project site include Mojave yucca, Wiggins cholla, cotton top cactus, hedgehog cactus, beaver tail cactus and (garbled) is still being quantified.
How will the tortoises be protected?	Theresa Bartoldus	The BLM and Fish and Wildlife Service work in coordination to reduce those impacts by requiring that tortoises be translocated prior to construction of the solar facility. The BLM and Fish and Wildlife Service designated the Trout Canyon and Stump Springs Translocation Areas that can potentially be used as recipient sites for the tortoises from the Golden Currant Solar project. Measures to reduce impacts could include post construction monitoring for 12 months, health assessments, treatment if needed. Specific measures would be developed in a desert tortoise translocation plan during the environmental review process.
How many feet away from the Stump Springs ACEC is the Golden Currant Solar project?	Shannon Salter	The Stump Springs ACEC lies adjacent to the Golden Currant project area. South of Tecopa Road.
Where would Noble Solar try to source water for the project?	Shannon Salter	live answered- Noble Solar has stated in the preliminary plan of development the most plentiful water source of construction and operations base water for the proposed project would be water purchased from a commercial source or a user with an existing appropriation. It would be trucked in or piped to the project site where it would be stored in an onsite water storage tank. The project does not anticipate drilling any new water wells, the Nevada division of water resources is responsible for the allocation of water resources within the state of Nevada. If the project receives a favorable application evaluation determination, the BLM will consider impacts from water use during the environmental review/NEPA process. BLM considers water, both surface and groundwater, within the border context of all resources on BLM administered lands and their interactions as they relate to BLM responsibilities.

Question	7/19/22 Asker	Answer
Where will the 1000-acre feet of water come from?	David Perlman	Noble Solar, LLC has stated in their preliminary Plan of Development that the most probable source of construction and operations-phase water for the proposed project would be water purchased from a commercial source or a user with an existing appropriation. It would then be trucked or piped to the Project site where it would be stored in an on-site water storage tank. The project does not anticipate drilling any new water wells. The Nevada Division of Water Resources is responsible for the allocation of water resources within the State of Nevada. If the project receives a favorable application evaluation determination, the BLM will consider impacts from water use during the environmental review/National Environmental Policy Act process. BLM considers water, both surface and groundwater, within the broader context of all resources on BLM administered lands and their interaction as they relate to BLM responsibilities.
If this project is in Clark County, shouldn't the water being used for this project come from that county and not from Nye County, where it has the potential to impact Pahrump. Is there something in the contracts for this?	Joni Hawley	Noble Solar, LLC has stated in their preliminary Plan of Development that the most probable source of construction and operations-phase water for the proposed project would be water purchased from a commercial source or a user with an existing appropriation. It would then be trucked or piped to the Project site where it would be stored in an on-site water storage tank. The project does not anticipate drilling any new water wells. The Nevada Division of Water Resources is responsible for the allocation of water resources within the State of Nevada. If the project receives a favorable application evaluation determination, the BLM will consider impacts from water use during the environmental review/National Environmental Policy Act process. BLM considers water, both surface and groundwater, within the broader context of all resources on BLM administered lands and their interaction as they relate to BLM responsibilities.

7/19/22

Question	Asker	Answer
Will the applicant be required to put sufficient amount of money in a non-withdrawable fund to assure the replanting of the site after decommissioning?	Erik Ven	As specified in the Record of Decision for the Solar Programmatic EIS, the BLM will require a Performance and Reclamation bond for all solar energy projects to ensure compliance with the terms and conditions of the right-of-way authorization. The BLM will identify the total amount of the Performance and Reclamation bond in the decision that supports the issuance of the ROW authorization. The BLM may increase or decrease the bond amount at any time during the term of the ROW authorization, consistent with regulations.
How much natural carbon sequestration would we lose if Golden Currant Solar were built?	Shannon Salter	We strive to provide the best information and at this moment we do not have an immediate response. Currently the BLM is reviewing the project through the variance process. If there is a favorable Variance Determination made for the project, the BLM would continue processing the application by initiating an environmental review/National Environmental Policy Act process. Carbon sequestration and greenhouse gases would be analyzed during that process.
How were the variance areas determined in the Solar PEIS of 2012? Were areas surveyed on the ground, what was the level of detail of analysis? (I don't know if this went through the first time).	William Helmer	live answered- The solar PEIS designated solar energy zones that are well suited for utility scale production of solar energy and designated variance areas on BLM administered lands that are outside of the solar energy zones and not otherwise excluded by the solar PEIS. Various areas are available for utility scale solar energy development and are evaluated through the BLM established variance process on a case-by-case basis. Pahrump valley is designated as a variance area, the lands being requested in the application were identified in the solar PEIS as variance lands. The BLM is currently considering the appropriateness of the application utilizing the variance process that was identified in the solar PEIS. The current public input meetings and public input period or a critical piece of the variance process and will inform bill limps decision on whether to continue processing the application by initiating the environmental review/NEPA process.

7/19/22

Question	Asker	Answer
How old do you estimate the desert pavement is on the Golden Currant site?	Shannon Salter	The BLM would work with the applicant to avoid, where appropriate, development in areas with biological soil crust. The loss of desert pavement and biocrust would be documented and analyzed as part of the environmental review process should there be a favorable decision on the Variance process.
Won't the construction of Golden Currant, Yellow Pine and other large solar sites in this area create a huge "checkerboard" of bulldozed sites? Wouldn't such a checkerboard result in massive impacts to the territory, migration routes, and breeding of desert creatures?	Jack Prichett	live answered- If the project receives a favorable application evaluation determination and proceeds to the environmental review/NEPA process, impacts to small mammals, and reptiles during construction of the solar facility would be analyzed. These impacts could include temporary displacement from the existing habitat and potential injury or mortality during construction.
As you mentioned that a decision would be made on this by the fall. When do you expect the Botanical Survey to be completed?	Erik Ven	live answered-The botanical surveys are underway, and we do not have an estimated date of completion at this time.
Where is the survey area? Can you define what area you surveyed?	Shannon Salter	Each specific resource has its own survey area to be determined in the NEPA process.
How many potential projects are out there?	Sharon Minsch	The BLM approved the Record of Decision for the Yellow Pine Solar Project in November 2020. Consisting of 2,987 acres with a plan generation of 500 MW. The BLM has five pending applications for solar energy projects located in the Pahrump Valley. The pending applications, along with the phase of the application review is as follows: Rough Hat Clark County Solar (initiating environmental review), Copper Rays Solar (initiating environmental review), Golden Currant Solar (application evaluation), Mosey Solar (pending processing priority determination), and Rough Hat Nye County Solar (paused).

7/19/22

Question	Asker	Answer
Will they be made to recycle the old solar panels when they are no longer of use, or will we find them in landfills like several other countries & counties???	Bond-Kuglin Tina L	If the project is approved, the developer will be required to provide a bond that will ensure that the site is reclaimed after the useful life of the project. At the time of decommissioning, the most appropriate methods for disposal will be utilized. The applicant will be required to develop a decommissioning plan, which would identify the methods of removal of the solar panels.
You do realize that this project is butting up to Nye County and is dead center in the south Pahrump Valley adjacent to the dry lake. Being so, it's known by those that live in the south valley that the dust is very extreme. How much more dust by this project is expected? What are your dust control measures?	Michael Fender	Mitigation measures have not been developed at this time. Currently, we are requesting information about potential impacts within the site. If the project receives a favorable application evaluation determination and the environmental review/National Environmental Policy Act process is initiated, relevant mitigation would be identified and addressed as part of the environmental review process. Additionally, applicable design features required by the Solar PEIS include methods to minimize dust.
How can you justify these projects that are wiping out Joshua tree and Yucca forests when these desert landscapes will never come back or take hundreds, even thousands of years to return to their original state?	Christian Gerlach	live answered- If the project receives a favorable application evaluation determination and environmental review is initiated, types and alternatives to replanting that vegetation species within the project area would be analyzed. During the environmental review process the BLM would make an effort again to avoid ,minimize ,and mitigate impacts to vegetation. Mitigation measures have not been developed at this time; we are currently requesting information about potential impacts within the site. If the project receives a favorable evaluation determination and environmental review process is initiated, relevant mitigation would be identified and address as part of the environmental review process.

7/19/22

Question	Asker	Answer
So, what is an estimate of the fees they will pay?	Sharon Minsch	The BLM is currently in the early phase of the application review. If the project receives a favorable variance determination, the BLM would initiate environmental review. It is through that process that mitigations and fees would be identified. As part of the right-of-way authorization process, rental fees and bonding would be required, in addition to mitigation fees.
Will the land be bladed? Will the topography be smoothed out?	Heather Gang	The Applicant is studying the project site to develop a more refined project design. If the project receives a favorable variance determination, options for site preparation methods will be considered during the environmental review process.
Could the water rights be purchased within Pahrump valley or Nye County?	Shannon Salter	The proposed project is located in the Pahrump Valley Basin, which no new water rights are currently available. The Nevada Division of Water Resources is responsible for the allocation of water resources within the State of Nevada. Water could be purchased from existing water rights holders within the basin. Noble Solar, LLC has stated in their preliminary Plan of Development that the most probable source of construction and operations-phase water for the proposed project would be water purchased from a commercial source or a user with an existing appropriation.
Earlier a question came through mentioning Prosopis (Mesquite) in the area, Jessica also mentioned that there has not yet been a botanical survey. Does this site have Prosopis on the site? When will a botanical survey be completed?	Christina Sanchez	Given the geographically limited range of mesquite trees within the proposed project area, the BLM anticipates mesquite bosques could be avoided. If mesquite bosques could not be avoided, off-site mitigation to improve conditions in adjacent mesquite habitat may be considered. Information about existing mesquite bosques in and around the proposed project location is being gathered help fully evaluate this resource. The botanical surveys are underway, but we do not yet have an estimated date of completion.

7/19/22

Question	Asker	Answer
How will the BLM justify the environmental justice impacts from the increase in dust and particulate matter that disproportionately affects low income and communities of color that will result from the removal of the cryptobiotic and living soil crusts currently keeping dust down?	Christian Gerlach	Currently, we are requesting information about potential impacts within the site. If the project receives a favorable application evaluation determination and the environmental review/National Environmental Policy Act process is initiated, potential environmental justice factors and potential impacts to biological soil crusts would be considered during the environmental review process. Additionally, applicable design features required by the Solar PEIS include methods to minimize dust.
Would you announce an outcome before the botanical surveys are complete?	Shannon Salter	live answered- The botanical surveys are underway, and we do not have an estimated date of completion at this time.
We have hiked in the proposed project site, and it appears that half the site is deeply incised badlands and washes. How can a solar project be built here? It is not flat.	Kevin Emmerich	The Applicant is studying the project site to develop a more refined project design. If the project receives a favorable variance determination, this will be considered during the environmental review process.
The rent guidance web site just talks about reduced rents. There are no dollar amounts? What is the estimated fee Golden Currant will pay? What is best email address to send written letters?	Sharon Minsch	The BLM will calculate acreage rent on or before the date of issuance of a right-of-way grant. The BLM will charge acreage rent on an annual basis by calculating the annual acreage rent by multiplying the entire number of acres authorized in the right-of way grant or lease by the appropriate per acre rate. BLM will charge a Megawatt (MW) capacity fee once generation of electricity starts on an annual basis based on MW capacity fee by multiplying the approved MW capacity by the appropriate MW capacity fee. BLM recently updated the rent guidance and rates; information can be found at https://www.blm.gov/press-release/department-interior-announces-steps-increase-clean-energy-development-public-lands Email: BLM_NV_SND_EnergyProjects@blm.gov

7/19/22

Question	Asker	Answer
What has the Pahrump Paiute Tribe said about this project?	Christian Gerlach	The BLM has initiated consultation with the Chemehuevi Indian Tribe, Colorado River Indian Tribes, Fort Independence Indian Community of Paiute, Fort Mojave Indian Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, Las Vegas Paiute Tribe, Moapa Band of Paiutes, Paiute Indian Tribe of Utah, San Juan Southern Paiute Tribe, The Hopi Tribe, Twenty-Nine Palms Band of Mission Indians, and Utu Utu Gwaitu Paiute Tribe (Owens Valley Paiute Benton Reservation) for this proposed project. The specific protocols for how consultation proceeds and what that consultation looks like is dependent on the BLM's relationship with each tribe. Generally, this consultation consists of coordination between the BLM's Authorized Officer and the individual tribal governments to identify specific tribal concerns and work with the necessary individuals to address those concerns. These efforts are part of an ongoing relationship between the BLM and each tribal government.
How would the BLM mitigate the destruction of ancient yucca that are 15 feet tall?	Shannon Salter	If the project receives a favorable application evaluation determination and the environmental review/National Environmental Policy Act process is initiated, post-construction ground treatment types and alternatives would be analyzed. This could include leaving cacti and yucca in place within areas where grading is not required. BLM's Restoration Plan states that cacti and yucca will be salvaged from temporary disturbance areas and replanted after construction in those areas.
What about the kit foxes??	Shannon Salter	Kit fox dens identified during on the ground surveys where ground-disturbing activities are to occur, all dens and cavities identified must be thoroughly inspected by a qualified biologist prior to this activity.

Question	7/19/22 Asker	Answer
There is a mountain lion that lives near the Kingston Mountain range. How would you mitigate impacts to him or her?	Shannon Salter	The BLM is currently in the early phase of the application review. If the project receives a favorable variance determination, the BLM would initiate environmental review. Mitigations for potential project impacts are identified through the environmental review process.
Would you mitigate the plant destruction the same way you did at Yellow Pine?	Shannon Salter	The Applicant is studying the project site to develop a more refined project design. If the project receives a favorable variance determination, options for site preparation methods will be considered during the environmental review process.
Will we have the opportunity to comment?	Christina Sanchez	Yes. Please submit your question/comment by August 5, 2022, through: Email: BLM_NV_SND_EnergyProjects@blm.gov Mail: BLM Southern Nevada District Office Attn: Golden Currant Solar Project Variance 4701 N. Torrey Pines Dr Las Vegas, NV 89130
What tribes are being asked to comment on the impact to the Salt Song Trail?	Susan Sorrells	The BLM has initiated consultation with the Chemehuevi Indian Tribe, Colorado River Indian Tribes, Fort Independence Indian Community of Paiute, Fort Mojave Indian Tribe, Hualapai Tribe, Kaibab Band of Paiute Indians, Las Vegas Paiute Tribe, Moapa Band of Paiutes, Paiute Indian Tribe of Utah, San Juan Southern Paiute Tribe, The Hopi Tribe, Twenty-Nine Palms Band of Mission Indians, and Utu Utu Gwaitu Paiute Tribe (Owens Valley Paiute Benton Reservation) for this proposed project. The specific protocols for how consultation proceeds and what that consultation looks like is dependent on the BLM's relationship with each tribe. Generally, this consultation consists of coordination between the BLM's Authorized Officer and the individual tribal governments to identify specific tribal concerns and work with the necessary individuals to address those concerns. These efforts are part of an ongoing relationship between the BLM and each tribal government.

7/19/22

Question	Asker	Answer
How were the variance areas determined in the Solar PEIS of 2012? Were areas surveyed on the ground, what was the level of detail of analysis? Sorry for the above repeated posts. My question wasn't answered. I asked how the variance areas were determined in the first place? There has to be criteria for this specific designation. What was the criteria? Who was on the ground conducting surveys? The level of detail in a PEIS is very important to know. Thank you.	William Helmer	Detailed information on how variance areas were identified and established is available in the Solar PEIS document which can be viewed online at https://solareis.anl.gov/documents/fpeis/index.cfm
I did not submit prior to the meeting to make a public comment. Can I comment?	Christina Sanchez	Thank you for your comment. If you would like, please sign up to give a verbal comment or you can also submit the comment using the methods below: Email: BLM_NV_SND_EnergyProjects@blm.gov Mail: BLM Southern Nevada District Office Attn: Golden Currant Solar Project Variance 4701 N. Torrey Pines Dr Las Vegas, NV 89130
This is a very inefficient way to take public comment.	Patrick Donnelly	Thank you for your comment. If you would like, please sign up to give a verbal comment or you can also submit the comment using the methods below: Email: BLM_NV_SND_EnergyProjects@blm.gov Mail: BLM Southern Nevada District Office Attn: Golden Currant Solar Project Variance 4701 N. Torrey Pines Dr Las Vegas, NV 89130
Jessica said that there is a rare buckwheat sp. in the area, I am unsure if Jessica said it was Crown valley buckwheat, what is the scientific name?	Christina Sanchez	Pahrump Valley buckwheat (Eriogonum bifurcatum), which is a BLM sensitive species, has potential habitat within the project area. 2022 botanical surveys have not yet been finalized, but there were skeletons of past season plants that were tentatively identified as Pahrump Valley buckwheat in one area within the project site.

7/19/22

Question	Asker	Answer
I would like to know how completely surrounding a residential area is any good. We in Pahrump will have panels right up to our houses and school. We will be encompassed by dust and heat. We are people! Put these where there are no people!!!!	Donna Neitz	Thank you for your comment. If you would like, please sign up to give a verbal comment or you can also submit the comment using the methods below: Email: BLM_NV_SND_EnergyProjects@blm.gov Mail: BLM Southern Nevada District Office Attn: Golden Currant Solar Project Variance 4701 N. Torrey Pines Dr Las Vegas, NV 89130
Can I still comment? I was called earlier but I had to work late. I am here now.	Debra Savitt	live answered-Yes, we will call on you.
Why won't anyone tell me an approximate dollar amount for the lease?? What is the lease amount for Yellow Pine? Use an est of acreage and please give me an answer.	Sharon Minsch	The BLM recently updated its rental policy. The BLM will be calculating rental under the new policy later this year. Rent for right-of-way grants is calculated at the time of offer.
Curtis Walker- how can you give me that answer? Measure to reduce impacts could include???? Why don't we have a plan for the tortoises before this thing keeps moving forward? You know there will be more projects. Why don't you folks have to protect the tortoises? Why don't we have a process to protect the tortoises before we proceed?? I am just so sad to see that more tortoises will be killed. You can't pick them up and move them and expect them to survive.	Sharon Minsch	Projects require full analysis prior to mitigation and minimization measures are definitively determined. Though, in addition to my previous answer, predator surveys will be conducted in translocation areas prior to the translocation of tortoises to assess predator diversity, abundance, and the likelihood of predation. Additionally, the BLM and Fish and Wildlife Service are considering multiple protective measures including the release of tortoises into pre-existing burrows within translocation areas during late fall, prior to the winter dormant season where they will be temporarily penned. Penning will serve to protect desert tortoises from predation through their winter brumation cycle and allow for individuals to acclimate to their new environment ahead of unpenning in the following spring when they become active.

7/19/22

Question	Asker	Answer
Where can I view the rent agreement for the acreage rent for the Yellow Pine project? Where can I see the anticipated charge for when they start once generation is started for Yellow Pine?	Sharon Minsch	The BLM has not yet calculated rent under the new policy for the Yellow Pine Solar Project. Members of the public can view the project case file by scheduling an appointment and coming into the office. The office number to schedule the appointment is (702) 515-5000.

7/20/22

Question	Asker	Answer
I have read that the desert crust, plants, and root systems store carbon and keep Co2 out of the atmosphere. Is this true? How will bulldozing the soil crust and plant life affect this carbon storage?	Shannon Salter	live answered- Currently, the BLM is reviewing the project through the variance process. If there is a favorable variance determination made for the project, the BLM would continue processing this application by initiating and environmental review/NEPA process. Carbon sequestration and greenhouse gases would be analyzed during that process. The applicant is studying the project site to develop a more refined project design and the BLM would work with the applicant to avoid, where appropriate, development in areas with biological soil press. If the project receives a favorable variance determination options for site preparation method and loss of soil press would be considered during the environmental review process.
How many feet away from the Stump Springs ACEC is the Golden Currant site?	Shannon Salter	live answered- The project is approximately 6293 feet away.
How many feet from Cathedral Canyon private property line is the Golden Currant site?	Shannon Salter	live answered- Golden Currant Solar Project site is adjacent to private lands in the vicinity of Cathedral Canyon.
How many feet from Queho's gravesite at Cathedral Canyon is the Golden Currant solar site?	Shannon Salter	The Gravesite is located on nearby private land. Since it is on private land, the BLM does not have information about the exact location of the gravesite to use to provide the distance from the project area. We can add a kmz file to the website for the project, to assist you when you are reviewing and providing input on the project.
What would happen to the giant yucca on the Golden Currant site that was featured in the March 13, 2022, Las Vegas Sun article photo gallery online?	Shannon Salter	live answered- If the project receives a favorable application evaluation determination and the environmental review?NEPA process is initiated, types and alternatives for replanting of vegetation species within the project area would be analyzed during the environmental review process the BLM would make effort to avoid minimize and mitigate impacts to vegetation.
How old is the untouched desert pavement on the Golden Currant site?	Shannon Salter	live answered- The age of the desert payment in the Golden Currant Solar Project site is unknown at this time, currently, there has been no extensive studies in the project area, the estimated age of other desert payments in general is up to 7000 years old.

7/20/22

Question	Asker	Answer
Will the developer be permitted to buy water rights from a landowner in Pahrump like Nextera did for Yellow Pine?	Shannon Salter	live answered- Noble Solar has stated in their preliminary plan of development that the most powerful source of construction and operation phase water for the proposed project will be water purchase from a commercial source or a use with an existing appropriation, it would then be trucked or pipes to the project site would be stored in or excuse me in an onsite water storage system. The project does not anticipate drilling any new water wells. The Nevada division of water resources is responsible for the allocation of water resources within the state of Nevada. If the project receives a favorable application evaluation determination, the BLM will consider impacts from water use during the environmental review NEPA process. BLM considers water both surface and groundwater within the broader context of all resources on BLM and ministered lands and their interactions as they relate to BLM responsibilities.
This project was labeled medium priority because of its proximity to Stump Springs ACEC and Old Spanish Trail. Why is BLM moving forward so quickly?	Shannon Salter	live answered- The BLM is responding to multiple applications received for large scale solar development in the Pahrump Valley. The southern Nevada district has 30 pending applications for renewable energy right-of-way, including the applications in Pahrump Valley and is utilizing a process provided for in the regulations for prioritizing processing of renewable energy applications. The application evaluation process involves a preliminary review by interdisciplinary resource specialist. Then, based on the preliminary review prioritization processing of applications that have the fewest resource conflicts and the greatest likelihood of success in the permitting process. The projects in the valley were rated as high there's three of them and medium priority one for processing and are subject to a case-by-case application evaluation process. BLM has initiated work on the Golden Currant Solar Project application determined by the BLM to be medium priority for processing and is in the application evaluation phase now.

7/20/22

Question	Asker	Answer
What is the tallest yucca that has been documented on this site?	Shannon Salter	live answered- The applicant has not yet conducted botanical resource service surveys on the site. BLM welcomes the submittal of any information that the public may have pertaining to resources located within the project site. If the project receives a favorable application evaluation determination, the BLM would proceed to a detailed environmental analysis in accordance with the National Environmental Policy Act that analysis would include a detailed evaluation of botanical resources.
Would the construction company use Cathedral Canyon Rd. to access the site?	Shannon Salter	live answered- The project proposes to utilize state route 160 and Tecopa Road for access. For more detailed information please see the preliminary plan of development for the project online at the at the link provided in the chat.
How would the developer build around the deep canyons, box canyons and washes on this site? Would they need to dig an extensive culvert to reroute water flow like at Yellow Pine Solar?	Shannon Salter	live answered- We are currently in the very early stages of application review conducting application evaluation if the project receives a favorable determination, the BLM will initiate environmental review. If the project is approved the project sponsor will submit engineering construction plans prior to BLM approving the project to proceed with construction activities.
Would the permitted herbicides be harmful to insects, birds, tortoises, and people riding ATVs, hiking, or camping near the Golden Currant site?	Shannon Salter	live answered- Only those approved in the record of decision for the 17 Western states, (garbled) decision for vegetation treatments, and so the Nevada district office's biological opinion would be used on the site.
How was the determination made for the need for the multiple solar farms now proposed?	Richard Tretter	live answered- The BLM is required to respond to applications that are submitted for renewable energy projects. We are currently in the early stage review process for this project conducting the application evaluation. If the project receives a favorable application evaluation determination, the BLM will initiate environmental review. The environmental review would include consideration of the purpose and need for the proposed project.
What is the financial renumeration to the Nye County commissioners and to the county of Nye and to the Town of Pahrump, and to the same of Clark County as a result of this potential project?	SUSIE GREENWALD HERTZ	live answered- The BLM does not have authority relating to payments to the county or town by the project sponsor.

Question	7/20/22 Asker	Answer
How many people are attending? There is no way to see that the way you have it set up.	Judy Branfman	live answered- Right now, we have 21 folks online for the meeting currently attending.
Would there still be public access to the area, i.e., could I hike through the area as I can now? If not, in what sense is the land still “public”?	Stephen Denham	live answered- The BLM is currently requesting information about potential impacts to public access and recreation within and adjacent to the proposed site. Helpful information to submit at this time could include local knowledge of trails/routes used within the project area and impacts to recreational experience on the trails. If the project receives a favorable application evaluation determination as part of the environmental review process potential impacts on trails and recreation, including potential mitigation measures as needed would be evaluated for past projects such measures have included changes to the proposed project layout to preserve trail segments and maintain access to specific recreational resources.
The planning area is Visual Resource Mgmt. category 2. VR=1 being the highest and most pristine ranking. Projects must be built to not dominate or negatively impact the viewscape. Is hiding the panels from view part of the planning criteria? How will it be done?	ROBERT ADAMS	live answered- Planning criteria guide development of the resource management plan amendment process by helping define BLM decision space. They are generally based upon applicable laws, BLM director and state director guidance and the results of public and government participation. Should the Golden Currant Solar Project receive a favorable application evaluation determination and the need for resource management plan amendment are identified in order to achieve conformance for visual resources or other resources, BLM will develop planning criteria prior to processing the detailed environmental analysis in accordance with the National Environmental Policy Act.
Alternative energy technologies rely on fossil fuels through every stage of their life. They rely on fossil fuels for raw material extraction, for fabrication, for installation and maintenance, and for decommissioning and disposal. Have those carbon emissions been calculated and what is that figure and its relation to the amount of carbon emissions savings for this project?	Carl van Warmerdam	If the project receives a favorable variance determination, the direct, indirect, and cumulative effects from greenhouse gases will be analyzed during the during the environmental review/National Environmental Policy Act process. During the National Environmental Policy Act process, the BLM would follow current Council on Environmental Quality guidance on the analysis of greenhouse gas emissions and climate change when evaluating federal actions.

7/20/22

Question	Asker	Answer
Commenters yesterday mentioned Mesquite woodland in the area. Is there a riparian habitat near the area and would this ecosystem be disturbed if the project is approved?	Christina Sanchez	live answered- Given the geographical limited range of mesquite trees within the proposed project area, the BLM anticipates mesquite bosque could be avoided. If mesquite bosque could not be avoided, off site mitigation to improve conditions in adjacent mesquite habitat may be considered. Information about existing mesquite bosque in and around the proposed project location being gathered is helpful to evaluate this resource, if you have any information about this resource, please provide it to the BLM project email provided in the chat.
Who will receive the power from the project?	Joyce Barishman	live answered- The project sponsor Noble Solar has indicated that a purchase for the power proposed to be generated from the project site has not been identified yet. The Golden Currant Solar Project proposes to interconnect to the Trout Canyon Substation which would allow the power to be provided to the California independent system operator and NV energy systems. Noble Solar has included job creation estimates for the proposed project in the preliminary plan of development which again, the site is listed on the website on the slide on the page now, thank you.
Isn't this public land for the public use?	Joyce Barishman	live answered- Congress tasks the BLM with a mandate of managing public lands for a variety of uses such as energy development, livestock grazing, recreation and timber harvesting, while ensuring natural, cultural, and historical resources are maintained for present and future use. To do this, BLM manages public lands to maximize opportunities for commercial recreational and conservation activities. This promotes healthy and productive public lands that create jobs in local communities, while supporting traditional land uses such as responsible energy development, timber harvesting, grazing and recreation, including hunting and fishing.

7/20/22

Question	Asker	Answer
Can public opinion convince BLM to stop a project during the variance process and before NEPA?	Kevin Emmerich	live answered- The BLM is responsible for making the determination on whether to continue processing the solar project application or deny the application. Currently, the project is being reviewed under the application evaluation determination process. Once sufficient information on the project has been collected by the BLM and from other parties like the public, other agencies, and tribes, the BLM will make a determination on the application after considering all of the information collected. The application evaluation determination will be made after the public information forums and periods have been completed. It's estimated, this will happen in late 22 to ensure a consistent application of the variance process. All solar application in variance areas that are determined to be appropriate for continued processing will be submitted by the BLM state director to the BLM Washington office for the director's concurrence.
How many people are attending? You keep saying there are many, but why can't we know how many?	Judy Branfman	live answered- We have 21 folks online for the meeting currently attending.
The local tribe (Pahrump Paiute Tribe) wasn't involved with the Yellow Pine Solar Project due to BLM never reaching out to them. Will the BLM be involving them in the proposed solar sites in Pahrump Valley and Amargosa or will they be left out again?	Eddie Ji	live answered- The BLM has initiated consultation with 13 tribes for this proposed project. These specific protocols for how consultation proceeds and what the consultation looks like is dependent on the BLM relationship with each tribe. Generally, this consultation consists of coordination between the BLM authorized officer and the individual tribal governments to identify specific tribal concerns and work with the necessary individuals to address those concerns. These efforts are part of an ongoing relationship between the BLM and each tribal government.
During the assessment, do you consider if alternative generation technologies would be better for the environment, e.g., roof top solar, brown-field solar?	Stephen Denham	live answered- The BLM is required by law to respond to applications filed on BLM managed lands and has no authority or influence over the installation or distributed generation system, also known as rooftop solar.

7/20/22

Question	Asker	Answer
How do the thousands of plants, root systems and 7000-year-old desert pavement store carbon?	Shannon Salter	Currently the BLM is reviewing the project through the variance process. If there is a favorable Variance Determination made for the project, the BLM would continue processing the application by initiating an environmental review/National Environmental Policy Act process. Carbon sequestration and greenhouse gases would be analyzed during that process.
What will the effect of this solar site have on the springs that we have left in the valley?	Eddie Ji	The Nevada Division of Water Resources is responsible for the allocation of water resources within the State of Nevada. If the project receives a favorable application evaluation determination, the BLM will consider impacts from water use during the environmental review/National Environmental Policy Act process. BLM considers water, both surface and groundwater, within the broader context of all resources on BLM administered lands and their interaction as they relate to BLM responsibilities.
In the map in the POD there are lines in the avoided washes that look like new roads. Are these roads? Thanks.	Kevin Emmerich	The map in the preliminary Plan of Development on page 63 shows the location of existing washes. However, the legend in the map is cut off. We will inform the applicant that the legend is not visible and will request a new map be provided and post to the project information webpage.

7/20/22

Question	Asker	Answer
What is the impact of solar reflection pollution on surrounding properties?	Linda Tamashiro	The BLM is currently in the application evaluation phase for the project and has not yet determined what resource impacts would be considered during an environmental review. If there is a favorable application evaluation determination made for the project, the BLM would continue processing the application by initiating an environmental review/National Environmental Policy Act process. Based on input during this current public input period (including your comment) and scoping input gathered when the environmental review process is initiated, the BLM would determine what resource impacts were appropriate for analysis.
Why can't BLM place these installations in lands other than population-affected and recreation-affected, and wildlife-affected areas, as all of these applications seem to be? If there are millions of acres of BLM land in the 6-state area, surely you could put these installations somewhere where the human and animal and plant populations would not contest them vehemently, thus making the approval process more successful?	SUSIE GREENWALD HERTZ	live answered- The applicant Noble Solar identified and applied for the proposed project site. The lands being requested in the application were identified in the solar PEIS as variance lands where solar energy development application can be considered on a case-by-case basis. The BLM must consider the appropriateness of the application utilizing the variance process that was identified in the solar PEIS. The current public input meetings and public input period are a critical piece of the variance process and will inform BLM decision on whether to continue processing the application which initiates the NEPA process.
Has the BLM actually been on the property? if so, you would know a great deal of it includes washes, some quite wide and deep, that run across the whole property. Is it even legal to tear up an area that facilitates the flow of water into an already low watershed?	Judy Branfman	live answered- The BLM has conducted site surveys to the proposed project site and is familiar with the terrain on the site. The applicant will be conducting site studies that would inform the design of their proposed project. If the project receives a favorable application evaluation determination, the BLM will initiate environmental review for the proposed project, the review would include mitigation and development of a range of alternatives.

Question	7/20/22 Asker	Answer
How frequently has the BLM had meetings with representatives from Noble Solar in the past month?	Shannon Salter	The BLM is required to respond to applications submitted. For the Golden Currant Solar Project, the BLM has discussions about the project with individuals from local, state, and Federal agencies, tribes, non-governmental organizations, stakeholder groups, the public, and the applicant. Coordination with various parties while BLM is considering an application is a common practice.
What is the success rate of replanting yucca that are hundreds of years old and 15 feet tall?	Shannon Salter	There are no current studies that BLM has conducted that evaluates transplanting success for yuccas of that height.
How would fugitive dust affect air quality for people camping at nearby Stump Springs and living in Charleston View?	Shannon Salter	live answered- Construction of solar energy facilities may disrupt drainage patterns and cause surface disturbances and soil compaction resulting in increased erosion, run off, dust and sedimentation. The solar PEIS has required design features for air quality and soil, which would be incorporated into this project. Construction related impacts are mitigated by implementing best management practices, site specific mitigation measures and standard operating procedures that would reduce soil erosion, potentially. If the project receives a favorable application evaluation determination mitigation would be determined during the environmental review of the project, the project would also have to comply with Clark County requirements such as air quality permit.
Would these panels contain cadmium and lead?	Shannon Salter	The most commonly used materials to construct solar panels are: Crystalline silicon (c-Si) Amorphous silicon (a-Si) Gallium arsenide (GaAs) Organometallics (soluble platinum)
Are there any at risk species in the proposed area?	Carl van Warmerdam	The Mojave Desert Tortoise occupies the area, and the sensitive Pahrump Valley buckwheat has potential habitat within the project area.
Can you please tell us again where Carl was quoting from? The complete info? Thanks	Judy Branfman	The public input forums are being recorded and will be posted to the project webpage.
Thank you all.	Carl van Warmerdam	Thank you for attending and for your input.
Good evening.	Carl van Warmerdam	Have a good evening.

Appendix D - Public Input from Virtual Public Information Forums

July 19, 2022
Public Input

Kevin Emmerich	I hope you can hear me; my name is Kevin Emmerich, and my organization is Basin and Range Watch. May I ask you about the visual resources and the plan amendment? You're going to amend the Copper Rays Solar Project plan and the plan amendment for Copper Rays and Rough Hat Clark. And I believe that's over visual resources because of what you have called a visual class three which allows some development, but it can't dominate the landscape and solar definitely does do that for Golden Currant. The problem is it's a class four and that encouraged a development that dominates the landscape, but that's based on an outdated resource plan from 1997. It's about two miles or so from the Old Spanish National Historic Trail managed by the park service. It was designated after the Las Vegas Resource Management, and had you updated that plan you might designate the whole area that Golden Currant as a visual Class two or a visual Class three which wouldn't discourage that kind of solar development. You're all telling us that you're going to have a Nevada wide update resource management plan coming up next summer and, if you would just wait on this review, whatever the company thinks, who cares what they're saying, this is a lot of important resources here, if you would just wait on this review, you could update your data plan and maybe we could update the visual class and stop this one from happening. Listen, all the people are concerned about this, this is going to be a nightmare, it's going to be a resource nightmare (garbled) badlands topography, desert tortoise, historical resources, public lands access, fugitive dust. It's one of those where the list goes on and on, thank you very much, that's my comment.
Kim Hover	Thank you and good evening. I just had a quick question on how many wild horses and burros will be impacted by all the projects, current and future in these areas? Thank you.
Teresa Bartoldus	Thank you. I'm really concerned about this project. I want to speak very strongly against it. I really hope that this doesn't get any type of approval at all to forward. It's going to create so much destruction for so much of our wonderful resources, plants and animals. It's going to cause us to waste water. It just seems like a very, very bad idea. The tortoises that have already been removed from one spot will be moved again. I understand a bunch of them died in that process so whole bunch more certain to die. And the next project, there are so many reasons, and it seems to me that there are other places that we can put solar that don't have to destroy our wonderful and undeveloped desert that I'd like to preserve as a resource for all people in the future who are using it. Now it's going to be irreversibly damaged. That's my comment.

July 19, 2022
Public Input

Michael Fender	Well, I’m a resident of Pahrump and I’ve been watching all this playing out over here down, where the Yellow Pine is and where this other project wants to go. I know there's plans for about seven projects, maybe even eight to encompass 17,200 acres of BLM land for these projects. Unfortunately, what this is going to do is not only is it going to be along the Tecopa Highway and along highway 160 as you enter Pahrump Valley from Las Vegas, you're going to see these solar farms coming down over the hill. Now I understand there's been a lot of lot of damage after I’ve actually been out the Yellow Pine, I’ve seen that, so I know what's going to happen out here at this Golden Currant. It's gonna be the same thing. And, quite honestly, this is not what people want to see when they drive through Las Vegas ,to Las Vegas, from Las Vegas or through the Nevada desert are solar farms and lined up along the highway. The use of these and similar areas to install solar farms is absolutely ridiculous. They have the technology to put these farms in other places throughout Nevada. Nevada encompasses 448 million acres of BLM land in Nevada alone, and here they want to use up this small little pinhead, 17,200, right here just south of Pahrump. Well, quite honestly, this is a pretty bad deal for all of this in the long run. Well, everybody, take care.
Christina Sanchez	Thank you, so my comment would be it's unclear as to what flora are occurring. I heard that plant species, like the mesquite and (garbled) and I forgot what species of yucca, I heard yucca from (garbled). I am just curious as to actually, it’s just curiosity, if the goal is to protect the environment, protect the climate, these species that I just mentioned, if they are true, I know there's hasn't been a botanical survey as of yet. But these plant species are one long list of species and here we know in the desert that things in the desert grow slow and they're not quick growing so these long life, slow growing plant species that you know, take hundreds and thousands of years to come back after disturbance are what are helping to mitigate climate change in terms of storing atmospheric carbon dioxide. Now somebody made a public comment that the solar can be placed on other areas. If the real end goal is to protect the environment and the land then it is your duty to protect the land by saying no to development projects such as solar because it's going to not only disturb the environment locally it's going to have an impact on the fauna that rely on many of these plant species for food, but it's also going to release carbon back into the atmosphere and we're seeing climate change accelerating. It is extremely unsustainable to clear cut this beautiful land to put in, you know solar panels when we can surely find better places to place them, thank you very much.

July 19, 2022
Public Input

Sharon Minsch	Good evening. I just want to state again that, I believe forcing the public to weigh in on these one solar farm at a time is a huge waste of the public's time. This piecemeal process does not take into consideration the cumulative impacts of destroying thousands of acres of desert as a habitat that we're giving away for money. We're tortoise owners, we know that the tortoise we got last year has taken a year to finally stop trying to go back to Las Vegas where he was turned loose. When you move those tortoises they have no burrow, they have no way to find food, they have no way to survive the heat and they die. How many tortoises have to die before somebody listens? Since they cannot come up with a plan where the tortoises will live, they should not be allowed to move one stinking tortoise. And to tell me when I asked what's the plan for the next farm to not have all of these deaths? Well, will we look at that when we get to that part of the process. We shouldn't be taking applications if we don't have a way to protect the animals that live there and belong. I do not believe that BLM is paying any attention to this critical public input, and I believe that decisions have already been made. But I just do not understand when we know so much about these desert tortoises. It's against the law to pick them up because they can't find their way home; they can't get to safety. So, again I'm begging somebody to take responsibility for the ones who have already died. I still can't believe nobody's responsible for putting them in front of a badger. So, something has to change, and I don't believe that we're going to stop the solar farms, because we have a President who says we have to have them, but we have to protect the tortoises Thank you.

July 19, 2022
Public Input

Patrick Donnelly	Hi, my name is Patrick Donnelly. I’m Great Basin Director with the Center for Biological Diversity and I’m a resident of California and a former resident of Nevada. Nevada has a big problem on their hands. They have a Congressional and executive mandate to permit 25 gigawatts of renewable energy on public lands, but they have absolutely no plan on how to do it. The idea that each of these projects is a standalone proposal unrelated to any other is a farce. The proposals on the table now would turn the Pahrump valley into a de facto solar energy zone. This is, by its nature, a landscape scale project requiring landscape scale plan. California faced similar dilemma several years ago and their solution was the DRECP the desert renewable energy and conservation plan. Regional level planning enabled reduced conflict over renewable energy in the ACP planning area and resulted in millions of acres of conservation and let's not forget, nobody litigated the DRECP. BLM Nevada needs to conduct landscape level planning, both statewide, but also at the localized scale in the valley. If you're going to proceed with turning this area into an industrial scale energy production zone, you must have a regional mitigation scheme to offset those impacts. This could include designating new protective areas such as ACP using design features to minimize impacts onsite and enacting a comprehensive offside mitigation plan. You know just sticking tortoises in burrows and calling it mitigation is unacceptable. Without regional level planning, you will not be able to achieve your renewable energy goals, because, as you see, from all the angry people on this phone call right now there is going to be obstacles put in the way of developing these projects. And you know the whole process may end up grinding to a halt, as one by one, these projects are challenged, based on the inadequacy of environmental review and the inadequacy of mitigation and unacceptable impacts. So, there's going to need to be a regional level plan in order to move forward in any way with these projects, thank you.
Christian Gerlach	Hello, thank you. My name is Christian Gerlach, like Gerlach, Nevada. I am a resident born and raised in the Las Vegas Valley. I have seen the dramatic loss of our public lands due to suburban sprawl. It is unconscionable that the Bureau of Land Management will allow this further degradation of our public lands and desert landscapes that take literally thousands, hundreds if not thousands of years to get to the point to where they're at. There will be tremendous cumulative impacts from all of these solar projects so again having us as the public comment on these individually, is a farce. It is horrible that we will have cumulative impacts, including this Golden Currant project which will only add through the use of these dark solar panels, to the urban heat island effect that has been well documented from solar fields. Beyond that the clearing of the desert living crust crypto biotic soils will allow for loose dust to get kicked up over the hump from Pahrump into the Las Vegas Valley further degrading the air quality of the Las Vegas Valley for individual residents, like myself, who have suffered from asthma my entire life. Communities of color, low-income communities that struggle with poor air quality, this is only going to add to those problems and issues. The environmental justice directive under President Bill Clinton requires Bureau of Land Management or an any Department of Interior agency or entity to look at the environmental justice impacts of any of it. So, this is clearly something that totally goes against those previous executive orders that require the Bureau of Land Management to consider environmental justice impacts. Thank you for your time.

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Joni Hawley	I just wanted to go on record that I am against this project. A lot of people have already covered points that I was going to so I'm not going to go over that again but you know the water that's being used out of Pahrump Valley, our watershed, for projects that are in a different county and there's too many of these projects, you know totaling around 20,000 acres if they all go in and like they said, you know this is going to be a solar field out here, nothing else. Destroying the pristine desert habitat, including you know issues with the endangered tortoises and other animals. I don't know if you have gone out and seen the Yellow Pine project, but it's been a complete dust storm out there in recent days. You know there's other places to put the solar; roof tops, parking lots, and I just feel like this is all about the money. It just is convenient for these companies to be close to the highway and I think that BLM needs to look at, I mean we're not going to stop it, but BLM needs to look at other areas to move these to, if they're going to put them in. Thank you
William Helmer	Yes, hello, yes. I think this project needs to be rejected. Out of hand it obviously doesn't fit in this area, especially looking at the cumulative impacts and seeing the destruction of The Yellow Pine project. That has to stop, I mean draw the line right there. You see what's going to happen, and this one is even closer to Stump Springs, a very Culturally sensitive area, the Old Spanish Trail goes nearby. There's just so many impacts and the question is, why should Pahrump Valley be an energy sacrifice? So, it's just going to be wall to wall solar? Yeah, the visual impacts, the impacts on traditional cultural landscapes are going to be just intense, so I think out of hand, this should be a quick decision to not waste people time. We are worried about whether this very special area is going to be destroyed because all we have to do is just look up the road from where this is supposed to be is Yellow Pine and it's just absolutely unnecessary. And my question about variance ,how it was determined was not answered but there's a question about these huge variance areas that are supposed to be decided, case by case. I don't think there was a great level of analysis to choose these variance areas 10 years ago in the solar PEIS, and that is a big problem and we're dealing with it now 10 years down the road, so no project! That's the way to go with this one. It's very simple to decide this one, thank you.
Jack Prichett	Yes, um. I want to say first of all that, I am extremely concerned about climate change, and I want to see the United States and other nations get off of fossil fuels, but solar power generation should take place in the cities and towns that use the power. Shouldn't be out in the desert. For example, electricity from these sites, including Golden Currant will go to Las Vegas and Los Angeles. Huge spaces available in those cities for solar panels parking lots, factory rooms, the rooms of large organizations, stores like Home Depot and so forth. 25% of the power will be lost in the transmission from Pahrump Valley to those areas. Secondly, utilities and solar farm developers are marketing this Pahrump Valley solar as "green power" to Community choice aggregations or CCA as in California. This is a deception. The impacts on the desert environment have been ignored in such a claim and several of the people who have spoken have described in great detail what the impact would be to desert cortices, to certain plant species and other things, so it shouldn't be marketed as 'green energy'. That's the end of my comment, thank you.

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Shannon Salter	Hi yep. Okay, yeah so, I'm Shannon Salter I am with an organization called Mojave Green, we have a website mojavegreen.org. I have been camping about 20 feet outside the proposed Golden Currant solar since October and I've been observing the destruction at the Yellow Pine solar site. You can see a lot of photos on my website at mojavegreen.org and we've also had reporters from the Las Vegas Sun documenting the destruction, as well as some of the flora on the Golden Currant site. I have to tell you I've hiked extensively now on the proposed Golden Currant site, there are some of the largest Mojave yucca I've ever seen; 15 feet tall and even higher than that. The site is not flat by any means. I've hiked the length of it with great difficulty. It's full of box canyons and washes that are very high, it would take an extensive amount of land moving and leveling. I'm also extremely concerned about the mesquite woodland around Cathedral Canyon Road and Cathedral Canyon itself. Cathedral Canyon itself is a historical treasure and a cultural resource. Every time I visit Cathedral Canyon, I see people from Pahrump there using their ATVs, so it's a popular area for ATVs and off roading vehicles from Pahrump to use those trails. It's also a popular camping site and the area around is a popular hiking site so, we're looking at extensive recreation. Lastly, we're not going to sit by and let this happen, this is an extremely misguided and sickening use of public land. I've watched the dust hazard explode at the Yellow Pine solar site. They bulldoze everything, and we will not sit passively by and watch this. Thank you.
Eric Ven	Yes, good evening to everyone. I had great anticipation for this event but really, I'm sorry but there's no better word than the non-answers that we have received were very disappointing and disillusioning. We got reading from the procedural information that we can find online and really the fact that many people in the question and answers section were asking for were just completely avoided. Also hearing that BLM doesn't know when the botanical survey will be completed but already know that that one decision, I don't remember exactly which phase would be made on August 5, which is only two weeks from now and the final evaluation will be done by this fall 2022. So all these things just telling me that as Miss Sharon mentioned earlier commentator said this decision had already been made by the BLM and I'm just baffled why several people mentioned that including me that the BLM was supposed to be a good steward of these lands and they have exact date on now and input from the people who live in this area about Yellow Pine and the mass devastation that they're doing there, it's a catastrophe. So, my feeling based on all that is that this procedure has been minimized into some kind of charade because it's required some kind of law or more decision. I personally don't feel that BLM is actually listening, but I'm glad that I could put this opinion on record. Thank you so much.

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Heather Gang	Oh, thank you. I'm concerned about the destruction of the soils in the Golden Currant site, the desert pavement in the northern part of the site would be irreparably destroyed and then where the pavement is less well developed the soils tend to be stabilized by biotic crusts that are also very delicate and take a very long time to form. In the southern part of the site, the soils are fine grain Pleistocene spring deposits, and they could potentially contain vertebrate fossil. Fossils were documented by Spalding and Quaid near Stump Springs. We have seen from the Yellow Pine destruction that desert pavements and crust to do not survive the solar panel installation, even when the so-called moaning technique is used. Abundant silt will create an unmitigated dust hazard and the carbon sequestered in the soil biota will be released. Just over the state line similar land is designated as wilderness. In 2012 Bright Source Energy proposed to build the Hidden Hills Solar Electric Project in Charleston View. This application was withdrawn in 2015 due to concerns over the effects on wildlife, groundwater, cultural and historical resources in the area. That's from Wikipedia. Why are we going through this again? But the greatest tragedy is the loss of our wild places. It's a beautiful place. People do recreate there. There are religious installations nearby; Cathedral Canyon and the St Theresa Mission, that exemplify the reverence that these lands inspire. Wild spaces, vast open landscapes, are the greatest features of the valley. I'm in Ohio right now. 98% of the land is modified by men. While you may think there's a lot of wild space left, but in the constant text of the entire nation, wild spaces are rare and becoming even worse. There's no need to destroy these remaining wild spaces there's plenty of space for solar power on rooftops and parking lots. Thank you.
Deborah Savitt	Yes, thank you. Yes, Okay, yes, I'm Deborah Savatt. I live in Yucca Valley, where we have a lot of Joshua trees and we try to protect them the best we can, so what I want to say to all of you here in support of us, all of you that want to protect your beautiful nature there. What upsets me is that big solar just tears everything down. It's in conflict with what it's trying to do, it's trying to go green, which is a good idea. But the problem is when you tear down all the plants and the trees and the ecosystems is throwing the planet off balance so it's in conflict kind of like a conundrum of what we're supposed to be doing. Some of the research that I've done has shown that big solar, if they can be a little more creative, can put panels over guardians, you know and shade crops. Where it would you know work in conjunction with maybe farming. I've seen them used as vertical walls. They're trying to use them in other countries, like on lakes and oceans. Also land that's not being used, you know or it's not disturbing an ecosystem. So, I'm trying to figure out why this is happening. It seems like big business is interfering and what really disturbs me is what we see in the state of California, as well as how some of the scientists that work for say the BLM or for the CFW, California Fish and Wildlife and Game, seems to be bought out to big money and this is going to devastate us and our planet. We as humans need nature in order to survive, and so to me it's craziness. We need to really think a lot more about where we're putting big solar. Yes, we need to go solar, maybe more rooftop or more creative ways of using big solar. Thanks so much.

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Laura Cunningham	I tried to ask a Q & A several times, I had technical problems, as Kevin Emmerich but I tried to ask a question, but I'll make it now, a comment. I have hiked in this project area extensively and half of the proposed project area is deep incised badlands and deep washes and I love hiking in this extensively rugged bad land terrain. I cannot fathom how the solar company thinks it can build a solar project on half of this proposed site. The badlands are very deep and rugged; they're beautiful, I mean this area could be a wilderness area. It's full of tortoises and honey mesquite so I wanted to ask a question, but you skipped over me as Kevin Emmerich. How does the project proponent proposed to build a solar photovoltaic project on such an extensively topographically challenging area that is not flat and is extremely just full of beautiful deep washes and badlands anyway? I just wanted to make that comment that like a good 40 to 50% of this area is actually not a flat desert, it is a very interesting badland desert, full of topography and I don't even think that a lot of this area is qualifies as a solar project. Somebody was sitting at their table looking at a map and drew a line and very few people have actually gone out there to look. Thank you.
Donna Neitz	Yes. I just have to say I am a resident (garbled) and I'd like to know why these people want to destroy our town? We all know, if we live out here, it's all about dust problems that we have, we all know that there are going to be water problems. They want to run these solar panels right up to residential areas and to schools. There's no way that they're ever going to get the land to not blow around. The whole valley is going to be one cesspool of dirt and I just don't understand like a lot of people upset. Let the people put them on the roof, let them put it on over parking lots to give shade. You're going to destroy this whole area and the whole town and it's about 40,000 people or maybe a little more and I don't think that's quite fair, especially since all of this solar energy is going to create electrical for Clark County or California. We ourselves are going to be destroyed because of this, thank you.
Michael Fender	Thanks for letting me talk again. I would, I would just like to add that this program that went into coming up with the solar project started way before 2008 and it was called the PEIS the programmatic environmental impact statement which was first put together in 2008 and it covered the deserts in the southwest of California, Nevada, Arizona, Utah, and New Mexico. With this information, it was finalized, believe it or not, the last final the last draft in 2012 and broke down these states into different zones in areas they have (garbled) they know what the country looks like. So, if you want a bit of good reading, to become on top of where this information comes came from, and why they selected this valley in itself. It's a lot of reading because the report is over 2500 pages, so if you're really interested here, it's called the PEIS the programmatic environmental impact statement. And the last draft was available in 2012 anyway, that will give you an insight that this didn't happen overnight, this was planned many years ago. And finally, now they're putting it there, decided to run this operation and just variance areas in these five states with the responsibility of providing our land and destroying the country that we live in for the others that aren't doing much of anything. Now there are some of their other states on the east coast and the Midwest yeah, they have solar farms, but nothing like they have planned for here. Anyway, thanks again and that's just some information I thought they would want people to know. Thanks a lot.

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Christian Gerlach	Thank you kindly and again Christian Gerlach like Gerlach Nevada. Again, executive order by President Bill Clinton, executive order 12898 signed on February 11, 1994, requires all federal agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations to the greatest extent possible, by public law. This includes the low-income community members of the valley, the Las Vegas Valley, who will suffer from greater increase in particulate matter and dust as a result of the clearing of our desert public lands. They take thousands of years to get to the point that they are in currently prior to any sort of destruction or devastation. We are already seeing literal brownouts along the US 95 southbound as result of many of the solar fields that have been installed. Headed southbound on the US 95 when the wind blows the US 95 is literally impossible and oftentimes they have to close down the US 95 southbound and northbound between Boulder City and Searchlight as a result of the brownouts from all the dust that blows. That from the ones that have been disturbed for these solar renewable energy projects again this doesn't even touch the urban heat island effect that results from the dark solar panels absorbing more light and heat from the sun and obliterating it into the surrounding habitat and area. I appreciate the time. I appreciate the Bureau of Land Management; they are a multi-use agency. You've got to balance, a lot of things, but this will impact human health negatively, and goes against that executive order aforementioned, thank you.
Christina Sanchez	Thank you once again for calling on me. I saw the mitigation efforts was mentioned earlier of relocating these yucca species, like the Joshua tree and the Mojave yucca and I just wanted to make a comment that the survival rate of relocating these plant species is low. I have been to sites to record where Joshua trees and Mojave yucca had been relocated from other projects sites and they do not survive. Survival rate is very low. Mitigation, can you know also dictate that there has to be some type of monitoring, where the species have to be watered and maintained, but I am ,I just, the survival rates are low and it's the species are there, I said earlier about the release of carbon back into the atmosphere. Other folks have discussed about the critical biotic crust how it's going to be releasing up atmospheric carbon, once again, this is just a really disheartening project because it's not it's not cleaning the earth, we're browning the environment, and we are already seeing how climate change is impacting like the desert tortoise. Also survival rate of relocating desert tortoises is low, very low to like nil so if your goal is to protect the species and also rare plants, I would love to see, and I would like to know when we can ask my question, but when will there be a botanical survey and the environmental surveys may public because I would like to go over that. But if the goal is to protect the environment you're not, you're not doing the job, thank you.

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Kevin Emmerich	Thank you again. Kevin Emmerich, Basin and Range Watch. People were asking why here and that's because we built the big substation and approved that and Trout Canyon can accommodate a lot more projects. It should be noted that there needs to be upgrades to the transmission system going into that line so you can all get involved in that when it happens so stay tuned. One of the sad things about Golden Currant it's being built or proposed to be built by Primergy who's building Gemini Solar right now. Primergy seems to be really friendly with the Nevada legislature and other politicians and got away with getting that approved in 11 square miles of pretty high conflict areas even wasn't good mitigation. They had to move about 180 desert tortoises some which are being held in a facility, so drought doesn't kill them. They're developing six to 700 acres of habitat for one of Nevada's rarest plants called the Three-corner Milkvetch and, finally, impacting about two to three miles of the Old Spanish National Historical Trail. I see that is a very similar project area and project site to the Golden Currant site and I'm going to echo every comment that we're hearing on this forum. Do not approve this, do not have a repeat of the disaster of Gemini Solar that's being built by the Valley of Fire State Park, another very valuable piece of public land that seems to have been sacrificed for unnecessary solar projects and we're just not utilizing our build environment enough and we need to look at those alternative and then need for (garbled) before we destroy more public lands. Thank you.
Shannon Salter	Yeah you know just I'll make it quick. I just wanted to add that you know at the at (garbled) Golden Currant site, I saw and am seeing kit foxes every single night and, interestingly enough when I asked a biologist working at the Yellow Pine solar site what they were doing to mitigate the kit fox on the site, she said that they hadn't found any and they didn't have any record of kit foxes on the Yellow Pine site which I know is was an outright lie. Another thing I wanted to add about air quality. There's some air quality measures that they just won't be able to mitigate, of course, as they're bulldozing and scraping and grading the soil that is, you know going everywhere, and of course they're spraying 350,000 gallons a day. As Chris the manager at the construction site of Yellow Pine told me they're spraying 350,000 gallons of water per day. That they bought legally from the Pahrump Valley, so I would presume that Noble Solar would try to do the same thing, buy water rights from the Pahrump Valley, of which has already been over-allocated badly and, in fact, has been depleted. But in addition to scraping the soil, after the soil is scraped away, then we have that poof after, of course, which they really can't spray enough water on to keep down. But another thing is that, for every solar panel, they have to drill they they use this this huge equipment to drill these massive poles into the earth and when they do that it's an explosion of soil that I also have photos of on Mojavegreen.org and they don't even try to mitigate it. They don't try to spray it down because it would be, it would be an absurd thing to do. So yeah, the air quality thing is a really, really big issue I think we need to focus on and target here. So, thanks a lot.

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Shannon Salter	Yeah, you know just one more quick thing. I just wanted to add that at Cathedral Canyon we have the grave of Quehoe. He was a famous Native American in the early 1900s and he was a person that survived alone. And he really took it upon himself to fight against the white settlers that had ruined his valley and his remains were brought there by Roland Wiley, who is the eccentric and wealthy, actually the first district attorney in Los Angeles and Las Vegas that owned the Cathedral Canyon property, and the Cathedral Canyon property is still owned by the Wiley estate. But he built Cathedral Canyon. You can see pictures of what it once looked like; an incredible incredibly sacred site where thousands of people came every year. A spiritual place, a place to think and the grave of Quehoe is still there and I think we would be, we would be moving in the wrong direction to encroach upon Quehoe grave and denigrate that landscape, thank you.
Eric Ven	Thank you. Just a very quick note to what Shannon said earlier that the dust mitigation of Clark County does a really good job with the regulation, how to mitigate dust during the construction, but of course those things were designed for the city. When things are being built in the city and the desert is very different, but the main issue is that mitigation is mandatory during the construction, but once the construction is over, they don't apply. We'll still be living here at that time and even though Clark County has those regulations, Pahrump is in my county and once again the construction is over and the vegetation is destroyed the dust is not going to just sit quietly there because the construction is over and the regulations don't apply anymore so we're just going to eat dust, for the following decades. Thank you that's all.

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Joyce Barishman	Ladies and gentlemen of Nye County and around you're being lied to. The only reason they want to come and destroy our environment, bring down our housing costs and set up solar farms that will raise the temperature and destroy our environment is because they want to use our roads and they want to suck the lifeblood out of our aquifers, our water. There's no other reason why they don't go deep into the desert where nobody lives, you know other than our roads, other than sucking the lifeblood of our water, out of our aquifers. Ladies and gentlemen of Pahrump, Nye County, I urge you call your friends get your relatives, get your neighbors, everybody involved in this, so we can stop this the same way that we stop this from happening at Rough Hat or whatever. We just moved here from Los Angeles. Oh, by the way, all of this power is not going to Pahrump, it's not going to Nevada, it's all going to be shipped to California. We are not even going to get trinkets and beads for this. The amount of jobs that they're going to provide is nothing. The taxes that going to be contributed is absolutely nothing. There's absolutely nothing that this will do that will make our lives better whatsoever, it will destroy our property taxes, it will destroy our environment, it will destroy our wildlife, it will destroy our farms and plants. It'll do nothing but take from us. It's not going to give us anything back whatsoever, they wouldn't even offer an extra dime of extra power to any one resident here and so I urge you get your family, get your friends, get your neighbors, get everybody involved. Just stop this! They're vampires. There's nothing in it for us. That's it, I'm done.

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Kevin Emmerich	Hello, this is Kevin Emmerich, I'm representing Basin and Range Watch, an organization that follows the badly cited renewable energy projects, and this one's a poster child of such a thing. I want to point out here that you mentioned, you didn't know the age of the desert pavement, there was no information about that, but the United States geological survey did make a map. Geologists Matt Mechanicmade us map and I'll get it to you as a reference, and the desert pavement is at 100,000 years old, according to some of the research. And that's what's really instrumental in holding the dust down and keeping everything together and that of course is all being destroyed for Yellow Pine Solar. I want to comment on the variance process. In 2014 the variance process (garbled) California for (garbled) and valley solar. A very similar project, a little smaller, but it was really close to the Old Spanish Trail, very visible from wilderness areas and even some nationalpark areas and it had a lot of conflict with the public and user groups. And the BLM in response to strong public opinion against it canceled that project in the variance process, and that would be because NEPA, the national environmental policy act, required you to consider substantive comments that are not only based on public opinion, but the variance process a little bit more loosely. I urge you, as a public agency that works for the public, to listen to the public and cancel this project. It's just no good and has a grave environmental impact, thank you.
Robert Adams	I'll just line up with the other opinions that this is just a project that's too big, it's too close to Pahrump. And it's exasperated by taking five projects, five big projects and put them together. In other words, these projects should be smaller. And they should be separated, that's something we don't want to have them do is dominate the desert landscape and limited use is a good resource plan and dispersing that limited use is a better resource plan. So limited or dispersed use. Let's make them smaller and let's separate them so they don't put up huge roadblocks to block the desert from other users, thank you.

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Judy Branfman	Hi, I'm calling from Los Angeles, and I oppose this project. Real stewardship of our public land should include a thorough and scientific review of the true intent of each project and where each fits into the much larger hole. Mainly if the energy can be produced most efficiently, more efficiently and with less cost to the public, without destruction of valuable biodiverse lands than these means should be prioritized and, as you know, mainly we need solar produced on the thousands of square miles of parking lots which will produce many more jobs than the time limited construction of these destructive projects in the desert. They should be placed on homes, warehouses, malls, schools, etc., etc. It's also there's no lack of irony in the idea that creating green energy by destroying desert lands that are well known to sequester carbon, it's beyond irony. In California at least 10% of the carbon sequestration is done through the desert lands and I assume in Nevada it's much, much, much higher amount of you know of the state, so why not prioritize letting the desert do what it does so well instead of destroying it. And I'd also like to say, this has been incredibly short public input period, I think, since I got the notice, less than a month. And I don't understand why that's happening and also 21 people is not a lot of attendees on an issue this important so I'm wondering why even more aren't involved in this input, thank you.

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Shannon Salter	Perfect yeah. So, you know I've been camping quite a bit outside the Yellow Pine solar site and documenting the destruction there. I am with an organization called Mojave green and I've been posting the photos of the massive destruction on Mojavegreen.org and Justin McAfee, a filmmaker in Las Vegas recently completed another episode of Desert Apocalypse and so on desertapocalypse.com you can see drone footage of the Yellow Pine Solar site, and you can see how they just completely decimated everything. The ancient pavement is completely gone. All of the vegetation is completely gone and even though they're spraying 350,000 gallons of water per day it's a total dust hazard. I've been documenting dust blowing off the site every single day. And in heavy winds it's just a dust storm out there. It's a mess. Another thing is that there are a number of trails running through the proposed Golden Currant site. There's some of them are jeep trails, clear jeep trails. There's one that starts at the border of the Yellow Pine site, the South border of the Yellow Pine site and it's accessed off of Tecopa Road. And it runs all the way to the Front Sight Road and then beyond it continues on to Cathedral Canyon Road and there's multiple OHV trails there and I've hiked extensively on those trails. I've documented yucca that are 15 feet tall; some of the biggest I've ever seen. And also, Cathedral Canyon there is a is a significant historical, cultural resource. I go there two to three times a week. I almost always see other people camping there, hiking there. People come from all over the country to see the grave of Quehoe who's been interned there for decades, and that would be a huge a huge blow and a huge loss, as well as the mesquite woodlands all around that area, so thank you.

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Susie Hertz	Good evening. The variance process as far as I can see really needs to be revisited by BLM to evaluate the lands that are under consideration to be far from populated and utilize lands, whether it be by humans, wildlife, flora, or fauna. It just doesn't seem to be logically looked at by any means, and I think it's irresponsible on the part of BLM to just open up these lands for variance analysis when they're clearly beside populated areas and clearly at the convenience of whoever the solar manufacturers and diggers of the solar installations are. You know it's to their convenience and what makes it easy for them and has nothing to do with what might make any logical sense to any of the rest of us. Secondly, I believe that, considering the fact that all of the benefit for these installations that you intend to try to put all over Southern Nye County and Western Clark County have everything to do with California and nothing to do with Nevada they need to be planted in California, not in Nevada. I don't think that Nevada should be the dumping ground for the abuse and the destruction of our environment and our tax dollars and our property values for the benefit, the pure benefit of California. And I come from California, and I've lived there for 45 years and, as a former Californian I don't want to see my land in Nevada destroyed because of it. These installations will destroy our property value and the environment, and we should not be the dumping ground, it's a crime, it's just a crime, thank you.
Don Hertz	Yes, I'm tired of hearing this every time I turn around that we're going to put solar panels around Pahrump. Eventually, this whole town is going to be. Property value only go so far down you won't have a town here at all. I'm tired of seeing California dictate to us telling us how we had to rip up our land, so they benefit from us, they need to get off their keesters and build their own solar panels and they're own saline plant for water instead of ripping us off and taking all of our water and destroying all of our land. I'm sick of California that's why I moved out of it. It's been mismanaged and they're going to try to put it right back on us and let us pay the bill while they benefit from us. I'm tired of it ,I'm tired of it, I'm tired of it, thank you.

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Public Input

Carl van Warmerdam	I'd like to put in the record an article from oilprice.com. It's entitled mining industry warns energy transition isn't sustainable. This is from July the third. So, this would be in reference to the meeting purpose. There's a glaring problem in the energy transition that not many people are acknowledging. It's being built on the back of finite resources. The mining industry is already warning that there aren't enough metals for all the batteries, solar panels, and wind turbines that the transition will require. Because of the short supply, prices are on the rise, as are prices across commodities sectors. The energy transition has been set by politicians, as the only way forward for human civilization. Not every country on the planet is on board with it, except for those that have the loudest voices. And even amid the fossil fuel crunch that's beginning to cripple economies, the transition goal remains. Seeker the transmission is that the scale that that the architects envision would require massive amount of metals and materials. What does not get talked about much is that most of these metals and minerals are already in short supply and they've only started the transition. So, this is not a renewable transition, because these are the same finite resources as fossil fuel is. So, these companies are not trying to help the environment, they're in the business of making a profit, so they don't really care about creating jobs. They're there to get the subsidies from government. Thank you.
Richard Tretter	My concern is about the groundwater. We're in a serious drought and I see water trucks leaving Pahrump and driving out to those sites every day, and people are concerned about their property values. Think what your property value will be when all the wells are dry and there's no water, that'll be a serious concern and I'd have to piggyback on everything that everybody else has said, I don't see any positive to this. I see only negatives and I think it's time to say no, thank you.
Shannon Salter	Thank you, actually can you hear me? So okay good you can hear me. Um I actually want to take one minute of silence during this public comment forum for all of the plants and animals and Mother Nature and the soils and everything out there, that has no voice so I'm going to start the one minute of silence now.

July 20. 2022
Public Input

Carl van Warmerdam	Okay, so I’ll continue on with that article out of oilprice.com. So, the combination of short supply and rising prices, of course, making energy transition even costlier than it has been projected to be. It has also reminded us all that because of these metals and minerals which are exactly as finite as crude oil and natural gas, the transition is not towards a renewable energy future, it is towards a lower carbon future and this future may perpetuate some of the worst models of the past that we want so much to leave behind; a lot of the battery material battery and solar panel metals, that the energy transition needs are sourced from Africa, the continent fraught with poverty, corruption and political uncertainty. It is also a continent that is currently threatened by a new sort of colonialism, based on energy transition. Recently, in our analysis of foreign policy, researchers wrote that the dirty secret of the green revolution is its insatiable hunger for resources from Africa and elsewhere, that are produced using the world dirtiest technologies. What's more is the accelerated ship threatens to replicate the destructive dynamics of the global economy. So, this systemic extraction of raw commodities from the global South in a way that made developing countries unimaginably rich, while leaving the trail of environmental degradation, human rights violations and semi-permanent under development of all the developing world. So, not only will we be destroying our own environment will also be destroying other countries by outsourcing the metals. Thank you.

July 20. 2022
Public Input

Joyce Barishman	Ladies and gentlemen of Nye County and Pahrump, I just want to point out that nobody on these panels live here in Pahrump or in Nye County. They come from San Francisco, they come from Los Angeles, they're coming from everywhere else but where we live. And again, all of this solar energy that is going to destroy our property values, going to destroy our environment, they're 1000 feet away from an elementary school that they wanted here at Rough Hat. So I want to point that out where there's absolutely no benefit to us whatsoever and according to our illustrious Minister of Transportation Pete Buttigieg, he would call these racist roads and redlining and I'm completely opposed to it, I encourage you, I implore you to speak to your friends, your neighbors, and everybody involved here in Pahrump and Nye county to kick these people out, get them here, stop them from doing this. We benefit nothing from it whatsoever. They think we run around with our kids going to school barefoot here. This is, this is a sham. It's low-grade energy is destroying our environment, it's going to destroy our land, they're going to tell you that your property values it's only going to go down only 5%. Oh, the temperature, oh it's only going to be raised about 5%. Oh, the water, oh you're only going to lose on maybe about 5% of your water it's all horse fool. They're lying to you, everything they say is lying to you, it's misinformation, it's disinformation and it's no information. That's it, I'm done.

July 20. 2022
Public Input

Shannon Salter	Yeah, you know, I just wanted to add, you know the Yellow Pine Solar site was one thing, and it's really bad, you know it's right, but you know it's really bad. It's four and a half square miles and it's really, really, or it was extremely dense yucca area. Just completely untouched desert pavement, flowering things, bees, and insects, I mean it is a beautiful incredible habitat. But the Golden Currant Solar Project site is so much worse, like the Golden Currant Solar Project site is like probably 1000 times worse than the Yellow Pine site in terms of public access, the way that the land is used, perhaps even the topography of the land, because it's so rich with gorgeous and extremely deep washes and extremely hilly terrain. The density of yucca is just as dense as the Yellow Pine Solar site and there are yucca like I said that are 15 feet tall. And there are yucca rings that are ancient rings that have root systems that are probably thousands of years old. Ancient creosote rings. But the fact that it's so close to the Stump Springs area of critical environmental concern you know where of course the tortoises from Yellow Pine have sadly been relocated. Because it's so close to that and it's so close to Cathedral Canyon and it's so close to Cathedral Canyon Road and there's so many hiking trails that run through this particular site, it's a really bad area, and I would like the opportunity to provide further information on the hiking trails that I use and yucca that I've documented that are very tall. If any BLM representatives would like to come out meet, I'd love to meet you out there anytime. So, thank you.

July 20. 2022
Public Input

Shannon Salter	Yeah, you know I, I know that you can't answer questions right now, but I had asked a question and then I see that there was a response in my Q&A. I had asked a question about how much carbon the plants on the Golden Currant site and the ancient desert pavement, that is anywhere between the 7000-year-old figure that you guys quoted and the 100,000-year-old figure that Kevin Emmerich quoted. I asked a question about how much carbon that's sequestering and as Judy pointed out earlier in the comments, the Mojave Desert land trust is really documented that in California, the deserts of California are storing about 10% of California's carbon and in Nevada it's probably far more actually. And so, I think you know when we're talking about the need for projects and the need to address greenhouse gases in the atmosphere, losing the carbon sequestration of this intact ecosystem is working against us. It just is and you know I asked a question about how much carbon that's storing and somebody responded from the BLM that if the project receives a favorable decision and they go forward with the NEPA process that they would then study the carbon storage of the plants and the soils, and I'm interested in that. I'm interested in how the BLM biologist would study the carbon sequestration of the soils on the site and how that data will be collected and how it would be made available to the public. And what other scientific agencies they might collaborate with because I think that there's a real need for that as we consider needs there's a need to find out how much carbon is this are these arid lands storing and what do we stand to lose if we lose these places? Thanks.

July 20. 2022
Public Input

Carl van Warmerdam	You can hear me? Just to follow up on what Shannon had mentioned about the carbon is that alternative energy technologies rely on fossil fuels through every stage of their life. They rely on fossil fuels for raw material extraction, for fabrication, for installation and maintenance, and for the decommissioning and disposal. So the amount of savings of carbon, and then that they're supposed to be saving carbon is minimal and then the destruction of the carbon, a natural carbon sequestration in the environment itself you're probably in the negative but, more importantly, the solution that they're trying to resolve is the false solution, because the global warming is only a symptom of a greater problem, which is loss of biodiversity, and if we continue to destroy habitat, we're in the middle of the sixth mass extinction, we will go along with it. So, this project is solving for the wrong problem it's a false solution, there will be no savings in the carbon emissions just in terms of as electric cars are not going to solve our problems. The problem is the car itself and not how we power the car, so this is the wrong direction: we should be saving habitat not destroying it. Thank you.

July 20. 2022
Public Input

Carl van Warmerdam	Yes, since nobody else is saying anything, I can fill the dead space in regard to this project. It will be degrading desert tortoise habitat on public lands. All tortoises would be evacuated from their burrows and translocated to Stump Springs translocation area across Tecopa Road and The Trout Canyon translocation area. Recently, the translocation for the adjacent approved Yellow Pine Solar project resulted in predation of 30 of the moved tortoises by badgers which are not common desert tortoise predators. This could very well be because they move the tortoises during a record- breaking drought year and the badgers were desperate for food. Common problems that result from translocation of desert tortoises include predation, savvy predators like coyotes often keep track of the recently moved disoriented desert tortoises and they have reduced tortoise numbers on certain translocation projects. This is a bigger problem on drought years which seems to be every year now. Ravens also search out newly moved tortoises. Overheating, hyperthermia translocated tortoises often become disoriented and will seek out their former homes. In many cases tortoises overheat during this. They have been observed pacing recently built fences, searching for former burrows and water sources. Tortoises are cold blooded, and they do not internally regulate their body temperatures that well, lack of reproductive success. Recent Smithsonian institution foundtranslocated male desert tortoises are not reproducing. So, one more reason not to permit. Thank you.

July 20. 2022
Public Input

Shannon Salter	Yeah, you know I, I just wanted to add that again, speaking to the proximity of the Stump Springs area of critical environmental concern and the Cathedral Canyon historical and cultural resource. You know I know that a lot of the big Green Groups, the Nature Conservancy and the Sierra Club and the Wilderness Society, and I believe some others wrote a letter to the BLM requesting that solar be developed in the Pahrump valley between Tecopa Road in the town of Pahrump, the Yellow Pine site, as I understand it was originally applied to build Yellow Pine closer to Sandy Valley on the South side of Tecopa Road. And to avoid that heavy Joshua tree area, those big Green Groups asked that solar be developed on the North side of Tecopa Road. But on their maps, it did not show solar going all the way up adjacent to the Stump Springs area of critical environmental concern. And it was really not anywhere past the Yellow Pine site. And then in their minds, they preferred it to be extending towards the town of Pahrump which I don't agree with any of that. But even the big groups who are too foolish perhaps to speak out against this or too you know, burdened with bureaucratic nonsense even them in their letter and the maps that they provided did not have solar going all the way running adjacent to Cathedral Canyon Road, and to the Stump Springs area of critical environmental concern. Nobody would advocate for that, even if they can't speak out against it, for whatever reason that's not what they were asking for.

July 20. 2022
Public Input

Shannon Salter	Yeah, I just wanted to say thank you all. I wanted to thank the BLM for so carefully considering the public input and being such careful stewards of this land. I understand, of course, you are charged with managing the land for multiple uses, but I also just want to say how much I appreciate you listening to public input and taking guidance from the public and being able to use discernment in the application process and deciding, you know which projects are truly catastrophic. Hopefully in in the decades to come, hopefully in the years to come you know the Department of Interior will take a different approach to public lands and in fact relish everything that intact ecosystems are providing, you know, carbon storage habitat for species biological diversity, you know, hopefully in the years to come before it's too late. Our entire administration will just truly value intact ecosystems and we'll figure out a way how to produce energy without destroying vast tracts of land. And until that time, I just wanted to reiterate that I appreciate you at the BLM and I appreciate you listening to the public and really taking note of what the public has to say so, thanks a lot.

Appendix E - Agency Input

[EXTERNAL] Proposed Golden Currant Solar Project & Variance Process

Brad Hardenbrook <bhrdnbrk@ndow.org>

Fri 8/5/2022 7:05 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Cc: Jasmine Kleiber <jkleiber@ndow.org>

Good evening,

Please find the attached pdf file presenting the Nevada Department of Wildlife's brief on the proposed project.

Best,

Brad

D. Bradford Hardenbrook
Supervisory Habitat Biologist
Nevada Department of Wildlife, Southern Region
3373 Pepper Lane
Las Vegas, Nevada 89120
702.668.3960 Desk
bhrdnbrk@ndow.org

STATE OF NEVADA

DEPARTMENT OF WILDLIFE

6980 Sierra Center Parkway, Suite 120
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STEVE SISOLAK
Governor

TONY WASLEY
Director

BONNIE LONG
Deputy Director

JACK ROBB
Deputy Director

August 5, 2022

NDOW-SR#: 23-005

Shonna Dooman, Field Manager
BLM – Las Vegas Field Office
4701 N. Torrey Pines Drive
Las Vegas, NV 89130
BLM_NV_SND_EnergyProjects@blm.gov

Re: Nobel Solar, LLC's Right-of-Way Application for Its Proposed Golden Currant Solar Project, Pahrump Valley, Clark County, Nevada

Dear Ms. Dooman:

The Nevada Department of Wildlife (NDOW) thanks the BLM for reaching out to agencies and the public for introducing the proposed project involving a siting variance for solar energy development. We understand the 400 MW solar power facility inclusive of a energy storage system would be situated on approximately 4,364 acres of BLM-managed public land. The proposed facility would be located ~5 miles SE of the town of Pahrump, abuts the Yellow Pine Solar Project under construction to the N-NE, touches the SE corner of the proposed Copper Rays Solar Project, and is in the vicinity of the proposed Rough Hat – Clark Solar Project and Rough Hat – Nye Solar Project. Present access is via SR-160, Tecopa Road, Front Sight Road and Cathedral Canyon Road.

Positive merit of the proposed project's potential contribution to renewable energy portfolios is obvious. NDOW's review also considered the potential change to the Pahrump Valley's landscape from a biological, ecological, and recreational perspective in view of ongoing and potential environmental changes. The Plan of Development (POD) provided descriptions of the site's resultant surface alterations and conversion, becoming largely unsuitable for most terrestrial and volant species presently using or seasonally using the area. Mindful of the Solar PEIS Programmatic Design Features for Ecological Resources, greater detail in the POD could have been given to minimization and offsetting effects of construction and operation phases. Restoration of desert vegetation communities and ecological function to pre-disturbance conditions may not be probable, however, we believe further exploration of measures to avoid and minimize impacts are warranted. Should the BLM advance the proposed project to NEPA and variance processes, we look forward to coordination for better informing our respective agencies and project proponent to this end.

Sincerely,

D. Bradford Hardenbrook
Supervisory Habitat Biologist
Nevada Department of Wildlife, Southern Region
3373 Pepper Lane, Las Vegas, NV 89120
702.668.3960; bhrdnbrk@ndow.org

[EXTERNAL] EPA's Comments on the Golden Currant POD

McPherson, Ann <McPherson.Ann@epa.gov>

Fri 8/5/2022 4:07 PM

To: Headen, Jessica A <jheaden@blm.gov>;BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Cc: Ransel, Beth E <bransel@blm.gov>

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

Good afternoon, Jessica –

Please find attached EPA's comments on the Plan of Development for the Golden Currant Solar Project (revised on June 8, 2022).

We appreciate the opportunity to provide feedback on this project. If you have any questions on our comments, please contact me.

Regards,

Ann

Ann McPherson

U.S. EPA Region 9
Tribal, Intergovernmental, and Policy Division
Environmental Review Branch, TIP-2
75 Hawthorne St.
San Francisco, CA 94105

Tel: 415-972-3545
Email: mcpherson.ann@epa.gov

Date: 2022-08-05	EPA's comments on the Golden Currant Solar Project Plan of Development (Rev. on June 8, 2022)

Page Number	Section or Table	Commentator Name and Office	Comment
1-4	1.1.1	EPA Region 9 – Ann McPherson	The POD states that the project will be located on approximately 4,364 acres of BLM administered land and that the ROW application area contains a larger area than required for the solar field to allow for adjustments in the facility layout to minimize environmental impacts. *Recommendation:* We appreciate the fact that the Applicant will need sufficient area to site the project and to allow for adjustments in the facility layout to minimize environmentalimpacts. Nonetheless, developing an accurate estimate for the actual acreage needed for the project – in particular for the solar arrays which will take up most of the space – should be a priority. BLM and the Applicant will be more successfulin strategically siting the project if the Applicant will develop and use accurate estimates for the actual project size. (See comment on pg. 1-10 for more information on developing accurate estimates for project size.)
1-6	1.2.1	EPA - AKM	The POD describes federal legislation between 2001 and 2013 that encourages the development of renewable energy, but the POD does not mention the national goal for renewable energy production on public lands as described in the Energy Act of 2020. *Recommendation*: Discuss the Energy Act of 2020 which includes the goal of permitting 25 gigawatts (GW) of solar, wind, and geothermal energy production on public lands no later than 2025.
1-6 & 7	1.2.2	EPA - AKM	The POD lists specific project objectives which include minimizing environmental effects, but the POD does not include the integration of lower-impact design elements such as mowing. Mowing would leave vegetation and natural contours in place, resulting in reduced erosion and runoff, preservation of soil structure and biological crusts, and less spread of invasive or noxius weed species. *Recommendation:* Include mowing as a design element that will minimize environmental effects. Utilize mowing and drive and crush over disk and roll whenever feasible.
1-7	1.2.3	EPA - AKM	The POD states that the Project is anticipated to create an average of 1,000 construction jobs at any given time and up to 20+ long-term full-time operational jobs.

			Comment: The Final POD for the Gemini Solar Project (690 MW) anticipates an average of approximately 275 – with a maximum of approximately 550 - onsite construction jobs and 19 full-time operational jobs. Given that the larger Gemini Solar Project forecasts fewer construction jobs, please reevaluate these numbers to ensure that they are accurate.
1-10	1.3.3 Table 1-3	EPA - AKM	Table 1-3 includes estimates for the permanent disturbance (4,423 acres), temporary disturbance (38.18 acres), and total proposed ROW acreage (4,522 acres) for the Golden Currant Solar Project. The EPA supports the concept of siting the project within a larger ROW application area but we believe it is critical to also accurately estimate the actual acreage needed for the project (within the larger ROW area) **up front**, so that BLM and the Applicant can work more effectively to strategica **l**y site the project, instead of doing this analysis after the NEPA process is complete or after the ROD is signed (as was the case with Gemini). We offer three examples to illustrate how much acreage may actually be required: 1) Consider the Gemini Solar Project (690 MWs) that was initially proposed on 7,100 acres. After the final calculations were complete, the final project area will encompass approximately 4,800 acres instead of 7,100 acres. Using simple ratios from Gemini, a 400 MW project would require around 2,782 acres. 2) Consider the Crimson Solar Project (350 MWs) which is situated on 2,000 acres of BLM land within the Riverside East SEZ in California. Using simple ratios from Crimson, a 400 MW project would require around 2,285 acres. 3) Researchers at the Lawrence Berkeley National Lab published an article[1] in March 2022 that provides updated estimates of land requirements for utility-scale PV projects based on empirical analysis of more than 90% of all utility-scale PV plants built in the US through 2019. Using the empirical data in this article we estimate the size needed for the 400 MW project array to be approximately 2,222 acres. *Recommendation:* The Applicant/consultant should use the most recent/accurate data available to better estimate the actualacreage required for a 400 MW solar project with BESS within the 4,364-acre ROW area; and disclose these numbers in both the POD and subsequent EISs.

[1] Bolinger, M. and G. Bolinger. March 2022. "Land Requirements for Utility-Scale PV: An Empirical Update on Power and Energy Density." IEEE Journal of Photovoltaics, Vol. 12, No. 22, pgs. 589-594. https://doi.org/10.1109/JPHOTOV.2021.3136805.

1-24	1.3.8.1	EPA - AKM	The Golden Current POD states that approximately 1,000 acre-feet of water would be required over the Project Construction period for construction-related activities including dust control. The presentation that was given during the public input forum stated that 300-400 ac-ft/year of water usage would occur during construction. *Comment:* Based on othersolar projects that we’ve seen in NV, that numbermay not be accurate. Consider the Gemini Solar Project (690 MWs) POD which estimates that a total of 500 acre-feet of water will be needed for project construction, primarily for dust control. The construction water use estimate for Geminiwas based on the median water use of other solar power plant installations in the desert of NV and neighboring states. *Recommendation*: We recommend that the Applicant re-evaluate their water estimates based on the amount of water used recently for construction at other solar projects in NV and CA. If water estimates are substantially higher than expected, please explain why that is so.
1-28 2-2	1.3.14 2.3.3	EPA – AKM EPA – AKM	The POD states that the site would be allowed to re-vegetatefollowing construction and that vegetation would typically be maintained to a height of no more than approximately 12 inches. The POD also states that the disk and roll technique would be used generally to prepare the surface of the solar field for post and PV panel installation. In areas where the terrain is not suitable for disk and roll, conventional cut and fill grading would be used. The presentation at the virtual input forum, however, states that it would be similar to Geminiin design with a mowing alternative and preservation of existing vegetation. *Comment:* The ‘disk and roll’ technique would completely remove vegetation on site and compact soils. Native vegetation may not naturally regrow in areas that are cleared of vegetation, graded, or compacted. If the ‘disk and roll’ technique is used at the site – as stated in Section 2.3.3 – successful revegetation is much less likely to occur. Restoration efforts could be an order of magnitude more expensive and lengthier. *Recommendation:* EPA recommends that mowing be used instead of disk and roll to the maximum extent feasible on site. After mowing, overland drive and crush is generally perceived to be the next best option. We also recommend that vegetation be maintained at a higher height – 18-24 inches – if feasible.

			The POD should also discuss if yucca and cacti will be salvaged (removed and transplanted in nurseries until they can be relocated) or destroyed.
1-29	1.4	EPA - AKM	The POD states that alternative technologies and project layouts will be defined by BLM staff. Alternatives considered may also include the use of an alternative, concentrating solar technology. *Recommendation:* Concentrating solar technologies generally require substantial amounts of water for operation and would not be as feasible in the desert environment as PV, particularly with the over-appropriation of groundwater resources, drought, and climate change. We would advise against considering concentrating solar technologies as an alternative technology. We encourage BLM/Applicant to consider alternative layouts within the ROW area using accurate estimates for solar array size, such that key resources can be avoided to the maximum extent feasible, and to use alternative construction techniques, such as mowing, that reduce environmentalimpacts.
2-2	2.3	EPA – AKM	Section 2.3 Site Preparation does not discuss methods of construction, particularly those that are less damaging to soil and vegetation. *Recommendation:* Section 2.3 should also discuss 'Methods of Construction' including the use of skid steer vehicles or other tracked vehicles, including tracked pile drivers, to minimize soil and vegetation crushing. Using alternative construction methods would likely enhance the viability and recovery of the native plant community.
2-2	2.3.3	EPA - AKM	The POD states that all earthwork required to install drainage control detention basins, access roads, and foundations for Project-related buildings would be balanced on site. *Comment*: Clarify what is meant by 'balanced' on site.
4-1	4.1	EPA - AKM	The POD states that to maintain generation performance, PV array washing may occur up to 24 hours per day (including nighttime panel washing) with approximately two panel washes anticipated per year. *Comment:* Many large-scale solar PV plants do not conduct panel washing. For example, the Gemini Solar Project POD states that it does not require water for panel washing (POD – March

			2022). There are also other novelways to clean the panels – including using devices that utilize electrostatic repulsion – which cause dust particles to detach and fly off the panels. *Recommendation:* Consider alternative options to panelwashing that do not use water.
5.4.3 to 5.5.6 5.5.5	5-6 & 5-7 5-7	EPA - AKM	Preliminary Applicant proposed mitigation measures are discussed in Section 5.4. The header numbers appear to be misnumbered – going from 5.4.3 to 5.5.4, 5.5.5, and 5.5.6. *Recommendation:* Revise the header numbers accordingly starting at 5.4.3 through 5.5.6. *Recommendation:* Consider adding dust monitors with real-time data that is accessible to the public and workers as a mitigation measure under'Air Quality'. Since it's likely that multiple projects (Yellow Pine, Rough Hat Clark County, Rough Hat Nye County, Copper Rays, Golden Currant) may be under construction at the same time in this general vicinity, we recommend that BLM set up a network of dust monitors in the area, standardize procedures to fund these monitors, and ensure that the data is uniformly retrieved, summarized, and released.
6-1	Attachment A – Figure 1	EPA - AKM	Figure 1 shows the array plan including annotated 50-foot setbacks from the washes, property line, and Front Site Road and a 300-foot setback from Tecopa Road. *Comment:* The Yellow Pine Solar Project is directly adjacent to the proposed Golden Currant Project Site. The Yellow Pine POD shows that a 400-foot offset was used at Tecopa Road to provide a safe distance for vehicular traffic, prevent damage from beyond the security fence, and to reduce visibility of the site from public use areas. In addition, 500-foot buffers on either side of the three large washes provide a 1,000-foot corridor between subareas at the Yellow Pine Site. *Recommendation:* EPA recommends that BLM consider greater setback from the washes and consider whether there is value in keeping the washes open – as corridors - between projects.

[EXTERNAL] Response Letter for the Golden Currant Solar Project

Townes, Daniel W CTR OSD OUSD A-S (USA) <daniel.w.townes.ctr@mail.mil>

Fri 8/19/2022 9:25 AM

To: Headen, Jessica A <jheaden@blm.gov>

Cc: Kiernan, Scott E CIV OSD OUSD A-S (USA) <scott.e.kiernan.civ@mail.mil>;Ransel, Beth E <bransel@blm.gov>

Good afternoon Ms. Headen,

Attached is the Informal Review Response Letter for the Golden Currant Solar Project.

Thank you for the opportunity to review your project.

Respectfully,

Dan Townes
Military Aviation and Installation Assurance Siting Clearinghouse
Office of the Assistant Secretary of Defense (Sustainment)
Desk: 571-372-8414 *(temporarily unavailable)*
NIPR: daniel.w.townes.ctr@mail.mil

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3500 DEFENSE PENTAGON
WASHINGTON, DC 20301-3500

SUSTAINMENT

August 18, 2022

Jessica Headen
Project Manager
Bureau of Land Management, Southern Nevada District
4701 North Torrey Pines Drive
Las Vegas, NV 89130

Dear Ms. Headen,

As requested, the Military Aviation and Installation Assurance Siting Clearinghouse coordinated within the Department of Defense (DoD) an informal review of the Golden Currant Solar Project. The results of our review indicated that the solar project, located in Clark County, Nevada, as proposed, will have minimal impact on military operations conducted in the area.

Thank you for working with us to preserve our military's operational, training, and testing capabilities. We have assigned the tracking code 2022-07-S-BLM-10 to this project If you have any questions, please contact me at scott.e.kiernan.civ@mail.mil or at 571-255-9507.

Sincerely,

Scott E. Kiernan
Deputy Director
Military Aviation and Installation
Assurance Siting Clearinghouse

[EXTERNAL] Golden Currant Solar Project Variance

Araceli Pruett <Araceli.Pruett@clarkcountynv.gov>

Wed 7/6/2022 9:15 AM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

The Department of Environment and Sustainability (DES) has reviewed the documentation associated with Noble Solar, LLC's application for a right-of-way grant for the construction, operation and eventual decommissioning of a proposed 400-megawatt alternating solar photovoltaic power generating facility and battery energy storage system on BLM-managed public land. The proposed Golden Currant Solar Project will be located on approximately 4,364 acres of BLM land designated as a solar variance area in the Pahrump Valley in Clark County, approximately five miles southeast of Pahrump and 26 miles west of Las Vegas. This letter provides DES's assessment of the project's conformity with Clark County Air Quality Regulations (AQRs).

DES determines that this action should have no significant impact to ambient air quality if the project complies with the AQRs. The proposed project is located in the Pahrump Valley (hydrographic area 162), an area designated by EPA as attainment/unclassifiable for all other National Ambient Air Quality Standards (NAAQS) criteria pollutants. PM_{10} is the pollutant primarily associated with construction activities and there are several provisions of the AQRs that regulate proposed construction within the County. In particular, the following regulatory requirements may apply depending upon the type of construction activities taking place.

Section 94 of the AQRs requires that a dust control permit be obtained prior to any of the following activities: Soil disturbance or construction that impacts 0.25 acres or greater of land; mechanized trenching of 100 feet or greater in length, or mechanical demolition of any structure 1,000 square feet or greater in overall area. Construction activities include, but are not limited to, the following practices: Land clearing; soil and rock excavation, removal, hauling, crushing or screening; initial landscaping; establishing and/or using staging areas, parking areas, material storage areas, or access routes to or from a construction site.

Section 94 also requires that a construction project of ten (10) acres or more in area, trenching activities of one (1) mile or greater in length, or structure demolition using implosive or explosive blasting techniques, shall require a detailed supplement to a Dust Mitigation Plan. This supplement shall be in the form of a written report and shall, at minimum, detail the project description, the area and schedule of the phases of land disturbance, the control measures and the contingency measures to be used for all construction activities. This supplement shall become part of the dust control permit as an enforceable permit condition.

Any construction project of fifty (50) or more actively disturbed acres must have in place an individual designated as the Dust Control Monitor to ensure that dust control measures are implemented, pursuant to the provisions of Section 94.8.

In addition, Section 12 of the AQRs requires the issuance of a stationary source permit for any applicable source located in Clark County that has a potential to emit a regulated pollutant that is equal to or greater than the thresholds listed in that section. Any mechanical equipment (e.g., backup generators, boilers, cooling towers) may trigger air quality “stationary source” permitting in accordance with AQR Section 12.1. Therefore, stationary source permits should be obtained before commencing construction of any emissions unit.

For more detailed information, select the link below to review Section 94 (Permitting and Dust Control for Construction and Temporary Commercial Activities) and Section 12.1 (Permit Requirements for Minor Sources) of the AQRs:
https://www.clarkcountynv.gov/government/departments/environment_and_sustainability/division_of_air_quality/rules___regulations/current_aq_rules.php
For further assistance, please contact me at (702) 455-3206 or the Air Quality Specialist at (702) 455-1524.

Araceli Pruett, *Senior Planner*
Clark County Department of Environment & Sustainability
Division of Air Quality
4701 W. Russell Road, Suite 200
Las Vegas, NV 89118
(702) 455-3206 – desk
(702) 455-5942 – front desk
(702) 383-9994 – fax

Appendix F - Public Emails & Letters

[EXTERNAL] Golden Current Solar Project Variance

[redacted]

Fri 8/5/2022 2:37 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Golden Current Solar Project Variance

4701 N, Torrey Pines Drive

Las Vegas, Nevada 89130

Who This May Concern,

The Pahrump Paiute Tribe is strongly against this Golden-Current Solar Project and all other solar projects that are proposed in the Pahrump and Armagosa Valleys. This is due to not only us doing our own research and knowledge of the valleys, but also we don't appreciate Nevada Bureau of Land Management's (BLM) under handed tactics in the proceedings of these solar sites in our territory. Let us explain why.

Let's start with the Native American issues. Our tribe has been left out of discussions over these recent solar sites. Take the Yellow Pine Solar Project for as example. It was forced on us. Many of the people believe that it's because we are the most vocal and BLM use our tribal status as an excuse not to contact us. As other tribes get one on one with the agency, we don't. Even though there is proof showing that we use to work with the agency for decades as a tribal entity they recognized as a historical tribe. Why the parlor tricks now?

Our tribe understand the environmental impact all too well. Especially when it involves our tribe's homeland. With some springs coming back but very weak or with endanger plants (mesquite trees, etc.) and animals (puffer fish, desert tortoise, Armagosa Toad, etc.) one or multiple solar sites will mess with the environments greatly. But no one will report what the cause and effect will happen to the environment when you multiple sites in these areas, as it could be catastrophic damage to the valleys. Bad enough that water usage and levels of the valley's aquifer are not in the environmental impact reports. As these solar sites will buy water credits from the local businesses to obtain water. There are so many things left out of these environmental reports it will cause more troubles for both valleys in the long run. It's scary to think about.

Sitting in these zoom meetings is a farce and wasting everyone's time. As every answer was a "copy and pasted" style. Showing no effort in doing any research or wanting to give the public real answers. As it was a imfomation meeting it was done horrible. The mentality was like all the solar sites were approved already. Let alone cutting the public response time from 90 days to a few weeks. When did the Nevada Bureau of Land Management become a pocket for cooperation's and not protecting the lands for the people? We do understand that solar sites are needed, but at what cost when it's not done right.

[redacted]

[redacted]

July 24, 2022

BLM Southern Nevada District Office,
Attn: Golden Currant Solar Project Variance,
4701 N. Torrey Pines Drive,
Las Vegas,
NV89130

To whom it may concern

Please reject the application for the Golden Currant Solar Project.

Approval of the project would result in the removal of tens of thousands of Mojave yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.

The project site is located in important desert tortoise habitat When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions. Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range.

Nearly 50% of the project site is made up of badlands eroded by canyons and over a 5% slope. This topography would need to be leveled to accommodate solar panels.

The project site contains old biological soil crusts and desert pavement that is about 100,000 years old. Removal of the desert surface and clay-based badlands topography will result in uncontrollable fugitive dust. This will impact public health in nearby Pahrump, Nevada and Charleston View, California.

The project site contains hundreds of rare Parish Club Challa, mesquite, kit fox, desert iguana, burrowing owl, coyote and several other species.

The project will probably require up to 1,200 acre-feet of water for construction and additional acre-feet each year for operation. The Pahrump Valley Basin is over-drafted by 12,000 acre-feet.

The project will destroy habitat for mesquite and associated species, a unique groundwater dependent habital

Solar projects can mimic lakes and will often kill a number of bird species. The project would be in the vicinity of Stump Spring and the Amargosa River which attract several birds species.

The project would be located less than 2 miles from the Old Spanish National Historic Trail. Developing an industrial eyesore so close to the trail will destroy the historic character of the region.

The project will cut off access to over 7 square miles of public land and be visible from recreation trails, Highway 160, Mt Charleston, the Kingston Range Wilderness in California and the South Nopah Range Wilderness also in California. Public access would be impacted on the Front Site Road and to Cathedral Canyon.

The Bureau of Land Management should not even consider reviewing this application until the Southern Nevada Resource Management Plan can be updated. The plan is outdated by 25 years. VISitor use to the Tecopa Road bas increased in this time and the visual resources along with other resources need to have better protection.

To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project.

Yours sincerely,

[redacted]

[EXTERNAL] Fwd: public does not want miles and miles of solar on opublicland no no no

[redacted]>
Thu 7/14/2022 12:23 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>;info@sierraclub.org <info@sierraclub.org>;info@pewtrusts.org <info@pewtrusts.org>

public comment on federal register
Subject: public does not want miles and miles of solar on opublicland no no no

i am totally oppoaws ro seizing 5500 acres of public land for solar panels. solar panels can be on tops of all buildings
can be on hazardous sites but i do not approve of them on farmland nor on public open space whereanimals and nature shoudl be allowed to flourish. thisis nasty and corrupt. clark co nevada is trying to continually grow with usa natiinoa land and i do not support that. let them ask the state for land and use state land, not federal land. ask nevada for land. this commetn is for the public record.please receipt. [redacted]

[Federal Register Volume 87, Number 127 (Tuesday, July 5, 2022)]
[Notices]
[Page 39866]
From the Federal Register Online via the Government Publishing Office
[www.gpo.gov]
[FR Doc No: 2022-14254]

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[LLNVS00000.L51010000.ER0000.LVRWF2108350.21X; N-100225; MO#4500162243]

Notice of Segregation of Public Land for the Golden Currant Solar
Project, Clark County, Nevada

AGENCY: Bureau of Land Management, Department of Interior.

ACTION: Notice.

SUMMARY: Through this notice the Bureau of Land Management (BLM) is segregating public lands included in the right-of-way application for the Golden Currant Solar Project, from appropriation under the public land laws, including the Mining Law, but not the Mineral Leasing or Material Sales Acts, for a period of 2 years from the date of publication of this notice, subject to valid existing rights. This segregation is to allow for the orderly administration of the public lands to facilitate consideration of development of renewable energy resources. The public lands segregated by this notice totals 5,571.82 acres.

DATES: This segregation for the lands identified in this notice is effective on July 5, 2022.

FOR FURTHER INFORMATION CONTACT: For further information and/or to have your name added to the mailing list, send requests to: Jessica Headen, Southern Nevada District Energy & Infrastructure Team, at telephone (702) 515-5206; address 4701 North Torrey Pines Drive, Las Vegas, NV 89130-2301; or email BLM_NV_SND_EnergyProjects@blm.gov. Individuals in the United States who are deaf, deafblind, hard of hearing, or have a speech disability may dial 711 (TTY, TDD, or TeleBraille) to access telecommunications relay services. Individuals outside the United States should use the relay services offered within their country to make international calls to the point-of-contact in the United States.

SUPPLEMENTARY INFORMATION: Regulations found at 43 CFR 2091.3-1(e) and 2804.25(f) allow the BLM to temporarily segregate public lands within a right-of-way application area for solar energy development from the operation of the public land laws, including the Mining Law, by publication of a Federal Register notice. The BLM uses this temporary segregation authority to preserve its ability to approve, approve with modifications, or deny proposed rights-of-way, and to facilitate the orderly administration of the public lands. This temporary segregation is subject to valid existing rights, including existing mining claims located before this segregation notice. Licenses, permits, cooperative agreements, or discretionary land use authorizations of a temporary nature which would not impact lands identified in this notice may be allowed with the approval of an authorized officer of the BLM during the segregation period. The lands segregated under this notice are legally described as follows:

Mount Diablo Meridian, Nevada

T. 22 S., R. 55 E.,
  Sec. 2, S\1/2\NW\1/4\, and SW\1/4\;
  Sec. 3, SE\1/4\NE\1/4\, and E\1/2\SE\1/4\;
  Sec. 7, lots 3 and 4, E\1/2\SW\1/4\, and SE\1/4\;

Sec. 8, S\1/2\;
Sec. 9, S\1/2\;
Sec. 10, NE\1/4\, SE\1/4\NW\1/4\, and SW\1/4\;
Sec. 15, NW\1/4\NW\1/4\;
Sec. 16, N\1/2\, SW\1/4\, N\1/2\SE\1/4\, and SW\1/4\SE\1/4\;
Sec. 17 thru 20;
Sec. 21, NW\1/4\, and NW\1/4\SW\1/4\;
Sec. 29, N\1/2\NE\1/4\, SW\1/4\NE\1/4\, and NW\1/4\;
Sec. 30, lot 1, NE\1/4\, and NE\1/4\NW\1/4\.

The area described contains 5,571.82 acres, according to the official plats of the surveys of the said lands on file with the BLM.

As provided in the regulations, the segregation of lands in this notice will not exceed 2 years from the date of publication unless extended for an additional 2 years through publication of a new notice in the Federal Register. The segregation period will terminate and the land will automatically reopen to appropriation under the public land laws, including the mining laws, at the earliest of the following dates: upon issuance of a decision by the authorized officer granting, granting with modifications, or denying the application for a right-of-way; without further administrative action at the end of the segregation provided for in the Federal Register notice initiating the segregation; or upon publication of a Federal Register notice terminating the segregation.

Upon termination of the segregation of these lands, all lands subject to this segregation would automatically reopen to appropriation under the public land laws, including the mining laws.

Authority: 43 CFR 2091.3-1(e) and 43 CFR 2804.25(f).

Stephen Leslie,
Assistant Field Manager--Las Vegas Field Office.
[FR Doc. 2022-14254 Filed 7-1-22; 8:45 am]
BILLING CODE 4310-HC-P

[EXTERNAL] Golden Currant Solar Project Variance - Please reject this project

[redacted]>
Tue 7/19/2022 2:57 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

Hello BLM-Nevada,

I am writing to ask you to reject the application for the Golden Currant Solar Project – and to update the Southern Nevada Resource Management Plan so that projects like this can be measured against the real value of the land set aside for destruction.

It has been scientifically proven that the pristine desert crust, which the Pahrump Valley is made up of, sequesters carbon, not just for a few years but forever. It is beyond ironic that you are tearing up soil that serves the highest need during our climate crises, only to roll out endless panels that will:
Only provide jobs for a few months;
Only provide electricity for a limited number of years;
Use vast quantities of water from an already limited and overtaxed water supply;
Destroy the desert crust and its ability to sequester carbon;
Destroy the biodiversity of the area in ways too numerous to detail here;
Destroy the waterways that run across that sloped land;
Destroy the vistas and historical/cultural landmarks that serve the many, many people who visit and travel through the area, many on their way to Death Valley, Tecopa, Shoshone, Mt. Charleston, the Kingston Range Wilderness and the South Nopah Range Wilderness, just over the border in California, and the Old Spanish Trail;
Dramatically change the character of the area, which is what attracts visitors and residents;

This is not the solution to our energy needs. It would be less expensive and provide many more jobs to put solar where it is used, on rooftops, warehouses. malls, schools, and parking lots, which would provide shade and power – and would not prevent the desert from sequestering carbon and serve the many vital purposes it provides. To preserve diverse Mojave Desert habitat on public lands for the longterm public good and preserve the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project. The BLM should be part of the solution, not the problem.

Sincerely,

[redacted]
Santa Monica CA

[EXTERNAL] Golden Currant Solar Project

[redacted]>

Tue 7/19/2022 10:56 AM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Please reject the application for the Golden Currant Solar Project.

Approval of the project would result in the removal of tens of thousands of Mojave yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.

The project site is located in important desert tortoise habitat. When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions . Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range.

Nearly 50 percent of the project site is made up of badlands eroded by canyons and over a 5 percent slope. This topography would need to be leveled to accommodate solar panels.

The project site contains old biological soil crusts and desert pavement that is about 100,000 years old. Removal of the desert surface and clay-based badlands topography will result in uncontrollable fugitive dust. This will impact public health in nearby Pahrump, Nevada and Charleston View, California.

The project site contains hundreds of rare Parish Club Cholla, mesquite, kit fox, desert iguana, burrowing owl, coyote and several other species. Millions of living organisms would be killed in the construction of the project.

The project will probably require up to 1,200 acre-feet of water for construction and additional acre-feet each year for operation. The Pahrump Valley Basin is over-drafted by 12,000 acre-feet.

The project will destroy habitat for mesquite and associated species, a unique groundwater dependent habitat.

Solar projects can mimic lakes and will often kill a number of bird species. The project would be in the vicinity of Stump Spring and the Amargosa River which attract several birds.

The project would be located less than 2 miles from the Old Spanish National Historic Trail. Developing an industrial eyesore so close to the trail will destroy the historic character of the region.

The project will cut off access to over 7 square miles of public land and be visible from recreation trails, Highway 160, Mt. Charleston, the Kingston Range Wilderness in California and the South Nopah Range Wilderness also in California. Public access would be impacted on the Front Site Road and to Cathedral Canyon.

The Bureau of Land Management should not even consider reviewing this application until the Southern Nevada Resource Management Plan can be updated. The plan is outdated by 25 years. Visitor use to the Tecopa Road has increased in this time and the visual resources along with other resources need to have better protection.

To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project."

sincerely,

[redacted]

[EXTERNAL] Golden Currant Solar Project Variance

[redacted] >

Tue 7/19/2022 1:35 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Please reject the application for the Golden Currant Solar Project. Our desert habitats have been misunderstood for too long. Some Americans have seen the unique beauty of the habitat and wildlife, but many have thought that there's "nothing" in the desert. There's great value in the desert. People from all over the world find the Mojave has a wonderful destination. Funny, that they see the value, but we are destroying it. Climate change is hitting us hard. Our deserts and other open space habitats are a key to helping us by offering carbon sequestration, areas for wildlife to migrate and live and refuge from our chaotic world.

Putting money into solar setups in the urban area is much more efficient and less destructive. We need to do this before destroying more desert and open-space habitats.

Approval of the project would result in the removal of tens of thousands of Mojave yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.

The project site is located in important desert tortoise habitat. When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions . Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range.

Nearly 50 percent of the project site is made up of badlands eroded by canyons and over a 5 percent slope. This topography would need to be leveled to accommodate solar panels.

The project site contains old biological soil crusts and desert pavement that is about 100,000 years old. Removal of the desert surface and clay-based badlands topography will result in uncontrollable fugitive dust. This will impact public health in nearby Pahrump, Nevada and Charleston View, California.

The project site contains hundreds of rare Parish Club Cholla, mesquite, kit fox, desert iguana, burrowing owl, coyote and several other species. Millions of living organisms would be killed in the construction of the project.

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The project will destroy habitat for mesquite and associated species, a unique groundwater dependent habitat.

Solar projects can mimic lakes and will often kill a number of bird species. The project would be in the vicinity of Stump Spring and the Amargosa River which attract several birds.

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The Bureau of Land Management should not even consider reviewing this application until the Southern Nevada Resource Management Plan can be updated. The plan is outdated by 25 years. Visitor use to the Tecopa Road has increased in this time and the visual resources along with other resources need to have better protection.

To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project."

Sincerely,

[redacted]
Warner Springs, CA 92086

[EXTERNAL] Golden Currant Solar Project

[redacted]>
Tue 7/19/2022 6:16 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>
Cc: Basin and Range Watch <emailbasinandrange@gmail.com>

"Please reject the application for the Golden Currant Solar Project.

We need solar on the roofs where we live, not at the cost of these fragile sites. This is just a bail-out for Southern California Edison and provides cheap energy market access via the grid to fossil fuel industries.

Approval of the project would result in the removal of tens of thousands of Mojave yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.

The project site is located in important desert tortoise habitat. When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions . Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range.

Nearly 50 percent of the project site is made up of badlands eroded by canyons and over a 5 percent slope. This topography would need to be leveled to accommodate solar panels.

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The project site contains hundreds of rare Parish Club Cholla, mesquite, kit fox, desert iguana, burrowing owl, coyote and several other species. Millions of living organisms would be killed in the construction of the project.

The project will probably require up to 1,200 acre-feet of water for construction and additional acre-feet each year for operation. The Pahrump Valley Basin is over-drafted by 12,000 acre-feet.

The project will destroy habitat for mesquite and associated species, a unique groundwater dependent habitat.

Solar projects can mimic lakes and will often kill a number of bird species. The project would be in the vicinity of Stump Spring and the Amargosa River which attract several birds.

The project would be located less than 2 miles from the Old Spanish National Historic Trail. Developing an industrial eyesore so close to the trail will destroy the historic character of the region.

The project will cut off access to over 7 square miles of public land and be visible from recreation trails, Highway 160, Mt. Charleston, the Kingston Range Wilderness in California and the South Nopah Range Wilderness also in California. Public access would be impacted on the Front Site Road and to Cathedral Canyon.

The Bureau of Land Management should not even consider reviewing this application until the Southern Nevada Resource Management Plan can be updated. The plan is outdated by 25 years. Visitor use to the Tecopa Road has increased in this time and the visual resources along with other resources need to have better protection.

To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project."

[redacted]

[EXTERNAL] Golden Currant Solar Project Variance

[redacted] >

Wed 7/6/2022 6:17 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Please reject the Golden Currant Solar proposal, as well as future projects located on pristine public lands that should remain open to the public for recreational purposes.

Razing huge swathes of the valley (as has already been done at Yellow Pine) decreases the recreational value of the surrounding landscape, impacting views, wildlife viewing, and creating barriers for through-hikers and backpackers, particularly those following the Old Spanish Trail.

In addition, these solar projects are being sited in places where they have the potential to create hazardous dust--something that has already occurred in the case of the solar project near Boulder City--and with increasin solar development, this increase days of hazardous air quality in the nearby towns of Pahrump and Charleston View.

There are millions of acres of uncovered parking lots and rooftops that can supply space for solar without loss of efficiency due to transmission lines, and loss of habitat for imperiled species such as the Mojave desert tortoise.

I urge the BLM to reconsider these poorly thought-out proposals that will have negative impacts on the desert, its residents, and it's plant and animal life for decades to come.

PLEASE do not approve Golden Currant Solar. Thank you.

[EXTERNAL] Golden Currant Solar Project Variance

[redacted]

Tue 7/19/2022 2:37 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Cc: Raby, Jon K <jraby@blm.gov>;SNDO_Web_Mail, BLM_NV <lvfoweb@blm.gov>;BLM_NV_GreenlinkNorth <blm_nv_greenlinknorth@blm.gov>;Knowles, Glen W <glen_knowles@fws.gov>;Berry, Kellie <Kellie_Berry@fws.gov>;Deffner, Flo <Flo_Deffner@fws.gov>

2 attachments (12 MB)

DTC Allison and McLuckie.2018.Popln trends in MDT.pdf; DTC 2019_Berry and Murphy_CRM_5_109_agassizii.pdf;

July 19, 2022

Dear BLM officials:

Please carefully consider my following comments and the attachments relating to the Golden Currant Solar Project Variance.

Approval of the project would result in the removal of tens of thousands of Mojave *yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.*

The project site is located in an important desert tortoise habitat. When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions . Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range. Please review the two attachments with additional scientific information on these dramatic tortoise population declines.

Nearly 50 percent of the project site is made up of badlands eroded by canyons *and over a 5 percent slope. This topography would need to be leveled to accommodate solar panels.*

The project site contains old biological soil crusts and desert pavement that is about 100,000 years old. Removal of the desert surface and clay-based badlands topography will result in uncontrollable fugitive dust. This will impact public health in nearby Pahrump, Nevada and Charleston View, California.

The project site contains hundreds of rare Parish Club Cholla, mesquite, kit fox, desert iguana, burrowing owl, coyote and several other species. Millions of living organisms would be killed in the construction of the project.

The project will probably require up to 1,200 acre-feet of water for construction and additional acre-feet each year for operation. The Pahrump Valley Basin is over-drafted by 12,000 acre-feet.

The project will destroy habitat for mesquite and associated species, a unique groundwater dependent habitat.

Solar projects can mimic lakes and will often kill a number of bird species. The project would be in the vicinity of Stump Spring and the Amargosa River which attract many bird species.

The project would be located less than 2 miles from the Old Spanish National Historic Trail. Developing an industrial eyesore so close to the trail will destroy the historic character of the region.

The project will cut off access to over 7 square miles of public land and be visible from recreation trails, Highway 160, Mt. Charleston, the Kingston Range Wilderness in California and the South Nopah Range Wilderness also in California. Public access would be impacted on the Front Site Road and to Cathedral Canyon.

The Bureau of Land Management should not even consider reviewing this application until the Southern Nevada Resource Management Plan can be updated. The plan is outdated by 25 years. Visitor use to the Tecopa Road has increased in this time and the visual resources along with other resources need to have better protection.

Distributed solar on existing commercial and residential rooftops is rapidly increasing. The funds for this proposed project would be much better spent to accelerate the expansion of this much less environmentally destructive alternative energy source. Distributed solar avoids habitat loss in remote areas of public lands as well as the energy lost in long-distance transmission to users.

To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject this *application and press for more responsible alternatives.*

Thank you very much for your consideration.

Sincerely,

[redacted]

cc: Interested parties

Tortoise related attachments

Herpetological Conservation and Biology 13(2):433–452.
Submitted: 19 February 2018; Accepted: 24 June 2018; Published: 31 August 2018.

Population Trends in Mojave Desert Tortoises (*Gopherus agassizii*)

***Linda J. Allison*[1,3] *and Ann M. McLuckie*[2]**

[1]*Desert Tortoise Recovery Office, U.S. Fish and Wildlife Service, Reno, Nevada 89502, USA*
[2]*Utah Division of Wildlife Resources, Washington County Field Office, 451 N SR-318, Hurricane, Utah 84737, USA*
[3]*Corresponding author, email: linda_allison@fws.gov*

***Abstract*.—Populations of the Mojave Desert Tortoise (*Gopherus agassizii*) experienced severe declines in abundance in the decades leading up to 1990, when the species was listed as threatened under the U.S. Endangered Species Act. Population responses to recovery efforts have not been well documented because of the difficulties of studying this low-density, cryptic species over a time period appropriate to its long generation time. We used line distance sampling to estimate annual adult densities since 1999 in Utah and since 2004 elsewhere in the range of Mojave Desert Tortoises. We used generalized least squares regression on log-transformed adult tortoise densities to estimate annual percentage change through 2014 in each of 17 Tortoise Conservation Areas (TCAs) in the five recovery units. We report annual proportional increases in density of adults in the Northeastern Mojave Recovery Unit, but declines in the other four recovery units. Adjusting these densities and trends for the area of potential habitat in each recovery unit, we estimated that in 2004 there were 336,393 adult tortoises (standard error [SE] = 51,596), with an overall loss of 124,050 adult tortoises (SE = 36,062) by 2014. The proportion of juveniles in our surveys has been decreasing in all five recovery units since 2007. Prevailing declines in the abundance of adults overall and in four of the five recovery units indicate the need for more aggressive implementation of recovery actions and more critical evaluation of the suite of future activities and projects in tortoise habitat that may exacerbate ongoing population declines.**

Key Words.—Colorado Desert; distance sampling; information theory; long-term monitoring; Mojave Desert; species recovery

Introduction

Turtles around the world face the highest level of endangerment of any vertebrate lineage today (Stanford et al. 2018). Historical extinctions and recent crises have characterized species on islands or with relatively localized and easily exploitable populations (Stanford et al. 2018). However, turtles as a group are vulnerable in part due to their shared life histories based on high adult survival, delayed age at first reproduction, and low rates of juvenile recruitment (Congdon et al. 1993; Stanford et al. 2018). Even tortoises with relatively large historical ranges are susceptible to threats with relatively small effects, in combination and acting over long generation times, and this life-history strategy also diminishes their ability to recovery quickly from population losses.

Populations of the Desert Tortoise (*Gopherus agassizii*, *sensu stricto*) experienced severe declines in abundance in the decades leading up to 1990, when populations in the Mojave and Colorado deserts west and north of the Colorado River were listed as Threatened under the U.S. Endangered Species Act (U.S. Fish and Wildlife Service [USFWS]1990). Murphy et al. (2011) split the full species into two: the Mojave Desert Tortoise (*Gopherus agassizii*) occupying the range north and west of the Colorado River (the same area listed as Threatened above and retaining this listing) and the Sonoran Desert Tortoise (*G. morafkai*) south and east of the Colorado River. Population responses to recovery efforts for *G. agassizii* have not been well documented, in part, because of the difficulties of studying this low-density, long-lived species. The current recovery plan (USFWS 2011) designates five recovery units for *G. agassizii* that are intended to conserve genetic, behavioral, and morphological diversity necessary for the long-term recovery of the entire listed species (Fig. 1). The recovery plan also defines criteria that form the basis for decisions about continued listing status. For instance, rates of population change of *G. agassizii* should be increasing for at least one tortoise generation (25 y) in all recovery units to warrant delisting (USFWS 2011).

Whereas *G. agassizii* (*sensu stricto*) were initially protected on the basis of population declines estimated on a limited number of small, selectively located mark-recapture study plots, over the longer term, status descriptions should be based on more extensive and rigorous population estimates (Tracy, R.C., R. Averill-Murray, W.I. Boarman, D. Delehanty, J. Heaton, E. McCoy, D. Morafka, K. Nussear, B. Hagerty, and

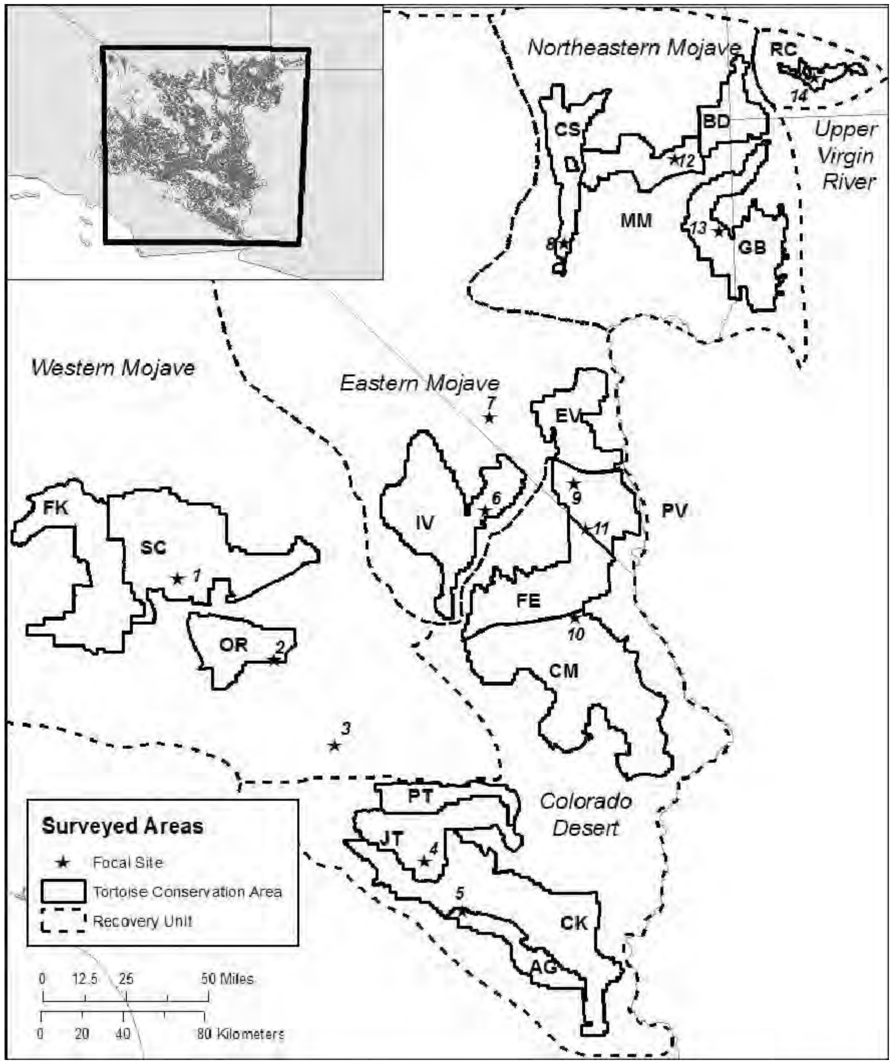

FIGURE 1. Tortoise Conservation Areas (TCAs, n = 17) for Mojave Desert Tortoises (*Gopherus agassizii*) that were monitored in the Mojave and Colorado deserts, USA. Sites were monitored through 2014 and began in 2004 except in the Red Cliffs Desert Reserve, where surveys started in 1999. TCAs and their codes are Chocolate Mountains Aerial Gunnery Range (AG), Beaver Dam Slope (BD), Chuckwalla (CK), Chemehuevi (CM), Coyote Springs Valley (CS), Eldorado Valley (EV), Fenner (FE), Fremont-Kramer (FK), Gold Butte-Pakoon (GB), Ivanpah (IV), Joshua Tree (JT), Mormon Mesa (MM), Ord-Rodman (OR), Pinto Mountains (PT), Piute Valley (PV), Red Cliffs (RC), Superior-Cronese (SC). Observations to estimate visibility were made of transmittered tortoises at the numbered focal sites: 1) Superior-Cronese, 2) Ord-Rodman, 3) Twentynine Palms, 4) Joshua Tree, 5) Chuckwalla, 6) Ivanpah, 7) Jean, 8) Indian Springs, 9) Piute Valley 1, 10) Chemehuevi, 11) Piute Valley 2, 12) Halfway Wash, 13) Gold Butte, 14) Red Cliffs. Potential habitat as defined in the text is overlain on the southwestern United States in the extent indicator.

P. Medica. 2004. Desert Tortoise Recovery Plan Assessment. Report to the U.S. Fish and Wildlife Service, Reno, Nevada. Available from http://www.fws.gov/nevada/desert_tortoise/documents/dtrpac/dtrpac_report.pdf [Accessed 15 August 2018]). In 1999, agencies cooperating on recovery of *G. agassizii* adopted distance sampling (Buckland et al. 2001) for estimating population density at large spatial scales. Surveyors use distance sampling to account for the proportion of the population that is not observed at increasing distances from the observers. We conducted distance sampling surveys for *G. agassizii* throughout Tortoise Conservation Areas (TCAs; Fig. 1), which include federally designated critical habitat for the species (USFWS 1994), as well as in contiguous areas with conservation designations and suitable tortoise habitat (Nussear et al. 2009). Most recovery units (USFWS 1994, 2011) contained more than one TCA (Fig. 1). Ongoing monitoring for *G. agassizii* based on distance sampling has been conducted since 1997 in the Upper

Virgin River Recovery Unit by the Utah Division of Wildlife Resources and by the USFWS in the remaining four recovery units starting in 2001.

In this paper, we start by developing annual density estimates for each TCA based on distance sampling. These efforts are typically collaboratively funded with each agency requiring annual reports that include annual population estimates. Our second and primary goal herein was to use these annual estimates to describe adult *G. agassizii* population trends for each TCA and recovery unit. These trends must account for precision of annual estimates that is often low, variable, and correlated between TCAs within years. Although we cannot fully evaluate the recovery criterion that requires increasing population numbers in each recovery unit until at least 25 y of surveys have been completed (USFWS 2011), this monitoring program is part of the adaptive management strategy for recovering *G. agassizii*. Our third goal was to use the interim regional population trends to evaluate the effectiveness of the recovery program. Our fourth goal was to characterize future trajectories for these populations based on changing patterns of relative abundance of juveniles.

MATERIALS AND METHODS

Study areas.—*Gopherus agassizii* occur throughout large, continuous regions of the Mojave and Colorado deserts of North America (Fig. 1). They occupy a broad elevational range (sea level to 2,225 m) from valley bottoms and bajada slopes at lower elevations to upper alluvial and mountain slopes at higher elevations (Luckenbach 1982). Typical habitat for *G. agassizii* is Creosote Bush (*Larrea tridentata*) scrub in association with White Bursage (*Ambrosia dumosa*) but they are also found in Joshua Tree (*Yucca brevifolia*) woodland, Blackbrush (*Coleogyne ramosissima*) scrub, microphyll woodlands, Shadscale (*Atriplex confertifolia*) scrub, saltbush (*Atriplex* spp.) scrub, cactus scrub, and warm season grassland (Germano et al. 1994; Nussear et al. 2009). Throughout their range, tortoises inhabit areas that include deeply incised washes, sandstone outcrops, rugged rocky canyons, and basalt-capped ridges interspersed with sandy valleys (Bury et al. 1994). However, tortoises most commonly occur in areas with gentle slopes, sufficient shrub cover, and friable soils to allow burrow construction (Bury et al. 1994).

Starting in 1997 in Upper Virgin River Recovery Unit and in 2001 elsewhere, we surveyed 17 TCAs across the five recovery units (Fig. 1). We did not survey every TCA every year, but the total area of 29,127 km^2 comprises the long-term monitoring frame (Table 1). The TCAs named for Red Cliffs Desert Reserve (RC) and Joshua Tree National Park (JT) exclude portions of these jurisdictions that were not potential tortoise habitat (USFWS 1994); RC also excluded a portion that was used for translocations of wild tortoises displaced by development. Each year we made behavioral observations on tortoises at up to 11 of the 14 focal sites within the overall study area (Fig. 1) to estimate the proportion of tortoises that were potentially visible to transect surveyors.

Data collection.—Initially, we placed transects randomly within each TCA. In RC, these were permanent transect locations from the beginning of the program, and we surveyed the 153 transects annually between 1999 and 2001, then every other year. Between 2001 and 2003 in the rest of the range, there was restricted sampling based on various environmental criteria (USFWS 2006), so for comparability we only used data collected starting in 2004 when transects were sited at random throughout TCAs. Beginning in 2007 in these areas outside RC, we shifted from strictly random placement to random selection from a set of systematically placed transects that covered each TCA. Both of these methods result in transects that were located at random with respect to the location of tortoises, so the resulting annual density estimates are unbiased. Each year, available funding determined the number of transects assigned in each TCA.

Sampling methods we used adhered to study design considerations for distance sampling (Anderson, D.R., and K.P. Burnham. 1996. A monitoring program for the desert tortoise. Report to the Desert Tortoise Management Oversight Group. Available from https://www.fws.gov/nevada/desert_tortoise/documents/reports/Anderson-Burnham.1996.monitoringplan.pdf. [Accessed 15 August 2018]). We based initial transect and overall survey length on preliminary estimates of encounter rate and associated effort required to estimate density with a coefficient of variation (CV) of 0.10–0.15. We modified the number and length of transects as specified in Buckland et al. (2001) during earlier years of the surveys and based on updated information about encounter rates.

We completed surveys between mid-March and the end of May each year, when preferred food plants flower and *G. agassizii* are generally active outside of burrows. We started transects early enough so surveys would be completed before the hottest time of the day, scheduling survey dates in specific TCAs to correspond to peak daily tortoise activity based on past experience as well as observation of tortoises outfitted with radio-transmitters (see below). Surveys generally started around 0800 during March but started as early as sunrise by the beginning of May.

Generally, each two-person team walked one transect each day, using a compass and pre-specified bearings. Standard transects were 12 km long, walked in a

Table 1. Tortoise Conservation Areas within each Recovery Unit including total area (km^2) and total effort (km) by year. Tortoise Conservation Areas (with acronym; Acr) are grouped under corresponding larger recovery units. Red Cliffs Desert Reserve was also surveyed in 1999 (307 km), 2000 (302 km), 2001 (314 km) and 2003 (309 km).

Tortoise Conservation Area	Acr	Area (km^2)	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014
Colorado Desert		13,530	3,319	3,984	2,007	1,348	1,375	2,383	1,316	1,403		
Chocolate Mtn Aerial												
Gunnery Range	AG	755	331	228	404	158	378	378		363	413	554
Chuckwalla	CK	3,509	1,083	866	747	112		613	280	213		
Chemehuevi	CM	4,038	836	1,129	180	84	119	458	354	176		
Fenner	FE	1,841	410	288	178	108	121	246	179	168		
Joshua Tree	JT	1,567	278	601	135	102	240	227	147	183		
Pinto Mountains	PT	751	56	155	131	72	162	213	118	140		
Piute Valley	PV	1,070	325	717	231	713	355	249	239	159		
Eastern Mojave		3,720	876	620	368	714	548	578	746	639		
Eldorado Valley	EV	1,153	361	452	188	594	427	212	331	320		
Ivanpah	IV	2,567	515	168	180	120	120	365	416	318		
Northeastern Mojave		4,889	1,037	1,489	2,304	1,485	4,154	4,265	3,984	4,184		
Beaver Dam Slope	BD	828		421	478	2578	631	662	751	819	683	
Coyote Springs Valley	CS	1,117	365	237	906	1,592	1,504	1,046	967	996		
Gold Butte-Pakoon	GB	1,977	361	432	300		733	1,258	1,039	1,116	923	
Mormon Mesa	MM	968	311	398	621	691	1,286	1,298	1,227	1,253		
Western Mojave		6,873	1,534	1,979	896	599	1,351	2,144	1,257	876		2,095
Fremont-Kramer	FK	2,417	463	661	300	216	361	566	264	193		815
Ord-Rodman	OR	1,124	381	310	141	102	197	270	174	158		472
Superior-Cronese	SC	3,332	690	1,009	456	281	793	1,307	820	525		808
Upper Virgin River		115		305	308		310		310		314	
Red Cliffs Desert Reserve	RC	115		305	308		310		310		314	

square that was 3 km on each side. Where relatively open creosote-bursage alluvial slopes dominated the landscape, we found that repeated searching near the centerline did not improve encounter rates or detection on the line (USFWS 2006), so we did not mark the transect centerline for additional search effort. Instead, the leader surveyed along a straight path with a 25-m cord trailing behind. The second observer followed at the end of the moving cord and searched independently. The cord served as the transect centerline when taking distance measurements, and we calculated the walked length of these transects as the straight-line distance between GPS point coordinates that were recorded approximately 500 m apart along the transect.

In RC, where terrain rendered tortoises less visible, surveyors used a three-pass survey to effectively search on and near the marked transect centerline. One crew member, Observer A, dragged the end of the 50-m surveyor tape, following the transect bearing to its intended location. Observer A then walked in a sinusoidal pattern back toward the beginning of the tape searching for tortoises on one side of the tape while the other crew member walked in a similar sinusoidal pattern on the opposite side. Observer A then searched directly along the tape back to the end. The process repeated itself, with the roles of the two surveyors reversing each time. This intensive searching and the rugged terrain limited transects to 2 km per team each day.

We measured the distance and bearing of the tortoise to the observer on the center line in order to calculate the perpendicular distance of the tortoise to the transect center line. We measured distances with 30-m fiberglass or 50-m surveyor tapes, and we measured bearings with compasses. We used all observations of tortoises > 180 mm carapace length (CL) to develop detection curves and density estimates, whether tortoises were in burrows, in the open, or under vegetation. When tortoises were on the surface or could be easily extracted from burrows, we recorded CL and sex. Without suggesting that there is a single size threshold for reproduction within or between populations (Germano 1994), we refer hereafter to tortoises that are at least 180 mm CL as adults and smaller tortoises as juveniles.

Because we placed transects at random with respect to terrain and human infrastructure, and because standard transects were 3 km on each side, it was not unusual for the surveyed path to cross through varied terrain or be blocked by an obstacle such as a highway.

The rules for modifying transects in these situations involved reflecting or elongating transects to avoid obstacles associated with human infrastructure (large roads, private inholdings, etc.), or shortening transects in rugged terrain. The sampling frame therefore represented the walkable area of each TCA. Transects that were partially outside TCA boundaries were initially completed without regard for these jurisdictional changes, but where the boundary was impassable, we reflected transect segments into TCAs as needed (Buckland et al. 2001) or pivoted shorter transects in RC on their northeastern corner to fit inside the TCA. By 2010 we reflected transects so that all paths were inside TCAs.

We used behavioral observations of tortoises carrying radio transmitters (Boarman et al. 1998) to estimate the proportion of individuals available to be seen above ground or in burrows during transect surveys, G_0 (Anderson and Burnham, *op. cit*.). Telemetry technicians used a VHF radio receiver and directional antenna to locate radio-equipped tortoises (n = 5–30) at each focal site (Fig. 1) during the same daily time period when field crews were walking transects in that region of the desert. Observers completed a survey circuit of all transmittered animals as many times as possible (range, 0–5 times per day) during the allotted time, recording each time whether the tortoise was visible.

Estimation of annual tortoise density in each TCA.—We used distance sampling (Buckland et al. 2001) to develop density estimates based on encounter rates in each TCA adjusted for imperfect detection of animals farther from the transect centerline. Estimates were developed each year separately for reporting to sponsoring agencies. We used Program DISTANCE, 6.2 (Thomas et al. 2010), to estimate P_a, the proportion of adult *G. agassizii* detected within w meters of the transect centerline. We truncated observations by distance from the centerline to improve model fit as judged by the simplicity of the resulting detection function (Buckland et al. 2001). Truncation typically reduced the number of observations overall by 5% or fewer, improving estimates of detection probability but reducing the number of observations to estimate encounter rate in each TCA. Sample size considerations also contributed to our decision to rely on pooling robustness (Buckland et al. 2001) rather than using covariates to model detection function estimates (Marques et al. 2007). Detection function estimation is robust in the face of pooling data from different observers, on different days, and in different areas (Buckland et al. 2001) as long as factors that cause variability in detection probability are represented proportionately (Marques et al. 2007). Such factors include vegetation that differentially obscures vision with distance and different detection patterns characteristic of individual crews (pairs). Crews on the same team walked the same number of transects although crews on different teams might not. For these reasons, we placed transects at random in each TCA and developed separate detection curves each year for each field team, pooling data from all TCAs surveyed by that team. Teams also correspond to regions of the desert, and years are correlated with precipitation conditions that affect spring vegetation height and cover, so detection curves that are created separately for teams and years also indirectly address additional factors that affect detection. In years when a team surveyed both in the Mojave and the Sonoran deserts, where the vegetation types may affect tortoise detection differentially, we used two separate detection curves if the sum of their AIC values was less than the AIC value for the single detection curve for the team. In RC, where the same transects were walked each year, we used a single detection curve for all years of the study. Although we pooled observations from multiple TCAs (or from multiple years in RC) for each detection curve, we estimated adult tortoise encounter rates (n/L) and the variance of n separately for each TCA each year.

The distance to which observations were truncated, w, determined the reported area searched in each TCA, $2wL$, where L is the total length in kilometers walked. We applied Akaike's Information Criterion (AIC) to select among detection-function models (uniform, half normal, and hazard-rate) and key function/series expansions recommended in Buckland et al. (2001). Where more than one model were strongly supported by the data, we selected on the basis of Chi-square goodness-of-fit statistics near the transect centerline.

If there is imperfect detection on the transect centerline, a further correction factor must be applied to estimate the true density of tortoises. Because transects in RC used a three-pass method to search the centerline, we assumed that all tortoises at the transect centerline were detected. Elsewhere, detections by two observers walking the centerline one after the other allowed estimation of the detection probability for tortoises within increasing distances from the transect centerline as for a two-pass removal estimator (White et al. 1982); this provides a test of the assumption that all tortoises on the transect centerline are recorded ($g(0) = 1$).

We used a final correction factor, G_0, to adjust the density estimate to account for tortoises hidden in burrows in addition to those that were visible. Each bootstrapped estimate of G_0 was based on one randomly selected visibility record for each tortoise outfitted with a radio transmitter on each day it was located. We generated 1,000 bootstrap samples in PASW Statistics (release 18.0.2, SPSS, Inc. Chicago, Illinois, USA) to estimate G_0 and its standard error by site.

Annual density in each TCA was estimated as:

$$D = \frac{n}{2wLP_a G_0 g(0)}.$$

Whereas n and L were estimated separately for each TCA, observations from multiple TCAs were used to generate a single estimate of P_a. We also applied estimates of G_0 to more than one TCA, and we based estimates of $g(0)$ on all observations from the two-pass surveys. This pooling of information can lead to covariance between TCA estimates in a given year (see below). Although two of the correction factors have similar symbols, when the parameter symbol involves a capital letter (G_0), we are referring to the proportion visible; the lower-case letter refers to the probability of detection of visible tortoises at the centerline.

Describing trends in adult tortoise densities.—We used R 3.4.1 (R Core Team 2017) to develop marginal models (Pinheiro et al. 2017) describing the natural log of tortoise density per km^2 as a function of year and location. Logarithmic transformations have a special interpretation when modelling trends; a modest linear trend in a logarithmic quantity represents a proportional change rather than a linear one (Keene 1995). A slope of 0.05 for ln(density) regressed on years, for instance, would be interpreted as a 5% increase per year. Our models included TCA, Year, and $Year^2$. Year was centered before modeling (Schielzeth 2010). $Year^2$ was included to capture any curvilinear population responses, and we anticipate modeling additional polynomial terms in the future when we are considering a longer time period. The full model also included two-way interactions between TCA and the linear and quadratic time factors. We used generalized least squares regression to also weight annual density estimates based on their variance and to add covariance structure to account for sets of density estimates that were inherently correlated because they shared correction factors of P_a or G_0 (Pekar and Brabec 2016). This second level of analysis therefore incorporated information about the first-level (annual density) variances and covariances.

We used a model based on the full suite of fixed effects to select among different variance weighting and covariance structures (Zuur et al. 2009). We used model selection procedures based on second-order AIC (AIC_c, Burnham and Anderson 2002; Mazerolle 2015) to decide whether to weight the analysis by the variance or CV of the annual density estimates. We also considered whether to model correlations among residuals for density estimates from the same Year, or due to use of pooled G_0 and P_a estimates for multiple TCA density estimates (see above). For all subsequent tests of potential fixed-effects models, we selected a covariance structure to account for within-Year correlation of residuals and weighted optimization procedures as a function of the CV of annual density estimates.

With the final variance weighting and correlation structures in place, we used AIC_c for selection among alternative models and examined the fit of the best model using marginal r^2 (Nagelkerke 1991). We used ANCOVA to examine whether slopes and intercepts of TCAs in each recovery unit described the same pattern (Zar 1996). To apply tortoise densities from the TCAs to entire recovery units, we estimated the area of potential habitat in each of the five recovery units based on Nussear et al. (2009). We only considered 1-km^2 grid cells assigned a probability of occupancy > 0.5 as potential habitat (Liu et al. 2005) after removing any area identified as an impervious surface (Fry et al. 2011).

Describing trends in representation of juvenile size class.—During surveys, we noted all observed tortoises of any size; however, smaller tortoises were less detectable than adults and there were too few observations of smaller tortoises to make density estimates based on distance sampling. Instead, to complement our analysis of changes in the abundance of adult tortoises, we used mixed effects logistic regression (Bates et al. 2015) to evaluate the relative proportion of juvenile tortoises detected in each recovery unit, fitting the observations to models including Year, $Year^2$, Recovery Unit, and two-way interactions between Recovery Unit and the time factors as predictors. We also included the categorical form of Year as a random factor to account for any enforced correlation across the recovery units in proportion of juveniles present due to annual conditions. Because we observed many fewer juvenile tortoises than adults, we report results at the larger spatial scale of the recovery unit rather than for each TCA. Tortoises that could not be extracted from burrows were often classified as unknown rather than as adults or juveniles, especially earlier in the study period. We conservatively assumed all unclassified tortoises were adults, so that estimates of the proportion of juvenile observations earlier in the time series were not inflated. Lacking information on detectability of juveniles to correct our raw data, the relative proportion of juveniles that we examined reflected their representation among detected animals, not the actual proportion of juveniles in the population. We used AIC for model selection, weighting, and averaging (Barton 2015). Note that because the continuous input variable Year was standardized to a mean of zero and divided by two standard deviations before model development (Schielzeth 2010), we could consider models with the quadratic form of this variable even if the linear form was not present in the model; this is equivalent to assuming opposing trends at the start and end of the study period

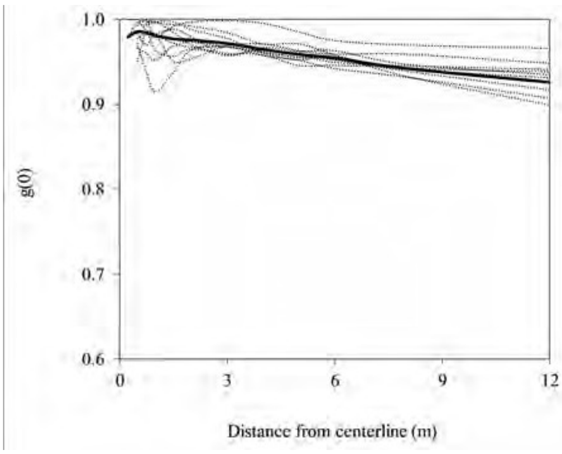

FIGURE 2. Detection of Mojave Desert Tortoises (*Gopherus agassizii*) at the transect centerline (*g(0)*) based on all two-pass survey observations as remote as x meters from the transect centerline. Dotted lines are annual curves; solid line is overall pattern across years from 2004 through 2014 (no surveys conducted in 2006). Note the convergence of *g(0)* on 1.0 as x goes to 0.

but no average trend overall. This standardization also allowed us to use model averaging on interaction terms (Schielzeth 2010). For models describing Year^2 effects, the inflection point at which trends shifted between increases and decreases in the odds of encountering juveniles on surveys was estimated as $-\beta_{Year}/2\beta^{2}_{Year}$.

RESULTS

Adult densities and trends.—Annual probability of detection within 2 m of the transect centerline varied from 0.95 to 1.00, and converged on *g(0)* = 1.0 (Fig. 2), so we added no *g(0)* correction to annual density estimates. In contrast, although estimated tortoise visibility (G_0) was generally greater than 0.80, it was estimated as low as 0.35 at Chemehuevi in 2012 (Fig. 3, Appendix A), illustrating the degree of bias possible if tortoise density estimates do not include corrections for tortoises unavailable for detection. Some of our focal sites were consistently characterized by more above-ground activity than others (Fig. 3). The half-strip width, w, was generally between 12 and 22 m (Appendix B). Detection rate, P_a, was 0.64 in RC and averaged 0.45 in the other TCAs, where two-pass surveys were implemented; however, whether two- or three-pass sampling was used, the detection shoulder near the centerline consistently indicated nearly complete detection out to 2 m (10% of w) as recommended by Buckland et al. (2001).

Annual density estimates ranged from 0.2 adult tortoises/km^2 (SE = 0.2) in GB in 2005 to 28.0/ km^2 (SE = 4.0) in RC in 2000 (Table 2). During the first years reported here (2004 and 2005), TCAs in the Northeastern Mojave Recovery Unit had lower mean densities (< 5.0/

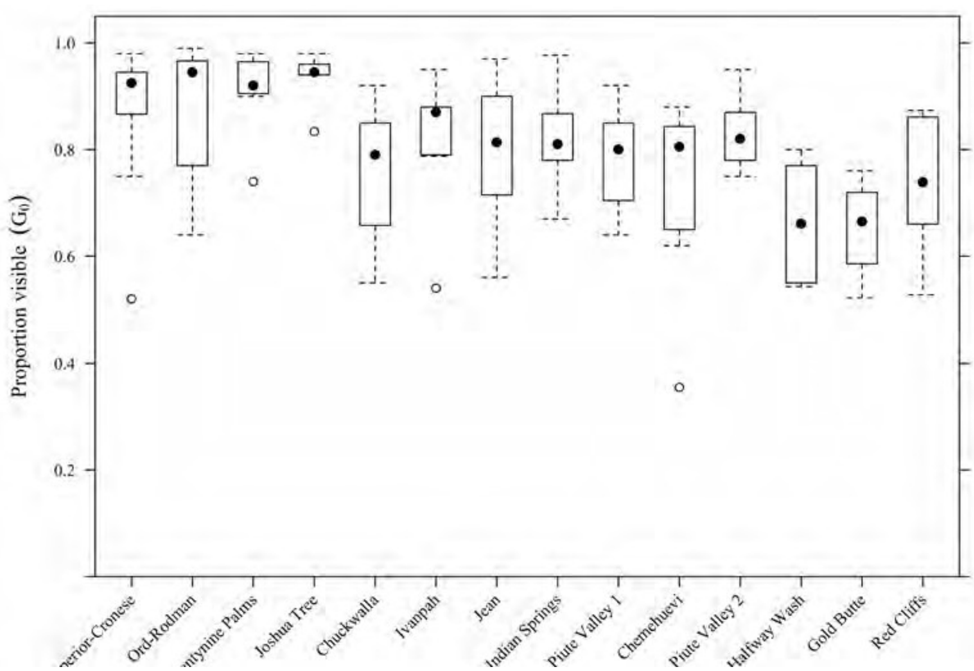

FIGURE 3. Box and whisker plots indicating the proportion of adult Mojave Desert Tortoises (*Gopherus agassizii*) visible (G_0) at each of 14 focal sites shown in Fig. 1 during transect surveys from 1999 through 2014. Boxes represent the interquartile range (values from the 25th – 75th percentile), crossed by a heavy bar at the median. Dotted-line whiskers indicate the extent of the 12.5–87.5 percentile, with any values outside this range shown as hollow dots below some whiskers. Sites are ordered from west on the left to east. Not all focal sites were used to correct density estimates each year. For instance, only Red Cliffs was monitored before 2004, and Jean was used in only one year of observation.

Table 2. Densities (n/km^2) of adult Mojave Desert Tortoises (*Gopherus agassizii*) and corresponding standard errors (SEs) in each Tortoise Conservation Area (TCA) from 2004 to 2014. Acronyms for TCAs are given in Table 1. RC was also surveyed earlier: 1999 (34.3, SE = 11.32), 2000 (25.7, SE = 5.61), 2001 (24.4, SE = 5.69), 2003 (14.0, SE = 2.79).

TCA within Recovery Unit	Year									
	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014
Colorado Desert										
AG	11.4 (3.55)	13.4 (4.31)	6.5 (1.50)	4.5 (2.56)	7.5 (2.74)	13.8 (3.52)		6.0 (1.84)	7.3 (1.96)	8.4 (2.09)
CK	4.9 (1.49)	6.0 (1.77)	4.3 (1.19)	4.2 (2.84)		3.7 (1.14)	3.9 (1.37)	3.9 (1.62)		
CM	6.7 (1.27)	10.3 (3.10)	3.9 (1.71)	4.8 (3.07)	9.4 (5.98)	4.2 (1.40)	4.0 (1.51)	0.8 (0.90)		
FE	8.2 (1.94)	13.5 (2.80)	6.2 (2.37)	6.6 (3.05)	8.3 (4.01)	6.9 (2.49)	6.8 (2.78)	0.9 (0.95)		
JT	1.9 (0.53)	2.7 (0.79)	3.0 (1.94)	2.3 (1.75)	2.3 (1.56)	2.8 (1.56)	3.5 (1.33)	3.4 (1.63)		
PT	2.2 (2.12)	9.9 (3.58)	1.9 (0.98)	3.3 (3.53)	4.3 (2.38)	3.4 (1.85)	3.3 (1.39)	3.7 (1.57)		
PV	2.9 (1.13)	3.7 (0.90)	4.1 (1.88)	4.1 (1.28)	3.6 (1.64)	3.8 (1.37)	6.6 (2.62)	1.9 (1.46)		
Eastern Mojave										
EV	2.6 (0.94)	5.0 (1.25)	4.1 (1.69)	1.8 (0.85)	3.8 (1.56)	1.0 (0.62)	2.8 (1.13)	0.9 (0.74)		
IV	4.4 (1.19)	4.4 (2.46)	5.6 (1.95)	5.1 (2.92)	4.1 (1.86)	1.0 (0.48)	4.5 (1.72)	2.8 (1.79)		
Northeastern Mojave										
BD		0.9 (0.49)	1.1 (0.57)	1.1 (0.59)	3.2 (1.61)	3.3 (0.93)	3.3 (1.22)	5.4 (1.60)	2.6 (1.06)	
CS	1.3 (0.54)	3.3 (1.23)	1.4 (0.47)	1.2 (0.37)	2.0 (0.74)	3.6 (0.87)	4.0 (0.88)	2.9 (0.66)		
GB	0.6 (0.34)	0.2 (0.18)	1.1 (0.58)		2.2 (1.14)	1.7 (0.61)	1.6 (0.58)	2.3 (0.74)	1.7 (0.68)	
MM	2.4 (0.88)	4.9 (1.37)	3.0 (0.93)	1.9 (0.73)	7.3 (2.83)	5.5 (1.15)	6.3 (2.10)	4.3 (1.30)		
Upper Virgin River										
RC		22.5 (4.59)	22.1 (10.76)		15.5 (3.74)		19.3 (4.14)		18.3 (5.58)	
Western Mojave										
FK	8.4 (2.31)	5.3 (1.28)	3.0 (1.46)	0.5 (0.51)	3.3 (1.13)	2.4 (0.60)	3.5 (1.11)	2.2 (1.07)		4.7 (1.05)
OR	7.3 (2.25)	7.7 (1.80)	7.1 (3.26)	5.0 (5.34)	7.2 (2.65)	7.5 (1.85)	3.2 (1.18)	4.6 (2.14)		3.5 (0.88)
SC	6.3 (1.84)	6.3 (1.32)	5.9 (2.28)	1.9 (1.19)	4.6 (1.12)	2.6 (0.49)	3.4 (0.79)	4.3 (1.41)		2.5 (0.60)

km^2) than TCAs in other recovery units. Each year we surveyed RC, it consistently had the highest densities of adult tortoises.

The best model to describe variation in adult tortoise densities supported the hypothesis that densities changed proportionally over time, with different linear trends in each TCA (Table 3). Models based on linear trends had strong support (cumulative model weights = $\sum w$ = 0.9996; Table 3), whereas those including quadratic effects of time had essentially no support ($\sum w < 0.0001$). We report tortoise trend estimates based only on the best-performing model, with $w > 0.999$ and describing a large amount of variation in $\log_e$(Density). Estimates of r^2 (marginal r^2 = 0.84, Nagelkerke's modified r^2 = 0.92) indicated that after weighting to address variance heterogeneity and building in covariance structure, there was considerable variance in adult densities that could be explained by the effects of Year, TCA, and their interaction. Covariance between TCA density estimates from the same year accounted for 17.0% of the total

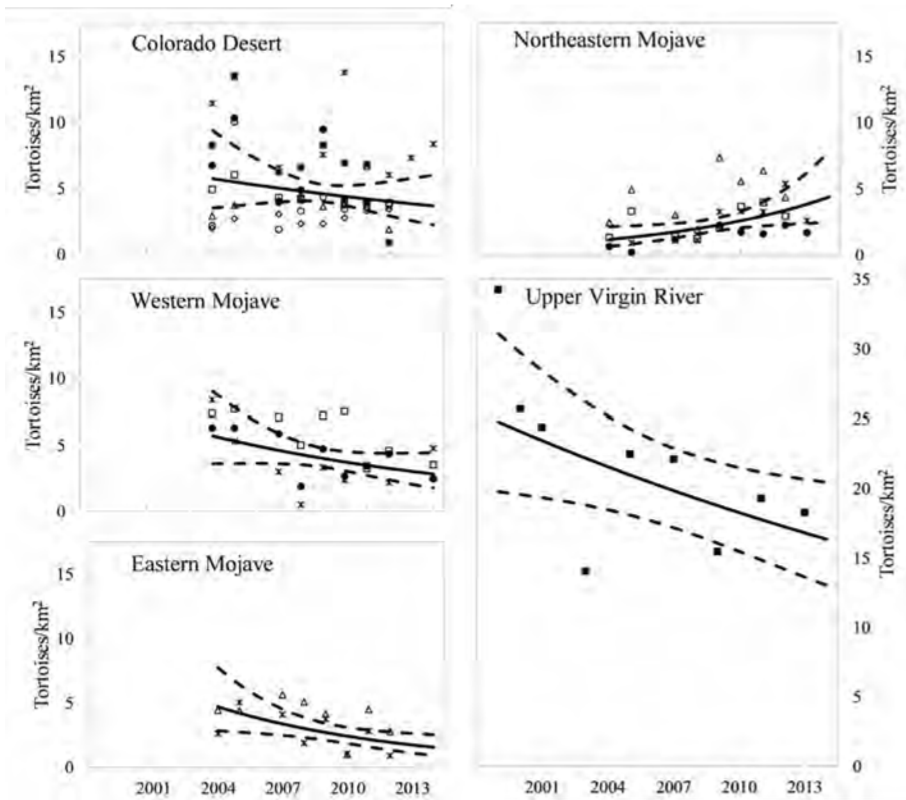

FIGURE 4. Trends in density (tortoises/km^2) of adult Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit through 2014: since 1999 for Upper Virgin River Recovery Unit and for all others since 2004. Separate markers are used for annual density estimates for each tortoise conservation area within the recovery unit. The modeled change in density is the bold line and its 90% CI is shown with the dashed line, reflecting the Type I error specified in U.S. Fish and Wildlife Service (2011).

variance. Visual inspection of residual plots did not reveal any obvious deviations from homoscedasticity or normality.

Densities of adult *G. agassizii* were declining, on average, in every recovery unit except the Northeastern Mojave (Table 4, Fig. 4). Average density of adult tortoises increased in the Northeastern Mojave Recovery Unit at 13.1%/y (SE = 4.3%) since 2004, with especially large rates of increase (> 13%/y) estimated in BD and GB. Adult densities in the other four recovery units have declined at different annual rates: Colorado Desert (-4.5%, SE = 2.8%), Upper Virgin River (-3.2%, SE = 2.0%), Eastern Mojave (-11.2%, SE = 5.0%), and Western Mojave (-7.1%, SE = 3.3%). Based on analysis of covariance, three of the four recovery units with more than one TCA could be characterized by common regression slopes (Eastern Mojave: $F_{1,12}$ = 0.305, P = 0.591; Western Mojave: $F_{2,21}$ = 0.094, P = 0.910; Northeastern Mojave: $F_{3,24}$ = 1.206, P = 0.317; Colorado Desert: $F_{6,43}$ = 2.391, P = 0.044), but intercepts indicate different initial densities in two of the recovery units (Eastern Mojave: $F_{1,13}$ = 2.560, P = 0.134; Western Mojave: $F_{2,23}$ = 3.326, P = 0.054; Northeastern Mojave: $F_{3,27}$ = 11.073, $P < 0.001$; Colorado Desert: $F_{6,49}$ = 5.090, $P < 0.001$). The estimates we report above and in Table 4 are therefore total regression results for the Colorado Desert and Northeastern Mojave recovery units to characterize this greater within-recovery unit variation in slopes and/or intercepts, but common regression results for the other recovery units. Slopes differed between recovery units ($F_{4,119}$ = 9.422, $P < 0.001$).

We applied estimated recovery unit densities based on TCAs to all potential habitat in each recovery unit, developing a high-end estimate of abundance for each recovery unit in 2004 and 2014 (Table 5). Despite the increasing population trend of adults in the Northeastern Mojave, its small area and low starting density resulted in a relatively small overall increase in the number of adult tortoises by 2014. In contrast, the much larger areas of the Eastern and Western Mojave and Colorado Desert recovery units, plus the higher estimated initial densities in these areas, explain much of the estimated total loss of adults since 2004. We estimate there were 124,050 fewer adult tortoises (SE = 36,062) range-wide in 2014 compared to the 336,393 tortoises (SE = 51,596) present in 2004.

Changes in representation of juvenile size class.—The full model of spatial and temporal effects describing the proportion of juveniles among observed tortoises

TABLE 3. Model selection table for all models fit to log-transformed annual densities of adult Mojave Desert Tortoises (*Gopherus agassizii*) through 2014 for all Tortoise Conservation Areas (TCAs), starting in 1999 for Red Cliffs Desert Reserve and in 2004 for the remaining 16 TCAs. Model weights (*w*) express the relative support for each model given the data and are based on relative scores for the second order Akaike's Information Criterion (AIC_c).

Model	Log likelihood	AIC_c	ΔAIC_c	*w*
TCA + Year + TCA×Year	-42.2	186.0	0.0	0.9996
TCA + Year	-76.7	203.2	17.2	0.0002
TCA	-78.4	203.9	17.9	0.0001
TCA + Year + Year^2	-76.0	204.7	18.7	0.0001
TCA + Year + Year^2 + TCA×Year + TCA×Year^2	-25.6	229.2	43.2	0.0000
Year + Year^2	-150.0	312.7	126.7	0.0000
Year	-155.3	321.1	135.1	0.0000
Random effects only	-160.3	329.0	143.0	0.0000

reduced the unexplained variance by 30.6% compared to the model of an overall average proportion, accounting for intra-year correlated proportions. Although the model with only Recovery Unit as a fixed effect had the lowest AIC, there was considerable support for models other than the top-ranking one (Table 6). The next five ranked models added Year or Year^2 effects and were within five AIC units of the best model; the cumulative weight of the top six models was > 0.95. As expected based on the ranked models, model-averaged parameter estimates indicated that the odds of finding a juvenile tortoise differed primarily between recovery units, with a weaker pattern of change over time (Table 7). This analysis approach does not allow us to estimate the true proportion of juveniles in the population, and indeed the higher proportion of juveniles found in the Upper Virgin River Recovery Unit is undoubtedly a product of the three-pass search technique used there in contrast to two-passes elsewhere. Of the four recovery units in which we used two-pass surveys, the probability of encountering a juvenile was consistently lowest in the Western Mojave Recovery Unit. The model-averaged Year parameter estimate indicated the average pattern over all years (1999 through 2014) because we standardized the input variable Year (mean = 2007.0, SD = 4.1). The model-averaged Year parameter for each recovery unit is close to zero, indicating similar proportions at the beginning and end of the survey period, with slightly fewer juveniles in the Northeastern and Western Mojave recovery units, and slightly more elsewhere. However, the negative sign of the Recovery Unit X Year^2 parameter estimates indicated that between the beginning and end of the survey period, there were increased odds of encountering juveniles (Schielzeth 2010); the proportion of juveniles was increasing when surveys began in 1999 but peaked in 2007 and have been declining in all recovery units since then.

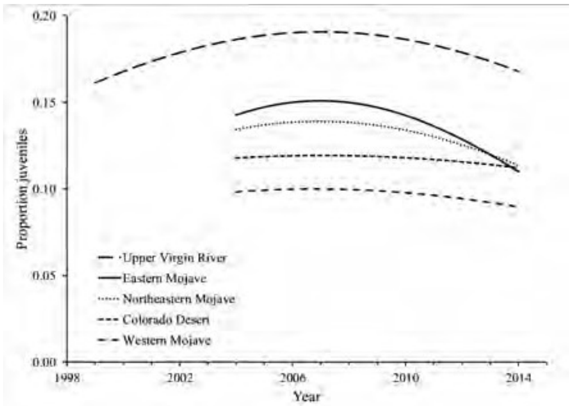

FIGURE 5. Relative proportion of juvenile Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit through 2014: since 1999 for Upper Virgin River Recovery Unit and for all others since 2004.

The linear and quadratic time effects indicate that in all recovery units the odds of encountering a juvenile have declined since 2007 (Table 7, Fig. 5), which is most of the period of surveys for four of the five recovery units. The magnitude of the Recovery Unit X Year^2 effects indicates this trend was strongest in the Eastern and Northeastern Mojave recovery units, so that in 2014 there were 23% fewer (Eastern Mojave) and 15% fewer (Northeastern Mojave) juveniles compared to 2004. In 2007, the year when the proportion of juveniles was estimated to be highest in all recovery units, $P(\text{juvenile}_{2007UpperVirginRiver}) = 0.189$, CV = 0.057 and, in contrast, $P(\text{juvenile}_{2007\text{Western Mojave}}) = 0.099$, CV = 0.067. The probability that an encountered tortoise was a juvenile was also consistently low in the Colorado Desert ($P[\text{juvenile}_{2007\text{Colorado Desert}}] = 0.119$, CV = 0.131) and lower than in the remaining two recovery units ($P[\text{juvenile}_{2007\text{Eastern Mojave}}] = 0.149$, CV = 0.187; $P[\text{juvenile}_{2007\text{Northeastern Mojave}}] = 0.140$, CV = 0.085).

DISCUSSION

Our analyses provide the first estimates of regional and range-wide population trends for *G. agassizii*. Overall this threatened species is experiencing large, ongoing population declines, and adult tortoise numbers have decreased by over 50% in some recovery units since 2004. Although TCAs within the same recovery unit had very different initial densities, trends were more similar within recovery units than between them. Only one of the five recovery units (Northeastern Mojave) exhibited population increases across all TCAs; this recovery unit also had the lowest densities at the start of our study period in 2004.

Maximum annual population growth rate projected in the eastern Mojave Desert during optimum forage conditions on a 2.59-km^2 study plot was 2% (Turner et al. 1987, unpubl. report), while Nussear and Tracy (2007) simulated annual population growth rates as

TABLE 4. Parameter estimates and standard errors (SEs) from the best-fitting model describing $\log_e$ transformed density/km^2 of adult Mojave Desert Tortoises (*Gopherus agassizii*). The model applies for the period through 2014 for all recovery units, starting in 1999 in Upper Virgin River and in 2004 for the remaining four recovery units.

Recovery unit / Tortoise Conservation Area	Intercept (SE)	Slope (SE)
Western Mojave	-3.174(0.102)	-0.071(0.033)
Fremont-Kramer (FK)	-3.195(0.103)	-0.068(0.030)
Ord-Rodman (OR)	-2.801(0.104)	-0.082(0.031)
Superior-Cronese (SC)	-3.149(0.092)	-0.093(0.029)
Colorado Desert	-3.051(0.078)	-0.045(0.028)
Chocolate Mtn Aerial Gunnery Range (AG)	-2.395(0.115)	-0.033(0.033)
Chuckwalla (CK)	-3.093(0.119)	-0.041(0.042)
Chemehuevi (CM)	-2.966(0.131)	-0.108(0.047)
Fenner (FE)	-2.574(0.127)	-0.073(0.048)
Joshua Tree (JT)	-3.553(0.132)	0.062(0.044)
Pinto Mountains (PT)	-3.144(0.149)	-0.083(0.058)
Piute Valley (PV)	-3.193(0.120)	0.044(0.049)
Northeastern Mojave	-3.870(0.119)	0.131(0.043)
Beaver Dam Slope (BD)	-3.975(0.143)	0.222(0.052)
Coyote Springs Valley (CS)	-3.750(0.100)	0.102(0.041)
Gold Butte-Pakoon (GB)	-4.365(0.148)	0.144(0.048)
Mormon Mesa (MM)	-3.148(0.101)	0.082(0.041)
Eastern Mojave	-3.544(0.132)	-0.112(0.050)
Eldorado Valley (EV)	-3.589(0.131)	-0.092(0.051)
Ivanpah (IV)	-3.273(0.126)	-0.074(0.048)
Upper Virgin River	-1.654(0.093)	-0.032(0.021)
Red Cliffs Desert Reserve (RC)	-1.654(0.093)	-0.032(0.021)

high as 5%. We describe regional population increases in some TCAs much larger than this, possibly indicating that optimal environmental conditions alone do not explain these increases. Several unpaved roads in these TCAs have been closed by the BLM and legal protections since the early 1990s may have reduced the number of tortoises purposely killed or removed from the wild. Nonetheless, the 3.7-fold increase in adults since 2004 that is described here would be unexpected even under much more active management. The large variance associated with these estimates of population trend probably factors into the magnitude of the estimate. Large variances that describe the best estimates of trends in adult density indicate that more modest increases are almost as strongly supported by the data.

Encounter rates make the largest contribution to variance in the annual TCA density estimates, reflecting the non-random pattern of tortoises on the landscape. High between-transect variability in encounter rate means that within-year encounter rate variance will be high, as will between-year variance unless the same transects are surveyed each year. This is the case only in RC, the only TCA where encounter rate variance was never the primary contributor to the density variance (more about variance considerations below).

Based on the rapid increase in the number of adults, juveniles in the Northeastern Mojave Recovery Unit must also be increasing in absolute terms despite the -0.021 change in their relative number since 2004. Locally focused demographic studies are required to describe the roles of increasing adult survivorship and/or recruitment into adult size classes; these studies could also further our understanding of the survivorship of the more cryptic juveniles (USFWS 2011). Population trends of the future (over more than a generation) will provide a measure of reproduction and juvenile survivorship since 2004 in the Northeastern Mojave TCAs.

Declining adult densities through 2014 have left the Western Mojave adult numbers at 49% and in the Eastern Mojave at 33% of their 2004 levels. Such steep declines in the density of adults are only sustainable if there were suitably large improvements in reproduction and juvenile growth and survival. However, the proportion of juveniles has not increased anywhere since 2007, and in these two recovery units the proportion of juveniles in 2014 has declined to 91% and 77% of their representation in 2004, respectively. This may be a continuation of ongoing population declines for at least part of the Western Mojave (Berry et al. 2013).

Reductions in the number of juvenile tortoises may reflect reduced reproduction and/or increased mortality of smaller tortoises. Drought indices for the deserts of the southwestern United States have increased in recent decades (USFWS 2006, Guida et al. 2014), with speculation that female tortoises consequently reduce annual reproductive effort (Henen 1997, 2002) or that hatchlings may be at increased risk of emerging to find too little moisture and related forage (Morafka 1994; Nagy and Medica 1986; Nagy et al. 1997; Wilson et al. 2001). Many other sources of mortality to smaller desert tortoises have been identified (Darst et al. 2013), but recent attention has focused especially on increased predation risk in the Western Mojave, Eastern Mojave, and Colorado Desert recovery units due to prey-switching during droughts by Coyotes (*Canus latrans*; Esque et al. 2010) and especially by increasing abundance of Common Ravens (*Corvus corax*), which typically prey on smaller tortoises rather than on adults (Boarman and Berry 1995; Kristan and Boarman 2003).

Ultimately, trends in adult and juvenile densities reflect the impact of numerous unquantified threats to *G. agassizii* populations over the period of the study (Tracy et al., *op. cit.*; Darst et al. 2013). With few exceptions, the multitude of threats, acting over the long lives of these animals, prevents more rapid and direct identification of specific agents responsible for *G. agassizii* population

TABLE 5. Estimated change in abundance of adult Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit between 2004 and 2014, including standard error (SE) of abundance estimates. Abundance estimates are based on recovery unit densities calculated from the model in Table 4 and applied to all areas of the associated recovery unit meeting criteria as modeled habitat, whether inside or outside TCAs.

Recovery Unit	Modeled Habitat (km^2)	2004 Abundance (SE)	2014 Abundance (SE)	Δ Abundance (SE)
Western Mojave	23,139	131,540 (35,415)	64,871 (17,465)	-66,668 (17,949)
Colorado Desert	18,024	103,675 (30,366)	66,097 (19,359)	-37,578 (11,006)
Northeastern Mojave	10,664	12,610 (4,304)	46,701 (15,940)	34,091 (11,636)
Eastern Mojave	16,061	75,342 (21,589)	24,664 (7,067)	-50,679 (14,522)
Upper Virgin River	613	13,226 (1,115)	10,010 (1,234)	-3,216 (340)
Total	68,501	336,393 (51,596)	212,343 (31,391)	-124,050 (36,062)

increases or declines. Local conditions in each TCA also determine whether the same threat will act with similar severity. For instance, although wildfires in 2005 in RC were associated with high tortoise mortality (McLuckie et al. 2014), similarly large fires that year in GB are believed to have impacted areas of poor tortoise habitat quality due to earlier overgrazing. These areas supported lower densities of tortoises at the time of the wildfire, so the impact of the fires was much less in GB than in RC (Tuma et al. 2016).

Techniques appropriate for describing survivorship and reproduction have characterized tortoise population dynamics in a handful of small, unrepresentative areas, while surveys in larger, more typical low-density areas are difficult to associate with specific local human activities. The trends we describe are consistent with published observations within some TCAs. As mentioned above in the Upper Virgin River Recovery Unit, RC experienced catastrophic wildfire as well as a drought-related die-off of tortoises during the period of this study (McLuckie et al. 2014). The vulnerability of this smaller recovery unit in the face of such large-scale impacts remains of paramount concern. In the Western Mojave Recovery Unit, decreasing population trends in the decades before 2004 were described based on multiple widespread but local mark-recapture plots (Doak et al. 1994; Berry and Medica 1995; Tracy et al., *op. cit.*); other evidence of population declines came from comparison of the frequency of live and dead tortoise sightings in the Western Mojave TCAs (Tracy et al., *op. cit.*). During the period covered by our study, Esque et al. (2010) also noted increased rates of predation by coyotes in the Western Mojave and linked this to decreases in their mammal prey base following drought.

In other parts of the desert, earlier research on local plots sometimes described population trajectories that differ from declines reported by us, such as static adult tortoise numbers on 2.59- km^2 plots in the IV TCA in the Eastern Mojave Recovery Unit, and in PV and FE in the Colorado Desert Recovery Unit (Berry and Medica 1995). The data in these cases were for earlier decades and describe patterns on single local plots that were not

TABLE 6. Model selection table for mixed model logistic regression describing the proportion of observations that were juvenile Mojave Desert Tortoises (*Gopherus agassizii*) from 2004 through 2014 for all recovery units (starting in 1999 for Upper Virgin River Recovery Unit). Year was also used as a categorical variable to capture the random effects of annual conditions. Model weights (*w*) express the relative support for each model given the data and are based on relative scores for Akaike's Information Criterion (AIC). Models with ΔAIC < 5 are shown (these model weights cumulatively account for > 0.95 of model support) as well as the top model for describing patterns in adult densities (Table 3) and the null model.

Model	Log likel.	AIC	ΔAIC	*w*
RU	-1967.8	3947.5	0.0	0.324
RU + Year2	-1966.8	3947.6	0.1	0.309
RU + Year	-1967.7	3949.5	2.0	0.119
RU + Year + Year2	-1966.8	3949.6	2.1	0.114
RU + Year2 + RU×Year2	-1964.1	3950.2	2.7	0.084
RU + Year + Year2 + RU×Year2	-1964.0	3951.9	4.4	0.036
RU + Year + RU×Year	-1965.9	3953.8	6.3	0.014
Random factors only	-1982.0	3968.1	20.6	0.000

TABLE 7. Parameter estimates (standard errors) for changes in the relative proportion of juveniles observed on surveys for adult Mojave Desert Tortoises (*Gopherus agassizii*) from 2004 through 2014 in four of the five recovery units and since 1999 in Upper Virgin River Recovery Unit. Estimates are model-averaged with shrinkage across the top six models in Table 6. For interpreting inflection points, the input variable Year was standardized based on mean = 2007.0 and standard deviation = 4.1.

Recovery Unit	Intercept	Year	Year^2
Colorado Desert	-1.999 (0.133)	0.003 (0.088)	-0.097 (0.380)
Eastern Mojave	-1.729 (0.206)	0.003 (0.106)	-0.484 (1.262)
Northeastern Mojave	-1.822 (0.107)	-0.001 (0.095)	-0.307 (0.534)
Upper Virgin River	-1.445 (0.066)	0.003 (0.003)	-0.212 (0.045)
Western Mojave	-2.198 (0.071)	-0.005 (0.105)	-0.154 (0.330)

selected to be representative of the larger TCA (Corn 1994; Anderson et al. 2001; Tracy et al., *op. cit*.). For instance, ongoing and long-term declines on a 2.59-km^2 plot in the JT TCA of the Colorado Desert Recovery Unit (Lovich et al. 2014) may reflect drought impacts they describe, in addition to consequences from the unimproved road that bisects the plot, and predator impacts reported elsewhere in a low relief site (Berry et al. 2013). These characteristics of the plot differ from large areas of the TCA, which are in more rugged terrain and where we characterize populations as increasing.

Throughout our assessment, we describe tortoise status based on adult densities, which is useful for comparison of areas of different sizes. However, if the area available to tortoises is decreasing, then trends in tortoise density no longer capture the magnitude of decreases in abundance. Some of the area of potential habitat (68,501 km^2) has certainly been modified in a way that decreases the number of tortoises present. We used area estimates that removed impervious surfaces created by development as cities in the desert expanded. However, we did not address degradation and loss of habitat from recent expansion of military operations (753.4 km^2 so far on Fort Irwin and the Marine Corps Air Ground Command Center), from intense large scale fires such as those that burned 576.2 km^2 in critical habitat alone in 2005, or from development of utility-scale solar facilities in the desert that have been permitted on 194 km^2 to date (USFWS 2016). The impact of the many smaller land use conversions (habitat loss) have not been compiled, but this and the small scale of habitat restoration projects (habitat gain) have been dwarfed by the scale of habitat conversion from military exercises, renewable energy facilities, and catastrophic fire. Due to loss and degradation of potential habitat, the recovery unit abundance estimates in Table 5 are maximum estimates. Habitat loss would also disrupt the prevailing population structure of this widely distributed species with geographically limited dispersal (isolation by distance; Murphy et al. 2007; Hagerty and Tracy 2010). Demographic connection with nearby local populations has enabled repopulation of at least one area after a local die-off of tortoises (Germano and Joyner 1988). We therefore anticipate an additional impact of this habitat loss is decreasing resilience of local tortoise populations by reducing demographic connections to neighboring populations (Fahrig 2007). Military and commercial operations and infrastructure projects that reduce tortoise habitat in the desert are anticipated to continue.

The high variability of population estimates and the serious consequences of hypothesis testing that fails to detect a true population decline are ongoing topics in conservation biology (Johnson 1989; Taylor and Gerrodette 1993; Taylor et al. 2007; Gerrodette 2011). Conventional hypothesis testing involves comparison of observed trend estimates to a null model of static population size; this unnecessarily restricts the scope and usefulness of monitoring programs to acquiring enough information to rule out no-action (Wade 2000; Gerrodette 2011). Instead, we used an information-theoretic approach in which the data are applied to each competing model; we drew conclusions based on the relative support for each model given the data (Burnham and Anderson 2002). In this case, regional trend models best described the data in hand. Our current analysis strongly concludes that there are similar population trends within recovery units, with different trends between recovery units.

The range-wide scope of our analysis also uses the power of replication in space to underline regional trends rather than attempting to describe one local trend in isolation (see Freilich et al. 2005; Inman et al. 2009). We would have reached less definitive conclusions if the monitoring effort had continued exclusively in a few dozen 2.59-km^2 study plots that had been initiated in the 1970s or if fewer TCAs had been surveyed, perhaps in a less coordinated effort. Instead, the current range-wide distance sampling program provides fairly coarse but clear summaries of patterns in tortoise density and abundance, definitive because they sample regionally and range-wide.

Although our results demonstrate the power of this monitoring program to detect large positive and negative trends over a 10–15-y period, large SEs for density trends we found reflect two important sources of imprecision in the population growth estimates. First, long-term monitoring programs spread over a large area are describing multiple underlying local phenomena. This can be seen in the consistent but TCA-specific within-recovery-unit trends. The same phenomenon is expected within TCAs. For example, each end of a valley may be experiencing different population dynamics, or lowland habitat may offer different population growth potential from upland habitat. It is also to be expected that there is some variation in the degree of population growth supported by year-to-year environmental conditions. These sources of variability in TCA- or recovery-unit-level population dynamics are reflected in the SE of our population trend estimates. By modeling intra-year covariation in TCA density estimates, we accounted for some of the process variation due to annual conditions.

Sampling error of the density estimate is a composite of the errors from the encounter rate estimates as well as from both correction factors that are applied. Estimation of P_a consistently contributes about 10% to the variance in the annual density estimates (e.g., McLuckie et al. 2002), and many more observations are needed to develop a detection curve than to estimate encounter rate. Detection curves based on 60 observations might be minimally acceptable (Buckland et al. 2001), whereas encounter rate estimates based on the same number of detections would be robust. This issue underlies the simulations by Freilich et al. (2005), which led them to reject distance sampling as a viable method for such sparsely distributed animals. The current monitoring program always applied much greater survey effort to estimate TCA-specific encounter rates than anticipated by Freilich et al. (2005); also, to avoid poor detection estimates, we pooled detection distances across all TCAs completed by a given team of surveyors. A certain amount of precision is also lost to the annual density estimates by correcting for G_0. However, this quantity can vary considerably between years, so failure to correct population estimates adequately would add bias to annual density estimates (Freilich et al. 2000).

Encounter rate estimation is consistently the largest variance component in all TCA density estimates (e.g., McLuckie et al. 2002). Most encounter rate variance is inherent to the distribution of tortoises on the landscape (Krzysik 2002), reflecting topographic and vegetation differences between transects with additional sampling variance reflecting relative survey effort. The planned and sustained effort in RC has resulted in much larger sample sizes than in other TCAs and more precision for annual population density estimates (CV = SE/density consistently between 0.12 and 0.15), contributing to lower between-year sampling error. Sampling error is also reduced because we survey the same transects in RC each year. The declining trend in abundance was therefore discernible even though RC was only monitored every other year, an approach that has not been pursued in the rest of the range where survey effort has fluctuated at a generally suboptimal level based on inconsistent funding.

Turtles and tortoises world-wide are as threatened with extinction as any other vertebrate lineage (Stanford et al. 2018). The crisis in turtle survival stems from ongoing direct exploitation that targets turtles for consumption or captivity as well as from indirect or untargeted harm such as mortality on roadways or non-lethal degradation of the habitat they need to survive. Most extinct turtle taxa in the past hundreds of years were extirpated from constrained areas (mostly giant tortoises endemic to islands), whereas the turtle species that are currently most endangered are primarily threatened by habitat alteration and collection for the pet trade or food market (Stanford et al. 2018). *Gopherus agassizii* is one of six North American species of *Gopherus*, part of all of which have protected status under U.S. or Mexican regulations or both. *Gopherus flavomarginatus* is listed among the top 25 threatened freshwater and terrestrial turtle species (Stanford et al. 2018), and populations have been decimated by habitat loss and ongoing collection for consumption. The remaining *Gopherus* species are widespread, which is not characteristic of turtles that have faced the first waves of extinction and local extirpation of the modern era. Population losses have nonetheless been documented in these *Gopherus* species (Bury et al. 1988; McCoy et al. 2006; Allison and McCoy 2014), and *G. agassizii* is now included in the list of the top 50 turtle and tortoise species at greatest risk (Stanford et al. 2018). Unlike earlier groups of turtle and tortoise species at risk of extinction, declines in *Gopherus* may instead reflect compounding impacts of threats that are not acutely lethal to individuals or populations (USFWS 2011). In common with other turtles and tortoises, their life history puts *G. agassizii* at greater risk from even slightly elevated adult mortality (Congdon et al. 1993; Doak et al. 1994) and recovery from population declines will require more than enhancing adult survivorship (Spencer et al. 2017). Currently, 60.8% of turtle species are designated Threatened on the International Union for Conservation of Nature (IUCN) Red List (IUCN 2017), including all *Gopherus* species except *G. berlandieri*. Although populations comprising *G. morafkai* and *G. evgoodei* were classified as conspecifics of *G. agassizii* at the time of the most recent IUCN status assessment, they are now recognized as distinct species, and are considered Vulnerable by the Tortoise and Freshwater Turtle Specialist Group, which officially consults to update the IUCN Red List (Rhodin et al. 2017).

The negative population trends in most of the TCAs for Mojave Desert Tortoises indicate that this species is on the path to extinction under current conditions. This may reflect inadequate recovery action implementation, slow response by tortoises and their habitat to implemented actions, or new and ongoing human activities in the desert that have not been mitigated appropriately. It may also be a result of stochastic or directional climatic events that impact large expanses of tortoise habitat (e.g., drought, fire, climate change) and are largely beyond the realm of local land management activities. Our results are a call to action to remove ongoing threats to tortoises from TCAs, and possibly to contemplate the role of human activities outside TCAs and their impact on tortoise populations inside them.

Long-term monitoring is an essential component of evidence-based management (Lindenmayer and Likens 2010). It determines whether the composite management efforts over ecologically meaningful time periods have been effective. For G. agassizii, the reinvigoration of the interagency management oversight group tasked with implementing recovery activities based on their predicted effectiveness has the potential to translate results from this monitoring program into decisions about maintaining or altering contemporary management activities. Monitoring of declining populations should be deeply integrated in conservation and recovery programs. Recovery plans under the U.S.

Endangered Species Act always stipulate population thresholds that would trigger removal of federal protection, but adaptive-management triggers based on monitoring results that show population declines are absent from most recovery planning (Lindenmayer et al. 2013) and have not yet been integrated into the management for *G. agassizii*.

Although these surveys were designed to provide a 25-y description of population growth, it is clear that this single purpose would be an underutilization of the program that can certainly address interim management questions (Nichols and Williams 2006). For long-lived *G. agassizii*, monitoring of the reproductive portion of the population also captures the effects of management on the population segment that must be the basis for recovery. Population recovery will necessitate accelerated, prioritized recovery activities (Darst et al. 2013). Targeted, local effectiveness monitoring (Lyons et al. 2008; Lindenmayer et al. 2011), where possible, would complement our larger population monitoring program. Both types of monitoring will be needed to characterize the effectiveness of recovery activities where the list of threats is so large and varied.

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APPENDIX A. Annual proportion visible, G_0 (standard error), at each focal site where we monitored transmittered adult Mojave Desert Tortoises (*Gopherus agassizii*). Sites are listed in order from the western-most to the eastern-most and their locations are indicated in Fig. 1. Red Cliffs was also surveyed earlier: 1999 (0.63, SE = 0.185), 2000 (0.86, SE = 0. 144), 2001 (0.86, SE = 0.167), 2003 (0.87, SE = 0. 135).

Site	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014
Superior-Cronese	0.95 (0.081)	0.92 (0.094)	0.96 (0.050)	0.75 (0.197)	0.90 (0.120)	0.98 (0.056)	0.94 (0.073)	0.94 (0.073)		0.91 (0.101)
Ord-Rodman	0.98 (0.035)	0.92 (0.083)	0.64 (0.213)	0.74 (0.130)	0.96 (0.054)	0.94 (0.072)	0.95 (0.062)	0.79 (0.156)		0.99 (0.030)
Twentynine Palms	0.98 (0.028)	0.90 (0.110)	0.97 (0.047)	0.74 (0.113)						
Chuckwalla	0.70 (0.183)	0.74 (0.153)	0.87 (0.060)	0.55 (0.105)	0.73 (0.175)	0.84 (0.125)	0.85 (0.108)	0.82 (0.075)	0.84 (0.058)	0.59 (0.087)
Ivanpah	0.95 (0.071)	0.87 (0.102)	0.94 (0.091)	0.79 (0.107)	0.79 (0.120)	0.88 (0.157)	0.87 (0.149)	0.54 (0.098)		
Jean	0.86 (0.142)									
Indian Springs			0.79 (0.140)	0.83 (0.153)	0.88 (0.118)	0.86 (0.130)	0.79 (0.093)	0.98 (0.049)		
Piute Valley 1	0.84 (0.148)	0.91 (0.118)	0.81 (0.178)	0.73 (0.127)		0.79 (0.218)	0.86 (0.141)	0.65 (0.148)		
Chemehuevi	0.88 (0.104)	0.65 (0.174)	0.62 (0.118)	0.80 (0.120)	0.84 (0.130)	0.81 (0.144)	0.80 (0.162)	0.35 (0.077)		
Piute Valley 2	0.80 (0.191)	0.87 (0.166)								
Halfway Wash					0.64 (0.167)	0.77 (0.200)	0.55 (0.152)	0.54 (0.116)	0.68 (0.136)	
Gold Butte						0.76 (0.141)	0.65 (0.155)	0.52 (0.118)	0.68 (0.123)	
Red Cliffs		0.86 (0.140)	0.53 (0.247)		0.68 (0.131)		0.74 (0.134)		0.66 (0.180)	

Appendix B. Detection statistics for field teams surveying separate Tortoise Conservation Areas (TCAs) each year. Teams walked *L* total km over *k* transects and detected n adult Mojave Desert Tortoises, which was P_a proportion of those available within *w* meters of the transect centerline. The coefficient of variation (CV) for P_a is also listed. Separate detection curves were built for each team each year, except in Red Cliffs Desert Reserve (RC), for which we report on the single composite detection curve. Other TCAs are abbreviated as Chocolate Mountains Aerial Gunnery Range (AG), Beaver Dam Slope (BD), Chuckwalla (CK), Chemehuevi (CM), Coyote Springs Valley (CS), Eldorado Valley (EV), Fenner (FE), Fremont-Kramer (FK), Gold Butte-Pakoon (GB), Ivanpah (IV), Joshua Tree (JT), Mormon Mesa (MM), Ord-Rodman (OR), Pinto Mountains (PT), Piute Valley (PV), and Superior-Cronese (SC).

Year	TCAs	*k*	*L*	*w*	n	P_a	CV(P_a)
1999 to 2013	RC	1,417	2,778	20	1,141	0.64	0.02
2004	AG, CK, CM, FE, IV, JT, PT	316	3,509	15	292	0.57	0.03
2004	FK, OR, SC	138	1,534	15	134	0.42	0.19
2004	BD, CS, EV, GB, MM, PV	175	1,723	22	57	0.47	0.10
2005	AG, CK, CM, FE, FK, IV, JT, OR, PT, SC	451	5,414	13	394	0.47	0.06
2005	BD, CS, EV, GB, MM, PV	267	2,852	18	108	0.40	0.10
2007	BD, CS, EV, GB, MM, PV	282	2,723	13	67	0.57	0.10
2007	AG, CK, CM, FE, FK, IV, JT, OR, PT, SC	271	3,174	16	155	0.39	0.09
2008	BD, CS, EV, MM, PM	566	5,705	18	127	0.41	0.10
2008	AG, CK, CM, FE, FK, IV, JT, OR, PT, SC	118	1,354	14	42	0.47	0.33
2009	BD, CS, EV, GB, MM, PV	568	5,525	15	109	0.25	0.23
2009	AG, CM, FE, FK, IV, JT, OR, PT, SC	225	2,492	14	103	0.35	0.10
2010	BD, CS, GB, MM	425	4,265	16	164	0.41	0.08
2010	CM, EV, FE, IV, PV	368	2,465	14	109	0.59	0.06
2010	FK, OR, SC	187	2,144	12	91	0.58	0.07
2010	AG, CK, JT, PT	140	1,431	8	85	0.67	0.10
2011	BD, CS, GB, MM	380	3,984	20	166	0.43	0.10
2011	CM, EV, FE, IV, PV	312	2,548	20	133	0.32	0.19
2011	CK, FK, JT, OR, PT, SC	160	1,802	16	100	0.53	0.08
2012	BD, CS, GB, MM	369	4,184	21	151	0.38	0.12
2012	CM, EV, FE, IV, PV	201	1,695	15	28	0.43	0.26
2012	AG, CK, FK, JT, OR, PT, SC	162	1,776	14	73	0.40	0.15
2013	AG, BD, GB	173	2,019	16	68	0.45	0.20
2014	AG, FK, OR, SC	230	2,649	10	118	0.61	0.06

CONSERVATION BIOLOGY OF FRESHWATER TURTLES AND TORTOISES

A COMPILATION PROJECT OF THE
IUCN/SSC TORTOISE AND FRESHWATER TURTLE SPECIALIST GROUP

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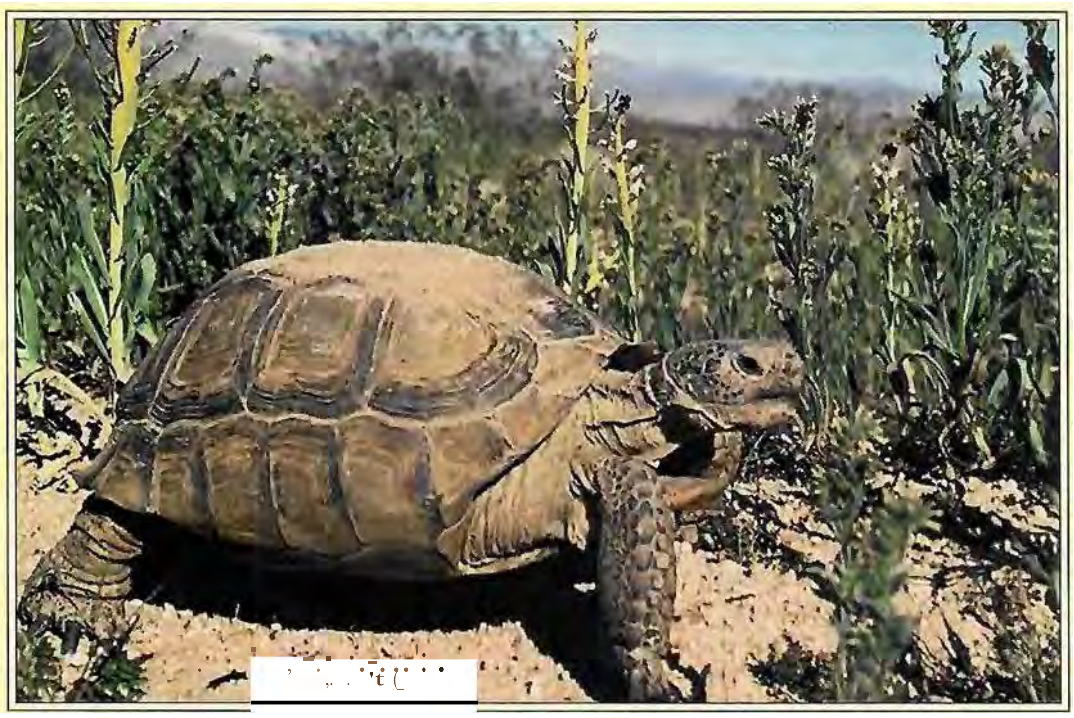

Gopherus agassizii (Cooper 1861) – Mojave Desert Tortoise, Agassiz's Desert Tortoise

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Gopherus agassizii {Cooper 1861) - Mojave Desert Tortoise,, Agassiz's Desert Tortoise

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SUMMARY. - **The Mojave Desert Tortoise, *Gopherus agassizii* (Family Testudinidae), is a large terrestrial species that can reach >370 mm in straight midline carapace length (CL) but most individuals are smaller. Both sexes reach adulthood at 12 to 21 years and ca. 180 mm CL. The species is sexually dimorphic, with males typically larger than females; sexual characteristics of males become more obvious with increasing size andage.Females lay from 1 to 10 eggs per clutch and fromO to 3 clutchesannually, witheggshatching after67 to104 days.Populations of *G. agassizii* have declined rapidly over the last several decades. Habitat throughout the geographic range has experienced major losses, degradation, and fragmentation as a result of urban and agricultural development, livestock grazing, military activities, transportation and utility corridors, high levels of visitor use, vehicle-oriented recreation, and energy development. Disturbedhabitats were vulnerable to invadingnon-native grassesandforbs,creatingan unnatural and destructive grass-fire cycle. When consumed by tortoises as their only diet, non-native (and native) grasses are harmful because of limited nutrients. Additionally, subsidized predators (Common Ravens, Coyotes, and dogs),infectious diseases,drought, and vandalism, add to the.catastrophiceffectsof habitat lossand degradation. Tortoise populations have declined .rapidlyin density, and most populations are bel,ow viability, with fewer than 3.9 adults/km^2· These declines occurred despite protections afforded by federal and state laws and regulations, ca. 26,000 km^2 of federally de.signated critical habitat units, two Recovery Plans, and efforts to reduce the negative impacts of human activities. As noted by Allison and McLuckie (2018), the negative population trends in most of the critical habitat units suggest that under current conditions *G. agassizii is* on the path to extinction.**

OISTRJBI.ITION. - **USA. Distributed in parts of the southern Great Basin, Mojave, and western Sonorandesertsinsoutheastern California,southernNevada,northwesternArizooa,and southwestern Utah, north and west of the Grand Canyon/Colorado River complex, with the exception of a small population eastof the Colorado River.**

SYNONYMY. - ***Xerobates** agassizii* **Cooper 1861, *Testudo** agassizii;* ***Gopherus agas izii, Goplierus polyphemus agassizii,Scaptoclrelys agassizii,Xerobates Iepulqcephalus*OttleyaniI VelazquesSolis1989.**

SUBSPECIES.- None currently recognized.

STNrus.-IUCN 2019Red List:Vulnerable(VUA1acde+2cde;assessed 1996);TFTSG Provisional **Red List:CriticaJly Endangered (CR;assessed2011,2018);CITES:AppendixIT(Testud.inidaespp.); US ESA: Threatened.**

Taxonomy. - The Mojave Desert Tortoise was first described as *Xerobates agassizii* by Cooper (1861), transferred to the genus *Testudo* by Cope (1875) and to *Gopherus* by Stcjnegcr (1893).lt was l.isted as a subspecies of *Gopherus polyphemus* by Mertens and Wennuth (I 955) and referred to the genus *Scaptochelys* by Bramble (1982). *Goph.eruslepidocephalus*,described by Ottleyand Velazques Solis (1989) based on introd11ced specimens from the Cape Region of Baja California Sur, Mexico, is a junior synonym of G. *agassizii*. Bramble erected *Scaptochelys* for the dade conraining the western sp<;icies of *Gopherus*, but this name was preoccupied (Bour and Dubois 1984). Recently, Brambleand Hutchison (2014) advocated for the splining of *Gopherus* jnto two genera, including *Xerobates* (for the desert species and *G. bertandieri).* but the splitting seems unnecessary, and their proposed taxonomy bas not been followed. Recentgeneticand morphological workon the previously wide-spread species G. *agassizii* scnsu lato has led to the recognition and description of the Sonoran or Morafka's Desert Tortoise, *G. morajkai* (Murphy et al. 2011) in Arizona and Sonora, Mexico, and the Sinaloan Thornscrub Tortoise, G. *evgoodei* (Edwards et al. 2016a) in southe01 Sonoraand.Sinaloa,Mexico, markedly limiting the rangeof *G. agassizii* sensu stricto.

Phylogenetic Relationships. - The genus *Gopherus* containssixspecies thatconsistof twomajorsister-groups:

Figure 1. Adult *Gopherusagassizii* in desert candles at the DesertTortoise Research Natural Area, Mojave Desert, California. Photo by Bev Steveson.

1) *G. polyphemus* and *G. fiavomarginatus,* and 2) *G. berlandieri,* G. *evgoodei,* G. *morajkai,* and *G. agassizii.* The phylogenetic relationships in the second group are given in order of ascending relationships (Bramble and Hutchinson 2014; Murphy 2014; Edwards et al. 2016b). *Gopherus evgoodei* and *G.morajkai* may have originated via environmental-dependent parapatric speciation where exogenous selection limited geneticintrogression(Edwards et al. 2016c). Later, the divergence of the sister species G. *agassizii* and *G. morajkai* may have been driven by either parapatric speciation or geographic isolation (Edwards et al. 2016b). Their divergence dates to about 4-8 million years ago, owing to the Bouse embayment (Lamb et al. 1989).

Description. - Thisand othersections focus primarily on peer-reviewed literatureinjoumals and on recent articles summarizing topics.The published literatureon *G. agassizii* contains papers on wild, free-ranging tortoises, tortoises maintained in small and large pens, head-started tortoises, and captives. For mosttopics,we emphasize studieson wild tortoises.

Adults of *G. agassizii* range in size from about 178 to >370 mm straight-line, midline carapace length (CL). Females tend to be smaller than males (Table I), but the

Figure 2. Adult male*Gopherus agassizii* from the Desert Tortoise Research Natural Area, Mojave Desert, California. First captured in 1979 at a CLof 292 mm, he was recaptured repeatedly and in 2012 had a CL of 300 mm (these photos) and estimated to be at least 70 years old. Photos by U.S.Geological Survey, courtesy of Kristin H. Berry.

Figure 3. Adult male *Gopherus agassizii* at Chuckwalla Bench, California (Colorado Desert Recovery Unit).Photo by Stevelsbii.

Figure 4. Adult *Gopherus agassizii* with a green beak (from foraging) in spring. Photo by Mark Massar.

largest recorded wild individual was a female from Lucerne Valley, California, first ma.t'ked in 1980 at 364 mm CL and recaptured in 1986 at374 mm CL(U.S. Geological Survey files; Beny, unpubl. data). The largest recorded wild male was 330 mm CL, marked in 1982 at the Desert Tortoise Research.Natural Area in the western M.ojave Desert (Table 1). At that location, 8.9% of adult males were :.:.300 mm CL. Larger tortoises may have been morecommon several decades ago.Ragsdale (1939) wrote that he frequently met healthy old tortoises *15* inches (ca. 380 mm) CL across the back25-30 yearsprior(!909-1914),beforepaved highways cameto theColorado Desert area.

The carapace shape rangesfrom relatively high-domed and rounded in the west to low-domed and oval in the southern and eastern partof the range. Females have a flat plastron, as compared to the posterior plastral concavity that develops and deepens in males as they age. Shapes of the gular horn and tail are secondary sexual characteristics that also distinguish adults. Adult males havea larger gu.lar horn, generally becoming more pronounced and upturned withsize and age.Incontrast.females haveasmaller,shorter, and generally flatter guJar horn. The gularhorn tends to be notched early in adulthood but norching may disappear in. old adults. Tbe tails in males are longer than in females, projecting beyond the shell and often leaving a linear line or U11es *in* sand when walking, whe.reas the tail of females does not extend beyond the carapace orplastron. Colors of theintegument of limbs and shell vary with age and locality.

Bjurlin and Bissonette (2004) measured 91 wild hatchlings within 24 hours of emergence in the southern Mojave Desert, California; they had a mean CL of 43.8 ±2.15 (SD) mm (range 37.0-48.7 mm) and a mean weight of 21.3 ±2.91 SD g (range 14.4-28.2). Shells vary from light (light yellow) to dark (dark charcoal) with and without lighter areolae, whereas young adults rangefrom shades of light to dark brown, gray, or black with yellowish, reddish, greenish,and olivetones.Limb colorsalsovarywithaxillary and inguinal scales tending to be lighter than hindlimb pads and anterior surfaces of forelimbs.

Gopherus agassizii is best separated from congeners *G. polyphemus* and *G. fiavomarginatus* by having relatively smaJJer feet. Further, the distance from the bases of the first and third claws on the front feet is about the same as the distance between the bases of the first and fourth claws of the hind feet in G. *polyphe171us* and *G,jiavomarginatus,* but the distancefrom tbe basesof the first tofourth claws is the same on all feet in *G. agassizii* (Auffenberg and Franz J978).*Gopherusagassizii*andclosely related G. *ber/andieri,*

Table 1. Mean sizes and weights of adult female and male Mojave DesertTortoises (*Gopherus agassi;Ji)* in three desert regions of the geograpltic range of the species. CL: straight midline carapace length (mm). None of the sites were in undisturbed habitat. The West Mojave site was grazed by cattle, then by sheep until 1980. The East Mojave site was grazed by cattle for decades previously, before and during the surveys.Both the East Mojave and Colorado Desertsites had tank tracks and litter from World War11 military exercises.

Sizes and Weights	West Mojave: Desert Tortoise Research Natural Area Interior	East Mojave: Fenner Valley	Colorado Desert: Chuckwalla Bench
Year sampled	L982	1980	1979
Total sample-size *(n)*	178	188	175
females, males	92,86	77,111	80,95
Mean CL, mm (range):			
females	230.5 (182-267)	2l45(183-247)	222.3 (188-254)
males	249.1()80-330)	2425(182-307)	243.3 (190-291)
Mean weight, g (range):			
females	2522 (1200-3750)	2148(1111-2915)	2215 (1350-3300)
males	3302 (1350-{\950)	3044(I 115-6000)	2897 (1350-4750)

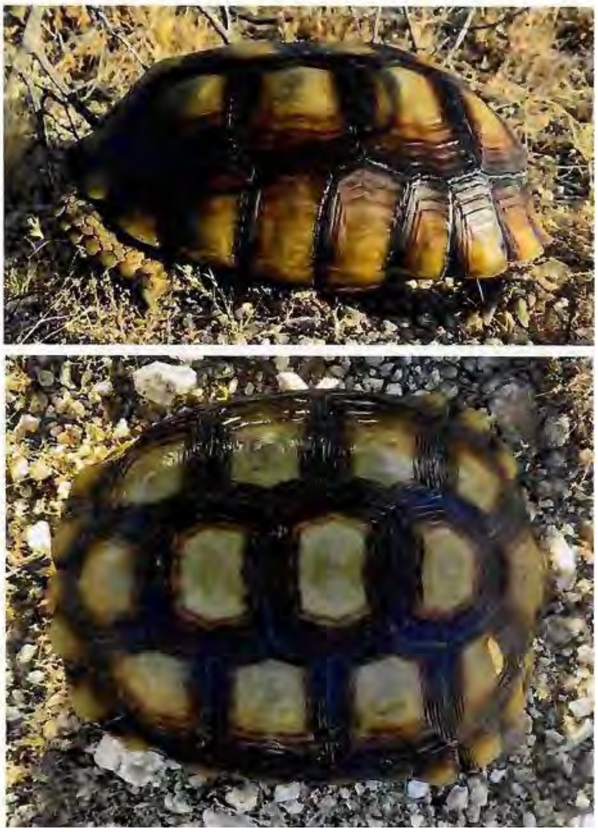

Figure 5. Young adult female *Gopherus a.gassizii* from Ward Valley in theColorado Desert,California. Photos courtesy of San Diego Zoo Global.

G. *morafkai,* and G. *evgoodei* individuals are most reliably distinguished by molecular data, especially in captivity, owing to extensive hybridization (Edwards et al. 2010) and abnormalities in shell, head and limb integument resulting from poor nutrition (Murphy et al.2011). In wild tortoises, *G. berlandieri* differs from *G. agassizii* (and *G. morafkai* and *G. evgoodei)* in havinga wedge-shaped versusa rounded snout (Auffenberg and Franz 1978). *Gopherus agassizii* differs from G. *morajkai* in having a significantly wider shell (Germano 1993),significantly longer gular scutes,and a significantly longer length of projection of the anal scales (Germano 1993),as well as a box-like versus a pear-shaped shell(Weinsteinand Berry I989).Finally,*G.agassizii*and*G. morajkai* both differ from the newly described G. *evgoodei* in having a higher shell in profile. *Gopherus evgoodei* also differs in having rounded footpads,multipleenlarged spurs on the radial-humeraljoint,a short tail,orange overtones in the skin and shell, and a distinctly shallower concavity on the plastron of males (Edwards et al. 2016a).

Distribution. -As originallydescribed,thegeographic range of *Gopherus agassizii* (sensu Jato) extended from southeastern Califomia,southem Nevada,andsouthwestern Utahsouth through ArizonaandSonoraand intothenorthern part of Sinaloa, Mexico (Stebbins 1966: Auffenberg and

Figure 6. Hatchling *Gopherus agassizii* from Edwards AFB in the western Mojave Desert, California. Photos courtesy of San Diego Zoo Global.

Franz 1978). However, in 2011, *G. agassizii* was split into two species along the Colorado River (USA), with *G. agassizii* (sensu stricto) occurring to the north and west of the river, and the new species *G. morafkai* distributed to the south and east (Murphy et al. 2011). With this division, G. *agassizii* (sensu lato) lost about 70% of its originally defined geographic range. Five yearslater, G. *morajkai* was further split into two species, with *G. evgoodei* described as encompassing the southern part of the geographic range in central to southern Sonora and northern Sinaloa, Mex:ico (Edwards et al. 2016a).

The northernmostlocations of*G. agassizii*are in southern Owens Valley, California, Beatty, Nevada, and Red Cliffs

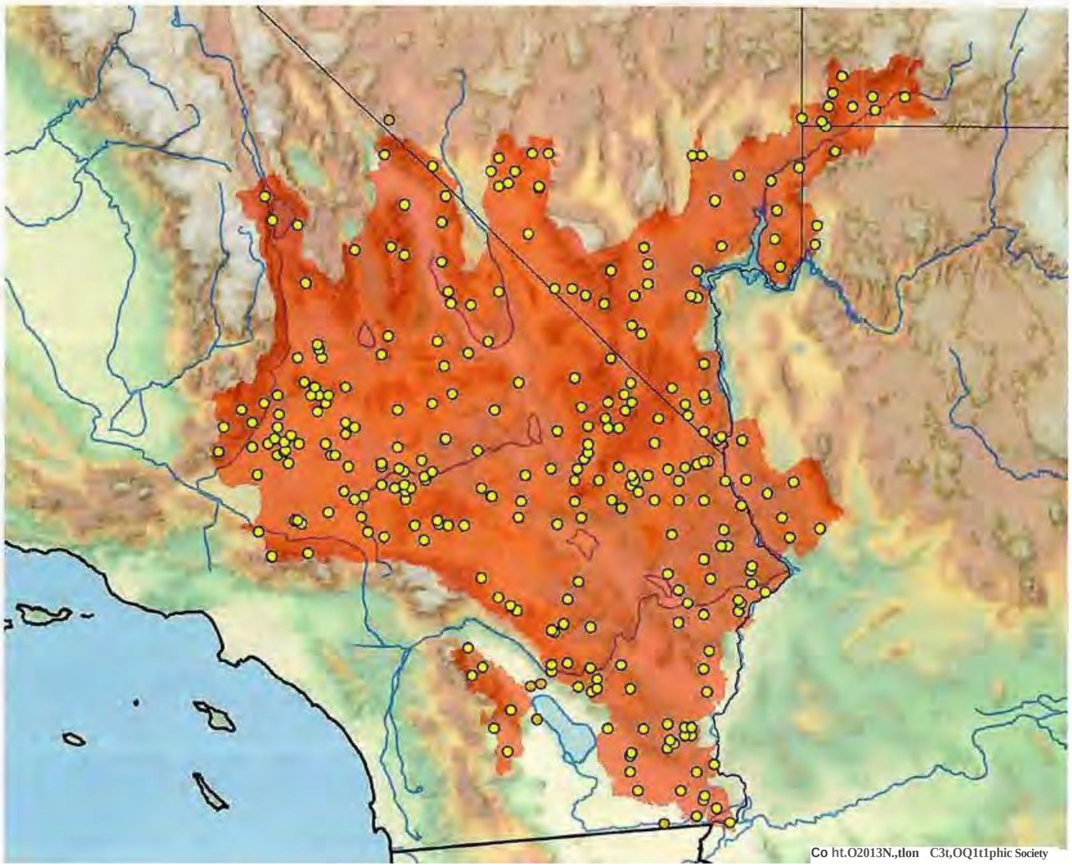

Figure7.Distribution of *Gopherus agassizii* in California, Nevada, Utah, andArizona in the USA.Yellow dote: museum and literature occutTcnce records of nativepopulations based on Iverson (1992) plus more recent and authors' data; orangedots= uncertain native or introduced specimens; red shading= projected historic distribution. Distribution based on GlS-defined level 12 HUCs (hydrologic unit compartments) constructed around verified localities and then adding HUCs that connect known point localities in the same watershed or physiographic region, and similar habitats and elevations as verified HUCs (Buhlmann et aJ. 2009; Tl'WG 2017), and adjusted based on authors' subsequent data.

DesertReserveand adjacent landsin southwestern Utah.The Colorado River forms the eastern and southern boundaries in California, parts of Nevada, northwestern Arizona, and Utah, with one exception. The exception to the Colorado River boundary is a small population of tortoises in Mojave Desert vegetation east of the Colorado River in the Black, Buck, and Hualapai mountains of Arizona (Edwards et al. 2015). Here, *G. agassizii* and *G. morafkai* meet in a contact zone where Mojave and Sonoran Desert vegetation types form an ecotone. With few exceptions, the two species have maintained theirtaxonomicidentities.Nineteen hybridswere identified by Edwards et al. (2015), most as Fi mixtures and were primarily ju the ecotone; one additional hybrid individual,a backcross,wasfound in theA:rrastra Mountains. Inman (2019)concurred,demonstrating separationof nkhes between the two species.

Most of the geographic range of G. *agassizii* occurs within theMojave Desert and western Sonoran or Colorado Desert, with small areas of southern Great Basin Desert in the north and on the slopes of desert mountain ranges. The western boundaries of the rangeoccur in ecotones with the lower slopes of the eastern Sierra Nevada and the Scodie and Tehachapi mountains, the lower north-facing slopes of the Transverse Range (specifically the San Gabriel and San Bernardino mountains), and the east-facing base of the Perunsular Range in the western Sonoran Desert. Using Recovery Units and critical habitat units or Tortoise ConservationAreasasaguide,approximately55%ofTortoise Conservation Areas are in the Mojave Desert and 45% are in the western Sonoran Desert (USFWS 2015).

The boundaries of the historic geographic range of G. *agassizii* havecontractedalong the marginsandfragmented in the interior, with lossesfrom agricultural, urban,energy, and military developments, as well as transportation corridors and roads. Hundreds of square blometers of tortoise habitat havebeen lost in the southwestern Mojave Desert,butdo notyetshowon mapsof habitat(e.g.,Nussear et al. 2009; Murphy et al.2011). Similarly,major parts of valleys once supporting high densities of tortoises have become urban, ex-urban, and industrialized; examples includeIndian Wells,Antelope,Victor,Apple,Chuckwalla, and Las Vegas valleys in California and Nevada, and St.

George in Utah. Averi.11-Murray el al. (2013) modeled potential linkages between Tortoise Conservation Areas (critical habitat units).

Gopherus agassi.zii can be found in unusual places and ecosystemsoutsideits-geographicrange,Captivesfrequently escape, are released or lranslocated (unauthorized) Wilh◊UL regard to sites oforigin.Animalsfound in the Cape Region of Baja California Sur,Mexico, weremislak.enlydescribed as the purported new species, G. *lepidocephalus* (Ottley and Velazques Solis 1989). In addition, mass authorized translocations haveoccurred (see summaries in Murphy et al. 2007). lna srody of the genetics of 180 captive tortoises in three cities in Arizona within the range of G. *morajkai,* more than 40% were G. *agassizii* from the Mojave Desert or were hybrids (Edwards er al. 2010). In a similar study of 106 captive tortoises from three desert communities in the Mojave Desert, the genotypes of only 44% we.re *G. agassizii* of local origin,55% wereassigned to oneof seven G. *agassizU* genetic units from outside the local area, and one tortoise was genotyped as *G. morafkai* (Edwards and Berry 2013).

Population Genetics. - Murph_y et al. (2007) provided the first anaJysis of population differentiation across the landscape to assess the correspondence between Recovery Unitsin thel994Recovery Planand genetic patterning.Their analysis used rntDNA sequenc s from 125 DesertTortoises and 16 microsatelliteJoci of 628 animals collectedfrom31 sample sites.Analyses recovered substantial differentiation within the Western Mojave Recovery Unit. However, the authors had very limited samplingin Nevada and Utah.

HagertyandTracy (2010) perfonneda similarassessment using 20 different microsatellite loci with larger sampling in Uta!1,Nevada, and the northern deserts of CaJifomi.a, but relatively poor sampling in the western and southern part of the species' range; they recovered an alternative panern. Later, Hagerty et al. (2011) applied landscape genetic analyses to those data and recovered patterns that were largely compatible with thoseof Murphy et al. (2007) when considering sample sizes; larger sample sizes in northern areas for Hagerty and Tracy (2010) and southern areas for Murphyetal.(2007) yielded moredetails.The *U.S.*Fishand WildlifeSerVice's (USFWS) Recovery Office assumed that a strategy of random sampling would outperform strategic samp1ing of populations,and therefore reliedon theHagerty and Tracy (2010) study. Rico et al. (2015) modeled the two sampling strategie& and discovered thatstrategic population sampling vastly outperformed random sampling, thereby giving credence to !he study of Murphy et al. (2007).

Recently, Sanchez...Ramfrez et al. (2018) evaluated 6,859 single nucleotide polymorphisms from 646 tortoises to reassess genetic patterns. Their results, which used newer genetic methods, were largely consistent with those of Murphy et al. (2007) in identifying significant genetic substructUring in the westernMojaveDesert.Theiranalyses also identified 12 highly differentiated outlier genes likely involved in adaptations,

On a microgeograplric scale, DesertTortoises at a study area in the central Mojave Desert exhibited weak genetic structure (Latch et al. 2011). Analyses identified two subpopulations with lowgeneticdifferences andevidence of gene flow.Topography, specifically slope (the predominant factor)androads,influenced local geneflow,with thechanges considered to be recent.

Habitat and Ecology. - The geographic range of G. *agassizii* covers parts of three deserts and mountain .ranges within and along their boundaries. Tortoises live in habitats ranging from 200 m to about 1570 m asl and in several vegetationassociations (Weinstein 1989;Rautenstrauch and O'Farrell 1998;Longsboreetal.2003;Keithetal.2008;Berty etaf.2006,2014a).Tortoises require topography, geological features, and soils suitable for cover and construction of shelters-burrows or dens, under rocks or rock crevices, and in banksor walls of ephemeral washes (Woodbury and Hardy1948;Burge**1978;**RautenslrauchandO'Farrell 1998; Andersen et al. 2000; Berry et al. 2006; Mack et al. 2015).

Habitat Use. - Cover of shrubs or trees is essential for protectionfromextremes of temperature, precipitation,and predators. Over 70% of cover sites (burrows, pallets) occur beneath sbrubs, with the larger sh.rubs or trees preferred (Burge 1978; Berry and Turner 1986). The vegetation of shrubs, trees, cacti, and perennial grassesdiffers regionally within lhe Mojave, southern Great Basin, and western Sonoran ecosystems. Regional differences are based on timing and amounts of precipitation, numbers of freezing days, and other climatic variables and topographic features (Rowlands etal. 1982; USFWS 1994,20U). Forexample, throughout the geographic range, most rainfall occurs in fall and winter. However, in the eastern and nortbeastem Mojave and western Sonoran deserts, summer rainfall is in1portant, resulting in shifts in vegetation types.Similarly, numbers of annual freezing days are high in the north (e.g., Desect Game Range, N'evada: 126 days) dropping to just a few days in the southern partof the range in the western Sonoran DcsertU to 16 days) (USFWS 1994).

Within the Mojave Desert ecosystem, tortoises occur in several vegetation associations. At lower elevations or adjacent to dry lake beds, saltbush associations *(Atriplex* spp.) and other members of the Chenopodiaceae provide babital. The most common associations contain creosote bush *(Larrea tridentaca),* usually with white bur-sage *(Ambrosia dumosa)* orcheesebush *(A. salsola)* and several other species of shrubs, cacti, and perennial grasses. With increasing elevation, multiple s-pecies of woody shrubs and tree yuccas (Joshua tree, *Yucca brevifolia,* and Mojave yucca,*Y.schidigera)* become more common, with blackbrush *(Co/eog;yne ramMissima)* associations

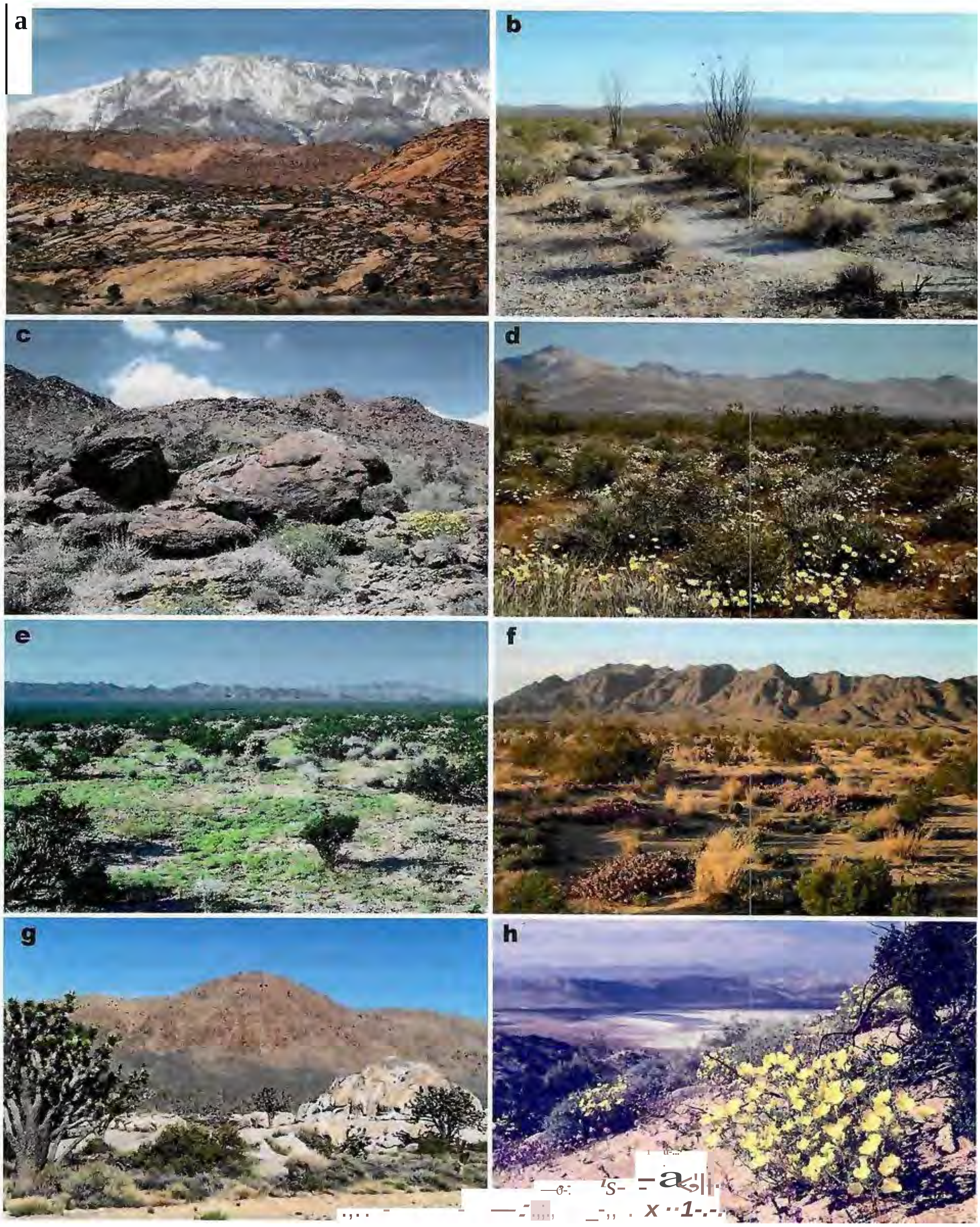

Figure 8. Habitats of *Gopherus agassizii*. **a.** Ecotone between Mojave and Great Basin deserts, Utah, Upper Virgin River Recovery Unit. Photo by Ann McLuck.ie. **b.** Chemhuevi Valley, Colorado Desert, California (creosote bush-ocotillo). Photo courtesy of U.S. Geological Survey. **c.** Soda Mountains, central Mojave Desert, California, Western Mojave Recovery Unit. Photo courtesy of U.S. Geological Survey. **d.** Northwestern Mojave Desert, California, Western Mojave Recovery Unit. Photo by Freya Reder. **e.** Eastern Mojave Desert, California, after summer rains, Colorado Desert Recovery Unit (formerly Eastern Mojave Recovery Unit). Photo by Betty L. Burge. **f.** Chuckwalla Valley, California, Colorado Desert Recovery Unit (formerly Eastern Colorado Recovery Unit). Photo by Freya Reder. **g.** Mojave National Preserve, California, Eastern Mojave Recovery Unit. Photo by Freya Reder. **h.** Desert Tortoise Research Natural Area, California, Western Mojave Recovery Unil. Photo by Kristin H. Berry.

present in higher elevations. In the northeast comer of the geographi1; range, in the Red Oiffs Desert Reserve in Utah,vegetationis transitional betweenMojaveDesertand Great Basin,combined with sand dune systems.Sand sage *(Artemisia .filifolia),* creosote bush, blackbrush, Nevada ephedra *(Ephedra nevadensis),* ahd big galleta *(Hilaria rigida)* are common (McLuckie et al. 2002).

The western SonoranDesertis a wanner,hotterdesertwith a higherproportionof precipitationoccurringinsummer.This desert is also characterized by creosote bushes, buta major difference is the presence of microphyll woodlands of blue *paloverde(Parkinsoniafiorida),*smoke tree*(Psorothamnus spinosus),*and iroowood(*Olneyatesota)*inephemer.il stream channels separated by desert pavements or open desert with oc-0tillo *(Fouqueria.splendens)* mixed with creosote bush, other shrubs, and cacti (Berry 1984).

More detailed descriptions of vegetation are in t11e first Recovery Plan and appendices, as well as in publications of individual field studies (USFWS 1994). Somo sites have rich assemblages of shrubs, trees, cacti, and native bunch grasses,whereas othersare lowin shrub and grassdiversity. Tortoises occur in very low densities or are absent where shrub cover1ssparse, precipitation is low and timingerratic, and annual food planrs are available only intemiittently (e.g., the lower elevations in Death Valley). They are also in low densities in moderately to severely disturbed areas, regardless of desert or region (e.g.,Bury and Luckenbach 2002; Keith et al. 2008; Berry et al. 2013).

Nussear et al. (2009) developed a quantitative habitat model using 16 layers of environmental data that were then joined with records on tortoise presence. Their model described the predicted habitat potential throughout the geographic range.This useful model does not exclude lands where tortoises no longer occur because of habitat lost to urbanization,agriculture, and other anthropogenic activities resulting io deteriorated habitat.

AdaptatioflS. - Tortoises have several adaptations or exaptations for dealing with environmental extremes found within the geographicrange.includingbehavio.ral responses, such as use of the burrow, cave, or den to escape extremes in environmental temperarures (e.g., Woodbury and Hardy 1948; Mack et al. 2015). They also exhibit physiological, hematologic and plasma biochemical responsesfor coping with lackofwater,food,andshelter, and reduction in annual output of eggs in response to drought. We review these subjects below (Morafka and Berry 2002).

TheTortoise Burrow. - Tortoises spend>90% of their lives inactive and underground in burrnws,pallets,caves,or 0th.er cover.For example, in the northempart<;>f the rangein Rock Valley, Nevada, where numbers of freezing days/year are high,Nagyand Medica(1986}reported thatlortoisesspent 98.3% of time underground. We define paUets as scrapes, often under a shrub, potentially rhe beginning ofa burrow, covering mdy partof theshell; they are often used in spring as a temporary refuge. Burrows are du.gin soil, are often 3 m or more in length with a soil cover of ameteror more in the deepestpart, and haveadownward slope.Dens occur in areaswith well-developedcalciclayers,areoften in washes, the tUnnels aregencr.illy horizontaland may havesiderooms and chambers that can be used by multiple tortoises. Caves are similar to dens, l.arger than_ the tortoise, with an arched roof, and are not the size and shape of a tortoise. Use of burrows and dens allows tortoises to shelter during times of extreme temperatures and when there is a lack of water ahdfood,and when in a deep burrow, tortoises reduce their metabolic rates (Henen etal.1998).

Types of cover site or sh.elter (pallet, burrow, cave, den) differ throughout the geographic range and depend on topography, geology, and soil types as well as seasons (Woodbury and Hardy 1948; Bulova 1994; Berry et al. 2006). Regardless of type of c-4ve or burrow, the opening for adult sites is half-moon shaped, curved side up, unless it has been altered by another species of animal (Woodbury an,dHardy 1948).Wild juvenileandsmallimmature tortoises also use small, balf-mooo shaped burrows matching their sizes at several Mojave an.d western Sonoran Desert sites (BerryandTurner 1986).Jna study ofh.ead-startedtortoises, most neonates (83%) hatched in pens constructed their own burrows withinafew daysofemergencefrom thenest;others used rodent burrowsor shared artificial burrowsconstructed for adults (Morafka et al. 1997).

In tbe northern part of the .range, caves and dens in the walls of ephemeral stream beds are more common than elsewhere. They occur in old alluvial deposits with consolidated gravelsandsandand with well-developedcalcite cementation (Woodbury and Hardy 1948;Macketal. 2015). These retreats can be several meters in length and used by multiple tortoises.Io the northeastern Mojave Desert,caves or dens were usually 2.4 to 4.6 m inlcugtb.occasionally 6. I to 9.1 m willi multiple side tunnels and rooms supporting as many as 17 tortoisessimultaneously (Woodbury and Hardy 1948). Tortoises can use a combination of burrows, caves, and dens(Woodbury and Hardy 1948; Macket al. 2015). In contrast, in thenorthwestern, western,and southem Mojave andColoradodeserts, tortoises primarily use burrows(Berry et al. 2006, 2013, 2014; Krzysik 2002; Harless et al. 2009).

Mostcoversiteswerefouodbeneath thecanopies of.large shrubs, regardless of size of the tortoise (Burge 1978; Berry and Turner 1986).Att heArden siteinNevada,Burge(1978) reported that 72% of large and small burrows were placed under shrubs withthe greatest shade-giving properties (i.c., catclaw, *Senegalia greggii [Acacia greggii],* Mojave yucca and creosote bush). For wild juveniles and srna.11 immature tortoises, 79% of burrows were under canopies or basal branchesof liveordead shrubs;creosote and white bur-sage were the most common species (Berry and Turner 1986).

The burrows of bead-started juvenile tortoises in pens also were under the canopies of shrubs (Wilson et al. 1999a).

Tortoises use more than one burrow or cave per season or year (Woodbury and Hardy 1948; Burge 1978; Bulova 1994;Rarless et al. 2009).The patiems of she) ter type and tunnel lengtb varied byseason (Woodbury andHardy 1948; Rautenstrauch et al. 2002), with tortoises tending to use sballowersitesinspring anddeeperand longertunnels infall and winter.Tortoises exhibited fidelity to specific burrows, repeatedly returning to burrows used from seasonto season (Burge 1978). If the burrow was damaged or collapsed, the tortoise would either rehabilitate it or construct another burrow' adjacent to the collapsed burrow. Freilich ct al. (2000) n;ported fidelity to the vit-'inity of a site, rather than to a specific burrow (i.e., 75% of all captures were within 300 mof a previous location). Woodbury and Hardy (1948) noted that torrojses tend to stay in familiar areas.

Tortoise dens, caves, and burrows are potentially importantas bornesitesandtemporary refugesfromextremes of temperature or predation for many species of vertebrates and invertebrates. Woodbury and Hardy (1948) physically entered dens occasionally a.nd thus were able to learn mqre about commensals and predators tlian the incidental observations reported more recently by others. We do not knowtheexteutofusebycommensalsortransients.However, the following compiled list, while not comprehensive and excluding invertebi:ates, suggests that burrows, dens, and caves occupied by tortoises are critically important to desert ecosystems. They are sbared by many other vertebrates, including mammals, birds, and reptiles.

Lizards observed in burrows or dens include the Gila Monster, *Helodemui suspectum* (Gienger and Tracy 2008), Desert Spiny Lizard *(Sceloporus magister),* Long-nosed Leopard Lizard *(Gamhelia wislizenii),* and Desert Banded Gecko *(Coleonyxvariegatus}*(Woodburyand Hardy 1948; Walde and Cunylmv 2015; Walde et a}. 2015; Agha et al. 2017). Snakes observed in burrows or dens include the Spotted Night Snake *(Hypsiglena torquata),* Coachwhip *(Masticophis flagellum),* and five species of Rattlesnake: Sidewinder *(Crotalus cerastes),* Great Basin{C. *oreganus littosus),* RedDiamond *(C.* ruber),Speckled (C. *mitchellii),* and Mojave (C. *scutulatus)* (Woodbury and Hardy 1948: Burge 1978;Lovicb2011;Waldeetal.2014;Agbaetal.2017; Berry et al.,pers. obs.). Birds observed in dens m burrows include the Burrowing Owl *(Athene cunicularia),* Cactus Wren *(Campylvrhynchus brimneicapillµs),* Roadrunner *(Geococcyx californianus),* and Horned Lark *(E1·emophila alpestris)* (Woodbury and Hardy1948; Burge, 1978;Walde et al. 2009;Agha et al. 2017). Mammals observed were rhe Desert*Woodrat(Neotomalepida),Merriam's*KangarooRat *(Dipodomys merriami),* White-fooled Mouse *(Peromyscus* spp.), Antelope Ground Squirrel *(Ammospermophilus leucurus),* Desert Cottontail *(Sylvilagus audubonii),* and Black-tailed *Jackrabbit(Lepu,l',cal{fi)rnicus)* (Woodbury and Hardy1948;Burge 1978;Agbaetal.2017),asweU as Desert Kit Fox *(Vulpes macrotis;* Berry, pers. obs.) and American. Badger *(Taxidea taxus)* (Germano and l?erry 2012).

In a camera study of tortoise burrows in the western Colorado Desert, Agha et al. (2017) substantially added to the list of vertebrates observed in or near tbe entrances of tortoiseburrowswithseveral additional speciesofmammal.s, birds,andreptiles.Excludinglarge vertebrates(e.g.,Bighorn Sl1eep,Black Bears),additional mammals seen were Desert Kangaroo Rat *(Dipodomys deserii),* Deseit Pocket Mouse *(Chaemdipus penicillatus),*and California Ground Squirrel *(Otospermophilus beecheyi).* Additional birds seen were Rock Wren *(Salpinctes obsoletus),* California Towhee *(Me/ozone crissalis),* Black-throated Sparrow *(Amphispiza bilineQta)*.LoggerheadShrike(*Laniusludovicianus),*Omkar Partridge *(Alectoris chukar),*Bewick's Wren *(Thryomanes bewickif),* CaliforniaQuail*(Calltpepla californica),*Wbite-crowned Sparrow *(Zonotrichia leucophrys),* California Thrasher *(Toxostoma redivivum),* Common Raven*(Corvus corax),*andVerdin *(Auriparusfiaviceps)*.Additional reptiles seen were Great Basin Wbiptail *(Aspidoscelis tigris tigris),* WestemSide-bJotcbedLizard (*Utastansburiana)*,Sagebrush Lizard *(Sceloporus graciosus),* and Long-nosed Snake *(Rhinocheilus lecontei).*

Seasonaland Daily Activities. - Ambient temperatures aboveandbelowground are animportantfactorindetennining activity, butnot the only factor.Tortoises primarily regulate bodytemperature bybehavior,avoidin.gexcessheatandcold by retreating to burrows, pallets, and dens. Early studies indicated tbat body temperatures of active tortoises were between 19:0 and 37.8°C. and that tortoises retreated to sbadeat17-38°C; thecritical thermal maximum of internal body teruperatures was between 39.5 and 43.0°C, and the lethal maximum was 43.0°C (J3ranstrnm 1961, 1965). At the lower limit of the lethal range (39.5°C), a tortoise will produce copious amounts of saliva, wh.ich spread along the neck and ax.illary area in an effortat cooling (McGinnis and Voigt 1971).

Temperatures insideburrowsand densarecooler than.on the mound or outside.Year-round tem.peratures 5-3m inside deep dens on the Beaver Dam Slope of Ulah (northeastern MojaveDesert) were between 10.0to15.6°C(Woodbury and 1:Iardy 1948). In a study in the central Mojave Desert,Mack et al. (2015) compared ann.ual. temperatures under shrubs. and at the entrance to and inside caves and burrows dug in soils. Average maximum summer and winter temperatures ca. I.Sm inside24caveswete33.7°C(rangc=29.2-38.3°C) and 13.5"C, respectively. They did not pJace temperature pcobes as deeply as Woodbury and Hardy (1948) did to avoid disturbing the tortoises.Tunnellength badthegreatest influence on temperalll{es: they were warmer in winter and coolerfo summer compared to outside the burrow or cave

(Mack el al. 2015). Cover sites in consolidated gravels and soilswerewannerthancavesin summer,but notsignificantly cooler in winter.

The microhabitats of burrows and dens and length of tunnels affected humidityand thuswaterloss(Bulova2002). Longer burrows withsmallerentries teuded to be cooler and more llumid. Wilson et al. (2001) showed experimenlalJ-y that hibernating juveniles lost body mass 1120th as quickly asactive juveniles. Juveniles in sbm;ter burrows in the field lost body mass faster than those in tholonger tunnels.

iime spent underground or in above-ground activities differedbyyear.individual,sex,size,.andrcgion(e.g.,Berry and Turner 1986;Zimmerman et al. 1994; Rautenstrauch et al.1998;Nusseatetal.2007;Aghaetal.20!Sa).Allseasonal and dailyactivitieswereinfluenced bytempetaturc tolerances of tortoises,temperatureexlTemesin the environment,timing and amounts of precipitation, availability of free water to drink, and available forage (Woodbury and Hardy 194$; Brattstrom 1961; Nagy and Medica 1986; Zimmerman et al. 1994; Henen et al. 1998; Rautenstrauch et al. 1998).

The general pattern for seasonal activity involved emergence from hibernation or brumation in late winter or early spring, followed by above-ground foraging (when foragewasavailable) andinteracting with othertortoises,and by retreat to burrows, pallets,dens, and rock shelters in late spring, with occasional emergence during summer in June and July early in the day or late in the evening. Starting in August and September, tortoises emerged for short periods and traveled; Chey were active inrertnittently until mid- to lateOctoberor November, whenthey retreated underground for hibernation (Woodbury and Hardy 1948; Rautenstrauch et al. 2002). How ver, tortoises sometimes emerged from underground retreats to drink ftee water and change shelter sitesat any timeof year;they\vereespeciallylikely to emerge with rainfall events during or aftet droughts (Me<lica et al. 1980: Henen et al. 1998). Males tended to be more active than females (Agha et al. 2015a).

Surfaceand air temperatures affected dailyandseasonal emergence from and retreat to burrows for adult tortoises (Woodbury and Hardy 194S; McGinnis and Voigt 1971; Zimmerman et al. 1994). ln late winter and early spring, tortoises sometimes emerged mid-morning and were active until late afternoon. However, from spring until October or November, above-ground activity became bimodal, with tortoises emergh1g earlier in the morningfrom burrows and retreating earlier to burrows, emerging again in afternoon or eYening. In summer, some tortoises emerged in late afternoon or evening and remained above gro1.U1d all night when burrow temperatures were warmer than the outs_ide surface temperatures. However, not all tortoises emerge once or twice daily during the active seasons.

Small wild juvenile tortoises of <60 mm CL were observed to be active at significantly lower temperatures in March, April, May,Md June thanlargerjuveniles and small immatl!l"e tortoises regardlessof the monthof observation in spring,e.g.,17.2°C(range 10.1-25.6°) in March (Berry and Turner 1986).Some head-startedjuveJtilesin penswerealso active in winter (Wilson eta!. 1999b). The small size and ability lo be active at cold temperatures may have allowed small tortoises to be active on more days per season and year than observed for adults.

Rainfall, available water for drinking, and available, high quality forage Strongly jnfluenced seasonal and dail,y activities. In years when precipitation was above the long-Lenn normal for the season and forage was plentiful or otherwise available, tortoises were more active above ground than during droughts (Henen et al. *1998;* Duda ct al. 1999; freilich et al. 2000; Krzysik 2002; Jennings and Ben:y 2015). During drought years, home range size, numbers of burrows used, and distances !rave.led per day decreased substantially.

Physiology, Water.Balance,and Energy Flow.-Thermoregulation, water balance and osmoregulation, metabolism, and responses to drought (deprivation of water and food) are critical to survival of tortoises in harsh environments. Henen ct al. (1998) summarized several years of srudy concerning the effects ot climate, specifically variation io rainfall andfoodavailability,onmetaboJic ratesand water flux rates in adult tortoises in we.stern, eastern, and northeastern regions of the Mojave Desert.Availability of water (and forage) varied substantially from year to year and thus affected metabolic rares. Water flux-rates and availability of free waterfor drinking also varied highly.In years of high rainfall,metabolic rates and water flux-.rares were higher than in dry years. Metabolic rates in males were higher than in females, possibly because of larger home ranges and courting females. In contrast, the annual field metabolic rate of females correlated positively with the number of eggs laid in spring. During droughts when forage and water were unavailable, metabolic rates and water influx rates were low. While some variations we.re due to season, rainfall was the critical factor in rates of metabolism aod ratesof watet inflnx. Differences in region were due to differences in rainfall and with more summer rainfall occurring at the eastern and northeastern sites in the Mojave Desert. Overall, the results indicated that tortoiseshave botllphysiological and behavi.oral flexibi Iities critical to surviving droughts and periods of rainfall and food abundance.

Another important adaptation to drought and variability in rainfall involves drinking free water during rain, voiding their bladders, and rapidly increasing th_eir mass (Peterson 1996).\Vheo droughts occl!l",tortoisescru1Jose up to 40% of initial body mass.They can resorb waterfrom their bladders and store wastes (sodium, chloride, and urea) both in blood plasma and the b!add'er.

Figure 9. Juvenile *Gopherus agassizii* eating Liohe.n in the Red Cliffs Desert Reserve, Utah. Photo by Cameron Rognan.

Figure 10. Adult *Gopherus agassi,zii* eating blue dicks*(Diche/o, stemma apitatum)* in the Western Mojave Recovery Unit. Photo courtesy of Dese.rt Tortoise Preserve Committee.

Tortoises may also void their bladders when handled or when approached by a human. Agha el al. (20L5b), in a study of 42 tortoises captured 1008 times in the western Sonoran Desert, found that tortoises voided on 8.2% of occasions. Factors contributing lo higher probabilities of voiding were increased .handling timeregardless of size or sex and increased precipitation for j.oveniles and females. Modelsindicated a negligibleeffectof voiding behavior and sex on survivorship.

Christopher et al. (1999) reported seasonal differences in hematologic aod plasma biochemical responses of adult tortoises in a live.year study in three Mojave Desert regions (westem, eastern,northeastern).The authorsreported year!y and seasonal variation in most variables associated with hibernation, the reproductive cycle, and seasonal rainfall. The effects of water and food intake were reflected in body weight and biochemical changes in blood plasma(decreased bloodureanitrogen[BUN]andincreased uricacid),nutrient intake (increased concentrations of glucose, total protein, albumin, phosphorus, cholesterol, iron, and potassium concentrations),and increased metabolicactivity (increased alkaline phosphatase, aspartate aminotransferase, alanine aminotransferaseactivities).The most sensitive indicator of food and water intake or lack was BUN.Seasonal changes, particularly during the dry summer or fall. were typical of decreased hydration:increased BUN,osmolality,electrolytes, and anion gap, and decreased body weight and total CO2' Males andfemales differedin packed cell volume,aspartate transaminase activity, and concentrations of hemoglobin, cholesterol, triglycerides,calcium, and phosphorus.

Wild tortoises that weremoribund fromdehydration and starvation during or following droughts exhibited clinical signs, such as weight loss and abnormal behaviors (Berry et al. 2002). These tortoises also exceeded the range or 95thpercentiles forfouror more hematological and plasma biochemical analytes for healthy tortoises (Christopher et al. 1999).Hematologic abnormalities were low packed cell volumes and heterophil counts, and plasma biochemical analytes were hypocalcemia, hyperbilirubinemia, marked azotemia, and elevated sodium and chloride (Berry et al. 2002). Gross necropsies revealed differences in juveniles vs. the larger tortoises. Shells of juveniles were softer and morepliable,musclemasswasbclownonnal,andosteopenia of some bones was evident. Handling and certain research activities alsohad detrimental effects, such as crowding of juveniles *in* headstart pens.

Foraging Behavior and Diet. - Early field Studies revealed that tortoises were herbivorous,foraged in spring and fall when food was plentiful, and consumed dry grass in summer (Woodbury and Hardy 1948). Grasses were the Qative bush muhly *(Muhlenbergiaporteri)*andthenon•native red brome and cheat grass*(Bromus madritensis* ssp.*rubens* and *B. tectorum);* the non.native redstem tilarce *(Erodium cicutarium)* wasobserved to beeaLenin winter.Duringspring, tortoise ate wildflowers until domesticsheep herds reduced availability. Field biologists have not observed tortoises to eat shrubs (Woodbury and Hardy 1948; Nagy and Medica 1986).

The need to know what tortoises were eating in greater detail came with concerns about conflicts between livestock grazing and tortoises and federal listing of the tortoise population on the Beaver Dam Slope (Berry 1978; USFWS 1980).Thisconflictoverfoodavailability in spring was first described by Woodbury and Hardy (1948) and was later observed and studied elsewherein theMojave Desert(Berry 1978; Avery and Neibergs 1997; Oftedal 2002; Oftedal et al. 2002; Jennings and Berry *2015).*

Tortoises are selective in choice of food items, when conditions allow for it. In Rock Valley, Nevada, tortoises kept in large pens ate only *four* of >25 species of forbs and grasses available (Nagy and Medica 1986). Burge and Bradley (I 976)observedforaging behaviorof wild tortoises in late winter and spring and reported on species and plant parts eaten. Subsequent research involved counting every bite taken as well as plant *parts* and species available (e.g., Avery and Neibergs 1997;Henen 2002a;Oftedal etal.2002; Jennings and Berry 2015). Results indicated that tortoises selectspeciesand plantparts.and thatfavored speciesdiffered by season, region, and availability. In late winter and spri.ng of a bighly ,productive year, tortoises prefer natives to non-natives, forbs to grasses, and succulent green plauls to dry plants. Choices of plant species tracked the phenology of species available during spring (Jennings and Berry 2015). In drought years when species and biomass of plants were limited, some tortoises consumed cacti (Turner et al. 1984).

The list of plant groups eaten included winter and summer annuals, a iew herbaceous perennials, succulents (cacti), and flowers and leaves of a few perennial shrubs. Tortoises favored species of forbs or he.rbaccous perennials from several plan! families: Asteraceae, .Boraginaceae, Cactaceae, Fabaceae, Malva.ceae, r-!yctaginaceae, Onagraceae, and Plantaginaceae (Burge and Bradley l976; Avery and Neibergs 1997; Jennings aod Berry 2015).

Oftedal (2002) and Oftedal et al. (2002) addressed why tortoises were selective in choices of plants and developed the concept of potassium excretion potential (PEP). Many plant species are high in potassium which requires loss of water and nitrogen to excrete; potassium is potentially toxic. The authors predicted that tortoises would choose plants bigh in water and protein but low in pot.assium. ln a study of plants consumed or by-passed by juveniles in head-start pens during a year of high rainfall and thus abundant forbs, juveniles selected plants and plant parts high in water and nitrogen and low in potassium (Offedal et al. 2002). The juveniles bypassed the abundant non-native Mediterranean grasses, *Schismus* spp.

Non-native forbs (e.g., redstem filaree) and grasses (Medirerranean grasses. red brome, and cheatgrass) invaded and became established throughout the Mojave Desert and fonn >60% of the biomass in years with above normal precipitation and >90% in drought years in tortoise critical habitat units in the western, central and southern regions of toe Mojave Desert (Brooks and Berry 2006). Other non-native species, such as Sahara or African mustard *(Brassica tourneforti1),* invaded and proliferated rapidly in the western Sonoran Desert and appear to be displacing native annual forbs (Beny et al. 2014b).

The nutrient value of native vs. non-native forbs and grasses was the subject of several experiments with tortoises in a range of sizes (Nagy et al. 1998; Hazard et al. 2009, 2010). In the experiments. the forb species were the native *Malacothrix glabrata* and non-native redstem filaree, and the grasses were the native aod perennial sand doe grass *(Sttpa [Oryzvpsis] hymenoides)* and non-native annual Mediterranean grasses *(Schismus barbatus).* The forbs were higher in dry matter and energy digestibilities than the grasses. The grasses provided little nitrogen and tortoises lost more water than th.ey gained in processing-them. Hazard et al. (2009) reported that juveniles gained weight rapidly when eating forbs but lost weight and body nitrogen when eating grasses. Dietary nitrogen might have limited growth of juvcniles. Tortoises gained more minerals from forbs than from grasses (Hazard et al. 2010). When eating grasses, the tortoises lost phosphorus and only gained the nutrients calcium and magnesium at low rates.

In several experiments, individual tortoises did not thrive or became ill when fed grasses (Ha7..ard et al. 2009, 20I0). Two animals offered the non-native Mediterranean grasses became ill and died early in the study and two others refused to eat. Drake et al. (2016) tested effects of five diets-native forbs, native six *weeks* grass *(Festuca octofiora)*, invasive red bromegrass, and native forbs combined with either native or invasi;ve grass-on growtb, body condition, immunological responses, and survival on lOO captive neonate and juvenile tortoises. Tortoises fed natlve forbs bad better body condition, growth. immune functions, and higher survival (>95%) than those fed the grass diets. About one.tbird of tortoises fed only grass diets died or were removed for poor condition. Tortoises fed the mixed forb and grass diet survived and were in good condition. ln addition, tortoises consuming red brome were observed with persisting injuries to their jaws from seeds, and seeds were also embe.dded in a nostril and comer of an eye (Medica and Eckert 2007). Drake et al. (2016) made similar observations and noted inflammation. Collectively, rhese studies point out the importance of selected native forbs to the health and overal condition of tortoises. Tortoises so consume non-plant material: dirt and sand at apparent salt licks, rocks, bone, dead lizards, and caterpillars (Marlow and Tollestrup 1982; Avery and Neibergs 1997; Walde et al. 2007a; Jennings and Berry 2015).

Home Range, Site Fidelity, and Movements. - Sizes of home.ranges for wild, free.ranging tortoises varied by type and length of study, sample sizes, sex, numbers of captures, location, and analytical lcchniques (e.g., Woodbury and Hardy 1948; O'Connor et al. 1994; Duda et al. 1999; Freilich eta!. 2000_; McLuckie and Fridell 2002; Harless et al. 2009, 20 lO; Franks et al. 2011). Most reports were for wild. free-living adult tortoises, involved small samples, and were confined to a few years. Woodbury and Hardy (1948) reported that home ranges were small, covering ca. 4 to 40 ha.

In studies where sizes of hpme range for both male and female adult tortoises were derived from radio-transmittered individuals, males had larger home ranges than females (Burge 1977a; O'Co.nnor et al. I994; Duda ct al. 1999; Freilich eta]. 2000; Harless et al. 2009). For example. Harless et al. (2009), in11 study of home range and movements in the central Mojave Desert, described home range sizes of 43-49 ha for males and 16-17 ha for females using minimum convex pol_ygons. Home ranges of juveniles were smaller than those of adults (Eric Coombs, unpubl. data).

Home range sizes potentially "increased in wet vs. dry years (Burge 1977a; Duda et al. 1999; Franks et al. 2011). Similarly, movements were more limited during drought years than in years with higher precipitation and forage production, e.g., years with El Nino Southern Oscillation (Duda el al. 1999; Freilicb et al. 2000; Ennen ct al. 2012). O'Connor et al. (1994) noted that home ranges were not exclusivefor individuals, in contrast to a study by Harlesset aJ.(2009),whoreported thathomerangesof malesoverlapped but those of females did no!.Tortoises ex.bibited fidelity to home ranges and activity areas; even after a fire when parts of borne ranges were burned, tortoises continued to use the same areas (Drake et al. 2015; Lovich et al. 2018a)..

Female Reproductive Cycle. - Female and male reproductivecyclesare notsynchrowzed (Rostal et al. J994; lance and Rosta.1 2002). ln April, after emergence from hibernation, plasma estradiol, testosterone. corticosterone, and lipids in feroales were elevated but declined to low levelsaftereggswerelaid. Whennesting occurred in spring, progesterone levels increased, but rapidly decreased to baseline after eggs were.laid. In summer, plasma levels of estradiol, lipids, and calcium(indicating virellogenin levels) increased and wereassociated with vitellogenesis and growth of ovarian follicles.Ovarianfollicles increased to ovulatory sizebefore hibernation.Testosterone levels were high(mean 6.22ng/mL) duringspring courtship (AI?.ril), decl.ini.ogto a mean of 0.37 ng/mLatthe endof the nesting period (July), but again rose between July and October dU1,1J1g tbe late summer and fall courtship and mating period.

Size and age at first reproduction vary across the geograpb.ic Jange. However, long-term studies have not been conducted for wild, free-ranging female tortoises for all regions. Woodbury and Hardy (1948) estimated age al first reproduction as15-20 yearsin thenortheastern Mojave Desert,wnoreasTurncrotal.(1987)estimated 12 to 20years forfemalesinlheeastemMojaveDesert,drawingonamulti-year study to developa life table for the species. Curtin et a.I.(2009),in a study based onskeletochronology,estimated thatfema.lesfromthe western MojaveDesert reached sexual maturity at 17-19 years. Medica et al. (2012), in a 47-year study of tortoises .in 9-ha pens in the northeastern Mojave Desert, estimated sexual maturity to occur between 16 and 21 years (average 18.8 years) and at a minimum size of about 190 mm CL.Turner et aL (1987) treated size at first reproduction as 185 mm CL; they reported a female with eggs at 178 mm CL but four other small females (182-186 mm CL) did not produce eggs.In thcfar northempartof the range in Nevada, the smallest tortoise to produce eggs was 209mmCL; 11sm.allertortofses estimated to be 15-26years old did not produce eggs (MueUet et al. 1998). Generation timefor*G.agassizii* has been estimated to be approximately 20-25 years (Turner el ai. 1987; USFWS 1994), but th.is appears to need Tevision upwards based on the late age of maturity and high survivorship and longevity of adults.

Females place nests within the den or burrow, on the burrow mound, in a pallet, and under shmbs (Woodbury and Hardy 1948; Roberson et al. 1985: Turner et al. 1986; Baxter et a.I. 2008; Ennen et al. 2012; Lovich ct a.I. 2014a; Sieg et al. 2015). Females dig nests within their normal activity areas but show no evidence of fideLity within or between seasons regarding locations (Lovich et al. 2014a). Oviposition occurs from April through July, depending on region, for first, second, and third clutches (Turner et al. 1986,1987; Wallis etal.1999; Mcluckie and Fridell 2002; Ennen et al.2012; Lovich et al.2018a). Nesting may occur earlierin the western Sonoran Desert - Lovich eta.I.(2018a) noted nestingApril 6 at a study site inJoshua Tree National Park, two weeks earlier thanpublished previously. Lovich et al. (20J 2) also described how the timing and appearance of shelled eggs on X-rays appeared to be affected by inter-annual variations in climate, e.g., appearru1cc of clutches was later in cool years.

Somefemales showed nest-guarding behaviors to Gila Monsters and humans (Hemm 1999; Gienger and Tracy 2008; Agha et a.I. 2013).Beck(]990) studied GilaMonsters in southwestern Utah; 29% of their scats and observations wereof predationontortoise nests.GiengerandTracy (2008) reported two differentobservationsof Gila Monstersentering shelters with a female tortoise and egg shell fragmentslater observed at the nest.Inone case, thefemale tortoise bit and chased the lizard. Henen (1999) reported that a 182 mm CL female ramme,d his leg and field equipment with her epiplastron a few days after laying her first clutch of eggs. In,anothercase report,Aghaet al.(2013) described a female tortoisetwiceresisting aresearcher's attem.ptsto removeher from her burrow, which contained a nest.

Few reports are available for incubation of eggs in wild, unconfined, or unprotected settings. Eggs of one *wild*female hatched after98-101days in southern Nevada (Burge 1977b) and of 12 wild females after 67-104 days with a mean incubation time of 89.7days (±3.25 days SE) insouthwestern Utah(McLucltie andFridell 2002).Ennen et al.(2012) reported hatching from 74 to I00 days (mean, 84.6days)at asitein the western Sonoran Desert.Incubation time was s.ignlficantly longer in the first than in second clutches. Nostpredationoccurred common)y (Roberson.et al.1985;Turn.eretal.1986;Enneueta.l.2012).Nestsplaced in c.,-ages to prevent predation may have hatched between 84 and 97 days in the eastern Mojave Desert (Roberson et al. 1985).

Dimensions and weights of eggs may vary by year,site, andwhether measured directlyorfi:om radiographs.Mcasur mentsfromradiographsmayunderestimatceggsiz.ess.lightly (Wallis et a.I. 1999). Burge (1977b) reported dimensions of four eggs from tortoises at Arden, Nevada (43.0 x 33.0, 45.0 x 36.0, 46.0 x 33.0,47.0 x 34.0 mm). Using X-mys to measme eggs, Wallis et al. (1999) described egg sizes for first and second clutchesand for twodifferent years at Goffs (n =137) in the eastern Mojave Desert and at the Desert Tortoise Research Natural Area (n = 330) in the western

Mojave Desert. Eggsfrom Goffs were generally about 40.9 mm in length and 34 mm in width, whereas those from the Desert Tortoise Research Natural Area females were about 45 mm in length and 37 mm in widtb.McLuckie and Fridell (2002) reported sizes of 81 eggs as having a mean length of 44.3 ± 0.33 mm SE (range 34 52) and mean width of 37.2 ± 0.26 mm SE (range 33-43)for tortoises from the Beaver Dam Slope, Utah_. Ennen et al. (2012) reported mean width of eggs as 38.6 mm at a study areain the western Colorado Desert,and Lovich et al. (2018b)reported averagex-ray egg widths of *36.5* ± 1.56 mmfrom a study area in.JoshuaTree National Park, also in the Colorado Desert.

Site and body size of females can affect egg shape. In a comparative study of females from the western Mojave Desert in the Desert Tortoise Research Natural Area with females*from* theeastern Mojave Desert, theeasternfemales produced eggs that were significantly narrower and shorter thanfemales from the western site, even after accounting for body sizes (Wallis et al. 1999).

The numbers of eggslaid per dutch range from I to 10, with femaleslaying from Oto 3 clutches peryear (fumer et al. 1986; Mueller et al. 1998; McLuckie and Fridell 2002; LoviCh et al. 2015). Stuclies undertaken at different sites and yearsdescribed mean clutch sizes ranging from 3.2.S to 5.9 l eggs and clutchfrequenpiesfrom133 to2.36clutches/ female/year (Turneret al. 1986;Muelleret al. 1998;Walliset al.1999;McluckieandFridell 2002;Bjurlinand Bissonette 2004;Baxter et al.2008; Lovichetal.2015,20 I8b).At some sites,researchers reported thatlargerfemalesproduced larger clutches (Turner et al. 1986; Wallis et al. l999; McLuckie and Fridell 2002) and females producing a single clutch laid larger eggs (I'umer et al. 1986; Mueller el al. I998). Clutchfrequencies werecorrelated positively withcatapace length (McLuckie and Fridell 2002), and annual fecundity was positively correlated with female size (Mueller et al. 1998; Wallisetal. J999;McLuckieand Fridell 2002).Wallis et aJ. (1999) observed females at a western Mojave Desert site that produced fewer but larger eggs than females at an eastern Mojavesite,andSiegeral.(2015)reported tharlarger females produced larger eggs, but carapace length did not affect clutch size.

Timing and amounls of rainfall and the subsequent prnduction of forbs and grasses consumed by tortoises likely affect one or more aspects of egg prodt1ction and tbe effects may differ regionally. For example, precipitation occurred primarily in late falJ and winter lil the western Mojave Desert compared with precipitation occurring both in fall-winter and summer in the eastern Mojave (Tomer er al.1986).Environmenlal conditions in the previousyearmay affect egg production in a subsequent year, becauseovarian follicles mature between July and October and the number maturing is dependent on available food and water (Heoen 1997; Muelletet al. L998). Hcnen (1997) also reported that the commitment of energy to eggs does not occur until the spring in which they are laid.

At a western Mojave location,females produced larger eggs, possibly increasing the chance of survival because of lack of summer rain (Wallis et al. 1999). ln contrast,in the eastern Mojave Desert,cggs weresmaller, possibly allowing the juveniles lo take advantage of the summer rains and associated foodsources. Also,in the eastern Mojave Desert, clutchfrequencieswere positivelycorrelated with production of annual forbs and grasses(Turner eta!.1986), and Henen (1997) described how the paucity of spring annual plants contributed to lower egg production.

Inthe ColoradoDesert,Lovkh et al.(20l5) reported that amounts of winter precipitation had no significant effecton clutch frequency or the percentageof reproducing femal.es. Sieget *al.*(2015) reported elevation to bea factor ina study of two sites in the northeastern Mojave Desert; females had larger egg volumes in first clutches at the higher elevation site than females at the lower elevation site.At the higher elevation site,precipitationwas bigberaudvaluesfor species richnessof shrubs,total cover.of plants.and herbaceousplant biomass were *all* higher than at lower elevations.

Females ap(>eared to use a breeding strategy intermediate between capital and income brecdjng wi"th bethedging (Henen 2002a, 2002b, 2004; Lovich ,et al. 2015). Desert Tortoises have shown the ability to re.lax or temporarily relinquish regulation of homeostasis regarding water, electrolytes,nitrogen, and energy.In field studies,females demonstrated extreme physiological tolerance and flcxibilicy in their water and energy budgets {Henen 2002a). Tb.ey reduced metabolic rates and produced eggs, even during periods of extreme droughts and lack of foiage (Hencn 2002b). Females exhibited characteristicsof both capital and income breeders: they limited egg production duri.ng droughts and when body reserves werelimited, acquired waterand protein reserves prior to winter and used reserves to produce eggs, had foJl-sized follicles prior to hibernation, and ovulated prior to eating in spring (Henen 2002b). They also responded rapidly by producing more eggswhen foragebecame available after hibernation.This mixed strategy constituted bet-hedging for reproducing lo the extremes typical of desert environments. Lovich el al. (2015) provided an additional example with a study population in the western Sonoran Desert.

Turner et al. (1987), drawing on a multi-year study in the eastern Mojave Desert of egg production and nest successes, estimated that 93.9% of eggs werefertile,93.4% wereunbroken,and 62.9% were not destroyed by predators. Bjurlin and Bissonette (2004) described tracking success of 17 and 25 nests laid in 1998 and 1999, respectively, at a site in Lhe southern Mojave Desert. Predation rates were high in I998 (47% of nests), but less so in 1999 (12% of nests). The auihors theu protected nests with cages70 days after incubation. Of the remaining 132 caged eggs, 81.6% and 83.0% hatched iu 1998 and 1999, respectively. When ill and deformed neonates were excluded, the figures for normal neonates were 73.7% and 67.0% in l998 and 1999, respectively. Ennen et al. (2012) described mean hatchling success (predation included) as 70.6% for the first clutch and 65.7% for the second clutch. Some eg.gs did i1ot hatch, were infertileor nonv.iable, and a few hatchlings wereill or deformed in several studies (e.g.,Turner ef al.1986; Bjurlin andBissonette 2004;.Ennen et al. 2012).

The sex of neonates was determined by temperatures during incubation in the nest (Rostal et al. 2002). In experiments, males were produced whenincubation occurred at constant temperatures of ::;;30.5°C, whereas females were produced at temperatures of 32.5°C. The pivotal temperature where sexes were in a .l:1 ratio was 31.3°C. Hatching success was high (90---100%) when temperatures ranged from 28 to 34°C and resulted in similar incubation times rangingfrom 68 to89 days. When temperatures were lower or higher, survival was lower. Ba>.--ter et al. (2008),in a study offemales ina head-starting enclosure in the central Mojave Desert, reported that early nests (Z2 May-2 June) were cooler and produced four all-male nests andtwo nests of mixed sexes. In contrast, six laccrnests (17June-16 July) were significantly warmer and produced onlyfemales.

Adult fem.a.le tortoises store sperm, potentially in the sperm-storage tubules within the albumen-secreting gland region of theoviduct(Palmeretal.L998). fnanexperimental study, batching success was 97.1% in females with spenn stored>2years.Fiveof12clutchesshowedtentativeevidence of multiple paternities. Davy et aL (2011) confirmed both polyandry andmultiplepaternitiesin clutches from-females: of 8clutcbesfrom 26femalesivithanaverageofsix neonates perc1utch,a minimum of 64% of females were polyandrous and a minimum of 57% of clutches had multiple sires.

Male Reproductive Cycle. - Testosterone primarily coa.trols changes in the male cycle (Rosta.l et al. 1994; Lance and Rostal 2002).Testosterone levels werelo\v when males emerged from hibernation and continued to decline until May, but then rose from late May to August .md September, reaching a peakat ameanof 243.60ng/mL,and then declined prior to hibernation. The low in testosterone !eve.ls (mean 18.37 ng/mL) occurred when females were nesting in May. Changes in the testesfollowed this cycle: when mal.es emerged from hibernation, the serrriniferous tubules were filled with debris from the previous cycle and by May the gonads were completely regressed. As summer progressed, mature spermatozoa appeared, and prior to hibernation in earlyfall,spermatogenesis was at a maximal level.Corticosteronelevelswerehigh when testosteronewas hi.gh but higher than i11Jemales at a:ily time of year. Body mass tracked thesechangesand wassignincantly higherirom June to September than at other times dwing theyear. The fall mating period may be more important than courtship activlty in spring and may beassociated with sperm storage in females (Palmer et al. 1998).

Table2. Demographic data from early surveys of populations of *Gopherus agassizii,* primarily from 60-day spring studies on 2.59 ktn^2 plots in California, Nevada, Utah, and Arizona.Adults are defined as ;;,:180 nun carapace Le.agth. For most plots., data were summarized in Berry (1984),a compilation of plotdata from 1948 through]981.The population at Beaver Dam Slope population, Utah, Was.studied by Woodbury and Hardy (I948) a.nd 1-Jardy (1976), the pqpulation in the Pinto Basin, Callfomia, by Bairow (1979), and the population at Arden, Nevada, by Burge and Bradley (1976). Significance level: *= *p<0.05.*

Study area	Plot size (km^2)	Year(s)	Study type	Total count	Counts ofadults	Counts of adults (per km^1)	SCJ\ .ratio F:M	% adults: non-adults
Argus,CA	13.70	1971-1972	Year-long	47	35	2.6	25:10*	76:24
Fremont Valley, CA	2.59	1979	Spring, 60d	209	108	41.7	59:49	52:4S
Desert Tortoise Research Natural Area (interior), CA	2.85	1981	Spring,60d	186	134	47.0	67:67	72:28
Desert Tortoise Research Natural Area (interp.center).CA	].80	1979	Spring, 180d	574	382	49.0	215:167*	67:33
Fremont Peak, CA	259	J980	Spring, 60d	43	27	10.4	11:16	63:37
Kramer, CA	2.59	1980	Spring,60d	146	84	32.4	42:42	58:42
Calico,CA	2,59	1978	Spring, 30d	18	13	5.0	8:5	72:28
Stoddard Valley,CA	'2.59	1981	Spring,60d	97	70	270	34:36	72:28
Lucerne Va.lley, CA	259	1980	srring, 60d	115	77	29.7	36:41	67:33
Johnson Valley, CA	2.59	1980	Spring,60d	65	40	15.4	20:20	62:38
Shadow Valley, CA	3.89	1978	Spring-,70d	27	23	5.9	9:14	85:15
Ivaopah Va!Jey, CA	2.59	1979	Spring, 60d	155	87	30.1	41:46	56:44
Gaffs. Fenner Va·)Icy, CA	2,.59	1979	Sp.ring,60d	296	186	62.8	74:112*	63:37
UpperWard Valley.CA	2.59	1980	Spring, 60d	14-0	81	313	31:50*	58:42,
Pinto Basin, CA	259	1978	Spring & fall, 19+4d	41	29	11.2	12:17	7l:29
Chemehuevi Valley, CA	4.66	1979	Spring, 60d	L49	LOO	21.5	43:57	67:33
ChuckwaJJ1;1 Bench, CA	2.59	l979	Spring,60d	265	166	64.1	81:85	63:37
Cbuckwalla Valley Il, CA	259	[980	Spring, 60d	91	50	J9.3	27:23	55:45
Arden, NV	3.03	1974-197,5	Multi-season	127	90	29.7	57:53	71:29
La1,t Chance, NV	3.89	1980	Spring. 30d	10	9	2.31	n/d	90;10
Piute Valley, NV	2.59	1979	Spring-,60d	79	48	185	26:22	6):39
Sheep Mountain, NV	2.59	1979	Spring, 60d	31	22	85	10:12	71:29
Beaver Dam Slope, UT	4.86	1930-1946	Primarily fall-winter	281	n/d	23.9	151:l01 *	99:0]

Figurell.AdultmaleGopherusagassiziiwithenlargedchinglands, asecondarysexualcharacteristicduringthehightestosteroneseason (August to October). Photo by Michael Tuma.

Physical changes in male chin glands occurred *in* association with the seasonal rise and fall of testosterone (AlbertsetaL 1994).Chingland volumechanged seasonally, reaching a maximum in late summer when testosterone levels were highest. In experimental studies, socially dominant individuals tended to havelarger chin glands than subordinates. Both sexes were able to discriminate between chin_gJand secretions offarniliar and unfamiliar males.

Population Structure. - Tortoises have been evaluated for size-class structure l.n populations usingCL and grouped into seven size classes: juv.enile 1, <60 mm; juvenile 2, 60-99mm;immatUre1, I00---139mm; immature2, 140-179 mm; subadult (small adult or-young or both), 180---207 mm; adult l, 208-239 mm; and adult 2, ;i:240 mm (Berry 1984; Berry and Christopher 2001). Season, time of day, and method of searching have profoundly affected reported size-age class structure. For example, in the classic study by Woodbury and Hardy (1948), the authors focused search effortson removing tortoisesfrom densinlatefalland winter (November-February) in Utah.. They marked 281 tortoises and published metricsfor 117.Of the 117 reported animals, 85 (72.7%) wereverylargeadults(adult2class),25(21.4%) were in the adult 1 class, 6 (5.1%) were subadults, and J (0.85%) was an immature 2. Thus, about 99% were adults and most were large. In contrast, searches and surveys of plots in California for all sizes of tortoises conducted in spring, between March and early Juneusing two censuses, produced a higher proportion of populations in the juvenile andimmatureclasses,especially when the surveyorsfocused onfindingsmalltortoises(BerryandTurner1986).Examples of study results wheredifferent survey tech.niqnes were used between the1930sand early 1980swhentortoises weremore common are presented in Table 2 (e.g., Berry 1984). With fewexceptions, when twocensuseswereconducted fnspring and efforts focused on finding juveniles, more juvenile and immature tortoises (28-48%) were located.

McLuckie et al. (2002) reported finding 850 tortoises overa4-year period at the Red Clilis DesertReserve, Utah, in a distance sampling effort focused on subadults and adults. The size-age structure was 7.1 % juveni)es, J0.4% immatures, and 82.59% subadults and adults. Keith et al. (2008)described a187.7km^2 site(where tortoises were rare) and onlyfouradultswereobservedin760one-b.a,randomly located plots. Berry et al. (2008) described surveys of a 4 km^{2}sile within a western Mojave StatePark;9 tortoises (4 immature, I subadulr,and 4 adults) wereobserved.Lovich et al. (2011a) studied a population in the Western Sonoran Desert with 69 marked tortoises of which 72.5% were adults.13erry et al. (2013) evaluated a 5 .42 km^2 site in the northwestern Mojave Desert and located 28 tortoises, of wb.ich 46.5% were adults and 53.6% were immature and juvenile tortoises. Berry et al. (2014a), *in* a study using randomly placed I ha piers in three management areas in the western Mojave Desert, located 17 tortoises; adults formed 76.5% of tbe sample.

Sex Ratios. - In studies conducted between the 1930s and early 1980s, sex ratios of adults in most populations were not significantly different lban the expected I: I ratio (female:male; Table 2). Since the 1990s, sample sizes for adults in some studies were small and results varied by location. lo the central Mojave Desert, Berry et al. (2006) reported that sex ratios differed significantly from the expected I: 1 ratio at I of 7 sites; the single site b.ad a female to male ratio of 2:9. At two sites in the western Mojave Desert, few adults were observed; female to male sex ratios were l:3 and 3: l with one unidentified individual at each site (Berry et al. 2008; Keith et al. 2008). In the northwestern Mojave Desert, Berry et al.(201,3) reported a I0:3 ratio, which differed significantly from the expected 1:1 ratio. In a western Mojave research project comparing threemanagement areas,the sexratiofor the combined areas was 9:4, but did not differ significantly from t:hc expected I: l ratio (Berry et al. 2014a). Berry etaJ.(2015a) evaluated l,004adulttortoisesin anepidemiologicalstudy in thecentral Mojave Desert: the female to male sex ratio was 1:1.58. In the western Sonoran Desert, Lovich et al. (201la) reported that a sex ratio of 51 marked tortoises did not differ from the expected 1: I ratio.

Growth Rates. - Early studies on growth of wild adult tortolses revealed a range of rates. Woodbury and Hardy (1948)reported negligiblegrowth in someadultsoverperiods of *Q* years; however, one male grew from 206 to 302 mm in 4.3 years aod one female grew from 204 to 239 mm in 7 years. Hardy (1976) re-visited the Woodbury and Hardy study area and described growth over periods of 17 to 26 yearsforfour males and nyo females.Males grew <0.5 mm per yearand females grew 0.36 mm aod 0.04 rnmper year.

Medica et al. (2012) conducted a 47-year study under semi-wild conditions in 9 ha pens in the northern partof the geographic range.They tracked growth in 17 batchJ ing and juveniletortoisesto adulthood and death.Grnwth (plastron length) did not differ significantly between females (7.03 mm/year) and males (7.49 mm/year) until the tortoises reached 23 to 25 years;after thatfemalegrowth was limited and males continued to grow slowly. One small female was stunted .u1d did not grow to sexual maturity. Growth rates were positively correlated with winter precipitation and growth of ephemeral vegetation. Growth rates were higher in years of high rainfall and were minimal when winter rainfall was <26 mm. Mack et al. (2018) reported a mean annual growthof 9.6mm/year in wild juvenile and immature tortoisesat tbe DesertTortoiseResearch Natural Area over multiple years.

Morbidityand Mortality, - Vulnerability to death varies by life stage,size, sex, and location or region. Predators:and human activities are sources of injury or death. Droughts and diseases contribute directly and indirectly to deaths. We review the many causative factors below.

Drougbt, Dehydration, Starvation, and Temperature Extremes: - Tottoises of all sizes are vulJlerable to death from dehydration aud starvation during or shortly after droughts,and especially ifdroughts are prolonged (Peterson I996; Berry er al. 2002; Longshore et al. 2003; Field et al. 2007;Lovich et al. 2014b; Nagy et al. 2015a). Necropsies of starviJ1 g and dehydrated tortoises have revealed several potential *bacterialpathogens,e.g.,Bordete/labronchiseptica, Pasteurella testudinis,*and *Pse udomonas cepacia* (Berry et al. 2002). Head-started juveniles released from pens and translocated adults have provided valuable information on sou.recs of mortality: some juveniles released from head-start pens die of exposure, dehydration, and starvation, as do some translocated adults (Nussear et al. 2012; Nagy et al.2015a.b),

Disease:-Jnfectious diseasesdescribedas contributing to illnessand deathin w.ild tonoiscs were upJ?crrespiratory tract disea.ses caused by *Mycoplasma agassiz;ii.* or *M. 1es1udlneum* or both (Brown et al. 1994, 1999;Christopher et al. 2003; Jacobson el al. 1991,2014) and herpesviruses (Christopher et al. 2003; Jacobson et al. 2012). Johnson et al. (2006) reported highlevels of exposure (86%) to *M. agassizii* or herpesvirus or both in captive tortoises living in the western, central, and southern Mojave. Berry et al. (2015a) described consistently higher prevalence of test-positive tortoises cJose to human households in the central Mojave Desertfor both *M. agassizii* and *M. testudineum.* The distribution of tortoises with *M. agassizii* aod *M_ testudineum* differed within the study area. Aiello et al. (2016)designedan experiment tomodel riskof transmission of *M. agassizii.* The models predicted low probability of infection when tortoise to tortoise interactions were brief; whereas tortoises with higher loads of the bacterium were predicted to transmit disease regardless of length of interaction. they observed encounters to be short in the wild and thus predicted more variability in responses. ln anotherexperimental study with captivetortoises,Aielloet al. (2018) discovcred thattortoises were shedding bacteria regardlessof theseverity of clinicalsigns,althoughtortoises with severeclinicalsigns(nasal discharge) generally tended to shedmote bacteria. Gennano eta!.(2014) conducted an experimental study to determineeffects of *M. a.gassizii* on olfaction.; the presence of a nasal discharge reduced sme1l and thus the ability to find food.

Bacterial and fungal pneumonia werereportedin 3 of24 aecropsied wild to1toises (Homer et al. 1998).Dickinson et al. (2001) described higher levels of *Pasteurella testudinis* in ill tortoises, and Christopher et al. (2003) reported that 62% of all tortoises in a multi-year srody at three Mojave Desert Sites had moderate to heavy growth of *P. testudinis.*

Several non-infectious diseases were identified. Cutaneous dyskeratosis, a shell disease, was associated with illness,deaths, and population declinesin theeastern Mojave and Colorado deserts(!acobsonetal.1994;Homer eta!.1998;Christopheretal.2003).Nutritional deficiencies or elemental toxicants may have caused this disease. Jacobson et al. (2009) described oxalosis, a disease of calciumoxalatecrystals inthe kidneya.nd thyroid.Renal and articular goutoccurred in a tortoiseexperiencing starvation and dehydration (Berry et al. 2002) and polyarticular and visceral gouc was seen in a translocated tortoise (Jacobson and Berry 2012). Urolirhiasis was documented in several tortoises in different areas of the desert (Jacobson 1994; Homer et al. 1998; Berry et al. 2002; and Christopher et al. 2003). Jacobson (1994) described osteopcnia in bones of 24 tortoises from the Beaver Dam Siope, Utah, and northwestern Arizona; malnutrition was identified as responsible for the condition.

ElementalTox.icantsand Toxicosis:-El e menral to xicants may affect health and contribute co responses to diseases (Jacobson et al. 1991; Jacobson et al. 1994; Selzer and Berry2005;Chaffee andBeny 2006).Jacobsoneta:l.(1991) reported that mercury concentrations iu livers of tortoises with upper respiratorytractdisease weresignificarttly higher than in controls. Toxicosis was noted as a potential cause of cutaneous dyskeratosis (Jac-0bson et al. 1994). Selzer and Berry (2005), drawing on 4 necropsied tortoises from Homer et al. (1998). reported elevated levels of arsenic in ill tortoises bnt not in the control. Selzer and Berry (2005) detected arsenic in scutes using ICP-MS analyses and obtained results similar to Homer eta!. (1998).

Parasites: - Ectoparasites include argasid ticks and an unidentified trombiculid mite (Woodbury and Hardy 1948; Jacobson 1994). Christopher et *al.* (2003) noted that ticks *(Ornithodoms* spp.) were significantly-morelikely to occur on tortoises the year prior to observing oral lesions. Descriptions of internal parasites have included cysts of

l!'igure 12. Rainwater catchment guzzler for wildlife at Mojave National Preserve, California; tortoises can become entmpped in guzzlers. Photos cour!esy of Mojave National Preserve.

*Sarcocystis-like*protozoa in skeletal tissues, pinworms, and *Balantidium-11ke*protozoain the colon (e.g.,Jacobson 1994; Homer et al. 1998; Berry et al. 2002),

Entombment and Burrow Collapse: - Tortoise burrows may collapse due to human-related activities (domestic Iivestockgrazing, vehicleuse)orheavy winter precipitation. Nicholson and Humphreys(1981)observedsheepgrazingon a Desert Tortoise study area in the western Mojave Desert; they reported damage and collapse of tortoise burrows and entrapment of a marked juvenile tortoisein its burrow (they dug out the burrow because the tortoise was unlikely to escape without assistance).Horner et al. (1998) reported the results of a necropsy of an adult female tortoise entombed in a burrow after winter rains; the tortoise had a cutaneous fungal infection and multicentric visceral inflammation resulting from the entombment. Loughran et al. (2011) described entrapment of four tortoises in burrows one was encased in dried soil and died, but the others were able to escape.Tortoises can also become entrapped wben burrows collapsefrom heavy rains and flooding (Homer et al. 1998; Christopher 1999; Field et al. 2007; Lovich et al. 2011b; Nussear etal. 2012).

Entrapment in Guzzlers and Cattle Guards: - Hoover (1995) examined 89 upland wildlife guzzlers (constructed rainwater catchments) in tortoise habitats in the western, northeastern,and eastern Mojave Desertand in theColorado Desert.Hefound remainsof 27 lortoises and one.Iivetortoise in 18 guzzlers. Tortoises were trapped in the guzzlers and remainswerefoundin allfourdesertregions.Later,Andrews et al.(2001) examined 13 tanksand guzzlers in the Colorado Desert, but did not find tortoise remains. Cattle guards are another sourceof entrapment for juvenile tortoises; theyfall through the bars in the guards and are trapped below with no way to escape (Berry, pers.comm.).

Anthropogenic Trash:-Balloons,garbage, cans,paper, plastic bags, shooting targets, casingsfrom shotgun shells, andordnance are common inDese.rtTortoise habitats (Berry et aL 2006, 2008,2013,2014a; Walde et al.2007b; Keith et al.2008). Somestudies have shown a negative relationship between trash and tortoise sign (e.g., Keith et al. 2008). In one study, models revealed a positive association between tortoise signand trash (Berry et al. 2014a), but this was an exception. Large objects (cars, refrigerators, detritus from construction sites)are also deposited in the desert.Tortoises can be attracted to and are known to consume balloonsand other detritus that can negatively affect health and cause deaths (Donoghue 2006; Wyneken et al. 2006; Walde et al. 2007b). TrilSh, especially edible items, also has attracted subsidized predatorsof tortoises,suchastheCommon Raven *(Con,us corax)* and Coyotes *(Canis latranli)* and can have a negative influence (Boarman and Berry 1995; Cypher et al. 2018).

Livestock Grazing and Trampling: - Early discussions about effects of livestock grazing on tortoises focused primarily on competition for food, loss of food for the tortoises,1rampling, and deterioration of habitat(Woodbury and Hardy 1948; Berry 1978). Berry (1978) described the evidence for probable trampling and death. of a juvenile tortoise as weU as potential conflicts in food availability and loss of shrub cover. Nicholson and Humphreys (1981) conducted a study of the effects of sheep grazing on a long-term, 2.59 km^2 tortoise plot in the western Mojave Desert. Sheep used about 77% of the plot, LO% of 164 monitored burrows weredamaged,4%wered.estroyed,and onejuvenile wastrapped insidea trampled burrow.Nusse.ar et al. (2012), in a study of both resident and rranslocated tortoises, noted that one tortoise died when livestock collapsed the burrow.

Predation:- Tortoise eggsare afoodsourcefor camivo-rousvertebrates.Amongreptiles,the GilaMonsterconsumes eggs (Beck 1990, Gienger and Tracy 2008) in the parts of the geographic range where the species overlap. Predatory mammals of tortoise eggs include Desert **Kit** Fox, *Vulpes macrotis* (Roberson et al. 1985;Turner et al. 1987; Bjurlin and Bissonette 2004; Sieg et al. 2015), Coyote (Roberson et al. 1985;Turner et al. 1987; Esque et al. 201 Oa;Berry et

Figurel3.JavenileOopherusagassizii,killed by Common Ravens wilh typical peck hole.. in shells. Photo by Bev Steveson.

al. 2006; Lovich ct al. 2014a; Sieg et al. 2015), American Badger,*Taxideataxus,and SpottedSkunks,Spilogalegracilis* (Roberson et al. 1985; Sieg et al. 2015).

Neonates and juveniles may be artacked and kiUcd by ants,includingfireAnls,*Solenopsis*spp.(Nagyeta!.2015a; Macketal.2018),CommonRavens(Campbell 1983; Farrell 1989; Lovich et al. 201Ja; Berry et al. 2013; Hazard et al. 2015; Nagy et al. 2015a,b), Bobcats, *Lynx rufus* (Nagy et al. 2015b), Desert Kit Fox (KelJy et al. 2019), rodents (Nagy et al. 2015a,b), and Burrowing Owls (Walde et al. 2008). Common Ravens are very successful predators of juvenile and small immature tortoises and leave typical patterns on the remains of shells (Campbell 1983; Berry et al. 1986; Boarma11 and Berry 1995). Multiple kills of Juveniles by Common Ravens have beendescribed along fence li.nes, transmission lines, towers and poles, utility poles.and at perches and nests (e.g.• Campbell 1983; *n*;::: 136, along a multi-kilometer fence line; Farrell 1989, *n* = 115, single nest). Kills have also been observed on open ground (Berry et al. 1986). Knight et al. (1998) reported finding remains of juveniles at cattle stock tanks. Parts of tortoises also werefound in scats or pellets collected from the nests of Common Ravens (Camp et al. 1993).

Populations ofCommon Ravens havegrown rapidlyin the Mojaveand western Sonorandeserts,supported byperennial food sourcesand walerin urban andagricultural areas,srnalI towns, and settlemenls (e.g., Knight et al. 1993; Boarman and BeO')' 1995; Boarman et al. 2006). The expansion of transportation and utility corridors, energy developments, livestock allotments, and recreational areas bas supported growth of Common Raven populations, such that Lhey are now considered subsidized predators subsldized by anthropogenic activities (e.g., Kristan and Boarman 2003, 2007; Kristan et al. 2004; Webbet al. 2004,2009; Boarman etal.2006).Thesedevelopmentshavenotonly provided food and water to allow Ravens to survjve and thrive, but also enabled their perching and nesting in hitllerto inaccessible areas, thus penetrating into Desert Tortoise range areas previously inaccessible to Ravens.

Remains of juvenile tortoises also were observed in pelletsof Red-tailed Hawks *(Buteo jamaicensis)* nesting on rransrnission linetowers in the Colorado Desert (Anderson and Berry 2019). Red-tailed Hawks may be a subsidized predator, expanding perch and nestsites using transmission line towers throughout the range of th.e tortoise. Spenceley et al. (20I5) described a failed attempt of a Glossy Snake *(Arizona elegans)* to kili a juvenile, bead-started tortoise. Coyotes and Bobcats preyed on immature to1tojses (Nagy et al. 2015b).

Carnivorous avian and mammalian predators have attacked and eaten wild and free-living adult torroi.ses. Common Ravens were observed to attack an adult tortoise (Woodman et al.2013). Golden Eagles *(Aquila chrysaetos)* kill and eat adult tortoises; multiple broken shells were observed below eagle nests in the Mojave Desert (BeO')', unpubl. data). Mammalian predators include Coyotes (Peterson 1994; Esque et al. 2010a; Lovich et al. 2014b), Bobcats and Mountain Lions *(Puma concolor;* Woodbury andHardy 1948;Fieldetal.2007;MedicaandGreger2009), American Badgers(Emblidgeetal .201S),a.nd domesticdogs (*Canis lupus familiaris;* Beny et al. 2014b). Both dogs and Coyotes were considered subsidized predators (Esque et aJ. 2010a; Cypher et al. 2018).

Collecting: - People have collected DesertTortoises for food, commercial sale, and pets, and lliesc activities have resulted i1.1 losses to wild populations. which we view as equivalent to deaths. Some Native American ti:ibes, early settlers, and later residents engaged in collecting (e.g., Anonymous 1881;Jarnes 1906;Stephens 1914;Camp1916; Jaeger 1922; Battye 1924; Gr.int 1936; Miller 1932, 1938; Woodbury and Hardy 1948; Schneider and Everson 1989).

1n 1939, the California Fish and Grune Commission published a regulation statingsaleor purchaseof any Desert Tortoise was uola\vful (Califomia Dept. of Fish and Game Code 1939-1981).By 1961, the regulation was amended to prohibit take, harm, and shooting. In 1972, regulations on possession and transport of tortoises were added, with the provision that persons able to demonstra.te possession of a DesertTortoise prior to publication of the 1972regulations could retain the tortoise under certain conditions. Further constraints on possessing to1tofses followed in 1989, culminating in the state and federal listings as a Threatened species (California Department of Fish and Wildlife 2016; USDI 1990). Other states did not have such stringent regulations as early.

In a collection of unpublished studies from the western Mojave Desert, Berry el al. (I996) summarized incidents of illegal take of tortoises using multiple data $Ou.recs: law enforcement records, visual observations of poachers,signs of tortoise burrows dug up with shovels on transects and a long-term mark-re aptureplot,demographic data from two long-term mark-recapture-plots,and other information.The observations occurred between the mid-i980s and mid-1990s; in retrospect, lhe observations appeatedlink:ed with the Asian Turtle Trade (see van Dijk et aJ. 2000). Several Cambodian nationals were arrested with 29 tortoises from a Jong-term plot, and several other Asians were observed in suspicious activities associated with collecting tortoises. Gl.ennStewart(pers.obs.)reported the disappearanceof29% of radio-transmittered tortoises between 1986 and J990 on hisproject; they were probably collected.Berry et al. (1996) estimated >2000 tortoises were removed from four study areas over a 10-year period.

Illegal colle.cting has continued,e.g.,from highwaysand roads,and someof tbesecollected tortoises were transported to urban communities, parks,preserves, Natural Areas,and out of their 011-tive states. Grandmaison and Frary (2012) conducted a studyontheprobability ofdecoySonoranDesert Tortoises (G. *morafka1)* being detected and collected from paved roads, and maintained and non-maintained gravel roads; out of 561 opportunities for detection, motorists detected tortoises 19.3%, and wben detected, 7.4% of motorists attempted to collect the tortoise. Detection was greatest on maintained gravel roads.This finding points out the vulnerability of tortoises living within short clistances of non-paved roads.

lo a genetic study comparing captive tortoises from three desert communities in California and Nevada, only 44% of !he captives were from the local communities and one was a *C. morafkai* (Edwards and Berry 2013). Studies of captive tortoises in desertcommunities in Arizona within the rangeof *G. morajkai* revealed that a highproportion of captives (25%) were G. *agassizii* and an additional 14% were hybrid *G. agassizU x G. mora}kai* (Edwards et al. 2010). These findings indicated transport of *G.. agassizii* into the geographic range of G. *morafkai*.In thelastdecade, wild *G.agassizii*,marked as part of research projects, have appeared in urban and ex-urban areas,obviously taken from the desert (Mark Massar, pers. obs.; California Turtle and Tortoise Club Adoption Program to Berry, pers. obs.).

Unauthorized Releases of Non-Native Tortoises: - Examples of unauthorized releases into *G. agassizii* habitat include a TexasTortoise (*Gopherus berlandieri)* and a Box Turtle at the DesertTortoise Research Narural Area (Berry etal.1986).SeveralAfricao'SpurredTortoises(*Centrochelys sulcata),* commonly sold as pets in the Southwest, were released illegally, discovered, and then removed from the Mojaveand Sonorandesertsof California,Utah,andArizona (e.g., Nelson 2010; Goolsby 2016;Anonymous 2018).This species can grow to a very large size (68 kg).1\voAfrican SpurredTortoises werediscovered and removed in October 2018inside theRed ClilisDesertReserve,and officiaJsat the Reserveexpressed concernabout the non-natives spreading disease and damaging habitat (Anonymous 2018).

Figure 14. Residual impact in 2009 of tank tracks and military training of troops in 1942 (67 years earlier) conducted by Cieneral Patton in Chernehuevi Valley, Colorado Desert.California. Photo courtesy of U.S. Geological Survey.

Figure15. Unauthorized motorcycleraceacross theDesertTortoise Research Natura!Area, western Mojave Desert,Califoroia,creating new destructive trails. Photo by Kristin H. Berry.

The introduction of infectious and other diseases by turtlesand tortoisesfrom otherpartsof theUnitedStatesand other countries has the potentiaJ for devastating effects on naive*G.agassizii.For*example,in2013,an ill CentralAsiao Tortoise *(Testudo horsfieldii)* wa. found and removed from thecentral Mojave Desert (Western Expansion Area of Fort lrwin),California. It was necropsied and tested positive for *Mycnplasma agassizii* using ELISAand also tested positive for a newherpesvirus usingPCR,previously unreported in *G. agassiz'ii* or *T. hQrsfieldii* (Jacobson et al.2013;J.Wellehan, pers. obs.).The predominant bacteria in lhe nasal discharge was *Mannheimia haemolytica,* the cause of the epizootic pneumonia in came known as Shipping Fever (Jacobson et al. 2013).

Vandalism: - Numerous early reports documented vandalism, such as deliberately running over tortoises with vehicles, shooting, and maiming (Ragsdale 1939; Jaeger 1950; Bury and Marlow 1973; Uptain 1983). Ben-y (1986) evaluated 635 carcasses collected between 1976 and J982 from 11 sites in the Mojave and western Sonoran desertsof California; 91 (14.3%) remainsshowed evidenceof gunshot. Gunshot deaths were more common in the western Mojave

Desert(l4.6-28.9%)thanin theeastern Mojave(0.0-3.1%) and Colorado deserts (1.8-2.8%). The higher levels of gunshot deaths in the western portion of the geographic range were attributed to much higher recreational use than in the eastand south. Evidence of gunshotdeaths was seen at Goldstone and within the southern edgeof the Fort Irwin National Training Center (Ben-yet al. 2006). On theAlvord Slope,8.5%of 47 shell remainsshowed evidenceof gunshot. In the western Mojave Desert at Red Rock Canyon State Park, 5 of 58 shells showed evidence of gunshot (Berry et al. 2008). *Also* in the western Mojave Desert, evidence of tortoises killed by shooting occurred both in the Desert Research Natural Area and in adjacent designated critical habitat for the tortoise (Berry et al.2014a).

VehicularImpacts:-Recordsof tortoiseinjuries and kills by vehicles are frequent in the literature (e.g., Woodbury and Hardy 1948;Homer et al. 1998; von Seckendorff Hoff and Marlow 2002; Lovich et al. 2011a). Woodbury and Hardy (1948) considered the killing of tortoises on roads and removal by tourists and others as one of the dangers to the species.ln a study of paved roads,vonSeckendorff Hoff and Marlow (2002) found remains of 6 dead tortoises hit by vehicles on the shoulders of two- and four-lane roads in southern Nevada. Hughson and Darby (2013), in a study of 216 kmof paved and two-lane roads in the Mojave National Preserve, estimated a minimum of 5.3 deaths of tortoises annually. Lovich ct al. (201la)found11dead tortoises over a 13-year period at a wind energy study site io the western Colorado Desert; one of the dead tortoises was killed by a vehicle.

Four studies have been undertaken to define the zoneof influence of roads of different ages and traffic volumes *on* tortoises, with the assumption that roads serve as mortality sinksforadjacent tortoise populations.vonSeckendorffHoff and Marlow (2002) studied the effects of the road impact zone at intervals parallel to the roadways on roads with differing traffic volumes (25 to 5,000 vehicles perday) and during different seasons. They fmmd effects (reduction in abundance of tortoisesign)atdistancesof>4,000mfromthe road at the highest traffic level.However, the zoneof impact ranged from 1,090 to 1,389 m for graded and maintained electric transmission line access roads.

Boarman and Sazaki (2006) conducted a more limited study along one major highway in the Mojave Desert with traffic of 8,500 vehicles per day. They found significant differences in sign counts between the highway edge and 400 m clistantfrom the highway.Nafuset al. (2013) studied road effectsin the Mojave NationalPreserVe,Califomia,and reported that tortoise sign was in greatest abundance along roads with low traffic volumes (<1 vehicle/day) compared with roads of intermediate (30-60 veb.icles/day) and high traffic volmnes (320-J100 vehicles/day). Importantly, tortoise size negatively correlated with traffic volume. Highwaysand roadscould affectthe potential for population growth rates becausereproductivetortoises wereabsentnear the roads.

Hughson and Darby (2013), using the techniques of Boarman and Sazak.i (2006), also saw similar depressions in tortoise sign near roads within the Mojave National Preserve. Agha et al. (2017) reported that mesocarnivore visits to tortoise burrows increased as distance to dirt roads decreased at a windfann facility in the western Colorado Desert; however in anearlierstudy at the windfarm, tortoise burrows were more likely to occur closer to roads than at random points (Lovich and Daniels 2000).

Berry et al. (2006) studied Desert Tortoise populations on 21 plots on a military reservation; remains with signs of vehicle crushing were present on all plots with military maneuversandrepresentedfrom2.lto45.5%ofdealhson20 of these plots.In a study in the northwestern Mojave Desert, Berry et al. (2013) modeled variables affecting distribution and abundance of tortoises on a military installation where no vehicle-relatedmaneuversoccurred; the modelsincluded paved roads, denuded areas, ordnance,signs of mammalian

Figure 16. Adult *Gopherus agassizii* standing In burned hahitat soon after the2005 tire at the Red Cliffs Desert Reserve in Utah. Photo by Ann McLuckic.

Figure**17**.Impaclsfrom fireand lbe resulting invasion of red brome grass *(Bromus madritensis* ssp. *rube/IS)* in the Red Cliffs Desert Reserve,Utah, Lwoyears post-fire(2007).PhotobyAnnMcLuckie.

predators,andobservationsof Common Ravens.The models suggested thatdensities of tortoises increased with distances frompaved roadsand denuded areas, as well as some other variables.

Buryand Luckenbach(2002)found animmature tortoise crushed on a vehicle ttail ju a recreational veruclcuse area. Remains of tortoises Likely killed by unauthorized vehicle use were foun_d in the Desert Tortoise Research Natural Area, an area closed to recreational vehicles (Berry et al. 2014a).

Fires: - Wild.fires injure and ki!J tortoises (Woodbury and Hardy. 1948; Homer et al. 1998; Esque et al. 2003; Lovich et al. 2011c; Nussear et al. 2012;Ann McLuckie, pers.obs.). Woodbury and Hardy (1948) reported deathsof about 14 tortoises from a fire covering ca. 5.2_km² on part of theBeaver Dam Slope south ofBunkerville in 1942.ln a post-fire study, Lovich et al, (20l lc) described a fire in the westem Sonoran Desert that killed an adult female tortoise and injured five other adult tortoises. Nussear et al. (2012) reported that three of 30 tortoises died from fire during a comparative study oflraaslocated and rcsideot tortoises.In the **Red** Cliffs Oe sert Reserve and critical habitat in Utah, 687 tortoises died in 2005 in a fire that burned ca. 23% of the approximately 251 km² habitat (A. McLuckic, pers. comm.). Drakeet al. (2012) described a tortoise recovering from burns three years post-fire.

Two studies, one in the northeastern Mojave Desert and a second in the western Sonotan Desert, revealed that activity areas of tortoises remained unchanged in the first few yearsafter a bum, indicating site fidelity, regardless of habitat condition (Lovich et aL2018b). However, Drake et al. (2015) reported thatsix to sevenyears post-fire,tortoises contracted areas of activity bee,-ause the post-fire growth of herbaceous perennial species (globemallow, *Sphaeralcea ambig1Ja)* declined.

Mining: - Tortoises have been found alive and dead in mining shafts and pits, often inmjni,ng districts such as the Rand Mining District in the western Mojave Desert where pits and shafts are common (Berry, pers. obs.). Nussear et al. (2012) reported that two of30 translocated and resident tortoisesunderstudy in the northeastern partof the geograpruc range were found dead in mineshafts.

Rattlesnake Bites:-An adult maletortoise, rr-anslocated 17 dayspreviously as partof a mass lranslocation program, was attacked in the orbit and ultimately died from probable envenomation by a rattlesnake (Jacobson and Berry 2012; Berry et al. 2016a). Based on the appearance of the wound at necropsy, venom was most likely from, the Speckled Rattlesnake,*C.pyrrus*,orPanamintRattlesnake,*C.stephensi*. Rattlesnake bites or strikes as a cause of tortoise deaths are likely undercounted. Finding a tortoise dying of snake bite and obtaining a couli,rming necropsy would be unlikely, unlessa tortoise was under observation or being tracked.

Mor/alityRates.-Deathratesaresumm.arizedfolJowing the reporting styles of the authors. Moststuiliesfocused on annualized death rates of subadult and adult tortoises (CL 2:L80mm). Insomecases, bl.Itnot all, sites with little human use had lowermortality rates than.sites with human-related activities. In their s111dy of Desert Tortoises on the Beaver Dam Slope, Woodbury and Hardy (I948) reported a 1% annual death rate for a large sample of mostly adults. In a demographic study of tortoises on 21 study plots sampled botween [997and2003 inamilitary installation inthe central MojaveDesert,aduH(2:l$0mmCL)deatb rates(adultsdying / ryr km•'lJ) differed by location, and current and historical uses; death ratesTanged from 1.9 Lo 95.2% annually (Berry eta].2006).Fifteen plots within the Goldstone area had the highestdeathrateat95.2%.Siles with recentmilitary vehicle userangedfrom4.7to 13.3% and thosewith ongoingmilitary verucle-oriented war games ranged from 1.9 to 23.8%.The single site surveyed adjacent to and outSide of the @litary base had an annual death rate of 9.7% (Berry et al. 2006).

ln the western MojaveDesert,Berryeta!.{2008)studied apopulation within Red RockCanyon StateParkand reported a death rate of 67%for adults between 2000 and 2004 (ca. 24% annually); the death rate exceeded recruitment rates. In a survey of a 5.42 km² plot on a naval testfacility in the northwestertl Mojave Desert, Berry et al. (2013) described a crude annual death rate of 1.8% for adults during the period 2006-2010. This site bad limited public access with no livestock and no vehicle-oriented recreation. Berry et al. (2014a) compared demographic attributes of tortoises i:n three differently managed areas in the western Mojave Desert and provided crude annual deathrates for adultsfor the 4 years preceding the survey. Death rates were lowest (2.8%/yr) for !he most protected area, lhe Desert Tortoise Research Natural Area, 20.4%/yr in critical habitat, and 6.3%/yr on unfenced private lands with unrestricted human use (but recently acquired for conservation, 2000-2009).

Survi al. - Few substantive studies have _provided estimates of survival rates of Mojave Desert Tortoise populati.ons.The mostcomprehensive ofth.ese was a study in the eastern Mojave Desert of California by Turner et al. (1987), covering the period 1977-1985. Tlie study drew on U sex-size groups (CL in mm}, of which the first six were pre-reproductive: <60, 60-79, 80-99, 100-119, 120-139, 140-154., 155-179, females 180-208, males 180-208, females>208, and males >208. The authors, using mark-recapture data, calculated annual survival rates for four periods between 1977 and 1985, as well as the geometric mean annual survival.The smallestthreeclasses (juveniles) hadgeometricannual survivalratesof0.767to0.804,andthe immature tortoises (100-179mm CL) had ratesof 0.821 to 0.861.Estimates for adult females were 0.90I to 0.944and for adult males were 0.876 to0.907.All estimates had wide confidenceintervals.Usingthisand otherinformation,Turner et al. (1987) prepared a life table and estimated an annual rate of increase of the population of ca. 2%..However, this population unfortunately crashed between 1994 and 2000, apparently duetodiseaseand otherfactors(Christopheretal. 2003). Freilichetal.(2000),ina1991-1995mark-recapmre study in Joshua Tree National Park, reported survival rate estimates of 0.84or 0.901, depending on method used, for both sexes of adult tortoises.

fn the western edge of the Sonoran Desert, Agba et al. (2015c) compared apparent annual survival rates of adult tortoises over l8 years at two sires: inside a wind energy facility.a disturbed landscape, and nearby in an undisturbed landscape. Estimates of survival rates were 0.96± 0.01 for the wind energy facility, significantly higher than observed for the undisturbed site, 0.92 ± 0.02. High survival was attributed in part to limited human use.

1n Nevada, Longshore et al. (2003) studied tortoises at two sites at Lake Meade National Recreation Area between 1994an_d 2001.Theseautuors reported annual survivalrates of 0.985at Grapevine and 0.829at Cottonwood sites, where drought conditions existedfrom 1996 to 1999.

Population Status. - Histori9 and recent reports provide data for evaluating changes in status of tortoise populations. Before describing data, we briefly discuss sampling techniques because the methods used affect the types of results available.

Albeit limited, only observational reports on local abundance of tortoises exist from the early 1900s until the Woodbury and Hardy(1948) publication. Forexample,Grant (1936) described tortoises collected near Helendale in the western Mojave Dese1t.

Since the Woodbury and Hardy (1948) study until the early 2000s,mark-recapturestudieson plotsof various sizes havemeasuredµopulation attributes(struct1U'e.densities.sex ratios, growth, survival, causes of death), and some plots becamelong-term plots of about 2.6-7.8 knl2(8erry 1984). Selection of sites to study demography differed from one investigator to another and from statetostate.InCalifornia, most sites represe.nted habitat in valleys. throughout the Mojaveand Coloradodeserts,whereasin Nevada,sites were chosenwhere belt tnmsectsindicated high countsof tortoise sign (Berry 1984), Mark-recapture surveys often spanned multipleyears.Densities,oileof several critical measures of population sratusand trendsfor the.species, werefrequently assessed through twoor moremark-recapturesurveyswithin a season. Data were analyzed using the Lincoln-Peterson index, stratified Lincoln index, Schnabel method,.and other analytical techniques. In somecases,professional judgment was used toestimatedensities.ln addition,amountsof eff01-t per unit area differed as well as season of survey. Changes in densities coupled with dataon short-term trends i.n death rates or annualized mortality rates an d survival for adults alsoprovidesupporting rnfonnation and arepresented above.

Tosummarizedatasetsonlivetortoisesfrom 1936through the early 1980s briefly, we used the following counts: (1) all sizes of tortoises, and (2) all sizes of adults (<!180 mm CL). These counts occurred within boundaries of plots (Table 2). Data are available for 24 sites with counts of <!2 tortoises/ktn\ sites with lower densities were oot included but are available in Berry (1984). Plot sizes ranged from .2.59 to 13.7 km2, with most plots 2.591on² and receiving two ce1)suses or complete surveys in spring, when tortoises were likely to be above ground (Zimmerman el al. 1994). Counts of tortoises wereconverted to adults/km²for rough comparisons between sitesand over time, and ranged from 2.31 to71.8adults/km²(Table 2). With few exceptions, most study plots Listed in Table 2 are within critical habitat units designated by USFWS (1994).

From 1985 to 2006, counts and estimated densities of populations in many study areas declined markedly after tbe studies were initiated (e.g., Woodbury and Hardy 1948; Hardy 1976; Berry 1984; Jacobson el al. 1991, 1994; Berry and Medica 1995; Brown et al. 1999\ Berry et al. 2002; Christopher ct al. 2003). the population studied by Woodbury and Hardy (1948) on the BeaverDam Slope was federally fisted as Threatened in 1980 becauseof population declines and otherfactors(USFWS 1980).The-listing of the entiremetapopulation north and west of the Colorado River followed in 1990 (USDI 1990).

Examples of decLines on mark-recapture plots include changes in adult tortoise populations i1 1the Dese.ttTortoise Research Natural Area between 1982 and 1992,a decline of ca. 94% to about *6* tortoises/km¹(Brown et al. 1999). Tbe population (all sizes) 1n the western Sonoran Desert at Chuckwalla Bench also experienced a marked decline between I979 and 1992.lncontrast,adultdensitiesremained relatively high during three surveys in lvanpah Valley conducted between 1979 and 1994 (between 80 and 100/ k.m²per survey)and duringfoursurveys conducted at Gaffs between 1980 and 1994 (between 145 and 190/km.² per survey) (Berry and Medica 1995 Berry et al. 2002). The Goffs popuJation experienced 92-96% decreases between 1994 and 2000 (Christopher et al. 2003). In Nevada, four populations with densitiesofadults<50/km² eitherremained stab.le, fncreased slightly, or decreased in the l 980s or between the 1980s and early 1990s (Berry and Medka 1995).

AtJeast twomark-recaprureplots listedin Table2,Arden in Nevada and FremontPeak in California, no longer have tortoises. Arden became urbanized shortly after the surveys were completed and is now rart of Las Vegas (B.L. Burge, pers.obs),and Premont Peakexperienced sheepgm.zingand intensive vehicle-oriented recreation (Berty, per.s. obs.).

Brief or one-Lime surveys of plots or study areas produced snapshots in timeof bothdensities and mortality rates of breecling adults for the four years prior to each study (e.g. Berry et al. 2006, 2008,2014a). Whl!e limited in time, these types of studies supplement long-term mark-recapture research and nionitoring of changes in density conducted at a landscape scale. For exam.pie, one-time surveys undertaken at 15 plotson Goldstone and an additional six plots on the National Training Center at Fort Irwin revealed mean densities of adults of 0.79/km² with a very high death rate of 95.2% annuallyfor adults oo the 15 Goldstone plots. 1n contrast, adult densities ranged from 1.4to 15 adu)ts/km² and death rates of adults from 1.9 to 23.8% annually on six Fort frwin plots. In a health and disease research project spanning five years (1990-1995), annualized mortality ratesfor adulttortoises with radio transmitters were available for three sites: the western (2.5%), northeastern (2.4%), and eastern (5.1 %) MojaveDesert regions (Christopher et al. 2003).Tortoises missing (some were potentially dead) at each site ranged from 22.9% (eastern Mojave) to 375% (western Mojave) over the5-year study.One-time studies usinghectare plots or study areas also indicated high mortality rates in some areas (Berry ct al. 2006, 2008; Keith et al, 2008). Small, remnant and potentially isolated populations remained in the north central and northwestern Mojave in the early 2000s (Berry et al.2006, 2008, 2013; Keitlletal. 2008). Death rates of adults tracked with radio-transmitters were hlgh in some studies (Longshore ef al. 2003; Christopher et aL 2003), buL not in others (Agha et al. 2015c).

Surveysat the landscape Scale. - The first*G. agassizii* Recovery Plan published in 1994 recommended sampling on a landscape scale within designated areas designed for conservation of the Desert Tortoise, i.e., Desert Wildlife Management Areas, in addition co maintaining long-term plots, where appropriate (USFWS 1994a}. After testing different approaches, in 2004 the USFWS implemented annual distance sampling of adults (::2:-180 *mm* CL) within designated critical habitat units (now called Tortoise Conservation Areas, TCAs) throughout the geographic range (McLuckie et al. 2002; USFWS 2015; Allison and McLuckie2018),Theprimary population attributepub!ished from distance sampling was density of adults within critical habitat units or TCAs (Table 3). The first Recovery Plan alsorecommended separating populationsin_tosixRecovery Units,eachof whichcontainedone ormorepopulatjons(e.g., critical habitat units), with a tot.al of>25,000 km² (USFWS 1994). In the revised Recovery Plan, the USFWS (2011) reduced the numberof Recovery Units to live and realigned boundaries based solely on genetic information in Hagerty and Tracy (20 I0).

Range-wide, the fiveRecovery Units contain 17TCAs scattered in the Mojave and western Sonoran desertsof the four states (Table 3). Grouped data for all TCAs showed a dec.Jineof32. l8%in adulttortoises between2004and 2014, with declines of 26.57 to 64.70% for 11 individual TCAs (USFWS 2015). Six TCAs showed increases of 162.36

Table 3. Summary of10-year trend datafor five Recovery Unils and 17 Tortoise Conservation Areas within the Recovery Units for the Mojave Desert Tortoi.se, *Gopherus agassizii,* between 2004 and 2014 (modified from Table10 in USFWS 2015).This table includes (he area of each Recovery Unit and Tortoise Conservation Area(= critical ha.bitat), the percent of total habitat in each of che five Recovery Units and 17 Tortoise Conservation Areas, density (number of breeding adults/km²aod standard errors, SE), and the percent IO-year change between 2004-2014. Note: according to Table 2 in the revised recovery plan (USFWS 2011), the total critical habitat is 26,039 lstn², whereas the textstales 24,281krn²• Numbe inbold representthe.totals for each Recovery Unit.*= Populations falling below the viabl.e level of 3.9 breeding iodividuals/km¹. 'Chocolate Mountains Aerial Gunnery Range.

Rec.overy Unit Tortoise Conservation Arca	Surveyed area (km')	% of total habitat in Recovery Unit&TCA	2014 de.nsity/km¹ (SE)	% 10-year change (2004-2014)
Western MQjave-, CA	**6,294**	**24.51**	***2.8 (1.0)**	**-50.7 decline**
Fremont-Kramer,CA	2.,347	9.14	*2.6 (l.0)	-50.6
Ord-Rodman, CA	852	3.32	*3.6 (1.4)	-56,5
Superior-Cronese,CA	3,094	12.05	*2.4 (0.9)	-{ij5
Colorado Desert (1° CA)	**U,663**	**45.42**	4.0 (IA)	***-36.3* decline**
Chocolate MAGR¹, CA	713	2.78	*72* (2.8)	-29.8
Chuckwalla, CA	2,818	10.97	*3.3(1.3)	-37.4
Chemehnevi, CA	'.\,763	14.65	*2.8 (J J)	-64.7
Fenner.CA	1.782	6.94	4.8 (1.9)	-52.9
Joshua Tree, CA	l,152	4.49	*3.7 (1 .5)	+178.6
PinLo Mountain, CA	508	1.98	*2.4 (1.0)	-60.3
PiuteValley, NV	927	3.61	5.3 (2.1)	+162.4
Northeastern Mojave, NV, UT, AZ	**4,160**	**16.2**	**4.5 (1.9)**	**+325.6 increase**
SeaverDam S., NV. UT,AZ	750	2.92	*62* (2.4)	+370.3
Coyote Spring, NV	960	3.74	4.0{1.6)	+265.1
Gold Butte, NV & AZ	1,607	6.26	"2.7 (1.0)	+ 384.4
Mormon Mesa, NV	844	3.29	6.4 (2.5)	+ 21'7.8
EasternMojave, NV & CA	**3,446**	**13.42**	*1.9{0.1)	---07.3 decline
El Dorado Valley, NV	999	3,89	*15 (0.6)	---01.l
Ivantah Valley, CA	2,447	9.53	'"*2.3* (0.9)	-56.1
Upper irgin River,UT	**115**	***OAS***	**l5.3(6.0)**	-26.6decline
Red Cliffs Desert Reserve, UT	115	0.45	15.'.3(6.0)	-26.6
Total Amountof Land	**25,678**	**100.00**		-32.2 decline.

to 384.37%. Ten TCAs were below a density of 3.9 adult tortoises/lan^2, a figure established for population viability described i.n the firstRecovery Plan (USFWS J994).Nodata are available on the sex ratios off em.ales to males in the 17 TCAs.

MostTCAs (10 of 17,75.9%) occur in California.Nine of these10 populationsdeclined by29.77to64.70% between 2004 and 2014, and eight were below the numeric level of viability (not considering the Standard Error,Table 3). The two populations that wereabove viabilil)I alsodeclined,and one population, Joshua Tree, showed an increase (USFWS 2015).

Nevada, with 17.9% ofTCAs, has parts or aU of six populations and five of these show increases; two of the si,c were below viability. About 4% of TCAs (parts of two populations) occur in Arizona and are shared with Nevada and Utah. Both TCAs were increasing but one was below viablli1y. Utah has<2% of populations in TCAs: the Beaver Dam Slope whichis showing an increase,and theRed Oiffs DesertReserve whichis declining.In addition.observations of juveniles havedecreased (Alllson and McLucki e 2018,), Reviewing all these results, Allison and McLuckie (2018) concluded that"The negative population trendsin most of theTCAs Lcritical l1abitat units]for MojaveDesertTortoises indicate that this species is on the path to exti'nctlon tmder current conditions."

Populations in protected or partially protected areas (State Parks, National Park system, Research Natural Areas, Reserves,Arcas ofOitical Environmental Concern) experienced do.,vnward trends and/or high mortality rates with few exceptions (Berry and Medica 1995; Longshore et al. 2003; Berry et aL 2008; Lovich et al. 20J4b; USFWS 2015 [Red Cliffs Desert Reserve]). A oneaseason study undertaken *in* the western Mojave in 2011 comparedeffect:s of different management practices on population status in a fenced and protected area (Deserl Tortoise Research Natural Area), adjacent unfenced private land, and critical habitat (Berry ct al. 2014a). Significantly higherdensity of cortoisesoccurred in theprotected area(10.2 adults/km\95% CmmdenceInterval [OJ:9.9-10.4)compared with adjacent private land (3.7 adultslkm^2; *95%* Cl: 3. 3 .8) and critical habitat (2.4 adults/km\ 95% CI: 2.3-2.6). Death rates of adults from 2007 to 2011 were also lower in the protected area (2.8%/yr) than on private land (6.3%/yr) or in critical .habitat (20.4%/yr).

Threats to Survival. - The decline of *G. agassizii* is often described by scientists *as* deatb by a thousand cuts. Population declines can be ascribed simply to the rate of loss of individuals greater than the rate of recruitment and the rate of loss or degradation of habitat.Causes of decJines varylocallyand regionally within the geographic range and by critical habitat unit or TCA (e.g., Jacobson ei al. 1991; Berry et al. 2014a; Tuma et al. 2016). Overall, the causes arc multiple, cumulative, and oftensynergistic, but the most importantdriversateanthropoge.nicactivities.Thesameand similaranthropogenicdriversan!the basisforenvironmental change and degradation elsewhe.re in the American West (Leu et al. 2008).

In the section on Morbidity and Mortality above, **we** described multiple sources of illness, death, and loss of individual tortoisesto populations. Highon thislistof threats are disease, poor nutrition, starvation and dehydration, predation by subsidized predators (e.g., Common Raven, Coyote, dog), loss to vehicle impacts, and destructive wildfires. The importance of other hazards and causes of mortality should not bediscounted or minimized,especially because tortoise popuiation den_sities are so low, bordering or below viability for breeding adults (Table 3; viability summarized in USFWS 1994). With continuing growth of human populations and industrial developments within and on the edges of the geographic rangefor G. *agassizii* (e.g., Hughson 2009), we expect 1hat deaths from known and additional sources will continue and likely increase.

Habitat Loss and Fragmentation. - Constrictions to and fragmentation of the geographic range of the Desert Tortoise began when early settlers arrived in the 1800s. Settlements. grew into town s and cities and land was converted to agriculture, ranching, and scattered mining operations. Transportation and utility corridors developed, and recreational focal points became popular.

AsoI2018,thesouthwestempartof thegeographicrange inAntelope,Victor,Apple,and partsof BrisbaneandPeerless vaUeys were in urban,ex-urban,industrial, and agricultural developments.T11c western edgeof the range was similarly compromised. Habitat across the southern,central,eastern, andnortbeastemregians.of the Mojaveand Coloradodeserts experienced similarlossesandfragmentation ofhabitatuntil and after the time of tilefederal listing in 1990 (e .g., Norris 1982;Hughson 2009; USFWS20 lO).Subseqvently, the area of tortoise habitat (including critical habitat) bas continued to decrease, with development of private and federal lands for urban, ex-urban, agricwtural, industrial, and energy developments, and expansion of Department of Defense military bases in the central, southern, and northeastern Mojave Desert and elsewhere (e.g., USFWS 2010). For example, between 1992and200 I *,4.51*k:m^{2}of criticalhabitat was lost from agricultural development, a small amount compared to the past, but J]evertbeless a C•ontinuing issue. Range-wide, 1,802km^2 of critical habitat occurred on U,S. Department of Defense lands (USFWS 20J0). Due to the expansion of the National Training Center at Fort Irwin in the central Mojave Desert, 760 km^2 of tortoise habitat was lost or degraded; ca. 304 krn^2 of this Joss was part of critical habitat(USPWS 2010),The ex'J)ansionoflh.e Marine Corps Air Ground Combat Center at Twentynine Palms in the southern Mojave Desert has had and is likely to have continued and profoundeffects-on tortoisepopulations Within and outsidecritical habitat units(USDD2017; Hemm2018). Since2000, development of renewable energy has resulted in loss of about 25 km^2 of high value tortoise habitat (but not critical habitat) in the northeastern Mojave Desert and ca.81 ktn^2 of marginal babirat in.the Colorado Desert (Mark Massar, U.S. Burea1L of Land Management, in Litt. 25 Ocr 2018).

Transportation,energyandutilitycorridors,and railroads connect cities,towns,settlements, and developments across and within the geographic range of the tortoise, resulting in lost and degraded habitat,fragmentation of habitat, and loss of connectivity (Forman et al. 2003; Chaffee and Berry 2006).The USFWS (2010) reported a total lengtl:lof 13,350 km of paved roads and highways in,critical habitatin 1990, with a sl.ightdi.fference in 2008. Uthe [3,350km are treated solely as two-lane highways withshoulders(width, 11.6 m), then total loss is 1,548 km^2. This figure does not include 4- and 6-lane or divided highways. The revised Recovery Plan showed substmitially fewerkilometers of roads where fencirigis needed, butdoesnot resolvediscrepancies wilhlhe 2010report(USFWS 2010,201l).TheUSFWS (2010) also noted l,634kmofutility lines within-corridors encompassing 1,743 krn^2 (width of utility corridors= 1.067 km). Utility corridors have one or more acce s roads, often dirt w.ith berms,and Lh.e roads have increased in length and area with development of renewable energy facilities on public and privatelands.Dataon otherlinear disnirbancesare available for TCAs, e.g., for railroads, 368 km (USFWS 2011).

In addition to acting as a mortality sink for tortoises, roads, whether dirt or paved, and railroads are sources of contaminants such as asbestos, cadmium, chromjum, lead, nickel,petroleum products,andorganiccompounds·(Forman et al. 2003; Chaffee and Berry 2006).

Solarandwind energydevelopments are presentinDese1t Tortoisehabitat(habitatmodeled byNussearet al. 2009).For cxample,as of2010,solardevelopmentwasimplemented on 114 kni2ofall modelled habitat,with.additionalsolarand wind projects pending for 230 km^2 (USFW"S 2011).As of 2018, more solar and wind sites are proposed or in development, generally not i_n crltical habitat, but occasionally close to or adjacent to critical habitat or protected areas.

The U.S. Bureau of Land Management has received pressurefrom users of off-highway vehicles since the early 1970s to provide easy access to the desert, and places for unrescricted play (e.g.,USBLM 1973,1980,2019). Several off-highway vehicle "Open Areas" where unrestricted vehicleuseoccurs weredesignated i•n California in1980and reaffirmed with the Desert Renewable Energy Conservation Plan in California, resulting in the gradual loss of ca. 898 km^2 of good, if not prime, tortoise habitat (USBLM 1980, 2016; Mark Massar, U.S. Bureau of Land Management, in litt.6 Nov 2018).

Thepressureforvehicle-orientedrecreationoff-highways and off-roads camefrom thousands of users and continues lo have a growing influence on degrading tortoise habitat through thousands of routes, trails, congregating areas for races(called pitareas),and tb.eproliferation ofunauthorized, cross-country use(e.g., BuryandLuckenbach 2002;Berry et al. 2014a). Numerous research articleson effects of vehicle travel off-road on soils and vegetation mtheMojave Desert have been published documenting severe damage to the environment (e.g., Adams et al. 1982; Webb and Wilshire 1983; Wilshire and Nakata 1976;Lei 2009;Brooks and Lair 2009).Althoughseveralmanagement plansdesigned to limit off-highway or off-road use were publisbed, proliferation of these uses into unauthorized areashas continued on both federal andprivatelands(USBLM1973,1980,2016,2019). Inpartsof critical habitat in the western,cenIra!,and southern Mojave Desert, visits and visitor days recorded annually from 2008 to 2018 ran,gedfrom 55,874 to 94,474 visits and from26,218 to90,445 visitordaysperyear(USBLM2019, Table 3.6-4). Off-bighwayand off-road usebas also grown in the Colorado Desert in the Chuckwalla Bench critical habitat, wberesome vehicle users have pushed down signs indicating "closed to vehicleuse"and dri.ven into sensitive areas, such as washes (Berry, pers. obs., 2018).

As of 2017,existing.routesand ttails developed by off-highway vehicle users covered an estimated 3,765 km in critical habitat in tbe Western MojaveRecovery Unit alone, with an additional148 lan^2 negatively affected bystopping, parking, and camping adjacent to the trails and routes (USBLM 2019).These figures do not include unauthorized tracks, trails, and routes, which are common in the region (Goodlett and Goodlett 1992; Keith et al. 2008; Egan et al. 2012; Berry et al. 2014a; Piechowski 2015).

The high density of off-road routes and trails, bot·h authorized and unauthorized, in. cdtical habitat and other sensitive areas forrare, threatened, and endangered species in this reg.ion continues to be of concern to nonprofit organizations and government agencies and is the subject of court cases (USDC 2009, 2011). The final management plau developed by the U.S. Bureau of Land Management for federal lands (USBLM 2019) indicates only 3,314km of open and limited routesfor off-highway vehicle (OHV) use, and 98 km^2 for camping, parking, and stopping adjacent to routes within critical habitat. When all disturbances from transportation linear features (all linear features on the ground) are considered, the figure is 4,l73 km(USBLM 2019, Alternative 5). Therefore, density of existing linear disturbances from OHV routes and otherlinear transportationfeaturesin critical habitat in the Western Mojave.RecoveryUnit is 1.05kmflun[1] (4173 lo:n/3963 km^2 of critical habitat). These fi_gures do not include individual tracks or areas degraded frorn parking, camping,and stopping ofOHVs,.tnining,piospheres created by livestock grazing,andother land uscs.Altl10ugh figures are not availablefor other Recovery Units, the Colorado Recovery Unit faces increasing and new pressures from unauthorized c,ross-couutry vehicular travel.

Subsidized Pr-edators. - Direct links exist between subsidies for Common Ravens, Coyotes, and dogs (e.g._, road kills, trash, and domestic pets) and desert cities, towns, and settlements. Thjs also involves transportation conidors (roads, railroads, utility corridors), renewable energyfaciIities,andrecreation vehicle use areas(Boarman 1993; Knight and Kawasl1ima 1993; Knight et al. 1993, 1999; Pcdriani et al. 2001; Kristan et al. 2004; Esque et al. 20.LOa; Cypher et al. 2018).Utility poles and transmission line towers serve asperches for foraging ii!ld nest sites for ComrnonRavens,allowingaccesstopreviouslyuninhabitcd or rarely used and remote parts of the desert.

In surveysconducted in the eastern Mojave Desert, the Colllmon Raven was I.be most commonly observed bird (Knight et al. 1999);*it* also was the mostcommon species observed over seven survey years at the Desert Tortoise Research NaturaJ Area in the western Mojave Desert between 1979 and 2012 (Berry et al., in review). Ravens form srnall and large flocks (250 to 5,900 individuals) at roosts in trees and along utility lines in or near desert towns aud ex-urban areas in the western, southern, and eastern Mojave Desert (Tim Shields, pers. obs. 2011 to 2018; Debra Hughson.,pers. obs.).Ones.ucb roost covered an area of0.8 x 0.8km and regularly had from 1,000 to 5,900 ravens. Shields (pers. obs.) reported that counts peak in late fall and winter. Kristan and Boarman (2003) in a study of raven predation on tortoises in the western MojaveDesertdescribed patternsof spillover predationand hyperpredatioh and stated that "anthropogenic resources for ravenscould indirectly lead to the suppression.decline. or even extinction of desert tortoise populations." Ravens also were observed to attack adult tortoises (Woodman et al. 2013).

Another subsidized predator, the Coyote,kills and cats tortoises.In a study ofilinesites IntheMojaveDesert,Esque et al. (2010a) reported that high mortality of adult 'tortoises correiared with sizes of nearby human populations, surface roughness of the landscape, and size and sex of the tortoise. Potential contributing factors were distance of the human population and density of roads.Tortoises weremorelikely to be killed during and a(ter droughts, when populations of typical prey-hares and rodents-were low. Mortality rates at the nine sites ranged from O to 43.5%; two sjtes experienced no deaths. In a 5-year study of Coyote diets in the central MojaveDesert, Cyphereta!.(2018) reported that in years of low precipitation, the diet of Coyotes included more anthropogenk food items.They also observed higher frequencies of tortoise remains tn Coyote scats in tl1e two years following releases of translocated tortoises.

Domesticdogs,alsosubsidized predators,attack,injure, and kiJI captivetortoises and were observed to attack wild tortoises (Boyer and Boyer 2006; Berry etal.2014a; Berry, pers.obs.).Dogsoccursingly and in large packs(e.g.,12-35 dogs) and have been observed in the western, central, and southern MojaveDesert(Berry,Rhys Evans,MichaelTuma, MarkBtatton,pers.obs.).Wtthoutexception,dog packs were close to 0:1.ilitary installations and associated with urban or ex-urban settlements. In all observations, dogs threatened the field workers.

Habitat Degradation. - Many sources of habitat degradation exist, such as military maneuvers, livestock grazing, and mining. Military maneuvers (tanks, other vehicles, troops) have negative effects on toJtoise habitat. DuringWorld WarU,between 1942and1944,General Patton trained an estimated one miIlion troopsfor North Africa on 50,000 km^2 in southeasteni California, southern Nevada, and westem Arizona, using thousands of tarixs and other vehicles (Prose 1986; Prose and Wt.lshire 2000). In 1964, Operation Desert Strike trained ia lilUch of the same area and covered 2,000 km^2. The affected habitats extend from thecentral Mojave Desert i11 the Western Mojave Recovery Un1t east into theEastern MojaveRecoveryUnit,and south to the entire Colorado Desert Recovery Unit

Depending on site and yearof impact, tank tracks from military vehicles and camps caused substantial and often significant and negative effects on soils and plants {Prose 1985, 1986; Prose et al. 1987, Prose and Wt.lshire 2000). Examples include,butare notlimited to,compaction of soils in tank tracks, lowered infiltration rates of soil, removal of the top layer of soil,and alteration of densities of drainage channels. Recovery of cryptobiotic crusts was lower in tank tracks (Prose and WiJsb.ire 2000). Cover and density of creosote bushes were greatly reduced where significant alterationsoccurred in the substrate;pioneerspeciesofshrubs dominated in mostdisturbed areas(Proseel aJ. 1987).Cover of some annual forbs consumed by tortoises, e.g., desert dandelion *(Malacothri.xglabrata)*and Fremont's pincushion (*Chaenacti.s fremoritii)* was lower in tank tracks (Proseand Wilshire 2000). However,annualforbs were oftenin higher densities in tank tracks thanin control areas,but plants we{e smallerin *si1,c.*Grasses also wern in greaterdensitiesin rank tracks.As of 2018, the scars of the tracked vehicles from the 1942 maneuvers remained evident on desert pavement (Berry, pers. obs.).

Gra.7.ing by cattle,.sheep, horses,and feral burros began in the mid-1800s in th.e Mojave and Colorado deserts and is responsible for habitat degradation in many areas *(e.g.,* Spears 1892; Wentworth 1948; Webb and Stielstra 1978; Johnston 1987; Stone 1989; Fleischner 1994; Abella 2008). The USFWS (2010) reported that ca. 12,881.5 km^2 or approximately 50% of critical habitat was grazed at the timeof thefederal listing in 1990;subsequently 8,479.9km^2

of the allotments and leases involved wereclosed, leaving 4,401.7 km^2 (17.1%)ofcritical habitat still with allotments andleases. Recently, some allotments were renewed for 10 years in the WestMojave Recovery Unit.

Fleischner (1994) described three broad categories of negative effects of grazing to habitat,including alteration of speciescomposjtionin vegetationassociations,disruptionof ecosystem functioning, and changes toecosystem structure. Reduction in biomass and diversity of native annual and herbaceous perennialspecies bas remafoed acriticaJ issuefor the Desert Tortoise, a selective forager, as bas competition for forage (e.g., Avery and Neibergs 1997; Oftcdal 2002; Oftedal e-c al. 2002; Jennings and Berry 2015).

The U.S.Bureau of Land Management, responsible for issuii:ig leases and managing allotments and licenses on public land, recognized the negative effects of sheep when establishing the Desert Tortoise Research Natural Area between 1972 and 1980 (Webb and Steilstra 1979 Berry et al. 2014a), and sheep were therefore excluded within tho boundar1es. ln 1990, the year the Desert Tortoise was listed asa Threatened species, sheep grazing was removed from areas expected to become critical habitat. Tuma et al. (2016), in a model of anthropogenic impacts to rwo study siteswithinthegeographicrange,listed grazing livestock and feral burrosasthe mostimportant disturbances contributing toseveredeclinesintortoisepopulations.Somecanlc grazing allotmeo,ts remain in critical habitat as of 2018.

Long-term grazing in the desert results in reduction and loss of cover of shrubs and changes in the species composition of shrubs; favoring short-liv.ed, weedy species (Webb and Steilstra 1979; Brooks et al. 2006). The composition and biomass of annual and pere)Ulial vegetation changes at sites where livestock concentrate: water sources, bedding areas, and loading and unloading areas(Webb and Steilstra 1979;Nicb.olson and Humphreys 1981; Brooks er al. 2006). Short-lived, coloniz,ing shrubs and non-nat'ivegi-a ses,tolerantof rusturbances and inedible or less desirable as forage by Jivestock, are more common than in relatively undisturbed areas. Brooks et aJ. (2006) described piospheres, a disturbance g.cadient associated with watering sites for domestic grazers. Vegetation was denuded and soils compacted within 15 to 70 m of th,e tanks and troughs, with significant effects extending up to 200 m from the watering sites. Densities of tbe alien forb redstem filaree and alien Mediterranean grasses increased with increasing proximity to the water source, whereas native annuals decreased in cover and species richness with increasing proximity to the stock tank or other water sources.Coverand species richnessof shrubs alsodecre3$ed with increasing proximity to sources of water. Livestock prefercert:a.inforbs, whenthey areavailable, and can rap1dly deplete available favoredfood plantsof the tortoise through trampling and foraging (Berry 1978, Webb and Stielstra 1978). The seedbank for native annuals and herbaceous perennials may also be reduced (Brooks 1995).

When livestock are moved from one place to another, whether in open desert or along stock driveways (e.g., Wentworth 1948). soils ate disturbed and cJouds of dust created. Importantly, stock tanks also are an attractant to and a subsidy used by ravens (Knight et al. 1998).Beschta et al. (2013) recommended removingor reducing *livestock* and feral burros and horses across public lands to make the lands less vulnerable to climate change.

MinerscametotheMojaveand Coloradodesertsseeking richesin the 1800s(e.g.,Spears 1892;VredenbergetaJ.1981) and mining continues to bea source of loss,distu,bance, and deterioration to tortoise habitat(e.g.,Chaffee and Berry2006; Kim eta!.2012, 2014).Early miners Leftpits,diggings, and shafts that trapped tortoises and that remain today; some shafts and pits are fenced and some are u_ot.

Chaffeeand Berry (2006), in an analysis of soil, stream sediments, and food pla1;1ts of tortoises in the Mojave and Coloradodesertsof California, reportedanomalies in arsenic deserc.wide.Jn th.eRandandAtoli.aMiningDistricts (Western Mojave Recovery Unit) they reported elevated levels in soil of arsenic, gold, cadmium, mercury, antimony, and/or tungsten 15 km from the miningsource and plantanomalies for arsenic, antim.ony, and/or tungsten up Lo 6 km from the mining source.Elevated levelsof mercuryoccurred asmuch as 6 km from old tailings piles. Arsenic and mercury were potential causes of illness in tortoises found in !he area (Jacobson et al. '1991; Selzer and Berry 2005). Elevated levels of arsenic also occurred in the Goidstone Mining District and extended outward about 8 lon. The highest arsenic concentrations occurred in 13 species of p.lants, of which five were species of legumes favored by tortoises (e.g., Jennings and Berry 2015). Kim et al. (2012, 2014) reported fluvial and aeolian transportof arsenicfromseveral mining communities (Western Mojave Rwovery Unit). Pluvial transport of arsenic from mining tailings occurred (and still occurs) ill pulses with episodic rain events, and, depending on location, extends to 15 km from the source. The authors described aolian transport to 6 km from the source and calculated the cancer exposure risk to humans. Elemental roxicanls can enter tortoises through breathing dust, consumptio,n of contaminated plants, and contact with the skin. Foster et al. (2009) identified endogenous sources of arsenic in both shell and lung tissues.

ln.vasive Pian.ts. - As a result of the disturbances to soil and vegetation described above, tonoise habitats in the Mojave and Colorado deserts have become vulnerable to invasion and establishment of non-native (alien, exotic) plants from arid areas in the Mediterranean, North Africa, Middle East, and Asia. Changes in plant composition and structure, especially cover and selected forage plants, are gi-eat threats to remaining tortoises. Several authors (e.g., D' Antonio and Vitousek 1992; Kemp and Brooks1998) suggested that most exotic species anived in the desert during the middle-to-late 18th century after the Gold Rush of I849 and became established with livestock grazing and construction of rnads and railroads. Later land-disturbing uses sucl! as agriculture, ranching. settlements, cities, and towns were additional contributors (Brooks 2009).

The following non.native species of grasses and a forb composed mostof theannual biomass intortoisehabitatsinthe early 2000s: Mediterranean grasses, red brome,cheatgrass, and redstem filaree(Huntcr 1991;KempandBrooks 1998), until the morerecentappearanceof Saharamustard *(Brcm1ica tournefortii)*(seebelow).In criticalhabitat within the Western Mojave Recovery Unit,non-native annuals composed 66% of the annual biomass in wet years and 91% in dry years, and positive correlations existed between richness of alien annual pla.ut species and density of dirt roads in a wet year and with nitrogen in the soil during a dry year (Brooksand Berry2006).Duringawetyear,totalalien biomasscorrelated positively with proximity to the nearest urban area or paved roadsand areaandnumbersof1·ecent (ires.During adry year, tolalalien biomass was negatively correlated with diversity of annuals and positively correlated with biomass of native annuals,and thehistory ofoff-highway,recreational vehicle use.Totalalienannualbiomass,especiallygrasses.con-elated positively with numbers of fires and area burned between 1980 and *1994* within 5km.of sampled plotsin both wetand dry years, likely due to the flammability of alien grasses. Further,Brooks (2000, 2003) found that non-native grasses wereespecially effective in competing with nativeforbs and the exotic forb redstem filaree.

Increased atmospheric nitrogen deposited in soilsfrom urban or other areas enhances dominance of alien annual plants, which in tum contributes to increases in frequency of fires (e.g., Brooks 2003; Rao and Allen 2010). Rao et al. (201I) followed with additional studies, and reported I.hat large-scale patterns in disturbance and exotic species negati\lely affected diversity of nativeannual plant species; native annuals persisted locally, however. Increases in atmospheric CO_2. ao effecl and cause of global climate chaJJge, may enhance thelong-termsuccessand dominance of exotic annual grasses (e.g., red brome) in the Mojave Desert (Smith et al. 2000).

Seed banks reflected the statusofha.bitat disturbance and invasion of alien species. At the Desert Tortoise Research Natural Area (fenced to exclude off-road vehicle use and grazing),Brooks(J995)reported thatseed biomass was two to fourtimesgreater inside thefencethan outside.Schneider and Allen(2012) noted that where invasions of non-natives were low, seeds of natives were in higher densities in seed banks, In high invasion sites, non-natives were higher in both seed banks and above-ground vegetation. Esque et al. (2010b) reported that invasive species (Mediterranean grasses, bromes, redstemfi1aree,and *plantain,Plantagospp.)* composed >95% of the seed bank following experimenta] tires of moderate temperatures in the Parashant NationaJ Monument of Arizona.

The non-native and invasive Sahara mustard was observedfirstintheColorado Desertin the 1920s(Minnich and Sanders 2000). Subsequently, it spread rapidly northward and westward into th.e ojavc Desert (museum records, Jepson Flora Project 2018; Berry, pers. obs.). lt has invaded most Recovery Units and is well establisJ1ed desert-wide. It can grow Up to> J .S m in height, produce large numbers of seeds, become a "tumble mustard" tbat can blow across landscapes, and appears to be a vigorous competitor of native annuals in the Mojave and western Sonoran deserts (Trader et al. 2006; Bangle et al. 2008; Bartowsetal.2009;Berry etal.2014b).Sahara mustard is a highly successful invaderthatpi-obablyposesa considerable threat to nati 'e annuals because of early germination and rapid phenology, and its ability to disperse qu.ickly across valleysandfansan.cl in ephemeral stream channels(Bangle et al. 2008; Marushia et al. 2012; Suazo et al. 2012; Berry et al. 20141:>). Desert Tortoises do not forage on Sahara mustard.

Fires. - Fires and invasive annual grasses are closely linked (D' Antoni.a and Vituosek 1992). Vegetation in the Mojave and western Sonoran deserts did not evolve with fire;occasional wildfires, ignited by lightning or campfires, occurred but were small because fuel was limited (Brooks and Chambers 20 ll).With the invasion and establishment of alien grasses, fuels became available and created an unnatural and destructive grass-fire cycle it1 which fires increased in frequency and area,potentially in intensiry,and werefollowed by regrowth of the alien grasses(D'Antonio and Vitousek 1992; Brooks and Matchett 2006).

According to D'Antonio and Vitousek (1992), the invasion of cheat grass and associated fire-s was the roost signi'ficanr plant invasion in North America. Mediterranean grasses and red brome also play important roles and have different rates of fire spread across interspaces-slowly and discontinuously with Medite,:ranea.11 grasses and more rapidly and continuously with bromes (Brooks 1999). The resultssuggested that red brome and cheatgrassfueledfaster moving, hotter fires, while Mediterranean gr!l,Sses fueled slower moving, cooler fires.

Fires increased in frequency between 1980 and 2004 across the Mojave and Colorado deserts in critical habitat and in California (Brooks and Esque 2002; Brooks and Matchett 2006).The latter authors reported lhat8,699 fires bumed2,920km^{1}between1980and2004.Mostfiresoccurred in shrub associations at middle elevatjo11.s where typical torroise habitatoccurs, e.g., creosote bush, Joshua tree, and blackbrusb vegelation associations. In 2005, a total of 576 km^1 burned in the northeastern Mojave Desert and Upper

Virgin River (USFWS 2010). The percentages of critical habitat bu11,1ed varied: 3% of Monnon Mesa, 13% of Gold Butte-Pak0<,m,25% of Beaver Darn,Slopein the Northeastern Mojave Recovery Unit,and 19%of the Upper Virgin River Recovery U11it. Many tortoises died, but numbers were not provided in the USFWS (2010) report.According toBrooks and Matchett (2006), the trend from the 1990s and on for human-caused fires was Loward a decreasing m1mber of ignitions and a greater area burned.

Burned habitat affects the tortoises living there. Drake et al. (20J5) studied how tortoises respond when about 45% of their home ranges were burned after a lightning-caused fire.They traveled increasingly deeper into the burned area to forage during the first 5 years post-fue, but returned to the unburned area for cover. One of the impoctant forage p)ants common after the burn, globemallow, declined &-7 years after the bum. At that time, tortoises reduced use of the burned area.[n spite of damagefrom the fire, tortoises maintained reproductive output and health during the srudy. Lovich et al. (2018a) compared populations of tortoises in burned and unburned areasafterawind turbine fire; tortoises in tho burned area continued use of the same activity areas after thefire.

Briefly, the many sources of habitatlossanddegradal'ion contin.ue to have profound negalive effects on the diversity, composition, and biomass of native annual and herbaceous perennial forbs and perennial shrubs and, importantly, the food supply and cover of shrubs essential for continued survival of *G.agasskii*.This pattern of changesand loss to the flora are not confined lo the tortoise (Minnich 2008).

Climate Change and Projected Effects. Global wanningandchangesin rainfall panemsare added negative impacts (Seager et al. 2007, Gartin et al. 2014; Allen et al. 2018; Sarhadi et al. 2018) and arc likely to have severe effects on remaining, declining, and fragmented Desert Tortoise populations. The U.S. Global Change Research Program (USGCRP 2017) has predicted increased drying with reduced winterandspringprecipitation in theAmerican Southwest. Reduced precipitation in winter and spring (droughts)audhigbertemperaturescontributetodeterioration in composition, structure, diversity, and biomass of trees and shrubs (Munson et al. 2016). Annual and herbaceous perennial plants would besimilarlyaffected.Forageof native food plants is likely to become more limited in dry years (see Brooks and Be1ry 2006).

Models of the effects of climate change and wanning on tortoises at the Mojave-Sonoran inte1faceindicated that someavailable habitat will belost(Barrows 2011).Tortoises may respond by shifti11g distribution ro higher elevations and away from the western Sonoran Desert if they have time and opportunity to do so. With increasing droughts, survival of tortoises is likely to be severely reduced (e.g., Berry etaJ.2002;Longshoreet al.200); Lovich et *al.*20i4b). Climate refu.gia can be modeled to identify areas where existing populations may survive at wanner temperatures and where tortoises may be successfully translocated (Barrows et al. 2016). Such models will need to take into account the prediction "that the-risk of American Southwest megadroughts will markedly increase with global warming" (Steiger et al. 20.19).

Consequences of Fragmentation. - The many land uses described above have resulted in degradation, fragmenration,and lossofconnectivitybetween populations within tb.e metapopulation of *G. agassizii.* As habitat fragments become smaller and increasingly isolated, they become more vulnerable to increased genetic drift and inbreeding, reduction of genetic variation, and decrease in heterozygosity-an ex:tin.ction vortex (Gilpinand Soule. 1986; Fagan and Holmes 2006). With the rapid decline in densities of tortoises in critical habitat units between 2004and 2014, and the non-viability of many populations in critical habitat (USFWS 1994, 20ll), the remaining populations are increasingly vu!nerable to addition.al disturbances, long periods of drought, and catastrophic events. The impacts and demands of rapidly expanding human populations across the geographic range add to the severity of the problem(Hughson2009).

Recovery of Habitat after Disturbance. - Tortoise habitats are likely to require Cenruries, if not thousands of yearsfor recovery. Creosote bushes, a prominent species in tortoisehabitat,formlong-lived clonesin theMojave Desert and sor:nc very large clones are estimated to be.as much as 11,700 yearsold(Vasek1980).Over thepastapproximately *10*years,scientistshaveinvestigated how quicklyvegetation can recover natllI<\lly after disturbances in creosote bush associations in the Mojave and Sonoran deserts. Most studies in tortoise habitats focused on natural recovery of shrubs (with minimal interventions) afterdisturbances from pipelines,aqueducts, borrow pits,andold militaryactivities (e.g.,Lathrop and Archbold 1980a,b; Vasek et aL l975a,b: Prose et al. 1987; Abella 20IO; Berry et al. 20J6b). The composition of perennial shrubs goes through successionaJ stagesin therecovery process,Estimatesforthetimerequired for recovery to pre-disturbance values for canopy cover of shrubs may bedecades, whereas a retum to pre-disturbance levels for flotistic structure and composition may require centuries.

Pew publicatious existonnatural and enhanced recovery of communities of native annual and herbaceous perennial species after different types of disturbances (Johnson et al. 1975; Vasek 1979,1980, 1983; HessingandJohnsoo 1982; Prose and Wilshire 2000; Berry etal.2015b). Vasek (1983) suggested that "some constellations of annual species may bemembers of stableoldcommunities [referencing creosote bushscruba sociations]and thereforeprobably haveevo.lved intricate highly integrated adaptations for long persistence in stable desert conditions." Estimated recovery times for cover, fforal composition, density, and biomass of annuals vary, but are likely to be much longer than for shrubs, depending on causes of disturbance, treatment and types of the soils, and whether or not non-native grasses and forbs are present. Berry et al. (2015b) concluded that return to pre-disturbance levels may requlre many centuries in their study of annuals Tecovering after 36 years of disturbance along a utility corridor in the western MojaveDesert.During the recovery process, annual communities may go through several seral stages(HessinganclJohnson 1982; Ben:y et al. 2015b).

Cumulative and Synergistic lmpllcls. - We nave reviewed numerous causes of declines and how many of thesecauses-arelinked to each otherand to human activities. 1n response to requestsfrom managers to identify the most important cause(s), some scientists have quantified and modelled negative impactsinspecificareas(e.g.,Keithet al. 2008;Berry et aJ.2008,2014a;Tumaet al.2016).Berry etal. (2014a) reported thatin critical habitat with recentexclusion of livestocl{, limited vehicular traffic, and a partial fence, tortoise abundance (counts of live and dead tortoises and tortoise sign) wasnegatively associated with vehicle lrncks and positively associated "Vilh mammalian predators and debris from firearms. Tuma et al.(2016) modelled severity of population decline rates al two sires, one in the central Mojave Desert and another in the northeastern Mojave Desert. lothe central MojaveDesert, modelsindicated that the most severe decline rates were associated with human presence, followed by subsidized predators, and habitat degradation on inholdings. fn contrast, in the northeastern MojaveDesert(Gold-ButtePakooncritical habitat),livestock and feral burros were associated with the most significant declines,followedby humanpresence,subsidized predators, and wildfires.

Conservation MeasuresTaken. - *Gopherus agassit.ii* has been listed as federally Thxeatened under the U.S. EndangeredSpeciesAct(USESA)since 1990.It wasassessed asVulnerablefortheIUCNRedLJstin l996andprovisionally re-assessed for the Red List as Critically Endangered by the IUCN Tortoise and Freshwater Turtle Specialist Group in 2011 and again in 20l8 (TCC 2018; Rhodin eta!.2018). It has been listed on Appei1dix II of OTES(2017) since 1975 as part of the genus listing of *Gopherus*, and since 1977 as partof the family Ii.sting of Testudinidac.

Gopherus agassizii occurs in several areas with some degree of protection.The Desert Tortoise Research Natural Area in California is the most protected, followed by the Red Cliffs Desert Reserve in Utah. Limited prmection is available in three national parks, especially in remote areas and wheresui.table habitar exists (JoshuaTree National Park andMojaveNational Preservein California,andDeathValley National ParkinCaliforniaandNevada) andeightstateparks (Red RockCanyon State Park,Anza BorregoStatePark,and Pro"idencc Mountains State Recreation Areain California; Red Rock Canyon National Recreation Area.Valley of Fire State Park, Lake Mead National Recreation Area, and the Desert National WildlifeRangein Nevada;andSnmvCanyon in Utah).Noneof the national or state parksprotect tortoises frompaved ordirt roads with exclusion fencing,and at least one of the national parks (Mojave National Preserve) still maintains a cattle grazing allotmentand feral burros within critical habitar.

Tortoises in parks with heavy visitor use are vulnerable to collecting and vandalism and road kills (e.g.. Berry et al. 2008; Hughson and Darby 2013). For example, Mojave National Preservecontains twocritical habitatunits(1vanpah and Fenner); in both, tortoise populations are declining (Table3). Visitor usein thePreservebetween 2004and 2018 ranged from 537,250 to a highof 787.404 peryea:r in 2018. In contrast, Joshua Tree National Park had a low density of tortoises. but the population was increasing (Table 3); visitor use in lhe Park was 2,942,382 in 2018. Lake Mead National Recreation Area has had over one million visitors per yearsince 1946 and growing;in 2018, 7.6million visits occurred.

As noted in the section on Threats, the Stale of California took incremental protective measures for tortoises begim:ii ngin 1939.Grass-roots efforts ad"ocating greater protection forasitewith highdensitiesbeganin the earlyI970s with the establishment of the Desert Tortoise Research Natural AreaiTJ the we stern Mojave Desert.The formation of the Desert Tortoise Preserve Committee, Inc. and Desert Tortoise Council, two non-profit, tax-exempt organizations, occurred about 1976. The Desert Tortoise Preserve Committee focuses l!fforts on public education, land acquisition and protection,'f.encing of protected areas, removing livestock grazing nd recreational vehicle use from the DesertTortoise Research Natural Area and other acquired lands.and research.The DesertTortoiseCouncil's goals and objectives include education through ammal symposiaand workshops, grantsfor travel and studies,and participation in government activities affecting tortoises and their habitats. Both organizations have promoted state and federal listings of the tortoise as a Threatened species. Afterthe Beaver Dam Slope population of DesertTortoises was federally listed as Threatened in 1980 under the U.S. Endangered SpeciesAct(DSFWS1980),theDesertTortoisc Council submitted a comprehensive report to the U.S. Fish and Wildlife Service in 1984 to also list thetortoise throughout its range (Berry 1984). Studies and research on the tortoise and its habitats, supported by federal and state agencies and academia, began in the early1970s and continued intermittently thereafter.

fn 1980, the U.S. Bureau of Land Management, the agency managing substantial amounts of tortoise habitat range-wide, published *rheCalifomia Desert Plan, 1980.* The Plan described lhe Desert Tortoise as a sensitive species, identified several crucial habitats (precursors to critical habitat units),establisb.ed Areasof Critical Environmental Concern for the tortoise, and outlined expansive areas for future habitat management plans for the species (USBLM l980). The Desert Tortoise Research Natural Arca was formally designated in this Plan, a protective fence surrounding the areaand a kiosk for visitors were completed, and a long-tem1 mark-recapture srudy was initiated.In 1989,Califomiadesignated the DesertTortoise as aThreatened species(California Department of Fish and Wildlife 2016).The U.S.Fish and Wildlife Service listed the tonoisc as Endangered on an intc,;im basis in Aug11s1 of 1989 and issued a final rule as Threatened lo April of 1990 (USFWS 1990).The U.S. Fish and Wildlife Service published a Recovery Plan in 1994and designated>2.5,000 km[1] of critical habitat units nortb and west of the Colorado River in the same year(USFWS 1994). ln response to the pending listing and designation of critical habitat, federal, state, and county governments formed a Management OversightGroupcomposedof seniormanagerswhoaddress a wide variety of topics associated with recovery of the species at meetings held at least once a year.

The 1994Recovery Plan contained numerous recommended management actions for Desert Wildlife Management Areas (defined as the best examplesof DesertTortoise habitatwithinregions):securehabital,developandimplement reserve-level management, monitor tortoise populations within recovery areas, and develop environmental education programs (USFWS 1994). Several examples highlight recommended regulationsand activitiesto be prohibited: all vehicle activity off designated roadsand all competitive and organized events on designated roads; habitat-destructive surfacedisturbancethatdiminishescapacityofland tosupport tortoises; domestic livestock grazing and gra1jog by feral burrosand horses; vegetationharvest,except bypecmit;collection of biological specimens, except by pennit; dumping and littering; deposition of captive or displaced tortoises except under authorized translocatioo research projects; uncontrolled dogsoutofvehicles;and dischargeof firearms, exceptforhuntingofgamefromSeptemberthrougb.February. The recommended actions included the following: control vehicular access; enforce regulations, restore disturbed areas; sign and fence Desert Wildlife Management Areas; implement appropriate adminisrration; modify ongoing and planned activities to be consistent with recovery objectives; control use of landfills and sewage ponds by predators of tortoises; and establish environmental education programs and facilities.An import.ant recommendation wascomonitor tortoise populations in critical habitat units at a landscape scale.This latter effort was initiated in 1999 and the early 2000s. e.g.,Table 3.

Government agencies responded to the Recovery Plan by preparing nine new or revised laud management plans to better protect the Desert Tortoise on public lands (Berry 1997). Additional plans on military installations were revised or amended to include the DesertTortoise. In 201 L, the USFWS published a revised Recovery Plan which incorporated many actions described ia the ·first Recovery Piao (USFWS 1994, 2011). The revised Recovery Plan described numerous recommendationsfor future research. Ooe important issue, hyper-predation by ravens, was the topicof a special plan, which has involved surveys, selected removal of Umited numbers of ravens. and egg-oiling (USFWS 2008). Part of the revised Recovery Piao was development of regional Recovery Implementation Teams composed of representativesfrom governmentagenciesand aon-profit organizations.Participants in fuese teams prepare proposals for recovery actions, seekfunding to support lhe proposals, and assist with implementation when funding becomes available.

In the nearly 30 yearssince the DesertTortoise wasfirst listed range-wide in 1990, much has been accomplished by changes in I.and use. Unfortunately, positive actions have remained insufficient in amounl and extent to stabilize tortoise populations in the designated critical habitat units (USFWS 2015;Table 3;Allisonand McLuckie2018).Land acquisition for the Desert Tortoise Research Natural Area, which began in the late1970s,bascontinucd.TheU.S.Bureau of Land Management and other government agencies and conservation organizations haveacquired substantial amounts of private lands in small-and large parcels to convert critical habitatand otherprotected areas to federal and conservation management.

Sheep grazing bas been removed from critical habitat, butcattle continue to grazeon about l 7% of critical habitat, and feral burros encroach on a few critical habitat units. Tortoise-exclusion fencing was constructed along many kilometers of roads; however, as of 2010. thousands of kiJomcrcrsofroadsandrai]roadsremainedunfenced(USFWS 20 JO).Experimental efforts torcducevehiclespeed onroads within the Mojave National Preserve to reduce road kills were unsucq:ssful (Hughson and Darby 2013). One of the more intractable problems is the high density of routes and tracks created by recreational vehicle use,the high levels of unauthorized and cross-country travel on 2- and 4-wheeh:d vehicles,and thenegativeeffectson tortoisesand thcir habitats (Goodlelt and Goodletl L992;Egan et al.2012; Piechowski 2015; USBLM 201.9).

The federal (and state) listings of the Desert Tortoise as Threatened Slimulated a great deal of interest and effort in addressing basic questions about the species, such as starus and distribulion of populations. ecology, genetics, and diseases, as well as solving conflicts with the many users of Desert Tortoise habitats. Conflicts existed over degradacion of habitat and threats to Desert Tortoises from historical users (livestock grazing, mining, aud recreation), developers, and some government agencies. Otheragencies,academicians.and no1l-profitorganizalions held more conservation-oriented views. As a resuJt, many basic and applied research projects were undertaken and completed,and the results were published in peer-reviewed journals between 1980 and 2018 (Grover and DcFalco 1995;>400 published papers, Berry et *al.* 2016c). Notably, many agencies and developers provided substantial funds to support studies and research, e.g., U.S. Department of lhe [nterior (U.S. Bureau of Land Management, U.S. Ge-ological Survey), U.S. Department of Defense (Army, Air Force, Marines), California Department of Fish and Game, California Department of Parks and Recreation, California Energy Commission, Utah Division of Wildlife Resources, and several universities. 'Many other entities also provided funds but not on the same scale.

Twocurrent conservation research topicsare augmentation of populations through head-starting and translocation. Experimental research has been conducted and continues in four desert regions on head-starting to learn more about neonates and juveniles arid their habitat requirements, to determine factors affecting survival both before. and after release.and toaugmentdepleted populations (e.g.,Morafk.a etal. 1997;Wilson et al. l999a,b, 2001;Nagy ctal.2015a,b, 2016;Todd etal.2016;Mack etal.2018).However,caution needs to beexercised,as some researchman.iptilations,such as crowding in head-start pens and cystocentesis of adults, can lead to increased morbidity and mortality (Berry et al. 2002; Mack et aJ. 2018).

TranslocatioJ1S to remove Desert Tortoises frolJl areas scheduled for development continue and are important research topics (e.g., Field ct a\. 2007: Nussear et al. 2012; Farnsworth ct al. 2015; Rinderle et al. 2015; Brand et al. 2016; Nafus et al. 2016; Mulder et al. 2017; ttenen 2018). Most research topics on translocatjoa were shortterm (1-3 years).The research undertaken by Farnsworth et al. (2015), Brand et *al.* (2016), and others were for short-distance translocationscovering fiveyears. When all elements of this study are published, they will provide a valuable addition to tb.e topic. Publications preparatory for and during mixed long and short-distance translocations include Esque et al. (2010a),Berry et al. (2015a),aodMulderetal.(20l7).When these longer-term projects (10 years) are published, more information will be available on survival of translocated anima!s.Inan importanlpaper,Mulderetal.(2017) reporled ongeoeticintegrationoftortoises translocated longdistances. After four years, translocated males produced significantly Jewer off-spring tba11 resident males in the same area.The length of delay in integration of tr;mslocated .males into residenl populations needs to be addressed through future research.

Another important recovery objective is restoration of disturbed and burned Des.ert Tortoise hab:itats (e.g., Abella 2010; Abella and Newton 2009; Abella and Berry 2016; Abellaetal. 2009,20.15a,b).T0pics beingaddressed include methods for salvaging soils and seed banks, restoring seed banks of native plants, improving survival of shrubs after seeding and planting, keeping transplanted shrubs aliveand growing, and plmting forage species for tortoises.

Conservation Measures Proposed. - Most of the >400 paperspublishedonDesertTortoisesand theirhabitats after thefederal listing in 1990 contained recommendations for recovering the tortoise and its habitats (Berry et al. 2016c). The revised Recovery Plan also contains a list of recovery actions to be taken, including development of partnerships to facilitate recovery, protection of existing pop11Jations and habitat, augmentfng depleted populations, conductingapplied researchru1d modeling.and implementing an adaptive management program (USFWS 2011). The Recovery implementation Teams have submitted projects for restoration of burned habitats and areas denuded by livestock, management of tmsh (a source of food for subsidized predators), control of invasive plants, fencing of major highways, and many other topics.

Research on geneticsof tortoi.sesprovidesaframeworkfor changes in management.The most detailed geneticanalyses of tortoise populations published Lo date (Sanchez-Ramirez et aJ. 2018) provided data on population differences within and between recovery units.as well as identification of 12 geneslikelyinvol ved in adaptations.The resultsof thispaper suggested that the Western Mojave Recovery Unit could defensibly be divided into three separate Recovery Units: western,central,and southern,sincethesethreesubunits are genetically equivalent to each of the other four Recovery Units. The results also suggested that it could be valuable to update Averill-MuTTay and Hagerty (2014), who had used Hagerty and Tracy (2010) and Hagerty et al. (2011) as a basis to suggest that 1ortoises could be translocated within a 200-276kmstraight-line radius of their nativesites without moving animalsbetween different geneticsubunits. The resultsof Sanchez-Ramirez eta!.(2018) suggested that caution is warranted when implementing such a practice, since such distances may involve different genetic units or subunits.

Another publication by Drake et al. (2017) coupled standard cljnical and classic blood diagnostics with gene transcription profilesinilland normal tortoises.Thesefindings indicate promisefor more robt1st diagnostic procedures in evaluating ill and healthytortoises andfor tortoisessubjected to disturbances. Publications of the .genome sequences for G. *agassizii* and *Mycoplasma resrudineum* provide a basis for further advances *in* diagnostic procedures (Tollis et al. 2017; Weitzman et al. 2018), with Weitzman et al.. (2017) offering another example through a comparison of different testing techniquesfor the pathogeD.*M. agassizii* with range-wide samp)jng.

Captive Husbandry. - Captive husbandry falls into two categories: research associated wit.b head-starting and augmeotingwildpopulations(seeabove),andmana,gemeotof tortoises keptaspets,inmany casesfordecades.InCalifornia, 13 chapters of the California Turtle and Tmtoise Club manage adoption programs for domesticorpel*G.agassizii* and other chelonian species under agreements with the CaliforniaDepartment of Fish and Wildlife(htips://tortoise. org/). In Nevada, this function is accomplished byTortoise Group(https://tortoisegroup.org/).Theseorganizations (and others) provide information on husbandry, state and federal reg1 1lations, and education.

Current Research. - Research on basic ecology, demography, and distribution continues, as does in-depth work on genetics, infectious and other diseases, epidemiology of diseases,effects ofanthropogenicactivities on tortoises, augmentation of populations, and effects of drought and global cljmate change. Updates on modelling viability of populations, survival rates of the different size classes, and causes of death are important building blocks for recovery strategies and adaptive management. Ongoing applied research focusesona widearray of topics, sucl1as effectiveness of different augmentation strategies, including h_ead-starting and translocation, control and management of subsidized predators, and restoration or habitatsdegraded by livestockgrazing,recreational vehide use, and industrial and energy de'1elopments. The effects of different anthropogenic impacts on tortoises remain an area of interest. New technologies (e.g., drones) are also areas of interest.

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[EXTERNAL] Please reject the application for the Golden Currant Solar Project Variance

[redacted]

Tue 7/19/2022 1:13 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

To whom it may concern,

Approval of the project would result in the removal of tens of thousands of Mojave yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.

The project site is located in important desert tortoise habitat. When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions . Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range.

Nearly 50 percent of the project site is made up of badlands eroded by canyons and over a 5 percent slope. This topography would need to be leveled to accommodate solar panels.

The project site contains old biological soil crusts and desert pavement that is about 100,000 years old. Removal of the desert surface and clay-based badlands topography will result in uncontrollable fugitive dust. This will impact public health in nearby Pahrump, Nevada and Charleston View, California.

The project site contains hundreds of rare Parish Club Cholla, mesquite, kit fox, desert iguana, burrowing owl, coyote and several other species. Millions of living organisms would be killed in the construction of the project.

The project will probably require up to 1,200 acre-feet of water for construction and additional acre-feet each year for operation. The Pahrump Valley Basin is over-drafted by 12,000 acre-feet.

The project will destroy habitat for mesquite and associated species, a unique groundwater dependent habitat.

Solar projects can mimic lakes and will often kill a number of bird species. The project would be in the vicinity of Stump Spring and the Amargosa River which attract several birds.

The project would be located less than 2 miles from the Old Spanish National Historic Trail. Developing an industrial eyesore so close to the trail will destroy the historic character of the region.

The project will cut off access to over 7 square miles of public land and be visible from recreation trails, Highway 160, Mt. Charleston, the Kingston Range Wilderness in California and the South Nopah Range Wilderness also in California. Public access would be impacted on the Front Site Road and to Cathedral Canyon.

The Bureau of Land Management should not even consider reviewing this application until the Southern Nevada Resource Management Plan can be updated. The plan is outdated by 25 years. Visitor use to the Tecopa Road has increased in this time and the visual resources along with other resources need to have better protection.

To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project.

Sincerely,
[redacted]

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FW: Golden Currant Solar Project - question submitted during public info forum

Klein, Matthew D <mklein@blm.gov>
Wed 7/20/2022 10:32 AM
To: Ransel, Beth E <bransel@blm.gov>;Headen, Jessica A <jheaden@blm.gov>

FYI: This is my response to [redacted] request that I provide him with specific citations within the Solar PEIS regarding the identification of Variance Areas. -Matt

---

From: Klein, Matthew D
Sent: Wednesday, July 20, 2022 10:28 AM
[redacted]
Subject: RE: Golden Currant Solar Project - question submitted during public info forum

[redacted]

Good morning. Thank you again for participating last night in the virtual public input forum.

I hope the information I am providing here helps answer your question regarding the establishment of solar Variance Areas in BLM's 2012 Final Programmatic Environmental Impact Statement (Solar PEIS).

Each of the Solar PEIS sections referenced below may be viewed online at this location:
https://solareis.anl.gov/documents/fpeis/Solar_FPEIS_Volume_1.pdf

- Solar PEIS Volume 1 - Section 2.2.2 explains that the Solar Energy Development Program Alternative (the alternative that was ultimately selected for implementation) proposed categorizing BLM-managed public lands as either [1] solar "Exclusion Areas", [2] Solar Energy Zones, or [3] solar Variance Areas.
- Section 2.2.2.1 provides a detailed description of how solar Exclusion Areas were identified using 32 exclusion criteria (See Table 2.2-2 for the full list).
- Section 2.2.2.2 describes how Solar Energy Zones were identified.
- Section 2.2.2.3 explains that BLM-managed public lands which are outside of solar Exclusion Areas or Solar Energy Zones are identified as solar Variance Areas. Therefore, because the eastern Pahrump Valley was not identified as either a solar Exclusion Area or a Solar Energy Zone, the area is designated as a solar Variance Area.
- The BLM must follow the Variance Process described in Section 2.2.3.1 when evaluating applications for proposed utility-scale solar energy development in the eastern Pahrump Valley. We are currently following the Variance Process to evaluate the proposed Golden Currant Solar Project.
- Upon completion of the Variance Process, if BLM determines that a proposed project is appropriate for continued processing, the BLM would commence detailed analysis of the proposal in accordance with the National Environmental Policy Act (NEPA) wherein additional opportunities for public involvement are provided.

Thank you again for your interest. If you need any additional information, please let us know.

Respectfully,
Matt Klein

Matt Klein
Planning & Environmental Coordinator
Energy and Infrastructure Team
BLM Southern Nevada District Office
4701 N Torrey Pines Drive
Las Vegas, NV 89130
mklein@blm.gov

From: Klein, Matthew D
Sent: Tuesday, July 19, 2022 8:13 PM
To: [redacted]
Subject: Golden Currant Solar Project - question submitted during public info forum

[redacted]

Thank you for attending this evening's virtual public input forum. We appreciate your comments and questions.

I will look into providing you with a specific citation regarding the establishment of Variance Areas in the 2012 Solar PEIS within the next 24 hours.

Thank you.

Respectfully,
Matt Klein

Matt Klein
Planning & Environmental Coordinator
Energy and Infrastructure Team
BLM Southern Nevada District Office
4701 N Torrey Pines Drive
Las Vegas, NV 89130
mklein@blm.gov

[EXTERNAL] Golden Currant Solar Project Variance

[redacted]

Wed 7/20/2022 8:45 AM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

I fully support the Golden Currant Solar Project. We cannot allow NIMBYs to thwart our green energy future.

[EXTERNAL] NO to Golden Current solar Project

[redacted]>

Wed 7/20/2022 1:13 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

To whom it may concern

Being a Pahrump resident I raise my concern to building solar field near Yello Pine site.
WE DO NOT WANT THIS SOLAR project.

Huge Dust issues, destruction of habitat for desert tortoise (no, we know you are promising to relocate them but we know that many died with Yellow Pine's Solar).

You are going to ruin this desert, trying to exploit its resources, we need much more of the desert to stay wild.

This is unsightly, bad on every kind of environmental frontier, bad for local home prices and tourism from Vegas to Death Valley.

Please STOP this immediately.

Sincerely,
Concerned resident

[EXTERNAL] Golden Current variance project.

[redacted]

Wed 7/20/2022 12:11 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

We are residents of Pahrump, and are opposed to the Golden Current project proposed for Pahrump Valley. So many issues and uncertainties are involved here.
- It's not flat desert land, it's badlands with canyons and hills. Any bulldozing will create massive dust issues.
- You say you're relocating desert tortoise. We know what happened with the relocation of Yellow Pine tortoises- many died. There's no guarantee this won't happen again.
- You are parsing out these projects and public input one project at a time. Almost 20,000 acres are involved, and the combined effect to the valley, including the gross aesthetic effect, will impact house prices, wildlife, dust issues, etc.
- The viewshed because of close proximity to the Old Spanish Historic Trail is an issue. We are surprised NPS is ok with this. Do they know? We were involved in a viewshed study for Death Valley NP and the park service is concerned with questionable views from their properties.

Many, many questions were not really clearly answered last night. There was a lot of reassurance without solid proof of the BLM truly knowing the right answer.

NO to Golden Current!

[redacted]

Pahrump Nevada

Sent from my iPhone

[EXTERNAL] Golden Current Variance

[redacted]
Wed 7/20/2022 12:27 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

I live in Pahrump, WE DO NOT WANT THIS SOLAR project.

Huge Dust issues, destruction of habitat for desert tortoise (no, we know you are promising to relocate them but we know that many died with Yellow Pine's Solar).

You are going to ruin this desert, trying to exploit its resources, we need much more of the desert to stay wild.

This is unsightly, bad on every kind of environmental frontier, bad for local home prices and tourism from Vegas to Death Valley.

Please STOP this immediately.

[redacted]
Pahrump, NV 89060

[EXTERNAL] "Golden Currant" Solar Project: utility scale solar "large array" infrastructure - proposed to be sited on ancient, intact, natural wild desert.

[redacted]

Thu 7/21/2022 12:58 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

I have just read Basin and Range Watch's informative, detailed assessment of predictable permanent damage to the natural open spaces - to the desert tortoise ecosystem - in the areas of the proposed "Golden Currant" solar project. I agree with their opinion.

I started work as a volunteer on desert tortoise habitat recovery projects (near the proposed Rough Hat Clark project), in 2016, because of my personal strong (hardwired) attachment to these particular animals.

Then I learned, from different sources, that the continued healthy, natural existence in the Mojave, of wild desert tortoise populations, actively doing the exact, attuned environmental engineering that - only they - provide, is immeasurably important to all the lifeforms, plant and animal, remaining, in the tortoise range. Desert tortoise natural range is "protected", until it - isn't: Legal and illegal human FizBin of all kinds, occurs there (despite "protections" in the 1973 ESA). 1976 FLPMA-culture, 1872 Mining Law and similar arrangements, allow international mining corporations' venture financiering, space- and watergrabbing by commercial Realty, other "takes" by DOE and the Mil/Ind Complex.

Longterm effects of the serious slide downwards, from "higher, better" natural resource conservation law, to 1976 FLPMA level - take time and money to repair in the temperate environments, even with the return of natural biological and geophysical processes. There is geologically slow, or presently - no return - of function or health to a ruined natural ancient waterbank desert.

As a concerned citizen, - with 20 years' information I have received, collectively, from the USGS, NPS, USFWS, USFS (wildland fire), BLM, the BIA and the wild tortoise environment support community - I'm now rushing to read up about evolving photovoltaics tech, business and engineering. There are enough solid biological, geophysical and sound ecosystem management reasons to decide against destructive 2000s engineering and the FLPMA business model, but the laddered contracting continues. - Which makes it imperative to immediately stop federal permitting. Commercial, utility scale, solar "large array" infrastructure - sited -- on any ancient, irreplaceable wild desert, especially healthy, waterbanking desert like the Mojave -- should now stop, be prevented, and recalled immediately.

Please redirect speculators' hot capital investment to the microgrid concept. Critical life cycle activity - necessary work - done by all the SW US animal and plant species in the desert tortoise ecosystem - should be openly recognized, in future, as singular, essential and not a subject for negotiation.

As an "irreplaceable" resource of "uncompensable" value to the living north-central half of the western hemisphere - continued natural existence of the Mojave Desert's "biological refugia" wildlands, - actually is - more necessary - than continued existence of 1976 FLPMA-culture, and speculative investor-driven, monopolistic, energy development corporations' short-term profitability. All very big money and very sharp tech north of the Mojave, is busily evolving ways to - not - need "large arrays" on the wild desert - (GreenLink West and Gridliance), as soon as possible. That is natural.

Sited on roofs, currently mined lands, built surfaces, parking lots, contaminated or disrupted industrial properties, the new solar is more reliable. Locally sited, its actually Green generation/transmission/storage/reliable delivery - built inside industry and population centers, close to where it gets used - is already proven to out-compete the 1990s business model (a physically destructive, utility scale "large array" infrastructure installation, sited and interconnected to equally extensive, habitat-disrupting, long-distance distribution infrastructure on, of course, "free", "unlimited" "wasteland".

Please consider that there is still time to redirect solar energy development, away from serial sly pitting of natural resource project against natural resource project, and that huge reserves of private and government money are coming available to plan with, ($500,000,000, for a US-wide DOE/DOI consideration of your suggestions, requests, plans, environment concerns, in August 2022) - about allowed uses for private corporate lands, and allowed uses for public natural wildlands (PVMagazine USA, Anne Fischer, 7. July 2022). Hold off permitting, while waiting for the newer panel and storage tech "efficiency" to keep rising, and then settle into redesigns of panels and storage that work together at night, in winter, and in the low-angle light of the higher latitudes. There will be smaller carbon emissions costs for production of panels, smaller amounts of extreme toxicity in materials, and even profitable recycling of all newer engineering components in the future. There is not likely to be a good desert health, or private investment ending, to the current, timing-out photovoltaics, and their 1976 FLPMA business culture.

All of us like "solar", just not the way it - has - to be done for the developers and FLPMA: Right now. They won't need that engineering done, when the real change we need, comes and renders their "large arrays on wasteland" projects, unproductive, unprofitable and costly to decommission.

No part of the Mojave Desert was or is "free", "unlimited" "wasteland".

Thank you for the presentations.

[EXTERNAL] "Golden Currant Solar Project Variance"

[redacted]

Sat 7/23/2022 8:28 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Below is a form letter: But first from me, who has loved our deserts for decades, all I can say is every time I see one of those completed "projects" I want to barf. Seriously. Deserts are slow growing, slow populating places. Once a desert environment has been harmed, it cannot be what it used to be. Ever. I can't believe those idiotic adults who make decisions to come onto our sensitive, fragile desert areas to just destroy whole ecosystems with their machinery and bull dozers. Those decisions makers must have pea-size brains. Seriously. How can anyone in good conscience create space for solar panels on land that is occupied by wildlife when we have roofs and roads all over the USA begging for solar panels? Where is the creativity in thinking? Where is the concern for wild life? sheesh.

Please reject the application for the Golden Currant Solar Project.

Approval of the project would result in the removal of tens of thousands of Mojave yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.

The project site is located in important desert tortoise habitat. When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions . Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range.

Nearly 50 percent of the project site is made up of badlands eroded by canyons and over a 5 percent slope. This topography would need to be leveled to accommodate solar panels.

The project site contains old biological soil crusts and desert pavement that is about 100,000 years old. Removal of the desert surface and clay-based badlands topography will result in *uncontrollable fugitive dust. This will impact public health in nearby Pahrump, Nevada and Charleston View, California.*

The project site contains hundreds of rare Parish Club Cholla, mesquite, kit fox, desert iguana, burrowing owl, coyote and several other species. Millions of living organisms would be killed in the construction of the project.

The project will probably require up to 1,200 acre-feet of water for construction and additional acre-feet each year for operation. The Pahrump Valley Basin is over-drafted by 12,000 acre-feet.

The project will destroy habitat for mesquite and associated species, a unique groundwater dependent habitat.

Solar projects can mimic lakes and will often kill a number of bird species. The project would be in the vicinity of Stump Spring and the Amargosa River which attract several birds.

The project would be located less than 2 miles from the Old Spanish National Historic Trail. Developing an industrial eyesore so close to the trail will destroy the historic character of the region.

The project will cut off access to over 7 square miles of public land and be visible from recreation trails, Highway 160, Mt. Charleston, the Kingston Range Wilderness in California and the South Nopah Range Wilderness also in California. Public access would be impacted on the Front Site Road and to Cathedral Canyon.

The Bureau of Land Management should not even consider reviewing this application until the Southern Nevada Resource Management Plan can be updated. The plan is outdated by 25 years. Visitor use to the Tecopa Road has increased in this time and the visual resources along with other resources need to have better protection.

To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project."

This is from [redacted]

[EXTERNAL] Opposing the Golden Current Solar Project

[redacted]

Mon 7/25/2022 6:08 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

I already sent this email, but I received a reply: "Thank you for your email. If you are providing public input or a question specific to a project, please provide the name of the project." I thought I had put in the name of the project on the subject line. But just in case: This letter is about opposing **The Golden Currant Solar Project**.

Below is a form letter: But first from me, who has loved our deserts for decades, all I can say is every time I see one of those completed "projects" I want to barf. Seriously. Deserts are slow growing, slow populating places. Once a desert environment has been harmed, it cannot be what it used to be. Ever. I can't believe those idiotic adults who make decisions to come onto our sensitive, fragile desert areas to just destroy whole ecosystems with their machinery and bulldozers. Those decisions makers must have pea-size brains. Seriously. How can anyone in good conscience create space for solar panels on land that is occupied by wildlife when we have roofs and roads all over the USA begging for solar panels? Where is the creativity in thinking? Where is the concern for wild life? Sheesh.

Please reject the application for the Golden Currant Solar Project.

Approval of the project would result in the removal of tens of thousands of Mojave yuccas and cacti. Many of the plants are hundreds of years old and provide habitat and food to the wildlife of the area.

The project site is located in important desert tortoise habitat. When desert tortoises were moved off the Yellow Pine Site in May, 2021, just to the east of the proposed Golden Currant project site, nearly 3 times more tortoises than predicted were found and 30 of the 139 moved were killed by hungry badgers in drought conditions . Please do not allow a repeat of the recent desert tortoise disaster that took place on the Yellow Pine Solar site. Desert tortoises are protected under the Endangered Species Act and are seeing sharp declines throughout their range.

Nearly 50 percent of the project site is made up of badlands eroded by canyons and over a 5 percent slope. This topography would need to be leveled to accommodate solar panels.

The project site contains old biological soil crusts and desert pavement that is about 100,000 years old. Removal of the desert surface and clay-based badlands topography will result in uncontrollable fugitive dust. This will impact public health in nearby Pahrump, Nevada and Charleston View, California.

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To preserve diverse Mojave Desert habitat on public lands and the quality of life in Pahrump, Nevada, BLM should reject the application for the Solar Project."

This is from [redacted]

[EXTERNAL] Golden Currant Solar Project Variance

[redacted]

Thu 7/28/2022 3:48 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

To whom it may concern,

I would like to voice my opposition to the Golden Currant Solar Project. We live in a time where various singularities threaten humanity. While climate change is one of them, so are numerous other impacts of industrial modern society, including and especially habitat destruction that is causing what scientists are calling the 6th Mass Extinction. The Desert Tortoise is on the brink of extinction and these solar projects allow them to be put in harms way by being translocated away from their homes and subject to predation among other mortalities that result.

I am concerned about the air quality from bulldozing these desert habitats. This will affect human health in the Pahrump Valley and likely in Las Vegas as well.

I am also concerned about the heat island effect that scientific studies have shown occur from construction of large photovolatic projects.

You cannot simply come in with brute force and alter the balance of the natural world without severe consequences. I would look long and hard at what solutions these projects offer to anything or anyone.

Sincerely,

[redacted]

[EXTERNAL] Golden Currant Solar Project Variance

[redacted]

Fri 7/29/2022 5:52 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Dear BLM,
I am writing to strongly oppose the Golden Currant Solar Project. There are many issues to be concerned about, including the loss of desert "crust" which will lead to lowered air quality and dust storms affecting nearby communities as well as natural communities; the project will heavily impact the view, which is significant given its location near the Old Spanish National Historic Trail; the project location is right next to the Stump Spring Area of Critical Environmental Concern; the project will create heat-island effects which can affect the health of nearby communities; and so on.

The two impacts I'm most concerned about however are 1) the loss of habitat for the critically endangered desert tortoise and other animals and plants who live in the project area, and 2) the collision danger that photovoltaic solar panels present to birds as a "lake effect." Why are you considering allowing the destruction of vital desert habitat in the middle of an extinction crisis?

Instead of destroying fragile desert habitat to develop more energy, we should instead be creating energy reduction programs, reducing the size of our houses, reducing our consumption, reducing our travel, and other measures to save electricity. We cannot risk losing any more wild habitat. Not only do the wild plants and animals have the right to their habitat, human well-being is inextricably linked to healthy and flourishing ecosystems, which are being damaged and destroyed every day. Eventually we will find out we cannot live without them -- I just hope by the time we realize this, it's not too late.

Thank you

[redacted]

[EXTERNAL] Re: Comments on the Golden Currant Project Variance Process

[redacted]
Wed 8/3/2022 6:34 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

I have re-read the B&RW and Western Watershed Biologists' paper about Golden Currant, and the other proposed interconnecting, utility scale grid projects for GreenLink West. I believe markets, changing users and their needs, and currently evolving tech and engineering, will soon make planned development of the old tech, engineering and the 1976 FLPMA-culture business model, unnecessary, even unacceptably unprofitable. There is still time to halt any wrong-direction busyness.

The old solar "large array" on free land idea, is already timing out. Do not allow irretrievable damage done by construction to start; see ahead and preserve the remaining irreplaceable wildlands. Neither Golden Currant, nor GreenLink West, nor the roads and Realty incursions which follow "large array" infrastructure "in" - should be sited on singular "biological refugia" open spaces, like the Mojave Desert. Especially when cascading Green "rooftop" tech here, to be sited where we use it, is not going away. New batteries may not even require lithium, soon.

Daily, new science about the way the desert spaces have always been working, even at night (waves of pollination, keeping groundwater in, safe animal and plant migration routes in all seasons, above and below-ground - naturally and efficiently
for the benefit of everything around it), shows not enough was known before, not enough is known now, and we can't afford to affect the desert, as if business is more important than the desert, a large western hemisphere ecosystem, or as if we will do a better job than it already does, doing what it does.

Yes, voting for solar, saving up for Green. But, for the right system, making sure, "First, Do No Harm" to the Mojave Desert - especially if all the destruction is about, is a speculator corporation's report on quarterly returns - that will soon be going down. Save us - all - a lot of actually, truly, important losses, not just loss of - corporation - time and money.

Thank you for the space.

No part of the Mojave Desert was or is "free", "unlimited" "wasteland".

[redacted]—

Pahrump, NV 8904.
[redacted] Text OK

[EXTERNAL] OSTA opposes variance for Golden Currants Solar Project

[redacted]

Wed 8/3/2022 8:50 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Cc: Conchita Marusich <conrik1@aol.com>;Jack Prichett <jprichett81@gmail.com>;Paul Ostapuk <postapuk@gmail.com>

OSTA Opposes Variance for Golden Currants Solar Site (in NV)

The Old Spanish Trail Association (OSTA) strongly urges the Bureau of Land Management (BLM) NOT to approve a variance approval for the proposed Golden Currants solar plant (no current project number). The proposed solar plant is located in Nevada's Nye County, with the Southern Nevada BLM office handling the project's application. Should the BLM grant a variance, OSTA will become an interested party in the required Environmental Impact Statement as specified by the federal National Environmental Policy Act (NEPA).

OSTA, under provisions of the National Historic Trails Act of 1968, works in conjunction with the BLM and the National Park Service (NPS), to provide on-the-ground trail monitoring and recording of field data. OSTA's deep concerns regarding the Golden Currants proposed plant are based on two important considerations:

- The location of the giant Golden Currants solar plant (sized at approximately 4364 acres) lies outside the Solar Energy Zones designated by the Programmatic Environmental Impact Statement (finalized in October 2012) for solar energy development. This plan established an initial set of 17 Solar Energy Zones, totaling about 285,000 acres of public lands, which will serve as priority areas for commercial-scale solar development. Since that time, two more zones have been added through regional planning processes. The plan also keeps the door open, on a case-by-case basis, for the possibility of carefully sited solar projects outside solar energy zones on about 19 million acres in "variance" areas. In 2020 the BLM's Southern Nevada office rated the Golden Currants solar site (then called "Sagittarius) a Medium Priority site. OSTA sees no need to provide a High Priority variance for Golden Currants.

- At its southwest corner, the project lies less than two miles from Stump Spring, a widely chronicled and historically important water site on the OST. This places it well within a corridor of five miles to either side of the official trail route as depicted by the NPS' map for the OST. To observe the site's proximity to the OSNHT, go to (https://nps.maps.arcgis.com/apps/webappviewer/index.html?id=24fc463363f54929833580280cc1a751 Zoom in several times to find Stump Spring near the

CA/NV state line). To avoid lasting impacts on the OST corridor near Stump Spring, the BLM should deny Golden Currants this proposed variance to extend its boundaries beyond the Solar Energy Zone in which it lies.

Thank you for your consideration,

[redacted]

[EXTERNAL] Re: Solar News of the Day | DOE offers $26 million to demonstrate that grid can run on clean energy -- informing "public input" questions, for permitting of BLM "Golden Currant".

[redacted]

Thu 8/4/2022 11:23 AM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

On Thu, Aug 4, 2022, 11:09 AM [redacted] wrote:

Hello,

I reside in Pahrump, NV, which our newspaper, PVTimes reports, is a center for international corporate financiered utility scale solar development. A large number of other residents besides myself, do not want that infrastructure here, or on anyone else's wildlands. We have read that evolving tech and engineering have already made the '"large array" on free land' (1872 Mining Law, 1976 FLPMA-culture) idea - unacceptably inefficient, not only because it always was wrong for the environment, but that now "panels on roofs" is better, all round, for users and providers. In 2020, NV SB 358, we voted for "panels on roofs", but instead got GreenLink West, Gridliance, Nevada Energy again, and Iberdrola.

So again, here we are submitting public input letters today, ("Golden Currant") and our (more than just sound) science and business concerns to the BLM and Mr. Helseth. Mr. Pay, the BLM local representative, finally laid it out: By Law, all extractive industry proposals here in Nevada, are started up - inherently - BLM- permitted. All who oppose, have to play catch-up self defense, "to prove" the destructive work should be halted - after - it has already been started, permanent harm done, against the advice of biologists and geophysicists.

For this new $26,000,000 test, was there any mention of the ongoing "good" available, and large "avoided costs", in keeping the desert intact? Was there any mention of extreme, and unpredictable losses of actual, on the ground, "Green value", in the desert being scraped? Was there mention of the expenses of an emergency fold-up and back-out of scrape scedules? Or calculations for - attempts - to repair? irretrievable damage to the scraped ecosystems, as newer tech and business models move 1976 FLPMA-culture deals off The Plan?

If everyone knows there are more economical, reliable, ecologically sound alternatives to utility scale solar infrastructure sited on natural, necessary, singular remaining wildlands - then why are the wrong plans always having to be turned around, or shut down, already having started into the damage? Very wasteful first, of money, but now more importantly - a waste of valuable time. These tests oddly, seem first about whether or not a preferred profit margin is possible. Then, about how far to stress the ecosystem - before - anyone sees it do something - unpredictable, but natural - that's not accounted for in its contract.

Thanks for the space.

[redacted]

On Thu, Aug 4, 2022, 7:07 AM pv magazine USA <daily.newsletter@pv-magazine.com> wrote:

Upcoming pv magazine Webinar

*On **August 10**, together with EagleView, we will cover how solar industry members can **benefit from the use of data** in their businesses and introduce the **concept of solar intelligence**.*

Register now

Latest News

DOE offers $26 million to demonstrate that grid can run on clean energy

By Anne Fischer on Aug 4 2022, 9:44am

The Demonstration Program intends to fund up to 10 projects that show how large-scale solar, wind, and energy storage can support the power grid by automatically adjusting to changing demand and disruptions.

Read more »

World's largest underground hydrogen storage project

By Emiliano Bellini on Aug 4 2022, 8:45am

Mitsubishi Power Americas and Magnum Development are set to begin construction on a 300 GWh underground storage facility in Utah. It will consist of two caverns with capacities of 150 GWh, to store hydrogen generated by an adjacent 840 MW hydrogen-capable gas turbine combined cycle power plant.

Read more »

Sunrise brief: Battery storage operation under net billing provides virtually no grid value, says Berkeley Lab study

By pv magazine on Aug 4 2022, 7:50am

Also on the rise: US added 15 GW generating capacity, 4.2 GW solar in first half 2022. Pairing agrivoltaics and pollinator habitat with community solar in New York. And more.

Read more »

Community solar market forecast to grow 7 GW by 2027

By Anne Fischer on Aug 3 2022, 2:00pm

State-level policy has fueled the growth, and pending legislation for community solar programs in five states could add another 1.2 GW, according to Wood Mackenzie

Read more »

US added 15 GW generating capacity, 4.2 GW solar in first half 2022

By Ryan Kennedy on Aug 3 2022, 1:46pm

EIA expects 17.8 GW of solar capacity to be added to the grid by the end of the year.

Read more »

Sungage Financial and Bodhi partner to help solar installers scale up

By Ryan Kennedy on Aug 3 2022, 10:08am

The solar financing provider and customer experience platform designer announce a new strategic alliance.

Read more »

Elsewhere on pv magazine...

GLOBAL

Agrivoltaics for rice growth

Emiliano Bellini Aug 4 2022, 6:50am

Scientists in Bangladesh have investigated the potential of agrivoltaics in rice fields. They analyzed the economic viability of bifacial agrivoltaic projects in Vietnam, Bangladesh, China, Egypt, Brazil, and India.

Read more »

INDIA

Roofsol Energy commissions 5 MW rooftop solar plant at ST Cottex

Uma Gupta Aug 4 2022, 6:41am

The rooftop solar plant at ST COTTEX factory in Ludhiana uses 10,700 JA Solar 465 Wp mono PERC modules and 39 Sungrow inverters of 100 kW.

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AUSTRALIA

Toshiba energises PV-powered hydrogen refuelling station in Japan

Emiliano Bellini Aug 4 2022, 2:52am

The system is reportedly able to refill about eight hydrogen fuel cell vehicles, each in three minutes. It is also able to supply electric power by using hydrogen produced with renewable energy within the station.

Read more »

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[EXTERNAL] Fwd: Golden Currant letter and references

[redacted]

Thu 8/4/2022 5:05 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>;Ransel, Beth E <bransel@blm.gov>;Dooman, Shonna <sdooman@blm.gov>

Greetings,

Please accept these comments and supporting documents for the Golden Currant Solar Project from conservation groups and individuals,

Thanks,

[redacted]

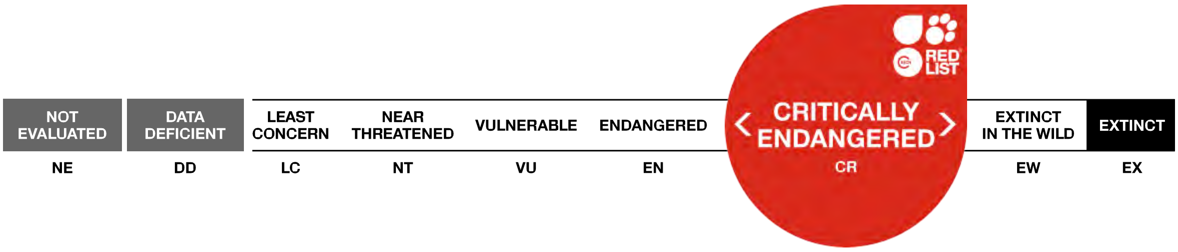
Golden Currant Variance Comments final2.pdf
(1,270K)

Connin et al 1998.pdf

The IUCN Red List of Threatened Species™
ISSN 2307-8235 (online)
IUCN 2021: T97246272A3150871
Scope(s): Global
Language: English

Gopherus agassizii, Mojave Desert Tortoise

Assessment by: Berry, K.H., Allison, L.J., McLuckie, A.M., Vaughn, M. & Murphy, R.W.



View on www.iucnredlist.org

Citation: Berry, K.H., Allison, L.J., McLuckie, A.M., Vaughn, M. & Murphy, R.W. 2021. *Gopherus agassizii*. *The IUCN Red List of Threatened Species* 2021: e.T97246272A3150871. https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T97246272A3150871.en

Taxonomy

Kingdom	Phylum	Class	Order	Family
Animalia	Chordata	Reptilia	Testudines	Testudinidae

Scientific Name: *Gopherus agassizii* (Cooper, 1861)

Synonym(s):

- *Xerobates agassizii* Cooper, 1861
- *Xerobates lepidocephalus* Ottley & Velázquez-Solis, 1989

Common Name(s):

- English: Mojave Desert Tortoise, Agassiz's Desert Tortoise
- French: Gophère d'Agassiz, Tortue d'Agassiz
- Spanish; Castilian: Tortuga del Desierto

Taxonomic Source(s):

TTWG (Turtle Taxonomy Working Group: Rhodin, A.G.J., Iverson, J.B., Bour, R. Fritz, U., Georges, A., Shaffer, H.B. and van Dijk, P.P.). 2017. Turtles of the World: Annotated Checklist and Atlas of Taxonomy, Synonymy, Distribution, and Conservation Status (8th Ed.). In: Rhodin, A.G.J., Iverson, J.B., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Pritchard, P.C.H., and Mittermeier, R.A. (eds), *Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group*, pp. 1-292. Chelonian Research Monographs.

Taxonomic Notes:

The Desert Tortoise was previously considered to be a single wide-ranging species, *Gopherus agassizii* (*sensu lato*), inhabiting the Mojave and Sonoran Desert regions of the southwestern USA and northwestern Mexico (Iverson 1992). The species was eventually found to be polytypic, and Murphy *et al*. (2011) split out the morphologically and genetically distinct Sonoran Desert subpopulations as *Gopherus morafkai,* the Sonoran Desert Tortoise. Further analysis demonstrated that *G. morafkai* was also polytypic and therefore split further to separate and describe the Sinaloan Thornscrub Tortoise further to the south as *G. evgoodei* (Edwards *et al*. 2016). This taxonomy of three species of desert tortoises has been accepted by TTWG (2017) and Berry and Murphy (2019).

Assessment Information

Red List Category & Criteria: Critically Endangered A2abce+4abce ver 3.1

Year Published: 2021

Date Assessed: October 1, 2020

Justification:

A provisional Red List Assessment of the widespread Desert Tortoise, *Gopherus agassizii* (*sensu lato*), was performed at a Desert Tortoise Council workshop in 2010 and updated by the IUCN Tortoise and Freshwater Turtle Specialist Group (TFTSG) in 2011, at which time the Mojave Desert subpopulation, now considered *G. agassizii* (*sensu stricto*) following taxonomic analysis and splitting into three separate species (*G. agassizii, G. morafkai,* and *G. evgoodei*), was assessed as Critically Endangered A2bce+A4bce based on population reduction (decreasing density), habit loss of over 80% over three generations (90 years), including past reductions and predicted future declines, as well as the effects of disease (upper respiratory tract disease / mycoplasmosis). *Gopherus agassizii* (*sensu stricto*) comprises tortoises in the most well-studied 30% of the larger range; this portion of the original range has seen the most human impacts and is where the largest past population losses had been documented. A recent rigorous range-wide population reassessment of *G. agassizii* (*sensu stricto*) has demonstrated continued adult population and density declines of about 90% over three generations (two in the past and one ongoing) in four of the five *G. agassizii* recovery units and inadequate recruitment with decreasing percentages of juveniles in all five recovery units. As such, we reaffirm the prior assessment of the taxonomically restricted Mojave Desert Tortoise, *G. agassizii*, as Critically Endangered, and add criterion “a” for direct population observations: CR A2abce+A4abce. The previously defined widespread species *G. agassizii* (*sensu lato*) was last assessed as Vulnerable on the IUCN Red List in 1996; a separate assessment currently in progress by the TFTSG for the Sonoran Desert Tortoise, *G. morafkai* (previously considered part of *G. agassizii*) has provisionally assessed that species as Vulnerable.

Geographic Range

Range Description:

The Desert Tortoise was previously considered to be a single wide-ranging species, *Gopherus agassizii*, inhabiting the Mojave and Sonoran Desert regions of the southwestern United States and northwestern Mexico from southern California and Arizona through Sonora and into northern Sinaloa (Stebbins 1966, 2003; Iverson 1992). The species was found to be polytypic by Murphy *et al*. (2011), who split the morphologically and genetically distinct Sonoran Desert populations as *Gopherus morafkai*, the Sonoran Desert Tortoise. Further analysis demonstrated that *G. morafkai* was also polytypic and split further to separate and describe the Sinaloan Thornscrub Tortoise further to the south as *Gopherus evgoodei* (Edwards *et al*. 2016).

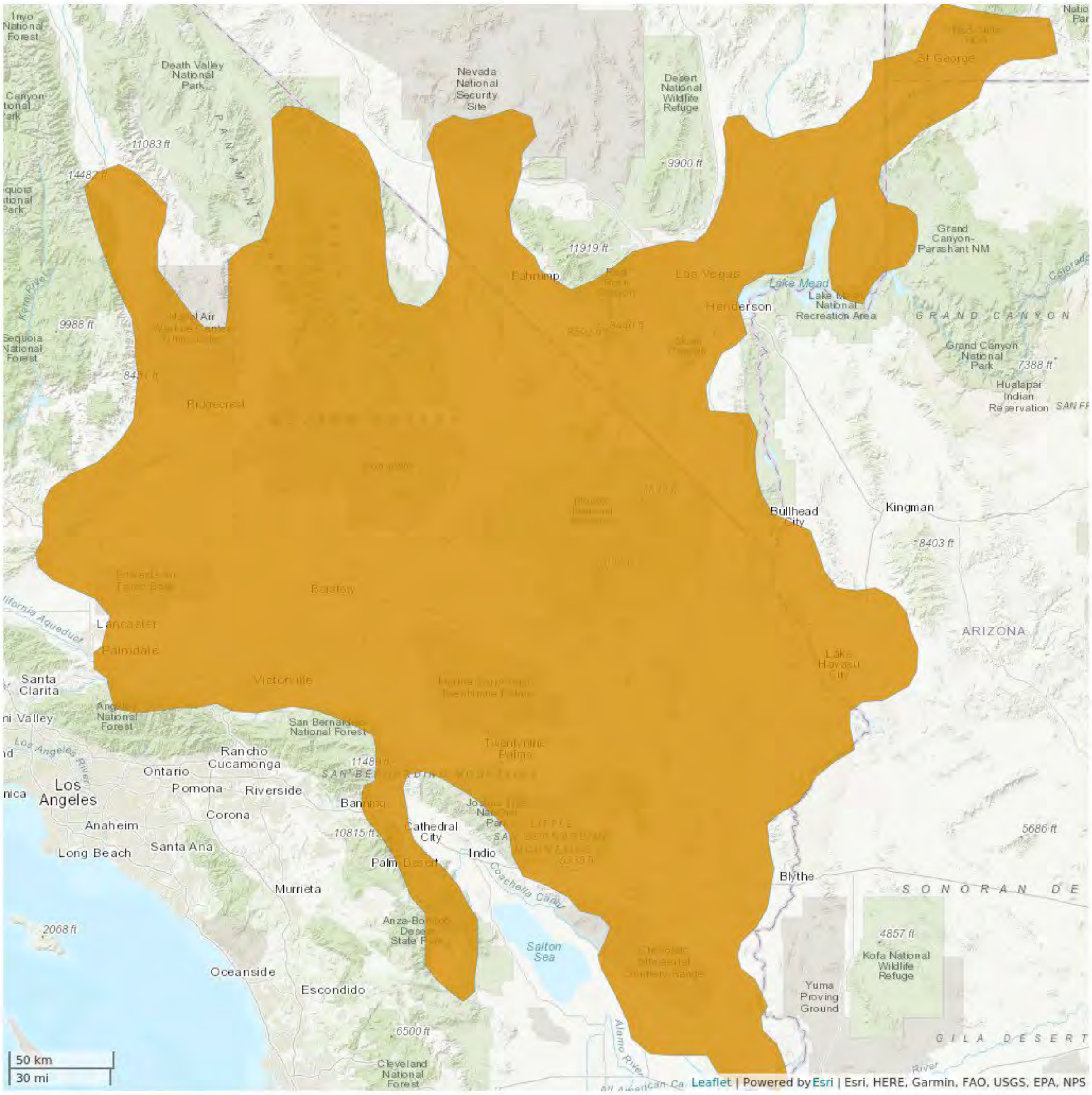
Geographically restricted *G. agassizii*, the Mojave or Agassiz’s Desert Tortoise, is endemic to the United States, inhabiting southeastern California, southern Nevada, southwestern Utah, and extreme northwestern Arizona west and north of the Colorado River (TTWG 2017, Berry and Murphy 2019). The Sonoran Desert Tortoise, *G. morafkai*, occurs in both the United States and Mexico, inhabiting Arizona south and east of the Colorado River, Sonora (including Isla Tiburón), and extreme northern Sinaloa (Murphy *et al.* 2011, TTWG 2017). The Sinaloan Thornscrub Tortoise, *G. evgoodei*, is endemic to Mexico and occurs in southern Sonora, northern Sinaloa, and extreme southwestern Chihuahua (Edwards *et al.* 2016, TTWG 2017).

Within its geographic range, *G. agassizii* occurs in the Mojave Desert, the western Sonoran or Colorado Desert, the ecotone of the Mojave with the Great Basin Desert, and ecotones with vegetation types typical of higher elevations on the lower slopes of the Sierra Nevada, Transverse, Peninsular and desert mountain ranges (USFWS 1994). McLuckie *et al*. (1999) identified a subpopulation of *G. agassizii* east of the Colorado River in the Black Mountains of northwestern Arizona in which morphometric and mtDNA characteristics of the majority of the subpopulation were typically Mojavean; however, elements typical of tortoises in the Sonoran Desert were also evident. Edwards *et al.* (2015), using new genetic techniques, examined this and other nearby tortoise subpopulations, and identified hybrids (F2) in three mountain ranges near the Colorado River in Arizona. The two *Gopherus* species come in contact in limited places where Mojave Desert habitats meet Sonoran Desert habitats. The two species likely maintain largely independent taxonomic identities due to ecological niche partitioning (Inman *et al*. 2019). The species has been recorded at elevations of up to 1,570 m asl (Rautenstrauch and O'Farrell 1998); however, tortoises may be found in unusual places, often transported by humans or other animals (e.g., the type specimen of *Xerobates lepidocephalus* [Ottley and Velázquez-Solis 1989] from southern Baja California, Mexico, is actually an introduced *Gopherus agassizii* [Murphy *et al*. 2011]).

Country Occurrence:

Native, Extant (resident): United States (Arizona, California, Nevada, Utah)

Distribution Map

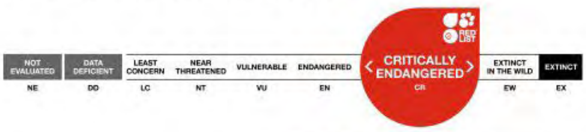


Legend

EXTANT (RESIDENT)

Compiled by:

Chelonian Research Foundation 2021



The boundaries and names shown and the designations used on this map do not imply any official endorsement, acceptance or opinion by IUCN.

Population

Population estimates and trends have previously been difficult to obtain with certainty for large segments of *Gopherus agassizii* populations due to their patchy distribution, difficulty of detection, and associated statistical weaknesses of population estimates. Population data have been variously documented or reviewed by Woodbury and Hardy (1948), Hardy (1976), Berry (1984, 1986, 1989), Bury and Corn (1995), Freilich *et al*. (2000), Ernst and Lovich (2009), and Berry and Murphy (2019). A recent rigorous range-wide population reassessment of *G. agassizii* by Allison and McLuckie (2018) has demonstrated continued adult population declines in four of the five *G. agassizii* recovery units and inadequate recruitment with decreasing percentages of juveniles in all five recovery units and low densities in nearly all subpopulations near the minimum required to remain viable (3.9 adult tortoises/km^2).

Between the 1930s and early 2000s, estimates of density and trends in populations were based on demographic data, habitat condition, and anthropogenic threats from both long- and short-term study plots of varying sizes, as well as reports by government agency personnel and expert observers (e.g., Woodbury and Hardy 1948; Hardy 1976; Berry 1984, 1989). The study plots were limited in number and did not represent the entirety of subpopulations across the geographic range (e.g., Berry 1984). The subpopulation on the Beaver Dam Slope, Utah, was federally listed as threatened in 1980 (USFWS 1980). A petition submitted by the Desert Tortoise Council in 1984 to list all wild populations in the United States was denied; the USFWS determined that listing of U.S. populations was warranted but precluded because of other higher priorities (USFWS 1985). In 1989 and 1990, the State of California and USFWS listed the tortoise as threatened (USFWS 1989, 1990; California Department of Fish and Wildlife 2016). The appearance of upper respiratory tract disease and rapidly declining populations in the western Mojave and a major decline in tortoises in parts of the western Sonoran (Colorado Desert, California) associated with appearance of shell disease were additional threats to the many causes of declines (USFWS 1990, 1994, and references therein). Reflecting its concern over these declines, USFWS (1994:3) stated that: “The most serious problem facing the remaining desert tortoise population is the cumulative load of human and disease-related mortality accompanied by habitat destruction, degradation, and fragmentation. Virtually every extant desert tortoise subpopulation has been affected by one or more of these factors.” As a result, the U.S. Department of the Interior (USFWS 1994) also designated federal critical habitat units for desert tortoises at that time. In October 2020, the California Fish and Wildlife Commission accepted a petition from Defenders of Wildlife to up-list wild desert tortoises from threatened to endangered status; California has the largest subpopulation and geographic range of the species. The petition is currently under consideration by the agency with a response estimated in 2021.

To better measure trends in densities of adult populations in the threatened subpopulations, the Recovery Team proposed development of a landscape scale program (USFWS 1994). At the same time, the Recovery Team also noted the importance of study plot data, because more population attributes were provided than density of adults. After experimenting with different techniques, the USFWS decided to use distance sampling and initiated a formal, range-wide program for estimating densities of adult populations in critical habitat units (USFWS 2015, and references therein).

In the first Recovery Plan (USFWS 1994), population size, viability, and sizes of protected areas were discussed. Assuming the minimum density of adults in a population was “approximately 10 adults per square mile" (equivalent to 3.9 adults/km^2), the target size for protected areas (then called Desert Wildlife Management Areas) was approximately 1,000 mi^2 (ca. 2,590 km^2). This would ensure that even at such low densities and assuming half of such large areas might support no or few tortoises, each protected area would support enough adults for a genetically minimum viable population. The Recovery Team recommended six Recovery units with 12 different populations. The updated Recovery Plan (USFWS 2011) is based on the same number of populations but configured into five revised Recovery units with 17 different monitored subpopulations.

Most demographic data from study plots collected from the 1930s on the Beaver Dam Slope and between 1979–1980 in California and Nevada during the spring season indicated counts of 5–64 adult tortoises/km^2 (Berry and Murphy 2019). In describing trends between 1978 and 1990 in California, the USFWS summarized data from 10 study plots in the Mojave and Colorado deserts and reported a highly significant downward trend (USFWS 1994). Additional data for the period showed some populations with low but potentially stable densities in Nevada (Berry and Medica 1995). A review of population status (Tracy *et al*. 2004) considered updated information from the permanent study plots in California and found that population declines in the western part of the range in California continued and declines were perhaps beginning in the eastern part of the California range.

The current population trends are based on landscape-level assessment using distance sampling for the 11-year period between 2004 and 2014 (USFWS 2015, Allison and McLuckie 2018). The sampling represented all five recovery units with 16 subpopulations in critical habitat units of from 115 to 3,763 km^2 described in the original Recovery Plan (USFWS 1994). Joshua Tree National Park is treated as a protected area and monitored as a 17th subpopulation although not designated as critical habitat. Consistent downward trends have continued in four of the five recovery units, with 11 of the 17 subpopulations registering declines in adult tortoises ranging from 26.6 to 64.7% during the 11 years. Most of the increasing subpopulations were in Nevada. Population densities for adults ranged from 1.5 to 7.2/km^2 in declining populations as of 2014; the exceptions were adult densities in the Red Cliffs Desert Reserve (15.3/km^2) and the Desert Tortoise Research Natural Area (10.2/km^2) (Berry et al. 2014, 2020). Unfortunately, in July 2020, a significant part of the Red Cliffs Desert Reserve burned and tortoises were found injured and dead. The Red Cliffs subpopulation declined from 2005 wildfires and with the recent 2020 fires, there will likely be further depression in densities. The six subpopulations with increasing densities had 2.7 to 6.4 adults/km^2 in 2014. However, most of the 17 populations were near or below the 3.9 /km^2 density of adults considered as a minimum for viable populations (USFWS 1994, 2015).

Current Population Trend: Decreasing

Habitat and Ecology (see Appendix for additional information)

The life history of *Gopherus agassizii* is typical of long-lived chelonians and has been reviewed by Berry and Murphy (2019). Tortoises require 17–20 years to reach sexual maturity at a straight-line carapace length (CL) of 18 cm or more (Woodbury and Hardy 1948, Turner *et al*. 1987, Medica *et al*. 2012). Variation in years is dependent on desert region, frequency of droughts, and quality of available forage. In the northern part of the geographic range, females smaller than 20.9 cm were not reproducing (Mueller *et al*. 1998). Maximum lifespan was estimated by Turner *et al*. (1987) at 75 years, but few live beyond 50 yrs in the wild (Germano 1992). Generation time was estimated to be 20–32 years (Turner *et al*. 1987, USFWS 1994). Based on data from three desert regions, mean sizes of females ranges from

21.4 to 23.1 cm, whereas the mean sizes of males ranged from 24.3 to 24.9 cm; the largest desert tortoises on record, a male, reached 38.1 cm carapace length (Stebbins 2003), whereas a female was 37.4 cm, but these animals were exceptions (Berry and Murphy 2019).

Mature females may lay clutches of one to 10 eggs in up to three clutches per year in spring and early summer; in some years, some females do not lay eggs (Rostal *et al*. 1994, Henen 1997, Mueller *et al*. 1998, Wallis *et al*. 1999, McLuckie and Fridell 2002, Ennen *et al*. 2012, Lovich *et al.* 2015). Annual fecundity ranges from 0 to 16 eggs (Mueller *et al*. 1998, Lovich *et al*. 2015). Several factors may affect egg production: site, year, size of female, size and number of eggs, and available water and protein from precipitation and forage in the year preceding egg laying, as well as the year eggs are laid (Henen 1997).

Incubation times for eggs range from 67 to 104 days (Burge 1977, McLuckie and Fridell 2002, Ennen *et al*. 2012). Hatching success varies and appears to depend on year, location of the nest, and whether it is the first or second clutch. Eggs may be infertile or broken during laying (e.g., 12%; Turner *et al*. 1987). Many nests are destroyed by predators before hatching and the loss of eggs (and nests) varies by year (Turner et al. 1987); they estimated an average loss of 37.1% of nests in a multi-year study. Hatching success in intact nests, undisturbed by predators, has been shown to vary from 73 to 100% (McLuckie and Fridell 2002, Rostal *et al*. 2002, Bjurlin and Bissonette 2004, Ennen *et al*. 2012).

Desert tortoises inhabit desert scrub habitats, including saltbush, creosote bush, Joshua Trees and Mojave yuccas, and microphyll woodlands with ironwood, palo verde, desert willow, and smoke trees (Berry and Murphy 2019). In the northeastern part of their geographic range, they occur in an ecotone between the Mojave and Great Basin deserts with sand sagebrush and junipers. Actual occurrences tend to be in valleys, alluvial fans, bajadas, and ephemeral stream channels, although tortoises can be found in low sand dunes and on steep slopes of mesas and cliffs (Berry and Murphy 2019).

Desert tortoises are herbivorous and selective in their choice of plant species (Jennings 1993, Oftedal 2002, Oftedal *et al*. 2002, Jennings and Berry 2015). They primarily eat forbs when available. In years of abundant precipitation, they are selective feeders and prefer specific species of annuals and herbaceous perennials in the legume, mallow, borage, aster, four o'clock, and cactus families (as well as other families). Although they eat grasses, a diet solely of grasses is deficient in nutrients and is likely to inhibit growth and survival, especially in neonate, juveniles, and immature tortoises (Hazard *et al*. 2009, 2010; Drake *et al*. 2016). The quality and quantity of preferred plant foods has diminished because of continuing invasion of non-native annual grasses and forbs and increased fire associated with the highly combustible non-native grasses (D'Antonio and Vitousek 1992, Brooks and Berry 2006, Brooks and Matchett 2006, Berry *et al*. 2014b).

Annual survival and mortality of adults is dependent on sex, size of the tortoise, frequency and severity of droughts, numbers and types of anthropogenic uses, location, and decade of study. In a multi-year study in the eastern Mojave Desert, annual survivorship of juveniles increased with size, ranging from 0.767 when <6.0 cm to 0.861 when 6.0 to 17.9 cm (Turner *et al*. 1987). When tortoises reach breeding age at an estimated 18.0 cm, survival rates were 0.87 to 0.944. Freilich *et al*. (2000) reported an annual survival of 0.883 for adults at Joshua Tree National Park. In a study in the Colorado Desert, Agha *et al.* (2015) estimated adult survival at a wind-turbine energy site (0.96) and an adjacent area (0.92). At two sites in the eastern Mojave Desert, Longshore *et al*. (2003) reported annual survival of adults of 0.985 and 0.829, with the lower survival rate at a site affected by drought.

Woodbury and Hardy (1948) estimated that 1% of adults died per year in a population mostly comprised of adults. In the northeastern Mojave Desert, Turner *et al*. (1984) reported mortality rates of 18.4% in a year of drought and 4.4% in a normal year. In the western Mojave Desert, death rates were lowest at a protected Research Natural Area (2.8%/yr) and highest in critical habitat (20.4%/yr). At Joshua Tree National Park, the mortality rate was 11.7% (Freilich *et al.* 2000), and in Red Rock State Park, 67% (Berry et al. 2008). In a demographic study of tortoises at 21 sites in the central Mojave Desert, mortality rates of adults ranged from 1.9 to 95.2% (Berry *et al*. 2006).

Turner *et al*. (1987) predicted an annual rate of population increase of *ca*. 2% in a model based on a tortoise subpopulation in the eastern Mojave Desert between 1977 and 1985. By 2000, this subpopulation had declined precipitously, apparently due to disease (see Christopher *et al*. 2003). Freilich *et al*. (2002) estimated the recruitment rate of young tortoises into the adult subpopulation at 0.092 in a plot in Joshua Tree National Park. This number of tortoises on this plot was thought to be stable between 1991 and 1995, but later declined (Lovich *et al*. 2014).

Systems: Terrestrial

Use and Trade (see Appendix for additional information)

Commercial take or use of *Gopherus agassizii* is prohibited by law, and few animals have been documented in (illegal) trade in recent decades. The evaluation of conservation status, conservation and monitoring actions for the species have generated significant financial investments in the species, supporting a range of local and visiting livelihoods. The approximate cost to develop and implement the 25-year recovery program for the Mojave Desert Tortoise was USD 100 million (USGAO 2002, Ernst and Lovich 2009, USFWS 2011, Averill-Murray *et al*. 2012). Thirty years have passed since the federal listing of *G. agassizii* as threatened in 1989–1990, declines of breeding adults continue, and many tasks to reduce deaths, described first in 1994 (USFWS 1994), remain to be implemented (see also USFWS 2011, Reports from the Recovery Implementation Teams). If fully implemented, the recommended actions could exceed 159 million USD plus additional costs that could not be estimated in the 2011 Recovery Plan (USFWS 2011). As one of the keystone species of the Mojave Desert, *G. agassizii* plays an unquantified but substantial role in generating tourism income to regional protected areas (see Joshua Tree National Park, Mojave National Preserve, and Lake Mead National Recreation Area (https://irma.nps.gov/STAT/).

Threats (see Appendix for additional information)

Gopherus agassizii faces multiple threats to individuals, populations, and habitat (for annotated bibliographies of reports and published papers, see Hohman *et al*. 1980; Berry 1984; USFWS 1990, 1994, 2010, 2011; Grover and DeFalco 1995; Bury and Luckenbach 2002; von Senckendorff Hoff and Marlow 2002; Lovich *et al*. 2011; Lovich and Ennen 2013a; Berry *et al*. 2015; Berry and Murphy 2019). Recent articles document further examples of threats (Tuma *et al*. 2016; Berry *et al*. 2020a,b,c). Much of the information with numerous references are contained in Berry and Murphy (2019). Substantial tortoise habitat was already lost to cities, towns, settlements, agriculture, energy developments, and military bases in the 20th century, and continuing habitat loss and degradation, combined with high mortality rates in dwindling low-density populations due to disease (upper respiratory tract disease / mycoplasmosis), road and off-road vehicle-induced mortality, subsidized predators (e.g., ravens), poaching for pets, and mortality from increasing droughts associated with climate change, are threatening most remaining populations of Desert Tortoises (summarized in Berry and Murphy 2019). The majority of desert tortoise populations are currently considered non-viable because of the low density of adults and their existence in isolated and fragmented pieces of habitat (Berry 1984, USFWS 2010, Allison and McLuckie 2018, Berry *et al*. 2020a,b).

Many threats are cumulative in nature and interact synergistically with others. By rating them separately in the Standard Threats Classification Scheme below, the severity of threats and their negative impacts are not described in full measure. One of the limitations of the classification scheme for threats are the ratings for severity. Severity is associated with declines (or not) by percent over 10 years or three generations, whichever is longer. For species such as desert tortoises with long generation times (*ca*. 20–30 years), this may be 60 to 90 or more years. Here we provide a detailed and expanded Threats Classification Scheme for *G. agassizii*.

Detailed Threats Classification Scheme

Classification Level

a. Examples
b. Timing and Scope

1.1 Housing & urban areas, towns, settlements, ranches
a. Desert cities, towns, settlements, scattered homes in rural areas, desert land entry, e.g., Inyokern, Ridgecrest, Red Mountain, Trona, Boron, Lancaster, Palmdale, Victorville, Lucerne Valley, Ft. Irwin, Barstow, Daggett, Mountain Pass, Joshua Tree, Twentynine Palms, Vidal Junction, Ludlow, Amboy, Needles, Las Vegas, St. George, Palm Springs, Borrego Springs, Parker, Blythe, El Centro, Stateline, Las Vegas, Mesquite, St. George.
b. Ongoing. Severe impacts, disappearance of tortoises and habitat; 20% of geographic range. Loss of habitat from widespread and rapidly growing and expanding cities, towns, and settlements associated with high levels of human population growth in the Mojave and western Sonoran deserts and loss and degradation of adjacent habitat (Hughson 2009, U.S. Census Bureau 2010). In the northwest and southwest portions of the geographic range, tortoise populations are locally extinct, absent from valleys and fans and in low densities on military bases.

1.2 Commercial & Industrial
a. Airports and landing strips, military bases, solar and wind farms.
b. Ongoing. Severe impacts, loss of tortoises and habitat; 8% of geographic range. Development and use of multiple airports, landing strips, several large military bases with ground disturbing activities (military manoeuvres), and solar and wind farms (with associated transmission lines and roads) result in degradation and loss of substantial habitat in both the Mojave and western Sonoran deserts.

1.3 Residential & commercial; golf courses, tourism, recreation
a. Golf courses are associated with cities and towns that currently exist or are expanding within or near Desert Tortoise habitat (e.g., Las Vegas, Henderson). Vehicle-oriented recreation and visitation are very high in many parts of both deserts including what is now critical habitat, several State Parks and National Parks, Lake Mead National Recreation Area, Red Cliffs National Conservation Area, museums,

and other points of interest.

b. Ongoing. Loss and degradation of habitat, illegal collecting of tortoises: 30%. The high levels of visitor use pose severe threats to *G. agassizii* throughout remaining habitat as well as in critical habitat. For example, at Lake Mead National Recreation, annual records of visitors from 1946 was >1 million visitors per year; by 2018 more than 7.5 million visits occurred (https://irma.nps.gov/Stats/Reports/Park/). In parts of critical habitat in the western Mojave Desert, visitor use is very high, e.g., visits and visitor days recorded annually from 2008–2018 ranged from 55,874 to 94,474 visits and 26,218 to 90,445 visitor days per year (USBLM 2019). Visitor use, particularly vehicle-oriented use, is very difficult to control; a substantial portion occurs off-highway and designated trails. Off-road vehicle recreational uses are associated with higher rates of deaths from gunshots in tortoises occurring in areas with high visitor use days (Berry 1986, 2020a).

2.1.3 Agriculture: Agro-industry farming

a. Farms for cotton, alfalfa, pistachio, goat-nut, and other crops and dry farming in parts of the geographic range (e.g., Fremont, Antelope, Indian Wells, Victor, Apple, Lucerne, Mojave River, Chuckwalla and Virgin River valleys, bordering the Colorado River).

b. Severe, cleared land, local areas, often expansive, throughout the geographic range. Historic and ongoing. Habitat and tortoises lost, 10%. Farming began very early (late 1800s) and continues to the present. Farming has negatively affected the water table locally, causing subsidence and fissures to develop in at least one area (Berry 1984), as well as altering vegetation in the vicinity. Habitat cleared for farming generally is used for industrial purposes, e.g., solar or off-road vehicle recreation after abandonment. Both agricultural and industrial uses are associated with influx and proliferation of non-native plants onto adjacent, high quality desert tortoise habitat and protected areas.

2.3.2 and 2.3.3 Agriculture: livestock farming & ranching

a. Cattle ranching, sheep grazing and driveways, allotments, licenses, and leases (often on federal lands); growing herds of feral burros and expansion into critical habitat.

b. Moderate to severe, historic (from 1850s), ongoing; 80% of the geographic range affected. Grazing of livestock and use of driveways was widespread and often intensive throughout the geographic range until the Taylor Grazing Act in 1932. Livestock grazing was widespread after that time but managed as an important desert use (e.g., Berry 1984, USBLM 1980). In 1990, after the tortoise was listed as threatened, sheep grazing continued but was excluded from critical habitat. Cattle grazing continued throughout much of critical habitat and still occurs in an estimated 17% of critical habitat (USFWS 2010). Feral burros also graze in tortoise habitats and are encroaching into one critical habitat (USFWS 2010; Berry et al. 2020c). Livestock cause degradation and loss of habitat through development of piospheres, trampling, altering cover, composition of shrubs and forage plants available for tortoises to eat (Webb and Stielstra 1979, Fleischner 1994, Brooks *et al*. 2006, Abella 2008, Tuma *et al*. 2016). The disturbances created by grazing contributes to growth and proliferation of non-native, fire-prone, invasive grasses (D'Antonio and Vitousek 1992).

3.1 Energy production & mining: oil and gas

a. Oil and gas, drilling and exploration.

b. Medium severity, local areas, <1% of geographic range. Exploratory drilling has occurred in tortoise habitat and has left degraded and cleared areas of < 1-2 ha, with spoil piles, drilling waste, and trash from the drilling operations spread over the area. These sites became focal points for camping and vehicle-oriented recreation, enlarging over time (K.H. Berry pers. obs.).

3.2 Energy production & mining: mining and quarrying

a. Small and large mines, exploratory pits, bulldozed areas, shafts, and major mines; quarries.

b. Ongoing, severe degradation on a local or regional scale; 5%. Mining on small and large scales began in the late 1800s, killing tortoises and destroying habitat. Roads were constructed to access potential mining areas and districts (Mojave, Rand, Atolia, Goldstone, Calico, Mountain Pass). Tortoises fall into pits and shafts and were killed. Some mines cover 7.8 km^2 or more and their influence can expand beyond that. Gold mines are associated with spread of mercury and arsenic in soils and plants far beyond the source (e.g., >12 km), transported by wind and water (Chaffee and Berry 2006; Kim *et al*. 2012, 2014). Tortoises are negatively affected by these elemental toxicants with poor health; these toxicants were reported in livers, integument, lungs, etc. (Jacobson *et al*. 1991, Selzer and Berry 2005, Foster *et a*l. 2009).

3.3 Energy production & mining: renewable energy

a. Windfarms, photovoltaic, solar fields; new utility and transmission lines, power poles and towers with adjacent roads accompany these developments.

b. Ongoing, future. Severe degradation and loss locally over large areas, 5% over the geographic range. Windfarms occur in tortoise habitat, generally on slopes or on hills and small mountains. Solar panels have been constructed on abandoned agricultural fields or in low density or marginal habitat. However, some projects were built in prime habitat, causing loss of habitat and displacement of tortoises. Solar and wind energy is a growing industry with losses of >106 km^2 as of 2019 (Mark Massar, U.S. Bureau of Land Management, pers. comm.).

4.1 Transportation and service corridors: roads & railroads

a. Freeways, 2-lane highways, county gravel or dirt roads, and roads to points of interest; railroads (two major) and several spurs with associated dirt roads and tower lay-down areas for power towers and poles.

b. Ongoing, severe loss and degradation of habitat. 5% throughout the geographic range. Roads were developed in the late 1800s and have proliferated and widened into freeways since that time. Several major freeways and state highways cross the geographic range. Importantly many more dirt roads exist to points of interest (e.g., mines, mining areas, water troughs and water sources, outlying rural areas, recreation areas). Tortoise populations are depleted on either side of highways and well-used roads for distances of >4,000 m (von Seckendorff Hoff and Marlow 2002). A very small portion of these roads and highways have tortoise-proof fencing.

4.2 Transportation & service corridors: utility & service lines

a. Telephone and electric poles and lines; major transmission lines and corridors.

b. Ongoing, moderate to severe. Telephone poles and electric poles and lines usually parallel major or minor paved and dirt roads and extend from towns and cities into remote areas to provide service to agricultural developments, mines, wind and solar farms and individual residences or small settlements. Electric transmission lines cross many parts of the geographic range, including critical habitat (critical habitat alone: 1,634 km of lines in corridors, total area of corridors, 1,743.5 km^2) (USFWS 2010). These corridors are accompanied by dirt roads and spurs to the towers. Often corridors contain several sets of towers and electrical lines. Utility lines also include ground disturbance from fibre optic cables, aqueducts, and gas lines, all of which disturb tortoise habitat. Utility poles and transmission lines have allowed for spread of predators (Common Raven, Red-tailed Hawk) into remote parts of the desert, because they make use of the towers and poles for perching and nesting, leading to increased predation on tortoises (Knight and Kawashima 1993, Anderson and Berry 2019).

4.4 Transportation and service corridors: flight paths or military use a. Commercial, non-commercial, and Department of Defence flight paths.
b. Numerous, ongoing. Flight paths are minor or no impact if not associated with release of ordnance (bombing ranges). The noise may have effects on wildlife, including tortoises (e.g., Bowles *et al*. 1999).

5.1.1 Biological resource use: hunting & trapping terrestrial animals: intentional use (species is the target)
a. Illegal collecting of *Gopherus agassizii* for commercial sale, food, cultural purposes, and for international trade, etc.
b. Ongoing, severe. Tortoises have been and continue to be collected for pets, food, tourism, commercial sale, and cultural purposes, although such collection has been unlawful since 1939 (Berry 1984, Berry *et al*. 1996, Berry and Murphy 2019, Berry *et al*. 2020b).

6.1 Human intrusions & disturbance: recreational activities
a. Visits to State and National Parks and Preserves, National Recreation Areas, federal and state lands, private lands, and Open Recreation Use Areas (unrestricted vehicle play areas) by vehicle-oriented recreationists.
b. Ongoing, severe impacts regionally and locally, especially in the western, central, and southern Mojave Desert and growing in the western Sonoran Desert; associated with proximity to cities, towns, and settlements. Formerly populated with Desert Tortoises, several intensively used areas are now severely degraded and have few if any tortoises (e.g., Bury and Luckenbach 2002, Berry *et al*. 2014a, USFWS 2015, Berry and Murphy 2019). Vehicle-oriented visitation is exceptionally high, ranging from >50,000 to 86,550 between 2008 and 2018 annually in some regions of the Mojave Desert (USBLM 2019). Other parts of the desert and critical habitat are also experiencing growing numbers of visitors. Deaths of desert tortoises from road kills and shooting is higher in areas with high levels of vehicle-oriented visitation (Berry 1986, Berry *et al*. 2020b).

6.2 Human intrusions & disturbance: war, civil unrest & military exercises
a. World War II and subsequent. Military manoeuvres across substantial areas of habitat in the western Sonoran and eastern Mojave deserts to train troops using tanks and other vehicles for the war in North Africa. Since the 1960s, military manoeuvres with armoured vehicles in extensive areas in the western, southern, and central Mojave deserts; aerial bombing training in limited areas in the western Sonoran Desert.
b. Ongoing, severe. Military manoeuvres in 1942 resulted in severely degraded habitat (compacted soils, damaged desert pavements, altered vegetation, including forage available for desert tortoises. Lands disturbed in 1942 have not recovered after 60 years (Prose 1985, 1986; Prose and Wilshire 2000). Similar disturbances have occurred and continue to occur in tortoise populations and habitat at military installations in the southern and central Mojave Desert. In the early 2000s, expansion of the Fort Irwin military installation in the central Mojave Desert caused loss and degradation of 760 km^2 of tortoise habitat and *ca*. 304 km^2 of the lost habitat was part of critical habitat (USFWS 2010, Berry and Murphy 2019). An estimated *ca*. 300 km^2 will be lost with additional, ongoing expansion of the same base. The western expansion of the Marine Corps base at 29 Palms caused hundreds of tortoises to be translocated and habitat lost in the southern Mojave Desert (USDD 2017).

6.3 Work and other activities: law enforcement, illegal immigrants, species research, vandalism

a. Border patrol agents and illegal immigrants travel cross-country by foot and vehicle in tortoise habitat in the southern border range. Vandalism, specifically wanton shooting or killing of tortoises has affected some populations more than others, probably associated with higher visitor use and vehicle-oriented recreation.

b. Ongoing, moderate severity. Border patrol agents travel north from the border into tortoise habitat, including critical habitat, to apprehend illegal immigrants. Vehicle travel can occur off dirt roads, widen existing roads, and create new disturbances. Shooting tortoises, running over them deliberately with vehicles, or otherwise killing them has been documented in both the Mojave and western Sonoran deserts (Berry 1986, Berry *et al*. 2006, Berry *et al*. 2020a,b).

7.1.1 Fires & fire suppression

a. Caused by lightning, car fires on highways or roads, arson.

b. Ongoing, severe, with the severity dependent on the critical habitat unit or protected area. Mojave and Colorado Desert habitats did not evolve with fire (D'Antonio and Vitousek 1992). Fires increased in numbers, frequency, and amounts burned with the invasion and proliferation of non-native grasses which are highly combustible (Berry and Murphy 2019). Fires have occurred throughout the geographic range and have burned significant amounts of critical and other protected habitats in the southern, central, eastern and northeastern Mojave Desert regions. Once habitat burns, it is likely to burn again with higher frequencies and with potentially increased biomass of non-native annual grasses. Tortoises die in these fires or are injured, but some survive (Berry and Murphy 2019). Loss of cover of shrubs and food supply for the tortoises is severe in most burned areas. When fires are very hot, the seed bed may be damaged or destroyed. The most severely burned protected habitat is in the Red Cliffs Desert Reserve with >30% burned as of summer 2020 (McLuckie *et al*. 2021); the Mojave National Preserve also experienced a major fire and loss or degradation of 7% of the critical habitat unit in summer 2020 (Darby *et al*. 2021).

7.2.8 Abstraction of ground water

a. For agriculture, primarily, followed by urban and cities.

b. Ongoing, long-term degradation of habitat adjacent to cities, towns, industrial and agricultural developments. Depletion of the ground water table causing subsidence and formation of fissures has occurred in at least one part of the western Mojave Desert and in the northeastern Mojave Desert in the Las Vegas Valley in what was once desert tortoise habitat (Berry 1984, Burbey 2002). In the western Mojave Desert, the water table was depleted by agricultural uses (cotton, alfalfa) and now with solar energy development; and by cities in the Las Vegas Valley by depleted associated aquifers. Other regions have and continue to experience depletion of the water table in areas with agriculture and desert cities, e.g., adjacent to the Mojave, Colorado, and Virgin rivers (Stamos *et al*. 2001). Water is sought from sources and regions outside desert tortoise habitat (e.g., the Colorado River) to support cities and towns, as well as agriculture, because existing water tables are insufficient to support them.

8.1.2 Invasive and other problematic species, genes & diseases: Named species

a. *Bromus madritensis* ssp*. rubens, B. tectorum, Schismus* spp*., Erodium cicutarium, Hirschfeldia incana, Brassica tournefortii.*

b. Ongoing, severe degradation of the Mojave and western Sonoran ecosystems. Landscape conservation forecasting (Provencher *et al*. 2011) quantified the pervasive abundance of annual brome grasses that foster destructive wildfires of a size and intensity far greater than the fire regime with which Mojave Desert habitats developed over the past millennia. In addition to supporting fires, the non-native grasses compete with native forage species of forbs required by tortoises to grow, reproduce, and remain healthy. Non-native grasses and forbs dominate the ecosystem in biomass in both wet and dry years in many tortoise habitats (Brooks and Berry 2006, Berry 2014b). Non-native grasses are not nutritious plants for tortoises to eat and cause weight loss and can cause death in juveniles (Hazard *et al.* 2009, 2010; Drake *et al*. 2016). The awns of *Bromus* also can injure tortoise mouths. The non-native *Hirschfeldia incana* and especially *Brassica tournefortii*, introduced through agricultural development, also compete with native forage species, changing the composition of the native flora (Berry *et al*. 2014b). They are not eaten by tortoises and can be high in oxalates, potentially a source of oxalosis in tortoises (Jacobson *et al*. 2009).

8.1.2 Diseases. Named species

a. Infectious diseases: *Mycoplasma agassizii, M. testudineum,* Testudinid herpesvirus 2 (TeHV2); Non-infectious diseases: oxalosis, gout, starvation, dehydration.

b. Infectious diseases: ongoing, severe in some areas. The two species of *Mycoplasma* are infectious pathogens. The first (*M. agassizii*) was discovered in wild populations in 1989 and the second (*M. testudineum*) a few years later (Jacobson *et al*. 1991, 2014). These pathogens are spread by contact between tortoises cause disease and death in some populations, and inhibit olfaction necessary for foraging (Jacobson and Berry 2012, Jacobson *et al*. 2014). *Mycoplasma agassizii* is common in captive desert tortoises, more so than in wild populations. Epidemiological studies indicate that the distribution of the two species differs, and that tortoises with antibody-positive tests for the diseases occur closer to human habitations rather than more distant (Berry *et al*. 2015). Mycoplasmosis has been implicated as a major contributor to a catastrophic die-off of tortoises at the Desert Tortoise Research Natural Area (Berry *et al.* 2020b). It is also associated with declines in other parts of the geographic range (Christopher *et al*. 2003). Non-infectious diseases of known etiology include oxalosis, gout, and starvation and dehydration (Homer *et al*. 1998, Berry *et al*. 2002, Jacobson *et al*. 2009). Some individuals and populations have been negatively affected by these diseases.

8.2.2 Problematic Native Species

a. The Common Raven (*Corvus corax)*, an uncommon to rare resident between the 1920s and 1940s in the Mojave and western Sonoran deserts, is now an abundant predator in ecosystems where the Desert Tortoise lives. Red-tailed Hawks (*Buteo jamaicensis*) is another similar predator, and Coyotes (*Canis latrans*) can also be a hyper-predator.

b. Ongoing, severe and negative effects on population structure; loss of juveniles and immature tortoises. Populations of the Common Raven have grown enormously, supported by subsidies of food, water, perch and nest sites available from humans (Boarman 1993, Boarman and Berry 1995). They have been able to access formerly remote parts of the desert by relying on settlements, road kills and trash along highways and roads, and utility poles and transmission lines for perching and nesting (Knight and Kawashima 1993). Common Ravens are very effective predators on hatchling, juvenile and immature tortoises, with dozens to hundreds of shells recorded beneath perch and nest sites. They are responsible for preventing recovery in many parts of the desert by depleting young tortoise cohorts in populations that can lead to local extinctions (Kristan and Boarman 2003). Red-tailed Hawks have expanded their use areas into remote parts of the desert ecosystems, using utility poles and towers as nest sites and juvenile tortoises for food (Anderson and Berry 2019). Similarly, Coyotes are subsidized predators found in increased numbers near cities, towns, and some military installations and at times have high predation rates on tortoises (Esque *et al*. 2010).

8.4.2 Problematic Species/ Diseases: Named Species
a. Several non-native species of tortoises and turtles carrying disease or potentially carrying disease have been released illegally into Desert Tortoise habitats, e.g., African Spurred Tortoise (*Centrochelys sulcata*; Nelson 2010; Anonymous 2018) and Central Asian Steppe Tortoise (*Testudo horsfieldii*; Jacobson *et al*. 2013, Winters *et al*. in prep.).
b. Ongoing, potentially severe. Releases of tortoises, whether native or non-native are illegal in large parts of the geographic range. Nevertheless, introduced, non-native turtles and tortoises such as the African Spurred Tortoise and Central Asian Steppe Tortoise have been found to carry new diseases that would negatively affect already declining *G. agassizii* populations (Nelson 2010; Anonymous 2018). The African Spurred Tortoise can do damage to habitat and to the native tortoise, *G. agassizii*, because of the large size and aggressive nature. One Central Asian Steppe Tortoise was captured in the Central Mojave Desert with a new herpesvirus not previously described in *G. agassizii* (Winters *et al*. in prep.). The concern is that this non-native tortoise may have transmitted the new herpesvirus to desert tortoises. New, non-native herpesviruses from other species and countries and continents are a threat to health in already declining *G. agassizii* populations.

8.5 Viral/Prion-induced Diseases
a. Herpesviruses are implicated in illness and mortality in tortoises.
b. Ongoing, potentially severe if coupled with other stressors. Herpesviruses are a threat to health and survival of desert tortoises, especially those herpesviruses introduced from other, non-native species to the desert. Tortoises with clinical signs of the disease were among populations that severely declined between the 1990s and 2000s; herpesvirus may have contributed in some areas (Christopher *et al*. 2003). Testudinid herpesvirus 2 was first identified in captive tortoises, then confirmed in wild *G. agassizii* (Jacobson *et al*. 2012). The estimated prevalence of this herpesvirus for captive and wild tortoises from the Mojave and western Sonoran deserts ranged from 15 to 56% (Jacobson *et al*. 2012).

8.6 Diseases of Unknown Cause
a. Shell diseases, i.e., cutaneous dyskeratosis, necrosis.
b. Ongoing, severe. A novel shell disease, cutaneous dyskeratosis and shell necrosis, was implicated in illness and deaths of Desert Tortoises (Jacobson *et al*. 1994; Homer *et al*. 1998, 2001) and a decline of ca. 80% in a once-robust population. Other populations in critical habitats appear to be affected similarly. This is a metabolic disease with lesions of the shell and integument as outward manifestations. The causes are suspected to be toxicants (e.g., elemental toxicants and/or nutritional deficiencies). The disease is implicated in elevated death rates in adult tortoises in the western Sonoran Desert and eastern Mojave Desert (Berry and Medica 1995, Christopher *et al*. 2003).

9.2.2 Industrial & military effluents
a. Seepage from mining.
b. Ongoing, unremediated regionally. There are links between some diseases in tortoises and toxicants from mining and other similar developments. Tortoises dying of upper respiratory tract disease caused by *Mycoplasma* spp. in the western Mojave Desert in close proximity to a mining district had high levels of mercury in livers compared to tortoises without the disease (Jacobson *et al*. 1991). Ill tortoises with high levels of arsenic occurred in an area mining district with high levels of mercury and arsenic (Selzer and Berry 2005). Waste from the mines was transported by wind and water to distances of 15 km

(Chaffee and Berry 2006; Kim et al. 2012, 2014). Mines in other tortoise habitat in different desert regions have yet to be examined.

9.4 Garbage & Solid Waste
a. Trash is a threat to tortoises because they can consume it or become entangled.
b. Ongoing, low to moderate. Consumption of trash can lead to illness and death (Donoghue 2006, Walde *et al*. 2007). Balloons and other trash are common throughout the desert and most abundant near human habitations, along roads, and recreation use areas (Berry *et al*. 2006, 2008, 2014a; Keith *et al*. 2008). Trash attracts predators—Common Ravens, Coyotes, and other canids—thus creating an additional risk to tortoises.

9.5 Air-borne Pollutants
a. Pollutants such as atmospheric nitrogen and increases in CO_2 enhance the growth of invasive grasses and thus fire.
b. Atmospheric nitrogen from urban or other areas is transported to deserts and tortoise habitat, and deposited on soils, thus enhancing growth of non-native grasses and plants prone to fire (Brooks 2003, Rao and Allen 2010).

11.1 Habitat Shifting & Alteration
a. Desertification; degradation of vegetation, soils, and topography
b. Ongoing, severe. Throughout the geographic range, most, if not all, tortoise habitats have received (and continue to receive) one or more anthropogenic uses and activities resulting in compacted or eroded soils and alteration of the natural structure and composition of annual and perennial vegetation (e.g., Lei 2009). Long-lived shrubs and native annual wildflowers and grasses have been replaced in part with short-lived colonizers (shrubs, non-native, fire-prone grasses) typical of disturbed areas. These changes have brought fewer places to dig burrows and a reduced supply of nutritious plants to eat (Brooks and Berry 2006, Webb and Wilshire 1983). In some areas, the rich diversity of shrubs and annual plants have been replaced by a few shrub species and the annuals replaced with primarily non-native annual species (Brooks and Berry 2006).

11.2 Droughts
a. Desert Tortoises require water from precipitation and a diverse diet of native annuals to grow, reproduce and survive.
b. Ongoing, increasingly severe with reduced survival throughout the geographic range, often associated with hyper-predation by coyotes. Although the Mojave and western Sonoran deserts are typified by droughts often lasting more than a year, tortoises have adaptations to cope. However, tortoises die of starvation and dehydration during prolonged droughts (Berry *et al.* 2002, Christopher *et al*. 2003, Longshore *et al*. 2003, Lovich *et al*. 2014). Juveniles are especially vulnerable. With climate change and warming, droughts, including megadroughts lasting 10 years or more, are predicted to occur in coming years (U.S. Global Change Research Program 2017, Steiger *et al*. 2019).

11.3 Temperature Extremes
a. Tortoises are able to withstand the extremes of temperature experienced in the desert; however, increases in warm temperatures coupled with drying and changes in precipitation patterns present high risks to the species.
b. Ongoing and a growing issue, with climate change having negative impacts throughout the

geographic range. Tortoises cope with the extremes of summer and winter temperatures (and lack of water, see 11.2) by using deep burrows and restricting above-ground activities and reproduction during drought. As temperatures rise with the rise in CO_2 and other greenhouse gases, tortoises will need to find habitats where deeper burrows can be excavated. At the higher temperatures, the spring season for foraging on ephemeral annuals and egg laying is likely to be shortened, reducing the time for eating, growing, and egg production. Sex of tortoises is determined by temperature of incubation in nests, with females produced at the higher temperatures and males at the lower temperatures. Eggs laid in nest that will experience the high temperatures of summer may be predominantly female, and if temperatures are excessive, may not be viable. Although the species could survive at higher (and cooler) elevations, the habitat in mountain ranges will be more limited, steep, rocky, with exposed bedrock in places with inadequate forage.

12.1 Other Threats
a. Climate Change.
b. Ongoing, see 11.2 and 11.3. Change in timing and amounts of precipitation coupled with increasing temperatures are likely to have profound negative effects on the species, further reducing available habitat (e.g., Barrows 2011). Profound changes are predicted to cause deterioration in composition, structure, diversity and biomass of trees and shrubs (Munson et al. 2016) that provide shade and cover to the tortoises. Barrows (2011) predicted that tortoises may survive if they move from the western Colorado Desert to higher elevations. However, the long-lived tortoises have strong fidelity to existing home ranges.

Conservation Actions **(see Appendix for additional information)**

Conservation Measures taken:

The first legal conservation measures for *Gopherus agassizii* came from the State of California in 1939 (California Department of Fish and Game Code 1939–1981). Additional protective regulations followed until *G. agassizii* was listed as threatened under the California Endangered Species Act in 1989 (California Dept. of Fish and Wildlife 2016). Federal legislation to protect *G. agassizii* first occurred in 1980 and was restricted to the Beaver Dam Slope population in Utah (USFWS 1980). In 1989–1990, *G. agassizii* was federally listed as threatened (USDI 1990 and references therein). The only population of *G. agassizii* that is not protected by the Endangered Species Act of 1973, as amended, is in the northwest corner of Arizona (Edwards *et al*. 2015). Recovery efforts have been underway since 1990. The U.S. Fish and Wildlife Service (USFWS 1994) published the first Recovery Plan in 1994, coupled with designations of critical habitat units by the U.S. Department of the Interior (USFWS 1994); this was followed by a revised Recovery Plan in 2011 (USFWS 2011), and regional Recovery Implementation Teams established in 2012. These teams are chaired by an employee of the USFWS Desert Tortoise Recovery Office, and are composed of federal, state, and county employees from the range of the desert tortoise, including representatives from local and national conservation and other stakeholder organizations.

The species is included in CITES Appendix II as part of Testudinidae spp., requiring that any commercial international trade be documented not to be detrimental to the survival of wild populations. CITES Trade records generally show very low levels of international exports of live animals; the vast majority of live traded Desert Tortoises are personal pets moving in-country with their owners, and many of the records in fact concern seizures of illegally transported specimens (CITES UNEP-WCMC trade database).

Conservation and recovery efforts began in the early 1970s, long before efforts of the federal actions by the USFWS in 1989–90. The Desert Tortoise Council formed in 1974-75 out of an interim recovery effort involving the four Southwestern states. This non-profit corporation was and continues to be dedicated to preserving representative populations of desert tortoises; educating the public; holding annual introductory workshops; and annual symposia to bring together representatives from government agencies, academia, and the public to learn and discuss important topics aimed at recovery of tortoise populations. The Desert Tortoise Council was instrumental in providing critical materials for federal and state listings of the species. The Desert Tortoise Preserve Committee, Inc., was formed in 1974 to establish protected areas for *G. agassizii*. This non-profit organization is a land trust and mitigation bank, a source of education, and research. They were instrumental in establishing the Desert Tortoise Research Natural Area and increasing its size.

Two preserves or protected areas exist with moderately high degrees of protection. One is the 100 km^2 (and increasing) Desert Tortoise Research Natural Area, which was formally designated by the U.S. Congress in 1980. It is fenced, with no vehicle access, livestock grazing, mining, or surface disturbances other than a few limited natural trails and a kiosk. The Natural Area is for wild tortoises only and populations are allowed to fluctuate naturally with no augmentation. Population density of adults throughout the Natural Area in 2011-12 was 10.2/km^2 (Berry et al. 2014a). The second preserve is Red Cliffs Desert Reserve in Utah (251 km^2). The Red Cliffs National Conservation Area provides additional protection for federal lands within the Reserve. Several paved roads, fenced and unfenced, run through the Reserve and recreation occurs throughout (e.g., hiking, horseback riding, mountain biking). The next and lower level of protection could be described as occurring within National Parks, State Parks, and National Recreation Areas such as Joshua Tree and Death Valley National Parks, Mojave National Preserve, Red Rock Canyon, Anza-Borrego, and Red Rocks State Parks, Lake Mead National Recreation Area, and the Beaver Dam Wash National Conservation Area. These parks and recreation areas have very high visitor use, unfenced paved roads, and some illegal collecting and release of captive tortoises of one or more species.

Twelve critical habitat units, the basis for Tortoise Conservation Areas (term defined in USFWS 2011), were designated by the USFWS (1994), and have far less protection than either the Desert Tortoise Research Natural Area or the Red Cliffs Desert Reserve and are subject to multiple land uses that fragment and degrade habitat and create vulnerabilities and risks to the tortoises (e.g., invasive non-native grasses and other non-native species; highways; roads; utility poles, towers, and electrical transmission lines; gas lines and fibreoptic cables; recreational vehicle use; shooting; domestic and feral dogs; cattle grazing and feral burros; mining; military installations; fire that causes degradation of habitat).

Seventeen monitored subpopulations in the 12 critical habitat units are contained within five recovery units which cover a total of 25,678 km^2. The following information for each recovery unit and the 17 Tortoise Conservation Areas reports area (km^2), and density of breeding adults per km^2 in 2014. Western Mojave Recovery Unit: Fremont-Kramer (2,347 km^2, 2.6/km^2), Ord-Rodman (852 km^2, 3.6/km^2), Superior-Cronese (3,094 km^2, 2.4/km^2); Colorado Desert Recovery Unit: Chocolate Mountains Aerial Gunnery Range (713 km^2, 7.2/km^2), Chuckwalla (2,818 km^2, 3.3/km^2), Chemehuevi (3,763 km^2, 2.8/km^2), Fenner (1,782 km^2, 4.8/km^2), Joshua Tree (1,152 km^2, 3.7/km^2), Pinto Mountain (508 km^2, 3.4/km^2), Piute Valley (927 km^2, 5.3/km^2); Eastern Mojave Recovery Unit: El Dorado Valley (999 km^2, 1.5/km^2), Ivanpah Valley (2,447 km^2, 2.3/km^2); Northeastern Mojave Recovery Unit: Beaver Dam Slope (750 km^2, 6.2/km^2), Coyote Spring (960 km^2, 4.0/km^2), Gold Butte (1,607 km^2, 2.7/km^2), Mormon Mesa (844 km^2, 6.4/km^2); Upper Virgin River Recovery Unit: Red Cliffs Desert Reserve (115 km^2, 15.3/km^2) (USFWS 2015; Allison and McLuckie 2018). The overall decline in tortoise populations in critical habitats (Tortoise Conservation Areas) between 2004 and 2014 was 32.2% (USFWS 2015). Four of the five recovery units are in a state of decline, with 11 of the 17 subpopulations registering declines in adult tortoises ranging from 26.6 to 64.7% during the 10 years (USFWS 2015). Most of the increasing subpopulations were in Nevada. Population densities for adults ranged from 1.5 to 7.2/km^2 in declining populations as of 2014 (USFWS 2015).

Extensive research has been published in peer-reviewed journals on many aspects of natural history, general ecology, physiological ecology, reproduction, health and diseases, population attributes, causes of death, movements and home range, predators, head-starting, translocation, and many other topics, making *G. agassizii* likely the most well-researched non-marine turtle species (Lovich and Ennen 2013b). Over 400 journal articles were published as of 2018, most between 1990 and 2018, as well as hundreds of reports (see three annotated bibliographies covering almost 160 years: Hohman *et al*. 1980, Grover and DeFalco 1995, Berry *et al*. 2016). Some information has been integrated into recovery programs, but many of the recovery measures recommended in the first Recovery Plan (USFWS 1994) have not been implemented as of 2020.

Economic relevance: The approximate cost of USD 100 million to develop and implement the first and second Recovery Plans is significant within the regulatory, scientific and local economic sectors involved and much remains to be implemented (USFWS 1994, 2011; Averill-Murray *et al*. 2012).

Conservation Measures needed:

The USFWS (1994) published recommended regulations for the areas that were designated as critical habitat. They described activities to be prohibited (e.g., all vehicle activity off designated roads; all competitive and organized recreational vehicle events on designated roads; habitat destructive military manoeuvres, clearing for agriculture, landfills and other surface disturbances; domestic livestock grazing, grazing by feral burros and horses; vegetation harvest; collection of biological specimens or vegetation harvest except by permit; dumping and littering; and deposition of captive or displace desert tortoises except under authorized translocation research projects; uncontrolled dogs out of vehicles; discharge of firearms except for hunting of game between September and February. There were many other recommended management actions but few of these recommendations were adopted when critical habitat units were officially described (USFWS 1994), and others have only been partially implemented by 2020. There were also recommendations for monitoring and research. In the second recovery plan, the USFWS (2011) identified and ranked (Darst *et al.* 2013) priority actions for recovering the Desert Tortoise and established regional Recovery Implementation Teams to implement these recovery actions. These Recovery Implementation Teams identify local, regional, and range-wide actions by submitting proposals to team members for discussion and prioritization. Ultimately the proposals are submitted to range-wide Management Oversight Groups composed of state, federal, and county government agencies for review, discussion, and potential sources of funding. Some projects are successfully funded and implemented, while many recommended in 1994 remain unfulfilled.

In association with the following standardized categories of Conservation Actions Needed, we provide

the following notes:

1.1. Land/water protection -> Site/area protection

a. Better protection of Critical habitats could ensure that populations of tortoises become stable and/or increase. Examples of protective measures included in recovery measures for the tortoise are exclusion fencing and culverts along highways and roads; reduction in populations of hyper-predators such as the Common Ravens; control and removal of newly introduced and previously existing non-native plants; and control of recreational vehicle use.

2.1. Land/water management -> Site/area management

a. The first recovery plan identified site-specific or critical habitat-specific measures to ensure protection of habitat and reduction of deaths of tortoises from anthropogenic sources (USFWS 1994). Most of these recommendations are still relevant. The Recovery Implementation Teams have provided recommendations similar to those in the first recovery plan. Many of these measures remain to be implemented. For example, in the State of California where most desert tortoise habitat and populations occur, acquisition of private land would be beneficial, because a substantial portion of habitat is in multiple private ownership. Both the USFWS and State of California recommend that developers of tortoise habitat acquire replacement habitat for habitat lost to development, and such actions have been occurring for ~20 years. Another topic and critical area that would benefit from protection is the population and hybrid zone with *G. morafkai* east of the Colorado River in Arizona (Edwards *et al*. 2015). This small population is not protected under the federal Endangered Species Act (Edwards *et al*. 2015).

2.2. Land/water management -> Invasive/problematic species control

a. Non-native grasses (e.g., *Schismus arabicus*, *S. barbatus*, *Bromus tectorum*, *B. madritensis rubens*) and forbs (e.g., *Brassica tournefortii*, *Hirschfeldia incana*) present serious and severe problems to tortoises because tortoises are selective in the choice of forage (Jennings and Berry 2015). The non-native annuals contribute to changes in forage availability, habitat structure, and increases in fire (D'Antonio and Vitousek 1992). These non-native species thrive under disturbance and spread via roads, livestock, military maneuvers, and disturbances created by recreational vehicle use off-road (e.g., D'Antonio and Vitousek 1992, Brooks and Berry 2006, Brooks *et al*. 2006, Brooks and Matchett 2006). The grasses are highly combustible and fire-prone in wildlands that did not evolve with short-term fire cycles (D'Antonio and Vitousek 1992). The grasses also compete with native annuals used as forage by the tortoises, and the species of grasses contain little nutrition, require water to metabolize, cause weight loss in the tortoises, and can become embedded in the jaws (Medica and Eckert 2007; Hazard *et al*. 2009, 2010; Drake *et al*. 2016). Similarly, *Brassica tournefortii* competes with native species used for forage and often occurs in dense stands, inhibiting movements of tortoises (Berry *et al*. 2014b).

3.2. Species management -> Species recovery

a. Species management and recovery are guided by the Recovery Plan and the U.S. Fish and Wildlife Service. On-the-ground management is by the administering agency, e.g., U.S. Bureau of Land Management, National Park Service, Department of Defense, States (for state land), and private owners. That being said, much can be done by implementing actions recommended in the first Recovery Plan (USFWS 1994) and by restoring degraded habitat (e.g., Abella and Berry 2016); controlling recreation vehicle use off-road and reducing fragmentation of habitat; limiting spread of invasive, non-native grasses and forbs; controlling hyper-predation in common ravens (USFWS 2008) and coyotes; preventing dogs and dog packs from running loose in the desert; and acquiring habitat.

4.3. Education & awareness -> Awareness & communications
a. See Conservation Actions in Place. Expansion of on-going programs to prevent take or shooting in the wild and release of captive tortoises of several species.

In association with the following standardized categories of Research Needed, we provide the following notes: While research on some topics is desirable, more is known about *G. agassizii* than most other reptiles (Lovich and Ennen 2013b, Berry *et al*. 2016 and references therein). Instead, implementation of previously identified actions to protect populations and habitat is more critical, specifically actions that will reduce deaths and loss or degradation of habitat.

1.1. Research -> Taxonomy
a. Genetic relationships between and within populations: human-mediated translocations of tortoises have occurred for decades, some authorized, some not (see Murphy et al. 2007). One recent question is the source of tortoises in Anza Borrego Desert State Park in the Colorado Desert of California. One might expect that the source would be tortoises occurring in the Colorado Desert, but instead tortoises have genotypes typical of the southwestern Mojave Desert population (Manning and Edwards 2019). More information on nearby tortoises (e.g. Lovich *et al.* 2020) occurring on the east-facing slopes of the Peninsular Range north of the Park may shed light on whether this is a naturally occurring population or a source that came from human-mediated translocations.
b. Translocation of thousands of tortoises has occurred in the last >20 years. Yet the only information available as to whether these translocated tortoises have been assimilated into the recipient or existing resident populations is research by Mulder *et al.* (2017) on assimilation of translocated males into the population of resident tortoises. Much more needs to be done on following males and females over a 10- to 20-year period to determine if and when adult males are assimilated into resident populations.

1.2. Research -> Population size, distribution & trends
a. More information on current population attributes such as size-age class structure, recruitment of juveniles into adult populations, sex ratios of adult tortoises, and causes and contributors to death is highly desirable. Landscape sampling undertaken and managed by the U.S. Fish and Wildlife Service's Desert Tortoise Recovery Office has provided valuable region-wide information on adult densities but not on other essential population attributes (i.e., Allison and McLuckie 2018). Resurvey of long-term, mark-recapture tortoise plots has been spotty for the past 20 years while support has increased for line-distance sampling representatively and on a landscape scale (see USFWS 2015, Allison and McLuckie 2018). Nonetheless, it is clear (USFWS 2011) that species recovery cannot be assumed based on patterns of adult counts alone, and active work to describe vital rates across the range will be an important part of assuring tortoise populations reflect healthy population dynamics or determining regional and size-specific recovery needs.

1.3. Research -> Life history & ecology
a. More information is needed on survival of neonate, juvenile, and immature size classes (first 12 to 15 years of life) and causes of mortality in the wild. Frequent input of new data on causes of and contributors to mortality for all size classes is essential for improving management of the species and for achieving upward trends.

1.5. Research -> Threats
a. The USFWS developed a model to identify major threats to the species (Darst *et al*. 2013); the information in this model is based on published research only, and not on the hundreds of reports and manuscripts available in Annual Reports to the USFWS on research permits. The model is outdated and needs major revisions to more accurately reflect available information and more recent priorities. In addition, support could be provided to speed up publication of important research projects that will lead to more protective management actions.

3.1. Monitoring -> Population trends
a. Monitoring is especially needed on population attributes in critical habitat, near highways, and in critical habitat near urban areas.

3.4. Monitoring -> Habitat trends
a. Monitoring is especially needed on wildfires, non-native plants, seed beds, and recovery of preferred forage plants.

Credits

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External Resources

For Supplementary Material, and for Images and External Links to Additional Information, please see the Red List website.

Appendix

Habitats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Habitat	Season	Suitability	Major Importance?
3. Shrubland -> 3.4. Shrubland - Temperate	-	Suitable	Yes

Threats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Threat	Timing	Scope	Severity	Impact Score
1. Residential & commercial development -> 1.1. Housing & urban areas	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
1. Residential & commercial development -> 1.2. Commercial & industrial areas	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
1. Residential & commercial development -> 1.3. Tourism & recreation areas	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 1. Ecosystem stresses -> 1.3. Indirect ecosystem effects 2. Species Stresses -> 2.1. Species mortality 2. Species Stresses -> 2.2. Species disturbance		
2. Agriculture & aquaculture -> 2.1. Annual & perennial non-timber crops -> 2.1.2. Small-holder farming	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.1. Annual & perennial non-timber crops -> 2.1.3. Agro-industry farming	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.3. Livestock farming & ranching -> 2.3.2. Small-holder grazing, ranching or farming	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.3. Livestock farming & ranching -> 2.3.3. Agro-industry grazing, ranching or farming	Ongoing	Majority (50-90%)	Slow, significant declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		

3. Energy production & mining -> 3.1. Oil & gas drilling	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
3. Energy production & mining -> 3.2. Mining & quarrying	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
3. Energy production & mining -> 3.3. Renewable energy	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
4. Transportation & service corridors -> 4.1. Roads & railroads	Ongoing	Majority (50-90%)	Slow, significant declines	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.1. Species mortality		
4. Transportation & service corridors -> 4.2. Utility & service lines	Ongoing	Whole (>90%)	Slow, significant declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
5. Biological resource use -> 5.1. Hunting & trapping terrestrial animals -> 5.1.1. Intentional use (species is the target)	Ongoing	Minority (50%)	Rapid declines	Medium impact: 6
	Stresses:	2. Species Stresses -> 2.1. Species mortality		
6. Human intrusions & disturbance -> 6.1. Recreational activities	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
6. Human intrusions & disturbance -> 6.2. War, civil unrest & military exercises	Ongoing	Minority (50%)	Causing/could cause fluctuations	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
6. Human intrusions & disturbance -> 6.3. Work & other activities	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
7. Natural system modifications -> 7.1. Fire & fire suppression -> 7.1.1. Increase in fire frequency/intensity	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.1. Species mortality		
7. Natural system modifications -> 7.2. Dams & water management/use -> 7.2.8. Abstraction of ground water (unknown use)	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		

8. Invasive and other problematic species, genes & diseases -> 8.1. Invasive non-native/alien species/diseases -> 8.1.1. Unspecified species	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
8. Invasive and other problematic species, genes & diseases -> 8.3. Introduced genetic material	Ongoing	Minority (50%)	Negligible declines	Low impact: 4
	Stresses:	2. Species Stresses -> 2.3. Indirect species effects		
8. Invasive and other problematic species, genes & diseases -> 8.5. Viral/prion-induced diseases -> 8.5.1. Unspecified species	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	2. Species Stresses -> 2.1. Species mortality		
9. Pollution -> 9.2. Industrial & military effluents -> 9.2.2. Seepage from mining	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
11. Climate change & severe weather -> 11.1. Habitat shifting & alteration	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		
11. Climate change & severe weather -> 11.2. Droughts	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation		

Conservation Actions in Place

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Action in Place
In-place research and monitoring
Action Recovery Plan: Yes
Systematic monitoring scheme: Yes
In-place land/water protection
Conservation sites identified: Yes, over entire range
Area based regional management plan: Yes
Occurs in at least one protected area: Yes
Invasive species control or prevention: Yes
In-place species management
Harvest management plan: No
Successfully reintroduced or introduced benignly: Yes
Subject to ex-situ conservation: Unknown
In-place education
Subject to recent education and awareness programmes: Yes

Conservation Action in Place
Included in international legislation: Yes
Subject to any international management / trade controls: Yes

Conservation Actions Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Action Needed
1. Land/water protection -> 1.1. Site/area protection
2. Land/water management -> 2.1. Site/area management
2. Land/water management -> 2.2. Invasive/problematic species control
3. Species management -> 3.2. Species recovery
4. Education & awareness -> 4.3. Awareness & communications

Research Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Research Needed
1. Research -> 1.1. Taxonomy
1. Research -> 1.2. Population size, distribution & trends
1. Research -> 1.3. Life history & ecology
1. Research -> 1.5. Threats
1. Research -> 1.6. Actions
3. Monitoring -> 3.1. Population trends
3. Monitoring -> 3.4. Habitat trends

Additional Data Fields

Distribution
Estimated area of occupancy (AOO) (km^2): 116993
Continuing decline in area of occupancy (AOO): Yes
Estimated extent of occurrence (EOO) (km^2): 166000
Continuing decline in extent of occurrence (EOO): Yes
Upper elevation limit (m): 1,570

Population
Population severely fragmented: Yes
Habitats and Ecology
Continuing decline in area, extent and/or quality of habitat: Yes
Generation Length (years): 20-32,30

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Population trends in Mojave desert tortoises (Gopherus agassizii)

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Population Trends in Mojave Desert Tortoises (*Gopherus agassizii*)

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***Abstract*.—Populations of the Mojave Desert Tortoise (*Gopherus agassizii*) experienced severe declines in abundance in the decades leading up to 1990, when the species was listed as threatened under the U.S. Endangered Species Act. Population responses to recovery efforts have not been well documented because of the difficulties of studying this low-density, cryptic species over a time period appropriate to its long generation time. We used line distance sampling to estimate annual adult densities since 1999 in Utah and since 2004 elsewhere in the range of Mojave Desert Tortoises. We used generalized least squares regression on log-transformed adult tortoise densities to estimate annual percentage change through 2014 in each of 17 Tortoise Conservation Areas (TCAs) in the five recovery units. We report annual proportional increases in density of adults in the Northeastern Mojave Recovery Unit, but declines in the other four recovery units. Adjusting these densities and trends for the area of potential habitat in each recovery unit, we estimated that in 2004 there were 336,393 adult tortoises (standard error [SE] = 51,596), with an overall loss of 124,050 adult tortoises (SE = 36,062) by 2014. The proportion of juveniles in our surveys has been decreasing in all five recovery units since 2007. Prevailing declines in the abundance of adults overall and in four of the five recovery units indicate the need for more aggressive implementation of recovery actions and more critical evaluation of the suite of future activities and projects in tortoise habitat that may exacerbate ongoing population declines.**

Key Words.—Colorado Desert; distance sampling; information theory; long-term monitoring; Mojave Desert; species recovery

Introduction

Turtles around the world face the highest level of endangerment of any vertebrate lineage today (Stanford et al. 2018). Historical extinctions and recent crises have characterized species on islands or with relatively localized and easily exploitable populations (Stanford et al. 2018). However, turtles as a group are vulnerable in part due to their shared life histories based on high adult survival, delayed age at first reproduction, and low rates of juvenile recruitment (Congdon et al. 1993; Stanford et al. 2018). Even tortoises with relatively large historical ranges are susceptible to threats with relatively small effects, in combination and acting over long generation times, and this life-history strategy also diminishes their ability to recovery quickly from population losses.

Populations of the Desert Tortoise (*Gopherus agassizii*, *sensu stricto*) experienced severe declines in abundance in the decades leading up to 1990, when populations in the Mojave and Colorado deserts west and north of the Colorado River were listed as Threatened under the U.S. Endangered Species Act (U.S. Fish and Wildlife Service [USFWS]1990). Murphy et al. (2011) split the full species into two: the Mojave Desert Tortoise (*Gopherus agassizii*) occupying the range north and west of the Colorado River (the same area listed as Threatened above and retaining this listing) and the Sonoran Desert Tortoise (*G. morafkai*) south and east of the Colorado River. Population responses to recovery efforts for *G. agassizii* have not been well documented, in part, because of the difficulties of studying this low-density, long-lived species. The current recovery plan (USFWS 2011) designates five recovery units for *G. agassizii* that are intended to conserve genetic, behavioral, and morphological diversity necessary for the long-term recovery of the entire listed species (Fig. 1). The recovery plan also defines criteria that form the basis for decisions about continued listing status. For instance, rates of population change of *G. agassizii* should be increasing for at least one tortoise generation (25 y) in all recovery units to warrant delisting (USFWS 2011).

Whereas *G. agassizii* (*sensu stricto*) were initially protected on the basis of population declines estimated on a limited number of small, selectively located mark-recapture study plots, over the longer term, status descriptions should be based on more extensive and rigorous population estimates (Tracy, R.C., R. Averill-Murray, W.I. Boarman, D. Delehanty, J. Heaton, E. McCoy, D. Morafka, K. Nussear, B. Hagerty, and

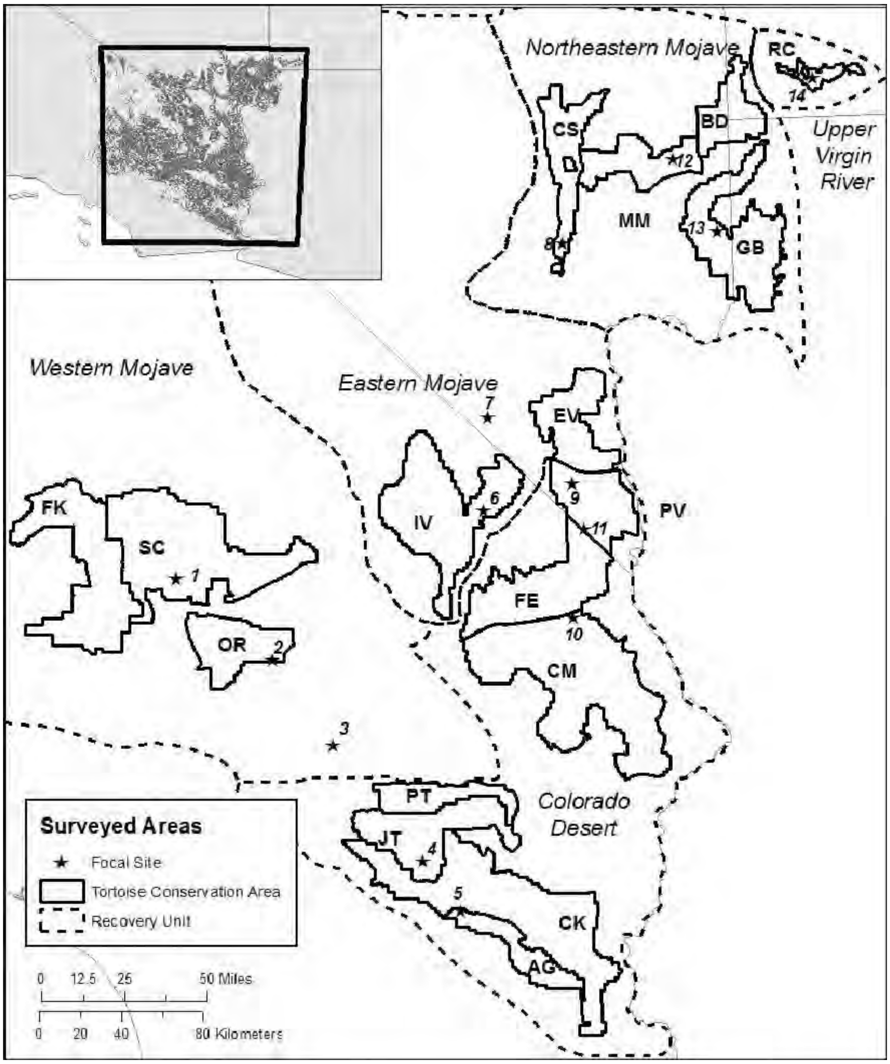

FIGURE 1. Tortoise Conservation Areas (TCAs, n = 17) for Mojave Desert Tortoises (*Gopherus agassizii*) that were monitored in the Mojave and Colorado deserts, USA. Sites were monitored through 2014 and began in 2004 except in the Red Cliffs Desert Reserve, where surveys started in 1999. TCAs and their codes are Chocolate Mountains Aerial Gunnery Range (AG), Beaver Dam Slope (BD), Chuckwalla (CK), Chemehuevi (CM), Coyote Springs Valley (CS), Eldorado Valley (EV), Fenner (FE), Fremont-Kramer (FK), Gold Butte-Pakoon (GB), Ivanpah (IV), Joshua Tree (JT), Mormon Mesa (MM), Ord-Rodman (OR), Pinto Mountains (PT), Piute Valley (PV), Red Cliffs (RC), Superior-Cronese (SC). Observations to estimate visibility were made of transmittered tortoises at the numbered focal sites: 1) Superior-Cronese, 2) Ord-Rodman, 3) Twentynine Palms, 4) Joshua Tree, 5) Chuckwalla, 6) Ivanpah, 7) Jean, 8) Indian Springs, 9) Piute Valley 1, 10) Chemehuevi, 11) Piute Valley 2, 12) Halfway Wash, 13) Gold Butte, 14) Red Cliffs. Potential habitat as defined in the text is overlain on the southwestern United States in the extent indicator.

P. Medica. 2004. Desert Tortoise Recovery Plan Assessment. Report to the U.S. Fish and Wildlife Service, Reno, Nevada. Available from http://www.fws.gov/nevada/desert_tortoise/documents/dtrpac/dtrpac_report.pdf [Accessed 15 August 2018]). In 1999, agencies cooperating on recovery of *G. agassizii* adopted distance sampling (Buckland et al. 2001) for estimating population density at large spatial scales. Surveyors use distance sampling to account for the proportion of the population that is not observed at increasing distances from the observers. We conducted distance sampling surveys for *G. agassizii* throughout Tortoise Conservation Areas (TCAs; Fig. 1), which include federally designated critical habitat for the species (USFWS 1994), as well as in contiguous areas with conservation designations and suitable tortoise habitat (Nussear et al. 2009). Most recovery units (USFWS 1994, 2011) contained more than one TCA (Fig. 1). Ongoing monitoring for *G. agassizii* based on distance sampling has been conducted since 1997 in the Upper

Virgin River Recovery Unit by the Utah Division of Wildlife Resources and by the USFWS in the remaining four recovery units starting in 2001.

In this paper, we start by developing annual density estimates for each TCA based on distance sampling. These efforts are typically collaboratively funded with each agency requiring annual reports that include annual population estimates. Our second and primary goal herein was to use these annual estimates to describe adult *G. agassizii* population trends for each TCA and recovery unit. These trends must account for precision of annual estimates that is often low, variable, and correlated between TCAs within years. Although we cannot fully evaluate the recovery criterion that requires increasing population numbers in each recovery unit until at least 25 y of surveys have been completed (USFWS 2011), this monitoring program is part of the adaptive management strategy for recovering *G. agassizii*. Our third goal was to use the interim regional population trends to evaluate the effectiveness of the recovery program. Our fourth goal was to characterize future trajectories for these populations based on changing patterns of relative abundance of juveniles.

Materials and Methods

***Study areas*.**—*Gopherus agassizii* occur throughout large, continuous regions of the Mojave and Colorado deserts of North America (Fig. 1). They occupy a broad elevational range (sea level to 2,225 m) from valley bottoms and bajada slopes at lower elevations to upper alluvial and mountain slopes at higher elevations (Luckenbach 1982). Typical habitat for *G. agassizii* is Creosote Bush (*Larrea tridentata*) scrub in association with White Bursage (*Ambrosia dumosa*) but they are also found in Joshua Tree (*Yucca brevifolia*) woodland, Blackbrush (*Coleogyne ramosissima*) scrub, microphyll woodlands, Shadscale (*Atriplex confertifolia*) scrub, saltbush (*Atriplex* spp.) scrub, cactus scrub, and warm season grassland (Germano et al. 1994; Nussear et al. 2009). Throughout their range, tortoises inhabit areas that include deeply incised washes, sandstone outcrops, rugged rocky canyons, and basalt-capped ridges interspersed with sandy valleys (Bury et al. 1994). However, tortoises most commonly occur in areas with gentle slopes, sufficient shrub cover, and friable soils to allow burrow construction (Bury et al. 1994).

Starting in 1997 in Upper Virgin River Recovery Unit and in 2001 elsewhere, we surveyed 17 TCAs across the five recovery units (Fig. 1). We did not survey every TCA every year, but the total area of 29,127 km^2 comprises the long-term monitoring frame (Table 1). The TCAs named for Red Cliffs Desert Reserve (RC) and Joshua Tree National Park (JT) exclude portions of these jurisdictions that were not potential tortoise habitat (USFWS 1994); RC also excluded a portion that was used for translocations of wild tortoises displaced by development. Each year we made behavioral observations on tortoises at up to 11 of the 14 focal sites within the overall study area (Fig. 1) to estimate the proportion of tortoises that were potentially visible to transect surveyors.

***Data collection*.**—Initially, we placed transects randomly within each TCA. In RC, these were permanent transect locations from the beginning of the program, and we surveyed the 153 transects annually between 1999 and 2001, then every other year. Between 2001 and 2003 in the rest of the range, there was restricted sampling based on various environmental criteria (USFWS 2006), so for comparability we only used data collected starting in 2004 when transects were sited at random throughout TCAs. Beginning in 2007 in these areas outside RC, we shifted from strictly random placement to random selection from a set of systematically placed transects that covered each TCA. Both of these methods result in transects that were located at random with respect to the location of tortoises, so the resulting annual density estimates are unbiased. Each year, available funding determined the number of transects assigned in each TCA.

Sampling methods we used adhered to study design considerations for distance sampling (Anderson, D.R., and K.P. Burnham. 1996. A monitoring program for the desert tortoise. Report to the Desert Tortoise Management Oversight Group. Available from https://www.fws.gov/nevada/desert_tortoise/documents/reports/Anderson-Burnham.1996.monitoringplan.pdf. [Accessed 15 August 2018]). We based initial transect and overall survey length on preliminary estimates of encounter rate and associated effort required to estimate density with a coefficient of variation (CV) of 0.10–0.15. We modified the number and length of transects as specified in Buckland et al. (2001) during earlier years of the surveys and based on updated information about encounter rates.

We completed surveys between mid-March and the end of May each year, when preferred food plants flower and *G. agassizii* are generally active outside of burrows. We started transects early enough so surveys would be completed before the hottest time of the day, scheduling survey dates in specific TCAs to correspond to peak daily tortoise activity based on past experience as well as observation of tortoises outfitted with radio-transmitters (see below). Surveys generally started around 0800 during March but started as early as sunrise by the beginning of May.

Generally, each two-person team walked one transect each day, using a compass and pre-specified bearings. Standard transects were 12 km long, walked in a

Table 1. Tortoise Conservation Areas within each Recovery Unit including total area (km^2) and total effort (km) by year. Tortoise Conservation Areas (with acronym; Acr) are grouped under corresponding larger recovery units. Red Cliffs Desert Reserve was also surveyed in 1999 (307 km), 2000 (302 km), 2001 (314 km) and 2003 (309 km).

Tortoise Conservation Area	Acr	Area (km^2)	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014
Colorado Desert		13,530	3,319	3,984	2,007	1,348	1,375	2,383	1,316	1,403		
Chocolate Mtn Aerial Gunnery Range	AG	755	331	228	404	158	378	378		363	413	554
Chuckwalla	CK	3,509	1,083	866	747	112		613	280	213		
Chemehuevi	CM	4,038	836	1,129	180	84	119	458	354	176		
Fenner	FE	1,841	410	288	178	108	121	246	179	168		
Joshua Tree	JT	1,567	278	601	135	102	240	227	147	183		
Pinto Mountains	PT	751	56	155	131	72	162	213	118	140		
Piute Valley	PV	1,070	325	717	231	713	355	249	239	159		
Eastern Mojave		3,720	876	620	368	714	548	578	746	639		
Eldorado Valley	EV	1,153	361	452	188	594	427	212	331	320		
Ivanpah	IV	2,567	515	168	180	120	120	365	416	318		
Northeastern Mojave		4,889	1,037	1,489	2,304	1,485	4,154	4,265	3,984	4,184		
Beaver Dam Slope	BD	828		421	478	2578	631	662	751	819	683	
Coyote Springs Valley	CS	1,117	365	237	906	1,592	1,504	1,046	967	996		
Gold Butte-Pakoon	GB	1,977	361	432	300		733	1,258	1,039	1,116	923	
Mormon Mesa	MM	968	311	398	621	691	1,286	1,298	1,227	1,253		
Western Mojave		6,873	1,534	1,979	896	599	1,351	2,144	1,257	876		2,095
Fremont-Kramer	FK	2,417	463	661	300	216	361	566	264	193		815
Ord-Rodman	OR	1,124	381	310	141	102	197	270	174	158		472
Superior-Cronese	SC	3,332	690	1,009	456	281	793	1,307	820	525		808
Upper Virgin River		115		305	308		310		310		314	
Red Cliffs Desert Reserve	RC	115		305	308		310		310		314	

square that was 3 km on each side. Where relatively open creosote-bursage alluvial slopes dominated the landscape, we found that repeated searching near the centerline did not improve encounter rates or detection on the line (USFWS 2006), so we did not mark the transect centerline for additional search effort. Instead, the leader surveyed along a straight path with a 25-m cord trailing behind. The second observer followed at the end of the moving cord and searched independently. The cord served as the transect centerline when taking distance measurements, and we calculated the walked length of these transects as the straight-line distance between GPS point coordinates that were recorded approximately 500 m apart along the transect.

In RC, where terrain rendered tortoises less visible, surveyors used a three-pass survey to effectively search on and near the marked transect centerline. One crew member, Observer A, dragged the end of the 50-m surveyor tape, following the transect bearing to its intended location. Observer A then walked in a sinusoidal pattern back toward the beginning of the tape searching for tortoises on one side of the tape while the other crew member walked in a similar sinusoidal pattern on the opposite side. Observer A then searched directly along the tape back to the end. The process repeated itself, with the roles of the two surveyors reversing each time. This intensive searching and the rugged terrain limited transects to 2 km per team each day.

We measured the distance and bearing of the tortoise to the observer on the center line in order to calculate the perpendicular distance of the tortoise to the transect center line. We measured distances with 30-m fiberglass or 50-m surveyor tapes, and we measured bearings with compasses. We used all observations of tortoises > 180 mm carapace length (CL) to develop detection curves and density estimates, whether tortoises were in burrows, in the open, or under vegetation. When tortoises were on the surface or could be easily extracted from burrows, we recorded CL and sex. Without suggesting that there is a single size threshold for reproduction within or between populations (Germano 1994), we refer hereafter to tortoises that are at least 180 mm CL as adults and smaller tortoises as juveniles.

Because we placed transects at random with respect to terrain and human infrastructure, and because standard transects were 3 km on each side, it was not unusual for the surveyed path to cross through varied terrain or be blocked by an obstacle such as a highway.

The rules for modifying transects in these situations involved reflecting or elongating transects to avoid obstacles associated with human infrastructure (large roads, private inholdings, etc.), or shortening transects in rugged terrain. The sampling frame therefore represented the walkable area of each TCA. Transects that were partially outside TCA boundaries were initially completed without regard for these jurisdictional changes, but where the boundary was impassable, we reflected transect segments into TCAs as needed (Buckland et al. 2001) or pivoted shorter transects in RC on their northeastern corner to fit inside the TCA. By 2010 we reflected transects so that all paths were inside TCAs.

We used behavioral observations of tortoises carrying radio transmitters (Boarman et al. 1998) to estimate the proportion of individuals available to be seen above ground or in burrows during transect surveys, G_0 (Anderson and Burnham, *op. cit*.). Telemetry technicians used a VHF radio receiver and directional antenna to locate radio-equipped tortoises (n = 5–30) at each focal site (Fig. 1) during the same daily time period when field crews were walking transects in that region of the desert. Observers completed a survey circuit of all transmittered animals as many times as possible (range, 0–5 times per day) during the allotted time, recording each time whether the tortoise was visible.

Estimation of annual tortoise density in each TCA.—We used distance sampling (Buckland et al. 2001) to develop density estimates based on encounter rates in each TCA adjusted for imperfect detection of animals farther from the transect centerline. Estimates were developed each year separately for reporting to sponsoring agencies. We used Program DISTANCE, 6.2 (Thomas et al. 2010), to estimate P_a, the proportion of adult *G. agassizii* detected within w meters of the transect centerline. We truncated observations by distance from the centerline to improve model fit as judged by the simplicity of the resulting detection function (Buckland et al. 2001). Truncation typically reduced the number of observations overall by 5% or fewer, improving estimates of detection probability but reducing the number of observations to estimate encounter rate in each TCA. Sample size considerations also contributed to our decision to rely on pooling robustness (Buckland et al. 2001) rather than using covariates to model detection function estimates (Marques et al. 2007). Detection function estimation is robust in the face of pooling data from different observers, on different days, and in different areas (Buckland et al. 2001) as long as factors that cause variability in detection probability are represented proportionately (Marques et al. 2007). Such factors include vegetation that differentially obscures vision with distance and different detection patterns characteristic of individual crews (pairs). Crews on the same team walked the same number of transects although crews on different teams might not. For these reasons, we placed transects at random in each TCA and developed separate detection curves each year for each field team, pooling data from all TCAs surveyed by that team. Teams also correspond to regions of the desert, and years are correlated with precipitation conditions that affect spring vegetation height and cover, so detection curves that are created separately for teams and years also indirectly address additional factors that affect detection. In years when a team surveyed both in the Mojave and the Sonoran deserts, where the vegetation types may affect tortoise detection differentially, we used two separate detection curves if the sum of their AIC values was less than the AIC value for the single detection curve for the team. In RC, where the same transects were walked each year, we used a single detection curve for all years of the study. Although we pooled observations from multiple TCAs (or from multiple years in RC) for each detection curve, we estimated adult tortoise encounter rates (n/L) and the variance of n separately for each TCA each year.

The distance to which observations were truncated, w, determined the reported area searched in each TCA, $2wL$, where L is the total length in kilometers walked. We applied Akaike's Information Criterion (AIC) to select among detection-function models (uniform, half normal, and hazard-rate) and key function/series expansions recommended in Buckland et al. (2001). Where more than one model were strongly supported by the data, we selected on the basis of Chi-square goodness-of-fit statistics near the transect centerline.

If there is imperfect detection on the transect centerline, a further correction factor must be applied to estimate the true density of tortoises. Because transects in RC used a three-pass method to search the centerline, we assumed that all tortoises at the transect centerline were detected. Elsewhere, detections by two observers walking the centerline one after the other allowed estimation of the detection probability for tortoises within increasing distances from the transect centerline as for a two-pass removal estimator (White et al. 1982); this provides a test of the assumption that all tortoises on the transect centerline are recorded ($g(0) = 1$).

We used a final correction factor, G_0, to adjust the density estimate to account for tortoises hidden in burrows in addition to those that were visible. Each bootstrapped estimate of G_0 was based on one randomly selected visibility record for each tortoise outfitted with a radio transmitter on each day it was located. We generated 1,000 bootstrap samples in PASW Statistics (release 18.0.2, SPSS, Inc. Chicago, Illinois, USA) to estimate G_0 and its standard error by site.

Annual density in each TCA was estimated as:

$$D = \frac{n}{2wLP_aG_0g(0)}.$$

Whereas n and L were estimated separately for each TCA, observations from multiple TCAs were used to generate a single estimate of P_a. We also applied estimates of G_0 to more than one TCA, and we based estimates of $g(0)$ on all observations from the two-pass surveys. This pooling of information can lead to covariance between TCA estimates in a given year (see below). Although two of the correction factors have similar symbols, when the parameter symbol involves a capital letter (G_0), we are referring to the proportion visible; the lower-case letter refers to the probability of detection of visible tortoises at the centerline.

Describing trends in adult tortoise densities.—We used R 3.4.1 (R Core Team 2017) to develop marginal models (Pinheiro et al. 2017) describing the natural log of tortoise density per km^2 as a function of year and location. Logarithmic transformations have a special interpretation when modelling trends; a modest linear trend in a logarithmic quantity represents a proportional change rather than a linear one (Keene 1995). A slope of 0.05 for ln(density) regressed on years, for instance, would be interpreted as a 5% increase per year. Our models included TCA, Year, and $Year^2$. Year was centered before modeling (Schielzeth 2010). $Year^2$ was included to capture any curvilinear population responses, and we anticipate modeling additional polynomial terms in the future when we are considering a longer time period. The full model also included two-way interactions between TCA and the linear and quadratic time factors. We used generalized least squares regression to also weight annual density estimates based on their variance and to add covariance structure to account for sets of density estimates that were inherently correlated because they shared correction factors of P_a or G_0 (Pekar and Brabec 2016). This second level of analysis therefore incorporated information about the first-level (annual density) variances and covariances.

We used a model based on the full suite of fixed effects to select among different variance weighting and covariance structures (Zuur et al. 2009). We used model selection procedures based on second-order AIC (AIC_c, Burnham and Anderson 2002; Mazerolle 2015) to decide whether to weight the analysis by the variance or CV of the annual density estimates. We also considered whether to model correlations among residuals for density estimates from the same Year, or due to use of pooled G_0 and P_a estimates for multiple TCA density estimates (see above). For all subsequent tests of potential fixed-effects models, we selected a covariance structure to account for within-Year correlation of residuals and weighted optimization procedures as a function of the CV of annual density estimates.

With the final variance weighting and correlation structures in place, we used AIC_c for selection among alternative models and examined the fit of the best model using marginal r^2 (Nagelkerke 1991). We used ANCOVA to examine whether slopes and intercepts of TCAs in each recovery unit described the same pattern (Zar 1996). To apply tortoise densities from the TCAs to entire recovery units, we estimated the area of potential habitat in each of the five recovery units based on Nussear et al. (2009). We only considered 1-km^2 grid cells assigned a probability of occupancy > 0.5 as potential habitat (Liu et al. 2005) after removing any area identified as an impervious surface (Fry et al. 2011).

Describing trends in representation of juvenile size class.—During surveys, we noted all observed tortoises of any size; however, smaller tortoises were less detectable than adults and there were too few observations of smaller tortoises to make density estimates based on distance sampling. Instead, to complement our analysis of changes in the abundance of adult tortoises, we used mixed effects logistic regression (Bates et al. 2015) to evaluate the relative proportion of juvenile tortoises detected in each recovery unit, fitting the observations to models including Year, $Year^2$, Recovery Unit, and two-way interactions between Recovery Unit and the time factors as predictors. We also included the categorical form of Year as a random factor to account for any enforced correlation across the recovery units in proportion of juveniles present due to annual conditions. Because we observed many fewer juvenile tortoises than adults, we report results at the larger spatial scale of the recovery unit rather than for each TCA. Tortoises that could not be extracted from burrows were often classified as unknown rather than as adults or juveniles, especially earlier in the study period. We conservatively assumed all unclassified tortoises were adults, so that estimates of the proportion of juvenile observations earlier in the time series were not inflated. Lacking information on detectability of juveniles to correct our raw data, the relative proportion of juveniles that we examined reflected their representation among detected animals, not the actual proportion of juveniles in the population. We used AIC for model selection, weighting, and averaging (Barton 2015). Note that because the continuous input variable Year was standardized to a mean of zero and divided by two standard deviations before model development (Schielzeth 2010), we could consider models with the quadratic form of this variable even if the linear form was not present in the model; this is equivalent to assuming opposing trends at the start and end of the study period

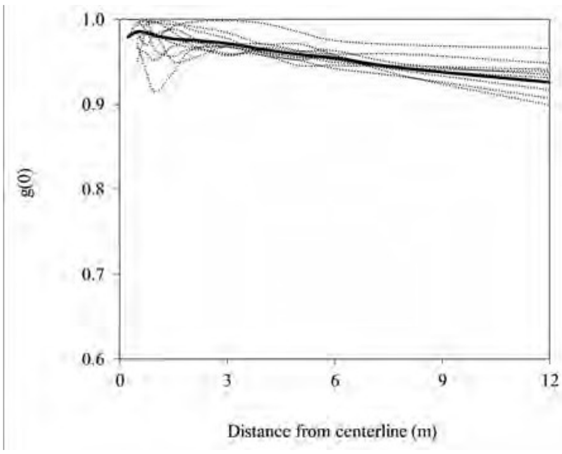

FIGURE 2. Detection of Mojave Desert Tortoises (*Gopherus agassizii*) at the transect centerline (*g(0)*) based on all two-pass survey observations as remote as x meters from the transect centerline. Dotted lines are annual curves; solid line is overall pattern across years from 2004 through 2014 (no surveys conducted in 2006). Note the convergence of *g(0)* on 1.0 as x goes to 0.

but no average trend overall. This standardization also allowed us to use model averaging on interaction terms (Schielzeth 2010). For models describing Year^2 effects, the inflection point at which trends shifted between increases and decreases in the odds of encountering juveniles on surveys was estimated as $-\beta_{Year}/2\beta^{2}_{Year}$.

RESULTS

Adult densities and trends.—Annual probability of detection within 2 m of the transect centerline varied from 0.95 to 1.00, and converged on *g(0)* = 1.0 (Fig. 2), so we added no *g(0)* correction to annual density estimates. In contrast, although estimated tortoise visibility (G_0) was generally greater than 0.80, it was estimated as low as 0.35 at Chemehuevi in 2012 (Fig. 3, Appendix A), illustrating the degree of bias possible if tortoise density estimates do not include corrections for tortoises unavailable for detection. Some of our focal sites were consistently characterized by more above-ground activity than others (Fig. 3). The half-strip width, w, was generally between 12 and 22 m (Appendix B). Detection rate, P_a, was 0.64 in RC and averaged 0.45 in the other TCAs, where two-pass surveys were implemented; however, whether two- or three-pass sampling was used, the detection shoulder near the centerline consistently indicated nearly complete detection out to 2 m (10% of w) as recommended by Buckland et al. (2001).

Annual density estimates ranged from 0.2 adult tortoises/km^2 (SE = 0.2) in GB in 2005 to 28.0/ km^2 (SE = 4.0) in RC in 2000 (Table 2). During the first years reported here (2004 and 2005), TCAs in the Northeastern Mojave Recovery Unit had lower mean densities (< 5.0/

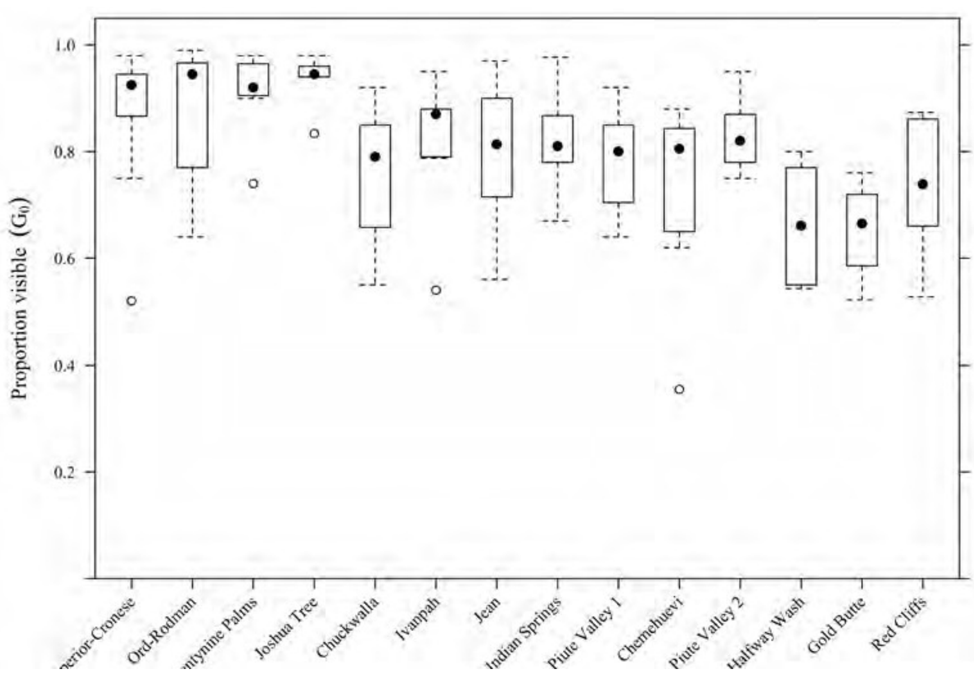

FIGURE 3. Box and whisker plots indicating the proportion of adult Mojave Desert Tortoises (*Gopherus agassizii*) visible (G_0) at each of 14 focal sites shown in Fig. 1 during transect surveys from 1999 through 2014. Boxes represent the interquartile range (values from the 25th – 75th percentile), crossed by a heavy bar at the median. Dotted-line whiskers indicate the extent of the 12.5–87.5 percentile, with any values outside this range shown as hollow dots below some whiskers. Sites are ordered from west on the left to east. Not all focal sites were used to correct density estimates each year. For instance, only Red Cliffs was monitored before 2004, and Jean was used in only one year of observation.

Table 2. Densities (n/km^2) of adult Mojave Desert Tortoises (*Gopherus agassizii*) and corresponding standard errors (SEs) in each Tortoise Conservation Area (TCA) from 2004 to 2014. Acronyms for TCAs are given in Table 1. RC was also surveyed earlier: 1999 (34.3, SE = 11.32), 2000 (25.7, SE = 5.61), 2001 (24.4, SE = 5.69), 2003 (14.0, SE = 2.79).

TCA within Recovery Unit	Year									
	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014
Colorado Desert										
AG	11.4 (3.55)	13.4 (4.31)	6.5 (1.50)	4.5 (2.56)	7.5 (2.74)	13.8 (3.52)		6.0 (1.84)	7.3 (1.96)	8.4 (2.09)
CK	4.9 (1.49)	6.0 (1.77)	4.3 (1.19)	4.2 (2.84)		3.7 (1.14)	3.9 (1.37)	3.9 (1.62)		
CM	6.7 (1.27)	10.3 (3.10)	3.9 (1.71)	4.8 (3.07)	9.4 (5.98)	4.2 (1.40)	4.0 (1.51)	0.8 (0.90)		
FE	8.2 (1.94)	13.5 (2.80)	6.2 (2.37)	6.6 (3.05)	8.3 (4.01)	6.9 (2.49)	6.8 (2.78)	0.9 (0.95)		
JT	1.9 (0.53)	2.7 (0.79)	3.0 (1.94)	2.3 (1.75)	2.3 (1.56)	2.8 (1.56)	3.5 (1.33)	3.4 (1.63)		
PT	2.2 (2.12)	9.9 (3.58)	1.9 (0.98)	3.3 (3.53)	4.3 (2.38)	3.4 (1.85)	3.3 (1.39)	3.7 (1.57)		
PV	2.9 (1.13)	3.7 (0.90)	4.1 (1.88)	4.1 (1.28)	3.6 (1.64)	3.8 (1.37)	6.6 (2.62)	1.9 (1.46)		
Eastern Mojave										
EV	2.6 (0.94)	5.0 (1.25)	4.1 (1.69)	1.8 (0.85)	3.8 (1.56)	1.0 (0.62)	2.8 (1.13)	0.9 (0.74)		
IV	4.4 (1.19)	4.4 (2.46)	5.6 (1.95)	5.1 (2.92)	4.1 (1.86)	1.0 (0.48)	4.5 (1.72)	2.8 (1.79)		
Northeastern Mojave										
BD		0.9 (0.49)	1.1 (0.57)	1.1 (0.59)	3.2 (1.61)	3.3 (0.93)	3.3 (1.22)	5.4 (1.60)	2.6 (1.06)	
CS	1.3 (0.54)	3.3 (1.23)	1.4 (0.47)	1.2 (0.37)	2.0 (0.74)	3.6 (0.87)	4.0 (0.88)	2.9 (0.66)		
GB	0.6 (0.34)	0.2 (0.18)	1.1 (0.58)		2.2 (1.14)	1.7 (0.61)	1.6 (0.58)	2.3 (0.74)	1.7 (0.68)	
MM	2.4 (0.88)	4.9 (1.37)	3.0 (0.93)	1.9 (0.73)	7.3 (2.83)	5.5 (1.15)	6.3 (2.10)	4.3 (1.30)		
Upper Virgin River										
RC		22.5 (4.59)	22.1 (10.76)		15.5 (3.74)		19.3 (4.14)		18.3 (5.58)	
Western Mojave										
FK	8.4 (2.31)	5.3 (1.28)	3.0 (1.46)	0.5 (0.51)	3.3 (1.13)	2.4 (0.60)	3.5 (1.11)	2.2 (1.07)		4.7 (1.05)
OR	7.3 (2.25)	7.7 (1.80)	7.1 (3.26)	5.0 (5.34)	7.2 (2.65)	7.5 (1.85)	3.2 (1.18)	4.6 (2.14)		3.5 (0.88)
SC	6.3 (1.84)	6.3 (1.32)	5.9 (2.28)	1.9 (1.19)	4.6 (1.12)	2.6 (0.49)	3.4 (0.79)	4.3 (1.41)		2.5 (0.60)

km^2) than TCAs in other recovery units. Each year we surveyed RC, it consistently had the highest densities of adult tortoises.

The best model to describe variation in adult tortoise densities supported the hypothesis that densities changed proportionally over time, with different linear trends in each TCA (Table 3). Models based on linear trends had strong support (cumulative model weights = $\sum w$ = 0.9996; Table 3), whereas those including quadratic effects of time had essentially no support ($\sum w < 0.0001$).

We report tortoise trend estimates based only on the best-performing model, with $w > 0.999$ and describing a large amount of variation in $\log_e$(Density). Estimates of r^2 (marginal $r^2 = 0.84$, Nagelkerke's modified $r^2 = 0.92$) indicated that after weighting to address variance heterogeneity and building in covariance structure, there was considerable variance in adult densities that could be explained by the effects of Year, TCA, and their interaction. Covariance between TCA density estimates from the same year accounted for 17.0% of the total

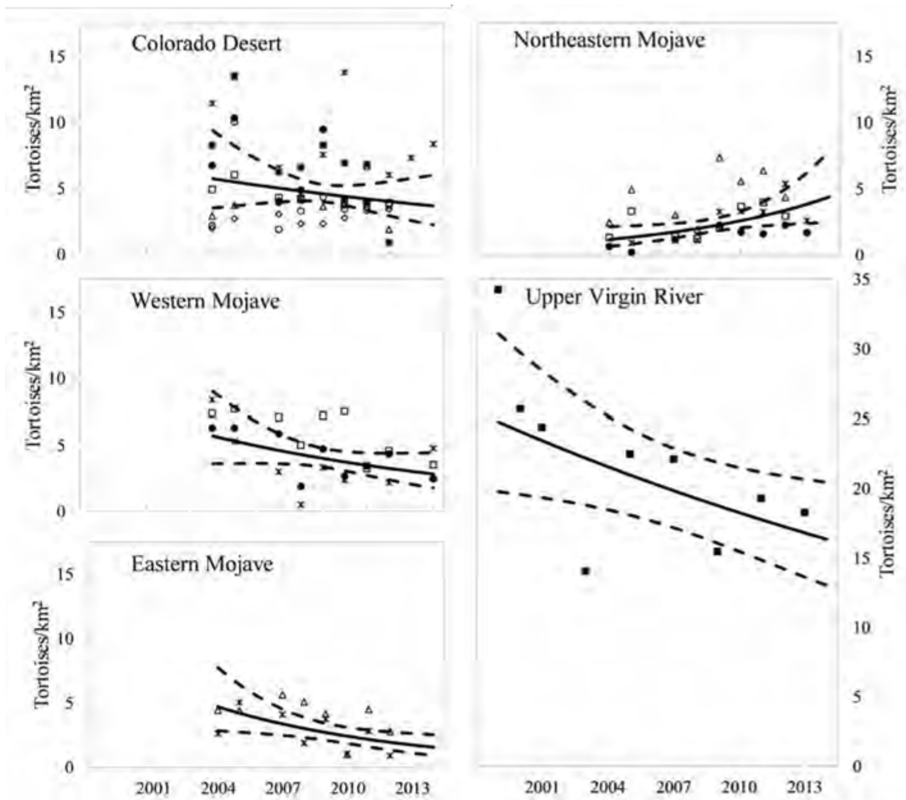

FIGURE 4. Trends in density (tortoises/km^2) of adult Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit through 2014: since 1999 for Upper Virgin River Recovery Unit and for all others since 2004. Separate markers are used for annual density estimates for each tortoise conservation area within the recovery unit. The modeled change in density is the bold line and its 90% CI is shown with the dashed line, reflecting the Type I error specified in U.S. Fish and Wildlife Service (2011).

variance. Visual inspection of residual plots did not reveal any obvious deviations from homoscedasticity or normality.

Densities of adult *G. agassizii* were declining, on average, in every recovery unit except the Northeastern Mojave (Table 4, Fig. 4). Average density of adult tortoises increased in the Northeastern Mojave Recovery Unit at 13.1%/y (SE = 4.3%) since 2004, with especially large rates of increase (> 13%/y) estimated in BD and GB. Adult densities in the other four recovery units have declined at different annual rates: Colorado Desert (-4.5%, SE = 2.8%), Upper Virgin River (-3.2%, SE = 2.0%), Eastern Mojave (-11.2%, SE = 5.0%), and Western Mojave (-7.1%, SE = 3.3%). Based on analysis of covariance, three of the four recovery units with more than one TCA could be characterized by common regression slopes (Eastern Mojave: $F_{1,12}$ = 0.305, P = 0.591; Western Mojave: $F_{2,21}$ = 0.094, P = 0.910; Northeastern Mojave: $F_{3,24}$ = 1.206, P = 0.317; Colorado Desert: $F_{6,43}$ = 2.391, P = 0.044), but intercepts indicate different initial densities in two of the recovery units (Eastern Mojave: $F_{1,13}$ = 2.560, P = 0.134; Western Mojave: $F_{2,23}$ = 3.326, P = 0.054; Northeastern Mojave: $F_{3,27}$ = 11.073, $P < 0.001$; Colorado Desert: $F_{6,49}$ = 5.090, $P < 0.001$). The estimates we report above and in Table 4 are therefore total regression results for the Colorado Desert and Northeastern Mojave recovery units to characterize this greater within-recovery unit variation in slopes and/or intercepts, but common regression results for the other recovery units. Slopes differed between recovery units ($F_{4,119}$ = 9.422, $P < 0.001$).

We applied estimated recovery unit densities based on TCAs to all potential habitat in each recovery unit, developing a high-end estimate of abundance for each recovery unit in 2004 and 2014 (Table 5). Despite the increasing population trend of adults in the Northeastern Mojave, its small area and low starting density resulted in a relatively small overall increase in the number of adult tortoises by 2014. In contrast, the much larger areas of the Eastern and Western Mojave and Colorado Desert recovery units, plus the higher estimated initial densities in these areas, explain much of the estimated total loss of adults since 2004. We estimate there were 124,050 fewer adult tortoises (SE = 36,062) range-wide in 2014 compared to the 336,393 tortoises (SE = 51,596) present in 2004.

Changes in representation of juvenile size class.—The full model of spatial and temporal effects describing the proportion of juveniles among observed tortoises

TABLE 3. Model selection table for all models fit to log-transformed annual densities of adult Mojave Desert Tortoises (*Gopherus agassizii*) through 2014 for all Tortoise Conservation Areas (TCAs), starting in 1999 for Red Cliffs Desert Reserve and in 2004 for the remaining 16 TCAs. Model weights (*w*) express the relative support for each model given the data and are based on relative scores for the second order Akaike's Information Criterion (AIC_c).

Model	Log likelihood	AIC_c	ΔAIC_c	*w*
TCA + Year + TCA×Year	-42.2	186.0	0.0	0.9996
TCA + Year	-76.7	203.2	17.2	0.0002
TCA	-78.4	203.9	17.9	0.0001
TCA + Year + Year^2	-76.0	204.7	18.7	0.0001
TCA + Year + Year^2 + TCA×Year + TCA×Year^2	-25.6	229.2	43.2	0.0000
Year + Year^2	-150.0	312.7	126.7	0.0000
Year	-155.3	321.1	135.1	0.0000
Random effects only	-160.3	329.0	143.0	0.0000

reduced the unexplained variance by 30.6% compared to the model of an overall average proportion, accounting for intra-year correlated proportions. Although the model with only Recovery Unit as a fixed effect had the lowest AIC, there was considerable support for models other than the top-ranking one (Table 6). The next five ranked models added Year or Year^2 effects and were within five AIC units of the best model; the cumulative weight of the top six models was > 0.95. As expected based on the ranked models, model-averaged parameter estimates indicated that the odds of finding a juvenile tortoise differed primarily between recovery units, with a weaker pattern of change over time (Table 7). This analysis approach does not allow us to estimate the true proportion of juveniles in the population, and indeed the higher proportion of juveniles found in the Upper Virgin River Recovery Unit is undoubtedly a product of the three-pass search technique used there in contrast to two-passes elsewhere. Of the four recovery units in which we used two-pass surveys, the probability of encountering a juvenile was consistently lowest in the Western Mojave Recovery Unit. The model-averaged Year parameter estimate indicated the average pattern over all years (1999 through 2014) because we standardized the input variable Year (mean = 2007.0, SD = 4.1). The model-averaged Year parameter for each recovery unit is close to zero, indicating similar proportions at the beginning and end of the survey period, with slightly fewer juveniles in the Northeastern and Western Mojave recovery units, and slightly more elsewhere. However, the negative sign of the Recovery Unit X Year^2 parameter estimates indicated that between the beginning and end of the survey period, there were increased odds of encountering juveniles (Schielzeth 2010); the proportion of juveniles was increasing when surveys began in 1999 but peaked in 2007 and have been declining in all recovery units since then.

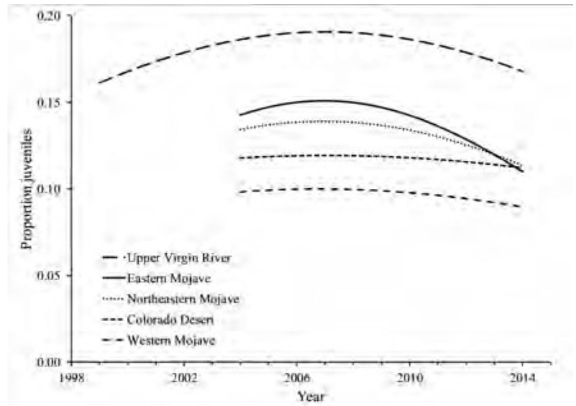

FIGURE 5. Relative proportion of juvenile Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit through 2014: since 1999 for Upper Virgin River Recovery Unit and for all others since 2004.

The linear and quadratic time effects indicate that in all recovery units the odds of encountering a juvenile have declined since 2007 (Table 7, Fig. 5), which is most of the period of surveys for four of the five recovery units. The magnitude of the Recovery Unit X Year^2 effects indicates this trend was strongest in the Eastern and Northeastern Mojave recovery units, so that in 2014 there were 23% fewer (Eastern Mojave) and 15% fewer (Northeastern Mojave) juveniles compared to 2004. In 2007, the year when the proportion of juveniles was estimated to be highest in all recovery units, $P(\text{juvenile}_{2007\text{UpperVirginRiver}}) = 0.189$, CV = 0.057 and, in contrast, $P(\text{juvenile}_{2007\text{Western Mojave}}) = 0.099$, CV = 0.067. The probability that an encountered tortoise was a juvenile was also consistently low in the Colorado Desert ($P[\text{juvenile}_{2007\text{Colorado Desert}}] = 0.119$, CV = 0.131) and lower than in the remaining two recovery units ($P[\text{juvenile}_{2007\text{Eastern Mojave}}] = 0.149$, CV = 0.187; $P[\text{juvenile}_{2007\text{Northeastern Mojave}}] = 0.140$, CV = 0.085).

DISCUSSION

Our analyses provide the first estimates of regional and range-wide population trends for *G. agassizii*. Overall this threatened species is experiencing large, ongoing population declines, and adult tortoise numbers have decreased by over 50% in some recovery units since 2004. Although TCAs within the same recovery unit had very different initial densities, trends were more similar within recovery units than between them. Only one of the five recovery units (Northeastern Mojave) exhibited population increases across all TCAs; this recovery unit also had the lowest densities at the start of our study period in 2004.

Maximum annual population growth rate projected in the eastern Mojave Desert during optimum forage conditions on a 2.59-km^2 study plot was 2% (Turner et al. 1987, unpubl. report), while Nussear and Tracy (2007) simulated annual population growth rates as

TABLE 4. Parameter estimates and standard errors (SEs) from the best-fitting model describing $\log_e$ transformed density/km^2 of adult Mojave Desert Tortoises (*Gopherus agassizii*). The model applies for the period through 2014 for all recovery units, starting in 1999 in Upper Virgin River and in 2004 for the remaining four recovery units.

Recovery unit / Tortoise Conservation Area	Intercept (SE)	Slope (SE)
Western Mojave	-3.174(0.102)	-0.071(0.033)
Fremont-Kramer (FK)	-3.195(0.103)	-0.068(0.030)
Ord-Rodman (OR)	-2.801(0.104)	-0.082(0.031)
Superior-Cronese (SC)	-3.149(0.092)	-0.093(0.029)
Colorado Desert	-3.051(0.078)	-0.045(0.028)
Chocolate Mtn Aerial Gunnery Range (AG)	-2.395(0.115)	-0.033(0.033)
Chuckwalla (CK)	-3.093(0.119)	-0.041(0.042)
Chemehuevi (CM)	-2.966(0.131)	-0.108(0.047)
Fenner (FE)	-2.574(0.127)	-0.073(0.048)
Joshua Tree (JT)	-3.553(0.132)	0.062(0.044)
Pinto Mountains (PT)	-3.144(0.149)	-0.083(0.058)
Piute Valley (PV)	-3.193(0.120)	0.044(0.049)
Northeastern Mojave	-3.870(0.119)	0.131(0.043)
Beaver Dam Slope (BD)	-3.975(0.143)	0.222(0.052)
Coyote Springs Valley (CS)	-3.750(0.100)	0.102(0.041)
Gold Butte-Pakoon (GB)	-4.365(0.148)	0.144(0.048)
Mormon Mesa (MM)	-3.148(0.101)	0.082(0.041)
Eastern Mojave	-3.544(0.132)	-0.112(0.050)
Eldorado Valley (EV)	-3.589(0.131)	-0.092(0.051)
Ivanpah (IV)	-3.273(0.126)	-0.074(0.048)
Upper Virgin River	-1.654(0.093)	-0.032(0.021)
Red Cliffs Desert Reserve (RC)	-1.654(0.093)	-0.032(0.021)

high as 5%. We describe regional population increases in some TCAs much larger than this, possibly indicating that optimal environmental conditions alone do not explain these increases. Several unpaved roads in these TCAs have been closed by the BLM and legal protections since the early 1990s may have reduced the number of tortoises purposely killed or removed from the wild. Nonetheless, the 3.7-fold increase in adults since 2004 that is described here would be unexpected even under much more active management. The large variance associated with these estimates of population trend probably factors into the magnitude of the estimate. Large variances that describe the best estimates of trends in adult density indicate that more modest increases are almost as strongly supported by the data.

Encounter rates make the largest contribution to variance in the annual TCA density estimates, reflecting the non-random pattern of tortoises on the landscape. High between-transect variability in encounter rate means that within-year encounter rate variance will be high, as will between-year variance unless the same transects are surveyed each year. This is the case only in RC, the only TCA where encounter rate variance was never the primary contributor to the density variance (more about variance considerations below).

Based on the rapid increase in the number of adults, juveniles in the Northeastern Mojave Recovery Unit must also be increasing in absolute terms despite the -0.021 change in their relative number since 2004. Locally focused demographic studies are required to describe the roles of increasing adult survivorship and/or recruitment into adult size classes; these studies could also further our understanding of the survivorship of the more cryptic juveniles (USFWS 2011). Population trends of the future (over more than a generation) will provide a measure of reproduction and juvenile survivorship since 2004 in the Northeastern Mojave TCAs.

Declining adult densities through 2014 have left the Western Mojave adult numbers at 49% and in the Eastern Mojave at 33% of their 2004 levels. Such steep declines in the density of adults are only sustainable if there were suitably large improvements in reproduction and juvenile growth and survival. However, the proportion of juveniles has not increased anywhere since 2007, and in these two recovery units the proportion of juveniles in 2014 has declined to 91% and 77% of their representation in 2004, respectively. This may be a continuation of ongoing population declines for at least part of the Western Mojave (Berry et al. 2013).

Reductions in the number of juvenile tortoises may reflect reduced reproduction and/or increased mortality of smaller tortoises. Drought indices for the deserts of the southwestern United States have increased in recent decades (USFWS 2006, Guida et al. 2014), with speculation that female tortoises consequently reduce annual reproductive effort (Henen 1997, 2002) or that hatchlings may be at increased risk of emerging to find too little moisture and related forage (Morafka 1994; Nagy and Medica 1986; Nagy et al. 1997; Wilson et al. 2001). Many other sources of mortality to smaller desert tortoises have been identified (Darst et al. 2013), but recent attention has focused especially on increased predation risk in the Western Mojave, Eastern Mojave, and Colorado Desert recovery units due to prey-switching during droughts by Coyotes (*Canus latrans*; Esque et al. 2010) and especially by increasing abundance of Common Ravens (*Corvus corax*), which typically prey on smaller tortoises rather than on adults (Boarman and Berry 1995; Kristan and Boarman 2003).

Ultimately, trends in adult and juvenile densities reflect the impact of numerous unquantified threats to *G. agassizii* populations over the period of the study (Tracy et al., *op. cit*.; Darst et al. 2013). With few exceptions, the multitude of threats, acting over the long lives of these animals, prevents more rapid and direct identification of specific agents responsible for *G. agassizii* population

TABLE 5. Estimated change in abundance of adult Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit between 2004 and 2014, including standard error (SE) of abundance estimates. Abundance estimates are based on recovery unit densities calculated from the model in Table 4 and applied to all areas of the associated recovery unit meeting criteria as modeled habitat, whether inside or outside TCAs.

Recovery Unit	Modeled Habitat (km^2)	2004 Abundance (SE)	2014 Abundance (SE)	Δ Abundance (SE)
Western Mojave	23,139	131,540 (35,415)	64,871 (17,465)	-66,668 (17,949)
Colorado Desert	18,024	103,675 (30,366)	66,097 (19,359)	-37,578 (11,006)
Northeastern Mojave	10,664	12,610 (4,304)	46,701 (15,940)	34,091 (11,636)
Eastern Mojave	16,061	75,342 (21,589)	24,664 (7,067)	-50,679 (14,522)
Upper Virgin River	613	13,226 (1,115)	10,010 (1,234)	-3,216 (340)
Total	68,501	336,393 (51,596)	212,343 (31,391)	-124,050 (36,062)

increases or declines. Local conditions in each TCA also determine whether the same threat will act with similar severity. For instance, although wildfires in 2005 in RC were associated with high tortoise mortality (McLuckie et al. 2014), similarly large fires that year in GB are believed to have impacted areas of poor tortoise habitat quality due to earlier overgrazing. These areas supported lower densities of tortoises at the time of the wildfire, so the impact of the fires was much less in GB than in RC (Tuma et al. 2016).

Techniques appropriate for describing survivorship and reproduction have characterized tortoise population dynamics in a handful of small, unrepresentative areas, while surveys in larger, more typical low-density areas are difficult to associate with specific local human activities. The trends we describe are consistent with published observations within some TCAs. As mentioned above in the Upper Virgin River Recovery Unit, RC experienced catastrophic wildfire as well as a drought-related die-off of tortoises during the period of this study (McLuckie et al. 2014). The vulnerability of this smaller recovery unit in the face of such large-scale impacts remains of paramount concern. In the Western Mojave Recovery Unit, decreasing population trends in the decades before 2004 were described based on multiple widespread but local mark-recapture plots (Doak et al. 1994; Berry and Medica 1995; Tracy et al., *op. cit.*); other evidence of population declines came from comparison of the frequency of live and dead tortoise sightings in the Western Mojave TCAs (Tracy et al., *op. cit.*). During the period covered by our study, Esque et al. (2010) also noted increased rates of predation by coyotes in the Western Mojave and linked this to decreases in their mammal prey base following drought.

In other parts of the desert, earlier research on local plots sometimes described population trajectories that differ from declines reported by us, such as static adult tortoise numbers on 2.59- km^2 plots in the IV TCA in the Eastern Mojave Recovery Unit, and in PV and FE in the Colorado Desert Recovery Unit (Berry and Medica 1995). The data in these cases were for earlier decades and describe patterns on single local plots that were not

TABLE 6. Model selection table for mixed model logistic regression describing the proportion of observations that were juvenile Mojave Desert Tortoises (*Gopherus agassizii*) from 2004 through 2014 for all recovery units (starting in 1999 for Upper Virgin River Recovery Unit). Year was also used as a categorical variable to capture the random effects of annual conditions. Model weights (*w*) express the relative support for each model given the data and are based on relative scores for Akaike's Information Criterion (AIC). Models with ΔAIC < 5 are shown (these model weights cumulatively account for > 0.95 of model support) as well as the top model for describing patterns in adult densities (Table 3) and the null model.

Model	Log likel.	AIC	ΔAIC	*w*
RU	-1967.8	3947.5	0.0	0.324
RU + Year2	-1966.8	3947.6	0.1	0.309
RU + Year	-1967.7	3949.5	2.0	0.119
RU + Year + Year2	-1966.8	3949.6	2.1	0.114
RU + Year2 + RU×Year2	-1964.1	3950.2	2.7	0.084
RU + Year + Year2 + RU×Year2	-1964.0	3951.9	4.4	0.036
RU + Year + RU×Year	-1965.9	3953.8	6.3	0.014
Random factors only	-1982.0	3968.1	20.6	0.000

TABLE 7. Parameter estimates (standard errors) for changes in the relative proportion of juveniles observed on surveys for adult Mojave Desert Tortoises (*Gopherus agassizii*) from 2004 through 2014 in four of the five recovery units and since 1999 in Upper Virgin River Recovery Unit. Estimates are model-averaged with shrinkage across the top six models in Table 6. For interpreting inflection points, the input variable Year was standardized based on mean = 2007.0 and standard deviation = 4.1.

Recovery Unit	Intercept	Year	$Year^2$
Colorado Desert	-1.999 (0.133)	0.003 (0.088)	-0.097 (0.380)
Eastern Mojave	-1.729 (0.206)	0.003 (0.106)	-0.484 (1.262)
Northeastern Mojave	-1.822 (0.107)	-0.001 (0.095)	-0.307 (0.534)
Upper Virgin River	-1.445 (0.066)	0.003 (0.003)	-0.212 (0.045)
Western Mojave	-2.198 (0.071)	-0.005 (0.105)	-0.154 (0.330)

selected to be representative of the larger TCA (Corn 1994; Anderson et al. 2001; Tracy et al., *op. cit*.). For instance, ongoing and long-term declines on a 2.59-km^2 plot in the JT TCA of the Colorado Desert Recovery Unit (Lovich et al. 2014) may reflect drought impacts they describe, in addition to consequences from the unimproved road that bisects the plot, and predator impacts reported elsewhere in a low relief site (Berry et al. 2013). These characteristics of the plot differ from large areas of the TCA, which are in more rugged terrain and where we characterize populations as increasing.

Throughout our assessment, we describe tortoise status based on adult densities, which is useful for comparison of areas of different sizes. However, if the area available to tortoises is decreasing, then trends in tortoise density no longer capture the magnitude of decreases in abundance. Some of the area of potential habitat (68,501 km^2) has certainly been modified in a way that decreases the number of tortoises present. We used area estimates that removed impervious surfaces created by development as cities in the desert expanded. However, we did not address degradation and loss of habitat from recent expansion of military operations (753.4 km^2 so far on Fort Irwin and the Marine Corps Air Ground Command Center), from intense large scale fires such as those that burned 576.2 km^2 in critical habitat alone in 2005, or from development of utility-scale solar facilities in the desert that have been permitted on 194 km^2 to date (USFWS 2016). The impact of the many smaller land use conversions (habitat loss) have not been compiled, but this and the small scale of habitat restoration projects (habitat gain) have been dwarfed by the scale of habitat conversion from military exercises, renewable energy facilities, and catastrophic fire. Due to loss and degradation of potential habitat, the recovery unit abundance estimates in Table 5 are maximum estimates. Habitat loss would also disrupt the prevailing population structure of this widely distributed species with geographically limited dispersal (isolation by distance; Murphy et al. 2007; Hagerty and Tracy 2010). Demographic connection with nearby local populations has enabled repopulation of at least one area after a local die-off of tortoises (Germano and Joyner 1988). We therefore anticipate an additional impact of this habitat loss is decreasing resilience of local tortoise populations by reducing demographic connections to neighboring populations (Fahrig 2007). Military and commercial operations and infrastructure projects that reduce tortoise habitat in the desert are anticipated to continue.

The high variability of population estimates and the serious consequences of hypothesis testing that fails to detect a true population decline are ongoing topics in conservation biology (Johnson 1989; Taylor and Gerrodette 1993; Taylor et al. 2007; Gerrodette 2011). Conventional hypothesis testing involves comparison of observed trend estimates to a null model of static population size; this unnecessarily restricts the scope and usefulness of monitoring programs to acquiring enough information to rule out no-action (Wade 2000; Gerrodette 2011). Instead, we used an information-theoretic approach in which the data are applied to each competing model; we drew conclusions based on the relative support for each model given the data (Burnham and Anderson 2002). In this case, regional trend models best described the data in hand. Our current analysis strongly concludes that there are similar population trends within recovery units, with different trends between recovery units.

The range-wide scope of our analysis also uses the power of replication in space to underline regional trends rather than attempting to describe one local trend in isolation (see Freilich et al. 2005; Inman et al. 2009). We would have reached less definitive conclusions if the monitoring effort had continued exclusively in a few dozen 2.59-km^2 study plots that had been initiated in the 1970s or if fewer TCAs had been surveyed, perhaps in a less coordinated effort. Instead, the current range-wide distance sampling program provides fairly coarse but clear summaries of patterns in tortoise density and abundance, definitive because they sample regionally and range-wide.

Although our results demonstrate the power of this monitoring program to detect large positive and negative trends over a 10–15-y period, large SEs for density trends we found reflect two important sources of imprecision in the population growth estimates. First, long-term monitoring programs spread over a large area are describing multiple underlying local phenomena. This can be seen in the consistent but TCA-specific within-recovery-unit trends. The same phenomenon is expected within TCAs. For example, each end of a valley may be experiencing different population dynamics, or lowland habitat may offer different population growth potential from upland habitat. It is also to be expected that there is some variation in the degree of population growth supported by year-to-year environmental conditions. These sources of variability in TCA- or recovery-unit-level population dynamics are reflected in the SE of our population trend estimates. By modeling intra-year covariation in TCA density estimates, we accounted for some of the process variation due to annual conditions.

Sampling error of the density estimate is a composite of the errors from the encounter rate estimates as well as from both correction factors that are applied. Estimation of P_a consistently contributes about 10% to the variance in the annual density estimates (e.g., McLuckie et al. 2002), and many more observations are needed to develop a detection curve than to estimate encounter rate. Detection curves based on 60 observations might be minimally acceptable (Buckland et al. 2001), whereas encounter rate estimates based on the same number of detections would be robust. This issue underlies the simulations by Freilich et al. (2005), which led them to reject distance sampling as a viable method for such sparsely distributed animals. The current monitoring program always applied much greater survey effort to estimate TCA-specific encounter rates than anticipated by Freilich et al. (2005); also, to avoid poor detection estimates, we pooled detection distances across all TCAs completed by a given team of surveyors. A certain amount of precision is also lost to the annual density estimates by correcting for G_0. However, this quantity can vary considerably between years, so failure to correct population estimates adequately would add bias to annual density estimates (Freilich et al. 2000).

Encounter rate estimation is consistently the largest variance component in all TCA density estimates (e.g., McLuckie et al. 2002). Most encounter rate variance is inherent to the distribution of tortoises on the landscape (Krzysik 2002), reflecting topographic and vegetation differences between transects with additional sampling variance reflecting relative survey effort. The planned and sustained effort in RC has resulted in much larger sample sizes than in other TCAs and more precision for annual population density estimates (CV = SE/density consistently between 0.12 and 0.15), contributing to lower between-year sampling error. Sampling error is also reduced because we survey the same transects in RC each year. The declining trend in abundance was therefore discernible even though RC was only monitored every other year, an approach that has not been pursued in the rest of the range where survey effort has fluctuated at a generally suboptimal level based on inconsistent funding.

Turtles and tortoises world-wide are as threatened with extinction as any other vertebrate lineage (Stanford et al. 2018). The crisis in turtle survival stems from ongoing direct exploitation that targets turtles for consumption or captivity as well as from indirect or untargeted harm such as mortality on roadways or non-lethal degradation of the habitat they need to survive. Most extinct turtle taxa in the past hundreds of years were extirpated from constrained areas (mostly giant tortoises endemic to islands), whereas the turtle species that are currently most endangered are primarily threatened by habitat alteration and collection for the pet trade or food market (Stanford et al. 2018). *Gopherus agassizii* is one of six North American species of *Gopherus*, part of all of which have protected status under U.S. or Mexican regulations or both. *Gopherus flavomarginatus* is listed among the top 25 threatened freshwater and terrestrial turtle species (Stanford et al. 2018), and populations have been decimated by habitat loss and ongoing collection for consumption. The remaining *Gopherus* species are widespread, which is not characteristic of turtles that have faced the first waves of extinction and local extirpation of the modern era. Population losses have nonetheless been documented in these *Gopherus* species (Bury et al. 1988; McCoy et al. 2006; Allison and McCoy 2014), and *G. agassizii* is now included in the list of the top 50 turtle and tortoise species at greatest risk (Stanford et al. 2018). Unlike earlier groups of turtle and tortoise species at risk of extinction, declines in *Gopherus* may instead reflect compounding impacts of threats that are not acutely lethal to individuals or populations (USFWS 2011). In common with other turtles and tortoises, their life history puts *G. agassizii* at greater risk from even slightly elevated adult mortality (Congdon et al. 1993; Doak et al. 1994) and recovery from population declines will require more than enhancing adult survivorship (Spencer et al. 2017). Currently, 60.8% of turtle species are designated Threatened on the International Union for Conservation of Nature (IUCN) Red List (IUCN 2017), including all *Gopherus* species except *G. berlandieri*. Although populations comprising *G. morafkai* and *G. evgoodei* were classified as conspecifics of *G. agassizii* at the time of the most recent IUCN status assessment, they are now recognized as distinct species, and are considered Vulnerable by the Tortoise and Freshwater Turtle Specialist Group, which officially consults to update the IUCN Red List (Rhodin et al. 2017).

The negative population trends in most of the TCAs for Mojave Desert Tortoises indicate that this species is on the path to extinction under current conditions. This may reflect inadequate recovery action implementation, slow response by tortoises and their habitat to implemented actions, or new and ongoing human activities in the desert that have not been mitigated appropriately. It may also be a result of stochastic or directional climatic events that impact large expanses of tortoise habitat (e.g., drought, fire, climate change) and are largely beyond the realm of local land management activities. Our results are a call to action to remove ongoing threats to tortoises from TCAs, and possibly to contemplate the role of human activities outside TCAs and their impact on tortoise populations inside them.

Long-term monitoring is an essential component of evidence-based management (Lindenmayer and Likens 2010). It determines whether the composite management efforts over ecologically meaningful time periods have been effective. For G. agassizii, the reinvigoration of the interagency management oversight group tasked with implementing recovery activities based on their predicted effectiveness has the potential to translate results from this monitoring program into decisions about maintaining or altering contemporary management activities. Monitoring of declining populations should be deeply integrated in conservation and recovery programs. Recovery plans under the U.S.

Endangered Species Act always stipulate population thresholds that would trigger removal of federal protection, but adaptive-management triggers based on monitoring results that show population declines are absent from most recovery planning (Lindenmayer et al. 2013) and have not yet been integrated into the management for *G. agassizii*.

Although these surveys were designed to provide a 25-y description of population growth, it is clear that this single purpose would be an underutilization of the program that can certainly address interim management questions (Nichols and Williams 2006). For long-lived *G. agassizii*, monitoring of the reproductive portion of the population also captures the effects of management on the population segment that must be the basis for recovery. Population recovery will necessitate accelerated, prioritized recovery activities (Darst et al. 2013). Targeted, local effectiveness monitoring (Lyons et al. 2008; Lindenmayer et al. 2011), where possible, would complement our larger population monitoring program. Both types of monitoring will be needed to characterize the effectiveness of recovery activities where the list of threats is so large and varied.

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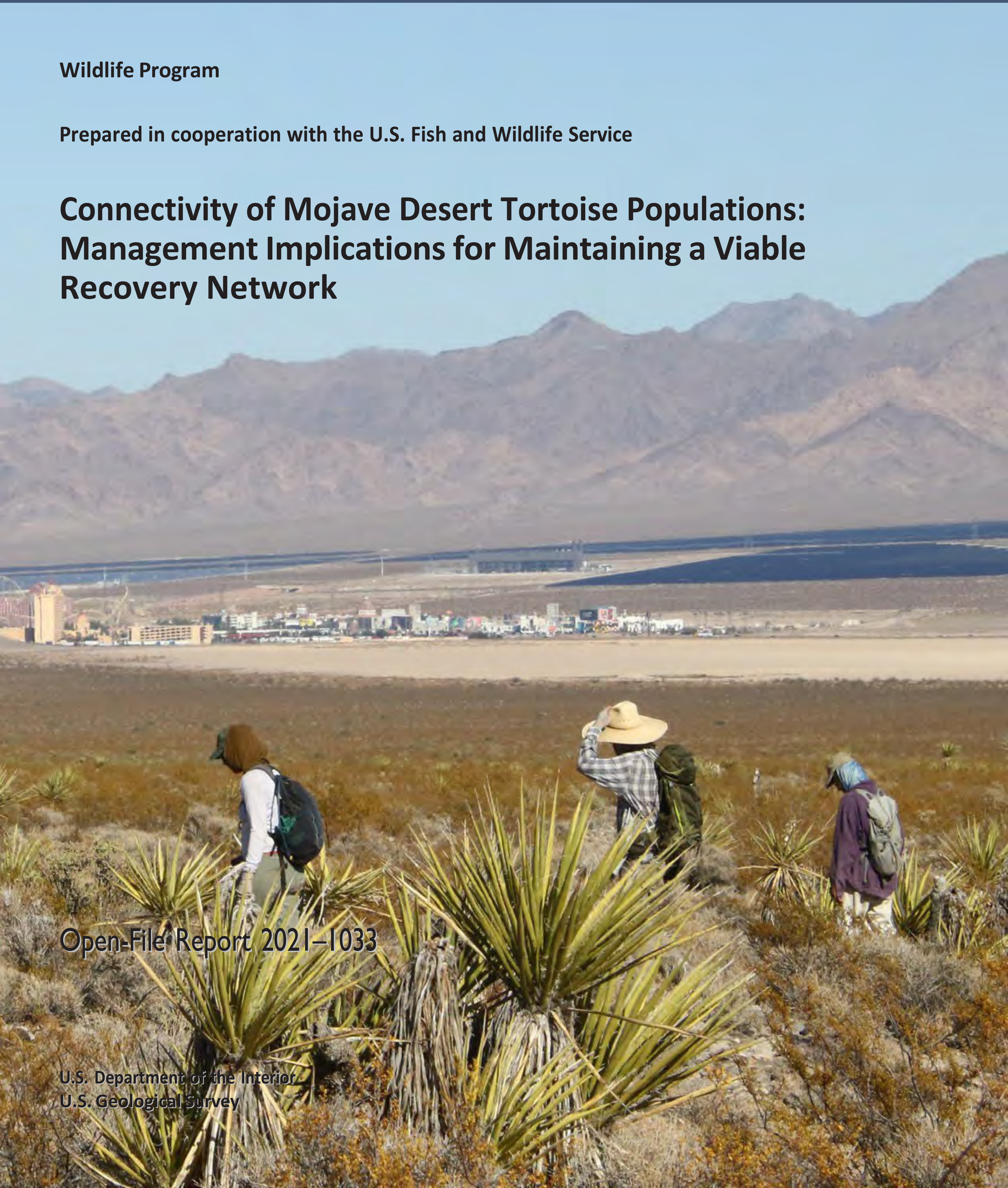
APPENDIX A. Annual proportion visible, G_0 (standard error), at each focal site where we monitored transmittered adult Mojave Desert Tortoises (*Gopherus agassizii*). Sites are listed in order from the western-most to the eastern-most and their locations are indicated in Fig. 1. Red Cliffs was also surveyed earlier: 1999 (0.63, SE = 0.185), 2000 (0.86, SE = 0. 144), 2001 (0.86, SE = 0.167), 2003 (0.87, SE = 0. 135).

Site	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014
Superior-Cronese	0.95 (0.081)	0.92 (0.094)	0.96 (0.050)	0.75 (0.197)	0.90 (0.120)	0.98 (0.056)	0.94 (0.073)	0.94 (0.073)		0.91 (0.101)
Ord-Rodman	0.98 (0.035)	0.92 (0.083)	0.64 (0.213)	0.74 (0.130)	0.96 (0.054)	0.94 (0.072)	0.95 (0.062)	0.79 (0.156)		0.99 (0.030)
Twentynine Palms	0.98 (0.028)	0.90 (0.110)	0.97 (0.047)	0.74 (0.113)						
Chuckwalla	0.70 (0.183)	0.74 (0.153)	0.87 (0.060)	0.55 (0.105)	0.73 (0.175)	0.84 (0.125)	0.85 (0.108)	0.82 (0.075)	0.84 (0.058)	0.59 (0.087)
Ivanpah	0.95 (0.071)	0.87 (0.102)	0.94 (0.091)	0.79 (0.107)	0.79 (0.120)	0.88 (0.157)	0.87 (0.149)	0.54 (0.098)		
Jean	0.86 (0.142)									
Indian Springs			0.79 (0.140)	0.83 (0.153)	0.88 (0.118)	0.86 (0.130)	0.79 (0.093)	0.98 (0.049)		
Piute Valley 1	0.84 (0.148)	0.91 (0.118)	0.81 (0.178)	0.73 (0.127)		0.79 (0.218)	0.86 (0.141)	0.65 (0.148)		
Chemehuevi	0.88 (0.104)	0.65 (0.174)	0.62 (0.118)	0.80 (0.120)	0.84 (0.130)	0.81 (0.144)	0.80 (0.162)	0.35 (0.077)		
Piute Valley 2	0.80 (0.191)	0.87 (0.166)								
Halfway Wash					0.64 (0.167)	0.77 (0.200)	0.55 (0.152)	0.54 (0.116)	0.68 (0.136)	
Gold Butte						0.76 (0.141)	0.65 (0.155)	0.52 (0.118)	0.68 (0.123)	
Red Cliffs		0.86 (0.140)	0.53 (0.247)		0.68 (0.131)		0.74 (0.134)		0.66 (0.180)	

Appendix B. Detection statistics for field teams surveying separate Tortoise Conservation Areas (TCAs) each year. Teams walked *L* total km over *k* transects and detected n adult Mojave Desert Tortoises, which was P_a proportion of those available within *w* meters of the transect centerline. The coefficient of variation (CV) for P_a is also listed. Separate detection curves were built for each team each year, except in Red Cliffs Desert Reserve (RC), for which we report on the single composite detection curve. Other TCAs are abbreviated as Chocolate Mountains Aerial Gunnery Range (AG), Beaver Dam Slope (BD), Chuckwalla (CK), Chemehuevi (CM), Coyote Springs Valley (CS), Eldorado Valley (EV), Fenner (FE), Fremont-Kramer (FK), Gold Butte-Pakoon (GB), Ivanpah (IV), Joshua Tree (JT), Mormon Mesa (MM), Ord-Rodman (OR), Pinto Mountains (PT), Piute Valley (PV), and Superior-Cronese (SC).

Year	TCAs	*k*	*L*	*w*	n	P_a	CV(P_a)
1999 to 2013	RC	1,417	2,778	20	1,141	0.64	0.02
2004	AG, CK, CM, FE, IV, JT, PT	316	3,509	15	292	0.57	0.03
2004	FK, OR, SC	138	1,534	15	134	0.42	0.19
2004	BD, CS, EV, GB, MM, PV	175	1,723	22	57	0.47	0.10
2005	AG, CK, CM, FE, FK, IV, JT, OR, PT, SC	451	5,414	13	394	0.47	0.06
2005	BD, CS, EV, GB, MM, PV	267	2,852	18	108	0.40	0.10
2007	BD, CS, EV, GB, MM, PV	282	2,723	13	67	0.57	0.10
2007	AG, CK, CM, FE, FK, IV, JT, OR, PT, SC	271	3,174	16	155	0.39	0.09
2008	BD, CS, EV, MM, PM	566	5,705	18	127	0.41	0.10
2008	AG, CK, CM, FE, FK, IV, JT, OR, PT, SC	118	1,354	14	42	0.47	0.33
2009	BD, CS, EV, GB, MM, PV	568	5,525	15	109	0.25	0.23
2009	AG, CM, FE, FK, IV, JT, OR, PT, SC	225	2,492	14	103	0.35	0.10
2010	BD, CS, GB, MM	425	4,265	16	164	0.41	0.08
2010	CM, EV, FE, IV, PV	368	2,465	14	109	0.59	0.06
2010	FK, OR, SC	187	2,144	12	91	0.58	0.07
2010	AG, CK, JT, PT	140	1,431	8	85	0.67	0.10
2011	BD, CS, GB, MM	380	3,984	20	166	0.43	0.10
2011	CM, EV, FE, IV, PV	312	2,548	20	133	0.32	0.19
2011	CK, FK, JT, OR, PT, SC	160	1,802	16	100	0.53	0.08
2012	BD, CS, GB, MM	369	4,184	21	151	0.38	0.12
2012	CM, EV, FE, IV, PV	201	1,695	15	28	0.43	0.26
2012	AG, CK, FK, JT, OR, PT, SC	162	1,776	14	73	0.40	0.15
2013	AG, BD, GB	173	2,019	16	68	0.45	0.20
2014	AG, FK, OR, SC	230	2,649	10	118	0.61	0.06



Wildlife Program

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Cover photo: View of field team searching for tortoises in northern Ivanpah Valley, on the border between California and Nevada and central to the Mojave Desert ecoregion. This area is an important habitat connectivity corridor for the Mojave desert tortoise. Photograph by T.C. Esque, U.S. Geological Survey, October 5, 2019.

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
mile	1.609	kilometer

International System of Units to U.S. customary units

Multiply	By	To obtain
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
kilometer	0.6214	mile

Abbreviations

DRECP Desert Renewable Energy Conservation Plan

TCA tortoise conservation area

USFWS U.S. Fish and Wildlife Service

Connectivity of Mojave Desert Tortoise Populations: Management Implications for Maintaining a Viable Recovery Network

By Roy C. Averill-Murray[1], Todd C. Esque[2], Linda J. Allison[1], Scott Bassett[3], Sarah K. Carter[2], Kirsten E. Dutcher[3], Steven J. Hromada[3], Ken E. Nussear[3], Kevin Shoemaker[3]

Executive Summary

The historic distribution of Mojave desert tortoises (*Gopherus agassizii*) was relatively continuous across the range, and the importance of tortoise habitat outside of designated tortoise conservation areas (TCAs) to recovery has long been recognized for its contributions to supporting gene flow between TCAs and to minimizing impacts and edge effects within TCAs. However, connectivity of Mojave desert tortoise populations has become a concern because of recent and proposed development of large tracts of desert tortoise habitat that cross, fragment, and surround designated conservation areas. This paper summarizes the underlying concepts and importance of connectivity for Mojave desert tortoise populations by reviewing current information on connectivity and providing information to managers for maintaining or enhancing desert tortoise population connectivity as they consider future proposals for development and management actions.

Maintaining an ecological network for the Mojave desert tortoise, with a system of core habitats (TCAs) connected by linkages, is necessary to support demographically viable populations and long-term gene flow within and between TCAs. There are four points for wildlife and land-management agencies to consider when making decisions that could affect connectivity of Mojave desert tortoise populations (for example, in updating actions in resource management plans or amendments that could help maintain or restore functional connectivity in light of the latest information):

1. ***Management of all desert tortoise habitat for persistence and connectivity.*** Desert tortoise populations continue to decline within most TCAs, and it is unlikely that trends are better in populations outside protected areas. Fragmentation exacerbates negative population trends by breaking large continuous populations into smaller isolated populations. Connectivity within large populations can enhance resilience to localized disturbances due to rescue by neighboring individuals. In contrast, smaller fragmented populations are resistant to rescue by their isolation and thus could suffer irreversible declines to extirpation from a variety of threats and stochastic events. Enhanced threat reduction to reverse declines within TCAs and to maintain occupied habitat in the surrounding matrix would help reduce the variability in population growth rates and improve the resilience of protected populations even while implementing efforts to improve connectivity.

Each TCA has unique strengths and weaknesses regarding its ability to support minimum sustainable populations based on areal extent and its ability to support population increases based on landscape connection with adjacent populations. Considering how proposed projects (inside or outside of TCAs) affect connectivity and the ability of TCAs to support at least 5,000 adult tortoises (the numerical goal for each TCA) could help managers to maintain the resilience of TCAs to population declines. The same project, in an alternative location, could have very different impacts on local and regional populations. For example, within the habitat matrix surrounding TCAs, narrowly delineated corridors may not allow for natural population dynamics if they do not accommodate overlapping home ranges along most of their widths so that tortoises reside, grow, find mates, and produce offspring that can replace older tortoises. In addition, most habitat outside TCAs may receive more surface disturbance than habitat within TCAs. Therefore, managing the entire remaining matrix of desert tortoise habitat for permeability may be better than delineating fixed corridors. These concepts apply, especially given uncertainty about long-term condition of habitat, within and outside of TCAs under a changing climate.

[1]Desert Tortoise Recovery Office, U.S. Fish and Wildlife Service.

[2]U.S. Geological Survey.

[3]University of Nevada, Reno.

Ultimately, questions such as "*What are the critical linkages that need to be protected?*" could be better framed as "*How can we manage the remaining habitat matrix in ways that sustain ecological processes and habitat suitability for special status species?*" Land-management decisions made in the context of the latter question may be more conducive to maintenance of a functional ecological network.

2. ***Limitations on landscape-level disturbance across habitat managed for the desert tortoise.*** Clearly delineating habitat linkages and differentiating them from non-delineated areas by the uses that are permitted or prohibited within them by specific management guidelines can help achieve functional connectivity. Such guidelines would be most effective if they considered and accounted for all surface disturbances (for example, temporary disturbances such as fiberoptic lines or off-highway vehicle routes, right-of-ways, utility-scale solar development, urbanization) to the extent possible. A weighted framework that varies with the permanence or severity of the disturbance, and can be additive to quantify cumulative effects, could be useful (Xiong, 2020). For example, minor roads can alter tortoise movements independently of other features (Peaden and others, 2017; Hromada and others, 2020), but if the isolated dirt road is accompanied by a powerline that encourages raven predation (Xiong, 2020), then the two features together may be additive. Ignoring minor or temporary disturbance on the landscape could result in a cumulatively large impact that is not explicitly acknowledged (Goble, 2009); therefore, understanding and quantifying all surface disturbance on a given landscape is prudent.

    a. In California, the Bureau of Land Management established 0.1–1.0 percent caps on new surface-disturbance for TCAs and mapped linkages that address the issues described in number 1 of this list.

    b. Nevada, Utah, and Arizona currently do not have surface-disturbance limits. Limits comparable to those in the Desert Renewable Energy Conservation Plan (DRECP) would be 0.5 percent within TCAs and 1 percent within the linkages modeled by Averill-Murray and others (2013). Limits in some areas of California within the Desert Renewable Energy Conservation Plan, such as Ivanpah Valley, are more restrictive, at 0.1 percent. Continuity across the state line in Nevada could be achieved with comparable limits in the adjacent portion of Ivanpah Valley, as well as the Greater Trout Canyon Translocation Area and the Stump Springs Regional Augmentation Site. These more restrictive limits would help protect remaining habitat in the major interstate connectivity pathway through Ivanpah Valley and focal areas of population augmentation that provide additional population connectivity along the western flank of the Spring Mountains.

    c. In a recent study that analyzed 13 years of desert tortoise monitoring data, nearly all desert tortoise observations were at sites in which 5 percent or less of the surrounding landscape within 1 kilometer was disturbed (Carter and others, 2020a). To help maintain tortoise habitability and permeability across all other non-conservation-designated tortoise habitat, all surface disturbance could be limited to less than 5-percent development per square kilometer because the 5-percent threshold for development is the point at which tortoise occupation drops precipitously (Carter and others, 2020a). However, although individual desert tortoises were observed at development levels up to 5 percent, we do not know the fitness or reproductive characteristics of these individuals. This level of development also may not allow for long-term persistence of healthy populations that are of adequate size needed for demographic or functional connectivity; therefore, a conservative interpretation suggests that, ideally, development could be lower. Lower development levels would be particularly useful in areas within the upper 5th percentile of connectivity values modeled by Gray and others (2019).

    d. Reducing ancillary threats in places where connectivity is restricted to narrow strips of habitat, for example, narrow mountain passes or vegetated strips between solar development, could enhance the functionality of these vulnerable linkages. In such areas, maintaining multiple, redundant linkages could further enhance overall connectivity.

3. ***Minimization of mortality from roads and maximization of passage under roads.*** Roads pose a significant threat to the long-term persistence of local tortoise populations, and roads of high traffic volume lead to severe population declines, which ultimately fragments populations farther away from the roads. Three points (a.–c.) pertain to reducing direct mortality of tortoises on the many paved roads that cross desert tortoise habitat and to maintaining a minimal level of permeability across these roads:

    a. Tortoise-exclusion fencing tied into culverts, underpasses, overpasses, or other passages below roads in desert tortoise habitat, would limit vehicular mortality of tortoises and provide opportunities for movement across the roads. Installation of shade structures on the habitat side of fences installed in areas with narrow population-depletion zones would limit overheating of tortoises that may pace the fence.

b. Passages below highways could be maintained or retrofitted to ensure safe tortoise access, for example, by filling eroded drop-offs or modifying erosion-control features such as rip-rap to make them safer and more passable for tortoises. Wildlife management agencies could work with transportation departments to develop construction standards that are consistent with hydrologic/erosion management goals, while also incorporating a design and materials consistent with tortoise survival and passage and make the standards widely available. The process would be most effective if the status of passages was regularly monitored and built into management plans.

c. Healthy tortoise populations along fenced highways could be supported by ensuring that land inside tortoise-exclusion fences is not so degraded that it leads to degradation of tortoise habitat outside the exclusion areas. For example, severe invasive plant infestations inside a highway exclusion could cause an increase of invasive plants outside the exclusion area and degrade habitat; therefore, invasive plants inside road rights of way could be mown or treated with herbicide to limit their spread into adjacent tortoise habitat and minimize the risk of these plants carrying wildfires into adjacent habitat.

4. ***Adaptation of management based on new information.*** Future research will continue to build upon and refine models related to desert tortoise population connectivity and develop new ones. New models could consider landscape levels of development and be constructed such that they share common foundations to support future synthesis efforts. If model development was undertaken in partnership with entities that are responsible for management of desert tortoise habitat, it would facilitate incorporation of current and future modeling results into their land management decisions. There are specific topics that may be clarified with further evaluation:

a. The effects of climate change on desert tortoise habitat, distribution, and population connectivity;

b. The effects of large-scale fires, especially within repeatedly burned habitat, on desert tortoise distribution and population connectivity;

c. The ability of solar energy facilities or similar developments to support tortoise movement and presence by leaving washes intact; leaving native vegetation intact whenever possible, or if not possible, mowing the site, allowing vegetation to re-sprout, and managing weeds; and allowing tortoises to occupy the sites; and

d. The design and frequency of underpasses necessary to maintain functional demographic and genetic connectivity across linear features, like highways.

Introduction

Connectivity of Mojave desert tortoise (*Gopherus agassizii*) populations has become an issue of increasing concern due to recent and proposed development of large tracts of desert tortoise habitat that cross, fragment, and surround designated conservation areas. Much of this development is a result of the recent renewable energy boom, but also includes long-planned urban expansion and infrastructure projects that are reaching the implementation phase. Researchers have studied the implications of existing tortoise conservation areas becoming isolated due to this development and have modeled past, current, and potential future population connectivity across the desert tortoise's range (see later in the text). Managers have incorporated much of the available information into individual planning decisions (for example, Desert Renewable Energy and Conversation Plan Land Use Plan Amendment to the California Desert Conservation Plan of 1980 [DRECP], draft Apple Valley Habitat Conservation Plan). However, general principles for maintaining functionally connected desert tortoise populations have not been synthesized to assist with a comprehensive, species-wide analysis, and several existing land-management plans lack the focus on desert tortoise population connectivity present in other plans such as the DRECP. The Management Oversight Group for the Mojave Desert Tortoise requested guidance to clarify the needs of the Mojave desert tortoise for habitat connectivity from the Western Ecological Research Center of the U.S. Geological Survey and the Recovery Office of the U.S. Fish and Wildlife Service for the Mojave Desert Tortoise. This report is a collaboration to provide that guidance by summarizing the underlying concepts and importance of connectivity for Mojave desert tortoise populations by (1) reviewing current information on connectivity and (2) providing information to managers for maintaining or enhancing desert tortoise population connectivity as they consider future proposals for development and management actions.

The Framework for Mojave Desert Tortoise Recovery

Historic Population Connectivity

The historic distribution of Mojave desert tortoises was relatively continuous across the range, broken only by major topographic barriers, such as the Baker Sink and Death Valley, California, and the Spring Mountains, Nevada (Germano and others, 1994; Nussear and others, 2009, respectively). Although desert tortoises generally do not move long distances over their lifetimes, historically, modest dispersal and connected home ranges occurred over a relatively continuous distribution across the tortoise's range. This contiguous distribution fostered historically high levels of gene flow and a population structure characterized as isolation-by-distance (Murphy and others, 2007; Hagerty and Tracy, 2010; Hagerty and others, 2011). Maintaining functionally connected landscapes is necessary to conserve historic genetic gradation (Frankham, 2006). Large, connected landscapes also are necessary to facilitate natural range shifts in response to climate change (Krosby and others, 2010; National Fish, Wildlife, and Plants Climate Adaptation Partnership, 2012; Hilty and others, 2020). Nevertheless, though gene flow and adaptive capacity are critically important in the long term, the need for extensive, unfragmented habitat is of more immediate concern for supporting populations that are demographically viable on time scales relative to management (Kuo and Janzen, 2004).

Design and Goals of the Current Network of Tortoise Conservation Areas

Tortoise conservation areas (TCAs[1]) form the foundation of the desert tortoise recovery strategy and are centered around 12 designated critical habitat units that range in area from approximately 220 to 4,131 square miles (U.S. Fish and Wildlife Service, 2011). Effective conservation areas are designed to support species viability according to ecological concepts of representation, redundancy, and resilience (U.S. Fish and Wildlife Service, 1994, 2016; Shaffer and Stein, 2000).

- Representation captures the breadth of genetic or ecological diversity of a species, and recovery units are distributed across the range in a pattern designed to capture this breadth (U.S. Fish and Wildlife Service, 2011).
- Redundancy, having multiple protected populations within representative units, protects against catastrophic loss of any particular population. In the case of the Mojave desert tortoise, each of the recovery units identified in the 2011 recovery plan contain multiple TCAs, except for the Upper Virgin River Recovery Unit in Utah (U.S. Fish and Wildlife Service, 2011).
- Resilience represents the ability of populations to recover from stochastic setbacks, such as drought-induced population declines or localized disease outbreaks. To maintain resilience, TCAs were envisioned to sustain a population of at least 5,000 adult tortoises (U.S. Fish and Wildlife Service, 1994). In situations where a critical habitat unit was smaller than the threshold of 1,295 square kilometers (km^2), or if the number of tortoises was found to be fewer than 5,000, land management was expected to maintain connectivity to larger populations outside the critical habitat unit and to other critical habitat units (U.S. Fish and Wildlife Service, 1994).

The importance of tortoise habitat outside of TCAs, to recovery, has long been recognized for its contributions to supporting gene flow among TCAs and to minimizing impacts and edge effects within TCAs (U.S. Fish and Wildlife Service, 1994, 2011). This dependence, on a reserve design of protected areas supported by surrounding areas that are not necessarily protected, is considered the linchpin of sustaining a resilient protected area network (U.S. Fish and Wildlife Service, 2011).

Challenges and Weaknesses of the Current Network of Tortoise Conservation Areas

When the original recovery plan was developed, there were no reliable abundance estimates for tortoises in any critical habitat unit. However, one unit in particular, the Upper Virgin River Critical Habitat Unit, was insufficient in size to support the necessary 5,000 adult tortoises, thus, it was identified as requiring intensive management since its establishment (U.S. Fish and Wildlife Service, 1994). Range-wide monitoring since 2004 (1999 in Upper Virgin River) provides population estimates and recent changes in tortoise density for each TCA. As of 2014, 11 of 17 TCAs had negative population trends, and 8 of 17 were estimated to contain fewer than 5,000 adult tortoises (Allison and McLuckie, 2018; fig. 1).

[1]Tortoise conservation areas include desert tortoise habitat within designated critical habitat, Desert Wildlife Management Areas, Areas of Critical Environmental Concern, Grand Canyon-Parashant National Monument, Desert National Wildlife Refuge, National Park Service lands, Red Cliffs Desert Reserve, and other conservation areas or easements managed for desert tortoises (U.S. Fish and Wildlife, 2011).

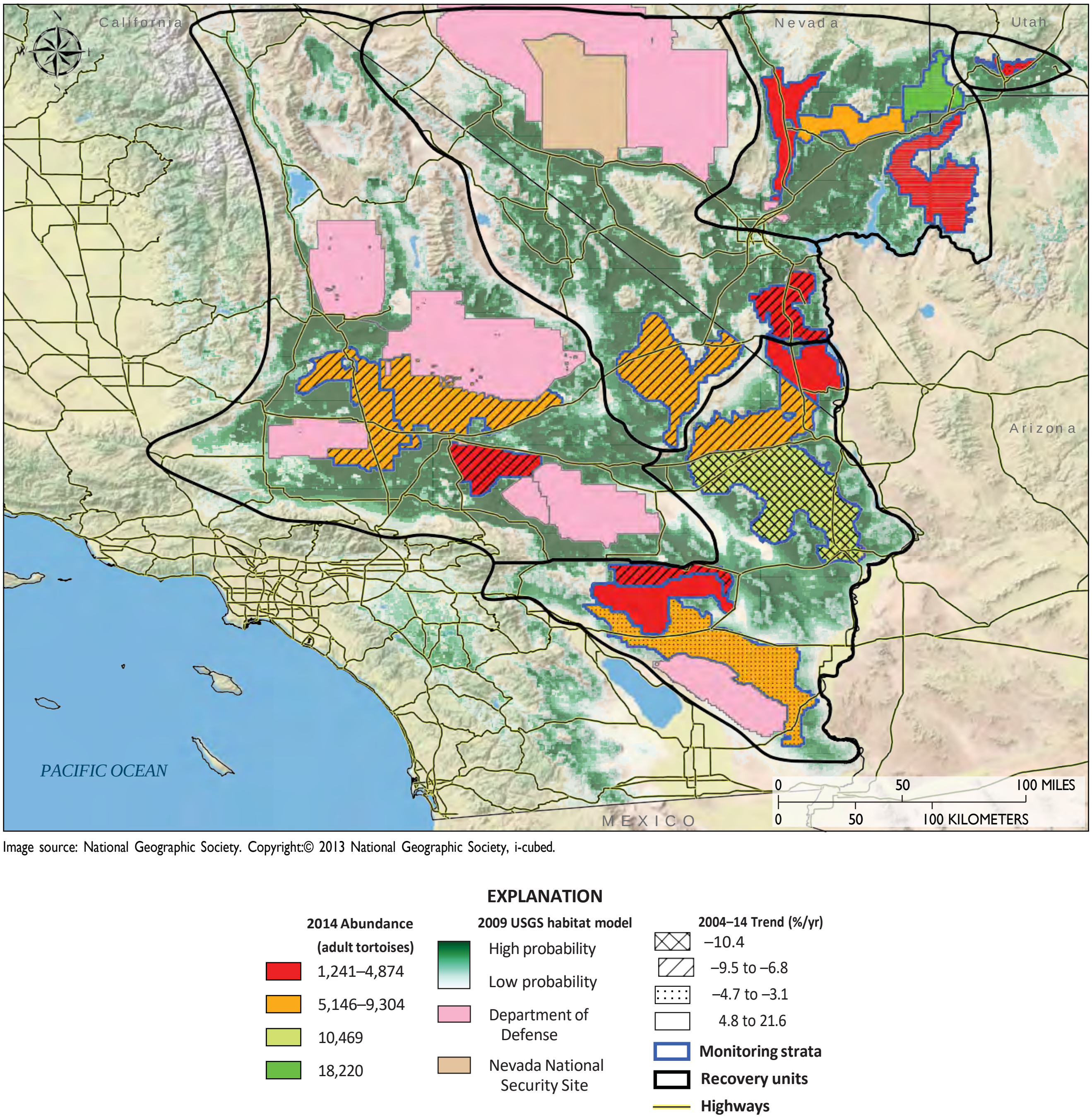

Figure 1. Population trends and abundance of adult Mojave desert tortoises within tortoise conservation areas (TCAs). Yellow lines represent major roads and highways. Color ramp from white to green represents low to high probability of tortoise presence, respectively.

In addition to concerns about the status of tortoise populations within the TCAs, the configuration of several TCAs is inconsistent with optimal reserve design. The theoretically optimal reserve shape would be circular to minimize the perimeter and potential edge effects relative to the area because the quality of habitat within conservation areas can be affected by factors present outside conservation area boundaries (Harrison and Bruna, 1999; Environmental Law Institute, 2003; Radeloff and others, 2010). For example, subsidized predators within the urban-wildland interface can affect tortoise populations well within TCAs (Kristan and Boarman, 2003; Esque and others, 2010). However, to capture the actual pattern of suitable habitat while accommodating land ownership considerations, all TCAs have complex perimeters, often with narrow extensions or projections into relatively unprotected habitat (fig. 1). This is partly because, prior to TCA establishment, the landscape already had many inholdings and disturbances that were avoided because they rendered the habitat incompatible for tortoise use. The result of this configuration is a network of land parcels of variable habitat quality and tortoise permeability (Gray and others, 2019). All of these issues emphasize the importance of maintaining, and ideally increasing, the availability of habitat connectivity within and among TCAs.

Functional Connectivity of Desert Tortoise Populations Across the Landscape

Connectivity can be viewed as the degree to which regional landscapes, encompassing a variety of natural, semi-natural, and developed land-cover types, are conducive to wildlife movement and to sustaining ecological processes (Ament and others, 2014; Hilty and others, 2020). Functionally, connectivity describes the degree to which landscapes facilitate or impede the movement of organisms and processes (Meiklejohn and others, 2010; Hilty and others, 2020). Decreased connectivity results from various degrees of landscape resistance. For example, natural linear features that entirely preclude movement for tortoises include impassable vertical cliffs, talus slopes, and large rivers. Semi-permeable features include natural habitats with questionably sufficient thermal cover, such as burned areas or playa edges, or other features typical of the urban-wildland interface, such as ploughed lots, roads, railways, and large berms, all of which can act as filters that reduce connectivity between populations in the absence of appropriate underpasses or overpasses (Peaden and others, 2015; Rautsaw and others, 2018; Dutcher and others, 2020a; Hromada and others, 2020).

The features listed in the previous paragraph are widespread across the Mojave Desert; for example, almost all TCAs are divided internally or separated from adjacent units by major roads and highways (fig. 1). Abundance of tortoise sign decreases closer to unfenced roadways, resulting in a zone of population depletion of up to 4 kilometers (km) from highways with the highest traffic volumes (Hoff and Marlow, 2002; Boarman and Sazaki, 2006; Nafus and others, 2013; Peaden and others, 2015). These depleted zones effectively eliminate or severely reduce connectivity of tortoise populations across the range. Many miles of tortoise-barrier fencing have been installed along roads, primarily within TCAs, with this fencing connected to culverts. Although individual tortoises cross through culverts (Boarman and others, 1998; Hromada and others, 2020), the effectiveness of culverts in mitigating the fragmenting effects of highways at a population scale is unknown. Even culverts designed to reduce resistance across linear barriers can be ineffective if materials such as rip-rap of talus-sized rocks prevent access by tortoises.

Structure and Dynamics of Desert Tortoise Populations

Desert tortoises do not occur at uniform densities across the landscape (Krzysik, 2002). Local population abundances fluctuate asynchronously because of differences in habitat quality and variability in precipitation patterns, such as localized declines attributed to drought, disease, or predation events (Peterson, 1994; Longshore and others, 2003; Tracy and others, 2004; Esque and others, 2010; Emblidge and others, 2015) or stochastic population dynamics (U.S. Fish and Wildlife Service, 2011). Adjacent habitat patches of sufficient quality to support healthy tortoise populations are necessary for local population declines or extinctions to be rescued by recolonization (Fahrig and Merriam, 1994). As habitat is lost and fragmented, habitat patches become smaller, patch populations (for example, clusters of tortoises) have fewer tortoises and become more disjunct, extinction probabilities within patches increase, and the number of occupied patches decreases (Fahrig, 2002; Ovaskainen and others, 2002). As described earlier, tortoise populations adjacent to and contiguous with populations within TCAs are essential for long-term species viability and recovery given the limitations of the existing TCA reserve design (fig. 2).

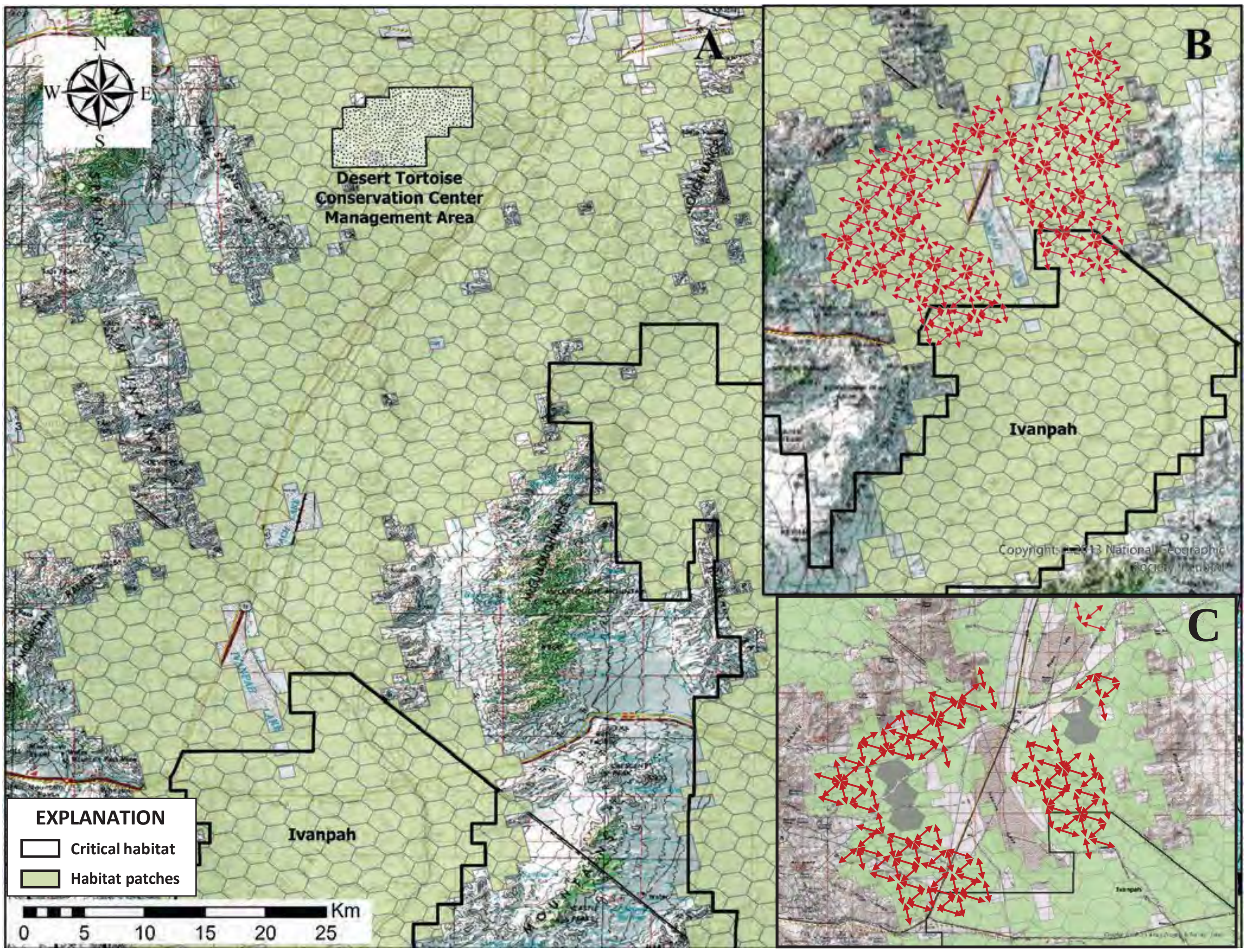

Figure 2. Inter-patch habitat connectivity of Mojave desert tortoises. Each hexagon represents a 259-hectare (640-acre) habitat patch. *A*, Historically interconnected habitat constrained by major topographic barriers; *B*, Inter-patch relationships across a part of the landscape are represented by red arrows; and *C*, Reduction in patch connections occurs with habitat loss and fragmentation, conceptually represented by gray patches.

Large expanses of high-quality habitat are necessary to increase the likelihood that tortoises from local areas, with higher recruitment, will emigrate and repopulate (or "rescue") adjacent areas of suitable habitat (for example, within TCAs) that may have fewer tortoises due to low recruitment or high mortality (Germano and Joyner, 1988; Morafka, 1994; Tracy and others, 2004). This rescue effect has been described and studied using island biogeography concepts and principles that lead us to expect that the probability a population will persist is related to the size and isolation of the habitat patch on which it exists (MacArthur and Wilson, 1967; Brown and Kodric-Brown, 1977). Figure 2*B* provides an example of the historical relationship between habitat patches for desert tortoises in the Mojave Desert. Patches suffering localized declines in tortoise numbers could be recolonized by tortoises emigrating from adjacent patches. As habitat is degraded, lost, or fragmented by anthropogenic barriers, however, inter-patch relationships may break down, resulting in a decreased likelihood that recolonizations will occur. In short, tortoises within remaining patches that have fewer connections are more likely to be extirpated and less likely to be replaced than tortoises inhabiting patches surrounded by permeable habitats with intact connections (fig. 2*C*; Lefkovitch and Fahrig, 1985). Such fragmentation could isolate and reduce the viability of regional populations, including those within TCAs, creating an "extinction debt" (Kuussaari and others, 2009; Hylander and Ehrlén, 2013) that extends well beyond the perimeters of parcels of lost habitats. Rescue of unoccupied habitat patches may not occur, or may be delayed, if few tortoises disperse from nearby small or declining populations (Adler and Nuernberger, 1994). Unoccupied patches present a special problem if the source of the decline is unknown because evidence is lacking to indicate whether the decline was due to temporary conditions for the occupants or if the site can no longer sustain tortoises. Obtaining better information about habitat quality requirements may resolve some of this uncertainty.

Effectively Connecting Current Desert Tortoise Habitat to Recover Populations

The patterns of population distribution and dynamics described earlier represent those of a "patchy" metapopulation (Harrison, 1991). For species with this type of metapopulation dynamic to persist over the long term, connectivity between patches must be provided through contiguous viable habitat. The Mojave desert tortoise requires interconnected habitat across its range to sustain populations within and outside of TCAs over multiple generations (Tracy and others, 2004). Low-mobility species, such as the desert tortoise, are considered "corridor dwellers" that may spend their entire life within corridors (Beier and Loe, 1992). In effect, low mobility of the species means that interconnected local populations of tortoises must persist across the landscape to ensure overall species persistence (fig. 2*B*).

In contrast, passage species may move through corridors between protected areas in days or weeks, even at large spatial scales (Beier and Loe, 1992). Though individual desert tortoises can move many kilometers in one season (Berry, 1986; Edwards and others, 2004), this type of movement has been observed in large, open areas rather than a long (for example, tens of kilometers), narrow strip of habitat a few meters—or even a few hundred meters—wide. Tortoises may traverse short culverts and thereby navigate the otherwise absolute barrier of a fenced road (Boarman and others, 1998) or may occupy narrow mountain passes (Dutcher and others, 2020b; Hromada and others, 2020), but tortoise movement patterns do not lead us to expect that a tortoise in one TCA would traverse a long narrow strip of preserved desert vegetation to another TCA many kilometers distant in its lifetime. For all these reasons, habitat linkages among TCAs must be wide enough to sustain multiple home ranges or local clusters of resident tortoises (Beier and others, 2008; Morafka, 1994), while accounting for edge effects, in order to sustain regional tortoise populations.

Recent Research Relevant to Desert Tortoise Habitat and Connectivity

A variety of spatial habitat models have been developed for the management of desert tortoise habitat, including models describing habitat suitability, levels of development within modeled habitat, landscape genetics, tortoise habitat linkages, and connectivity (appendix 1; figs. 1.1–1.4). These models have been used for project-proponent and regulatory planning, establishing survey requirements, evaluating reports for project compliance, and as base inputs for subsequent spatial models. Furthermore, many of the natural resource layers developed for these models (for example, soil texture layer by Nowicki and others, 2019; wash layers by Gray and others, 2019) have been applied to understand habitats for other species of management concern across the southwestern United States (for example, Mohave Ground Squirrel by Inman and others, 2013; multiple species and energy development by Vandergast and others, 2013).

Spatial models that focus on habitat connectivity that are in development were presented at the annual symposium of the Desert Tortoise Council in February 2020 (https://deserttortoise.org/wp-content/uploads/ABSTRACTS_2020-DTC-FINAL-Feb72020.pdf), and included syntheses of habitat status (Nussear and others, 2020), genetic responses to landscape disturbances (Dutcher and others, 2020a), desert tortoise movements (Hromada and others, 2020), demographics (Shoemaker and others, 2020), and alternative future habitat scenarios (Bassett and others, 2020). The development of these models is ongoing and dynamic. For example, three of the 'working' models have been published since the presentation in February (Dutcher and others, 2020b; Carter and others, 2020a; Hromada and others, 2020). In particular, these studies reinforced evidence of reduced movements and gene flow across linear barriers (highways and railroads), while reporting movements and gene flow across mountain passes (Dutcher and others, 2020b), and documented limited tortoise observations in areas with greater than 5-percent surface disturbance per km^2 (fig. 3; Carter and others, 2020a). For these models, surface disturbance was derived for nationally available datasets, and does not necessarily include temporary disturbance.

Several additional models are still in development but can be accessed as they become ready for distribution. Available data and modelling, along with the models still in development, will further inform management agencies seeking to address connectivity issues for the Mojave desert tortoise.

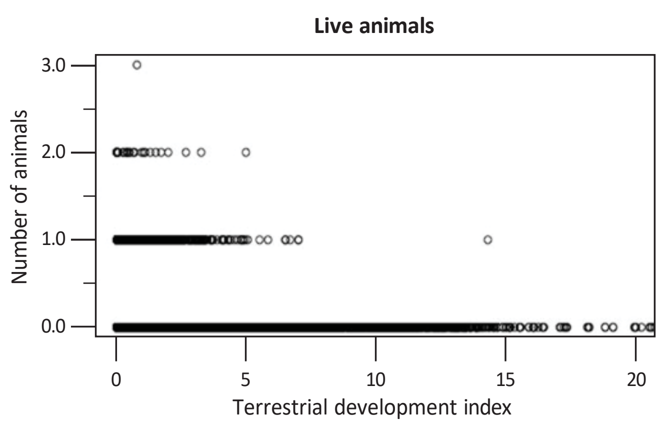

Figure 3. Observations of live Mojave desert tortoises from the U.S. Fish and Wildlife Service range-wide monitoring program relative to the proportion of development in the surrounding landscape within 1 kilometer (km) of the observation location (Terrestrial Development Index). A development index value of 5 indicates that 5 percent of the area within 1 km of that location has been altered by development. Adapted from Carter and others (2020a).

Management Implications

Maintaining an ecological network (recovery network) for the Mojave desert tortoise, with a system of core habitats (TCAs) connected by linkages (Hilty and others, 2020), is necessary to support demographically viable populations and long-term gene flow within and between TCAs. There are three points for wildlife and land-management agencies to consider when making decisions that could affect connectivity of Mojave desert tortoise populations (for example, in updating actions in resource management plans or amendments that could help maintain or restore functional connectivity in light of the latest information).

(1) Management of All Desert Tortoise Habitat for Persistence and Connectivity

Desert tortoise populations continue to decline within most TCAs (Allison and McLuckie, 2018), and it is unlikely that trends are better in populations outside protected areas. Fragmentation exacerbates negative trends by increasing the probability that isolated populations will suffer irreversible declines due to stochastic (unpredictable) effects acting on their smaller local abundances, especially when combined with multiple external threats within the population fragments. Enhanced threat reduction to reverse declines within TCAs and maintained occupied habitat in the surrounding matrix would help reduce the variability in population growth rates and improve the resilience of protected populations, while implementing efforts to improve connectivity.

Each TCA has unique strengths and weaknesses regarding its ability to support minimum sustainable populations based on areal extent, and its ability to support population increases based on landscape connection with adjacent populations. Considering how proposed projects (inside or outside of TCAs) affect connectivity and the ability of TCAs to support at least 5,000 (the numerical goal for each TCA) adult tortoises could help managers maintain the resilience of TCAs to population declines. The same project in an alternative location may have very different impacts on local or regional connectivity. For example, within the habitat matrix surrounding TCAs, narrowly delineated corridors may not allow for natural population dynamics if they do not accommodate overlapping home ranges along most of their widths so that tortoises reside, grow, find mates, and produce offspring that can replace older tortoises (Beier and Loe, 1992; Beier, 2018). In addition, most habitat outside TCAs may receive more surface disturbance than habitat within TCAs (Carter and others, 2020a). Therefore, managing the entire remaining matrix of desert tortoise habitat for permeability may be better than delineating fixed corridors (Beier, 2018; Gray and others, 2019). These concepts apply, especially given uncertainty about long-term condition of habitat within and outside of TCAs under a changing climate.

Ultimately, questions such as "*What are the critical linkages that need to be protected?*" may be better framed as "*How can we manage the remaining habitat matrix in ways that sustain ecological processes and habitat suitability for special status species.*" Land-management decisions made in the context of the latter question could be more conducive to maintenance of a functional ecological network and the recovery of the Mojave desert tortoise.

(2) Limitations on Landscape-level Disturbance Across Habitat Managed for the Desert Tortoise

Clearly delineating habitat linkages and differentiating them from non-delineated areas by the uses that are permitted or prohibited within them by specific management guidelines can help achieve functional connectivity. Such guidelines would be most effective if they considered and accounted for all surface disturbances (for example, temporary disturbances such as fiberoptic lines or off-highway vehicle routes, right-of-ways, utility-scale solar development, urbanization) to the extent possible. A weighted framework that varies with the permanence or severity of the disturbance and can be additive to quantify cumulative effects may be useful. For example, minor roads can alter tortoise movements independently of other features (Hromada and others, 2020; Peaden and others, 2017), but if the isolated dirt road is accompanied by a powerline that encourages raven predation (Xiong, 2020), the two features together may be additive. Ignoring minor or temporary disturbance on the landscape could result in a cumulatively large impact that is not explicitly acknowledged (Goble, 2009). Therefore, a commitment to understanding and quantifying all surface disturbance on a given landscape is needed.

a. In California, the Bureau of Land Management established 0.1–1.0-percent new surface-disturbance caps for TCAs and mapped linkages that address the issues described in the "(1) Management of All Desert Tortoise Habitat for Persistence and Connectivity" section (fig. 4; table 1; U.S. Bureau of Land Management, 2016).

b. Nevada, Utah, and Arizona currently do not have surface-disturbance limits. Limits comparable to those in the DRECP would be 0.5 percent within TCAs and 1 percent within the linkages modeled by Averill-Murray and others (2013). Limits in some areas of California within the DRECP, such as Ivanpah Valley, are more restrictive at 0.1 percent (fig. 4; table 1). Continuity across the state line in Nevada could be achieved with comparable limits in the adjacent portion of Ivanpah Valley, as well as the Greater Trout Canyon translocation area and the Stump Springs Regional Augmentation Site (fig. 5). These more restrictive limits help protect remaining habitat in the major interstate connectivity pathway through Ivanpah Valley (Hagerty and others, 2011) and focal areas of population augmentation that provide additional population connectivity along the western flank of the Spring Mountains.

c. In a recent study that analyzed 13 years of desert tortoise monitoring data, nearly all desert tortoise observations were at sites in which 5 percent or less of the surrounding landscape within 1 km was disturbed (Carter and others, 2020a). To help maintain tortoise inhabitance and permeability across all other non-conservation-designated tortoise habitat, all surface disturbance could be limited to less than 5-percent development per square kilometer because the 5-percent threshold for development is the point at which tortoise occupation drops precipitously (Carter and others, 2020a; fig. 3). However, it is important to note that 5 percent may not maintain population sizes needed for demographic or functional connectivity; therefore, ideally, development thresholds should be lower. Lower development thresholds would be particularly useful in areas within the upper 5th percentile of connectivity values modeled by Gray and others (2019; fig. 1.3; fig. 5).

However, although individual desert tortoises were observed at development levels up to 5 percent, we do not know the fitness or reproductive characteristics of these individuals. This level of development also may not allow for long-term persistence of healthy populations that are of adequate size needed for demographic or functional connectivity; therefore, ideally development should be lower. This would be particularly useful in areas within the upper 5th percentile of connectivity values modeled by Gray and others (2019).

d. Reducing ancillary threats in places where connectivity is restricted to narrow strips of habitat, for example, narrow mountain passes or vegetated strips between solar development, could enhance the functionality of these vulnerable linkages. In such areas, maintaining multiple, redundant linkages could further enhance overall connectivity. Attention to the spatial configuration of allowed disturbances also would help ensure that any existing bottlenecks to connectivity are not severed.

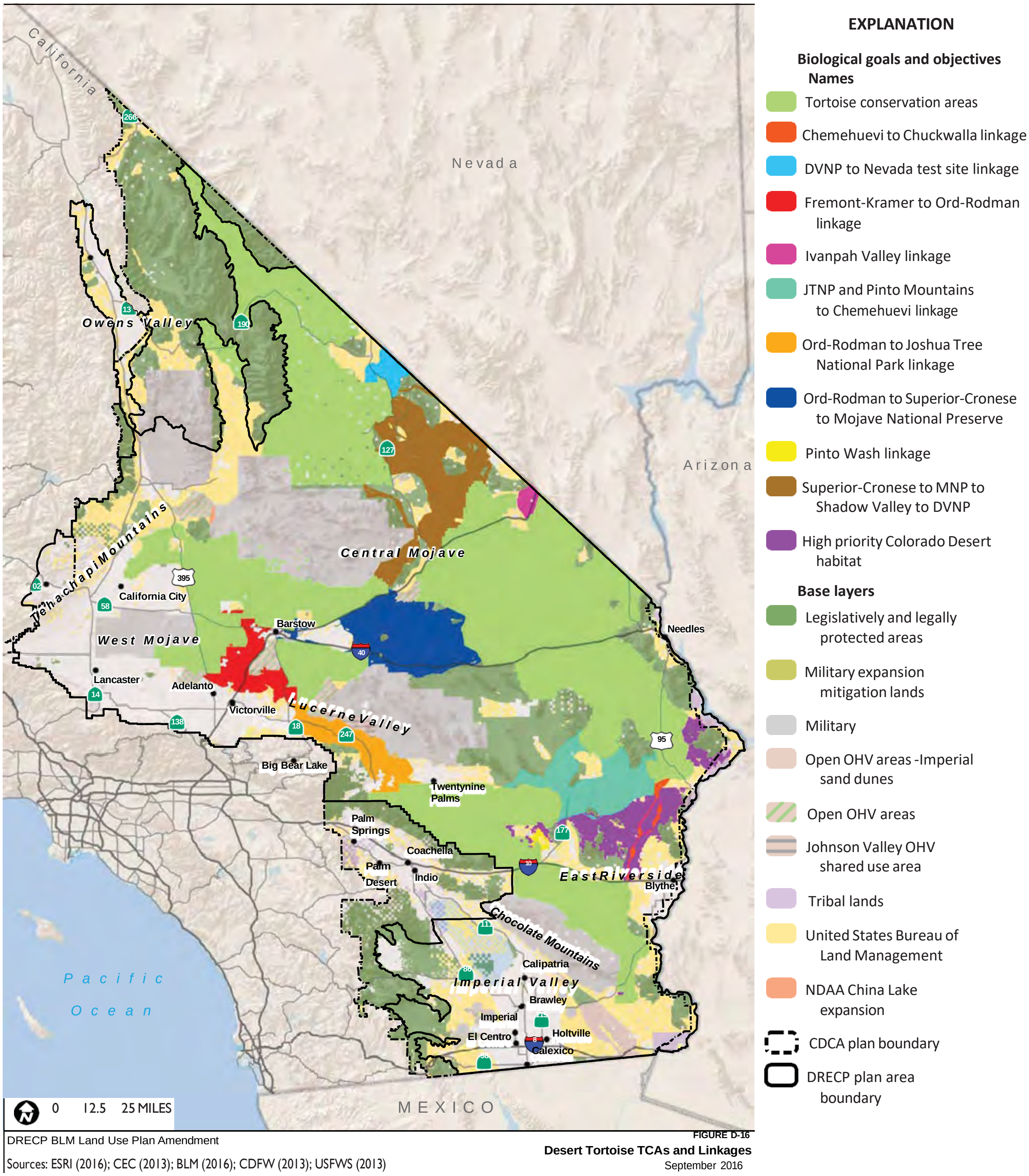

Figure 4. Desert tortoise conservation areas (TCAs) and linkages in the California Desert Renewable Energy Conservation Plan (U.S. Bureau of Land Management, 2016). Tortoise conservation areas are labeled according to table 1.

Table 1. Surface-disturbance caps in desert tortoise conservation areas and linkages in the California Desert Renewable Energy Conservation Plan (U.S. Bureau of Land Management, 2016).

[ACEC, Area of Critical Environmental Concern; CHU, critical habitat unit]

Location	Disturbance cap (percentage)
Tortoise conservation area (numbers correspond to fig. 4)	
1. Desert Tortoise Research Natural Area	0.1
2. Fremont-Kramer ACEC and CHU	0.5
3. Superior-Cronese ACEC and CHU	0.5
4. Ord-Rodman ACEC and CHU	0.5
5. Pinto Mountains ACEC and CHU	0.5
6. Chuckwalla ACEC and CHU	0.5
7. Chemehuevi Desert ACEC and CHU	0.5
8. Piute Valley ACEC and CHU	0.5
9. Shadow Valley ACEC	0.5
10. Ivanpah Valley ACEC (includes critical habitat on Bureau of Land Management land)	0.1
Desert tortoise linkages (see legend in fig. 4)	
Ord-Rodman to Superior-Cronese to Mojave National Preserve	1
Superior-Cronese to Mojave National Preserve to Shadow Valley to Death Valley National Park	1
Joshua Tree National Park and Pinto Mountains to Chemehuevi	1
Death Valley National Park to Nevada National Security Site	1
Ivanpah Valley	0.1
Chemehuevi to Chuckwalla	0.1
Pinto Wash	0.1
Ord-Rodman to Joshua Tree National Park	0.5
Fremont-Kramer to Ord-Rodman	0.5
High-value Colorado Desert Habitat	1

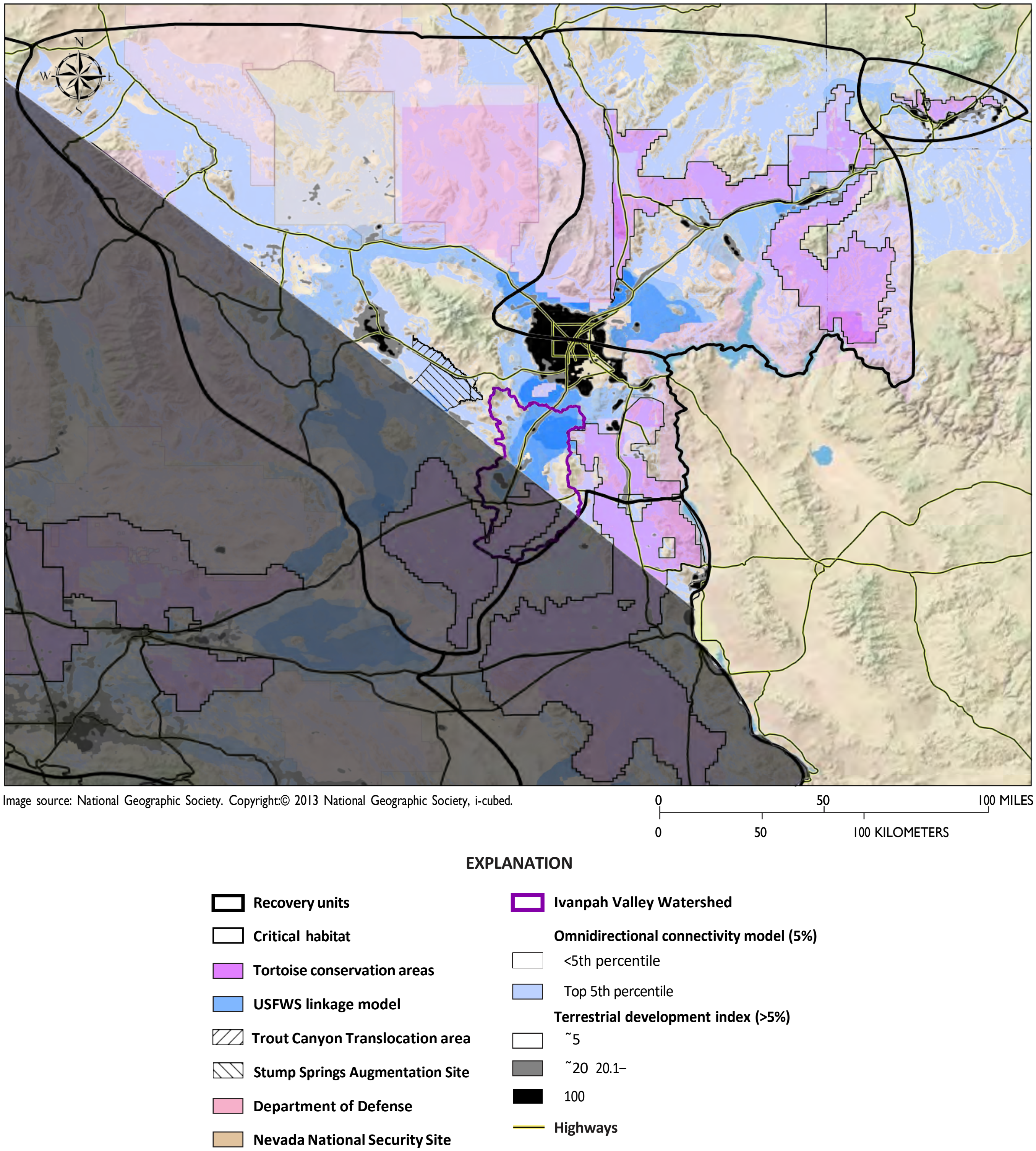

Figure 5. Tortoise conservation areas, linkages, and other habitat managed for desert tortoise population connectivity in Nevada, Utah, and Arizona.

(3) Minimization of Mortality from Roads and Maximization of Passage Under Roads

Roads pose a significant threat to the long-term persistence of local tortoise populations, and roads of high traffic volume lead to severe population declines (Peaden, 2017), which ultimately fragments populations farther away from the roads. Three points pertain to reducing direct mortality of tortoises on the many paved roads that cross desert tortoise habitat and maintaining a minimal level of permeability across these roads.

a. Tortoise-exclusion fencing tied into culverts, underpasses or overpasses, or other passages below roads in desert tortoise habitat, would limit vehicular mortality of tortoises and would provide opportunities for movement across the roads (Boarman and others, 1997). Installation of shade structures on the habitat side of fences installed in areas with narrow population-depletion zones would limit overheating of tortoises that may pace the fence (Peaden and others, 2017).

b. Passages below highways could be maintained or retrofitted to ensure safe tortoise access, for example, by filling eroded drop-offs or by modifying erosion-control features, such as rip-rap, to make them safer and more passable for tortoises. Wildlife management agencies could work with transportation departments to develop construction standards that are consistent with hydrologic/erosion management goals, which would also maximize the potential for tortoise survival and passage and make the standards widely available. The process would be most effective if the status of passages was regularly monitored and built into management plans.

c. Healthy tortoise populations along fenced highways could be supported by ensuring that land inside tortoise-exclusion fences is not so degraded that it leads to degradation of tortoise habitat outside the exclusion areas. As one example, invasive plants inside road rights of way could be mown or treated with herbicide to limit their spread into adjacent tortoise habitat and to minimize the risk of these plants carrying wildfires into adjacent habitat.

(4) Adaptation of Management Based on New Information

The models described herein have already been useful for informing management of tortoise habitat to support population recovery and connectivity. Future research will continue to build upon and refine these models and develop new ones. New models could consider landscape levels of development and be constructed such that they share common foundations to support future synthesis efforts. If model development was undertaken in partnership with entities that are responsible for management of desert tortoise habitat, it would facilitate incorporation of current and future modeling results into their land management decisions (Carter and others, 2020b). There are specific topics that could be clarified with further evaluation:

a. The effects of climate change on desert tortoise habitat, distribution, and population connectivity (Nussear and others, 2020; Shoemaker and others, 2020);

b. The effects of large-scale fires, especially within repeatedly burned habitat, on desert tortoise distribution and population connectivity;

c. The ability of solar energy facilities or similar developments to support tortoise movement and presence by leaving washes intact, leaving native vegetation intact whenever possible, or if not possible, mowing the site to allow vegetation to re-sprout, managing weeds, and allowing tortoises to occupy the sites; and

d. The design and frequency of underpasses necessary to maintain functional demographic and genetic connectivity across linear features such as highways.

Summary

This report summarizes the underlying concepts and importance of landscape connectivity for Mojave desert tortoise populations by reviewing current information on connectivity and providing information to managers for maintaining or enhancing desert tortoise population connectivity as they consider future proposals for development and management actions.

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Appendix 1. Recent Desert Tortoise Habitat and Connectivity Models

The figures provided in this appendix (figs. 1.1–1.4) were important in the development of guidance on the habitat connectivity needs of the Mojave desert tortoise for natural resource managers.

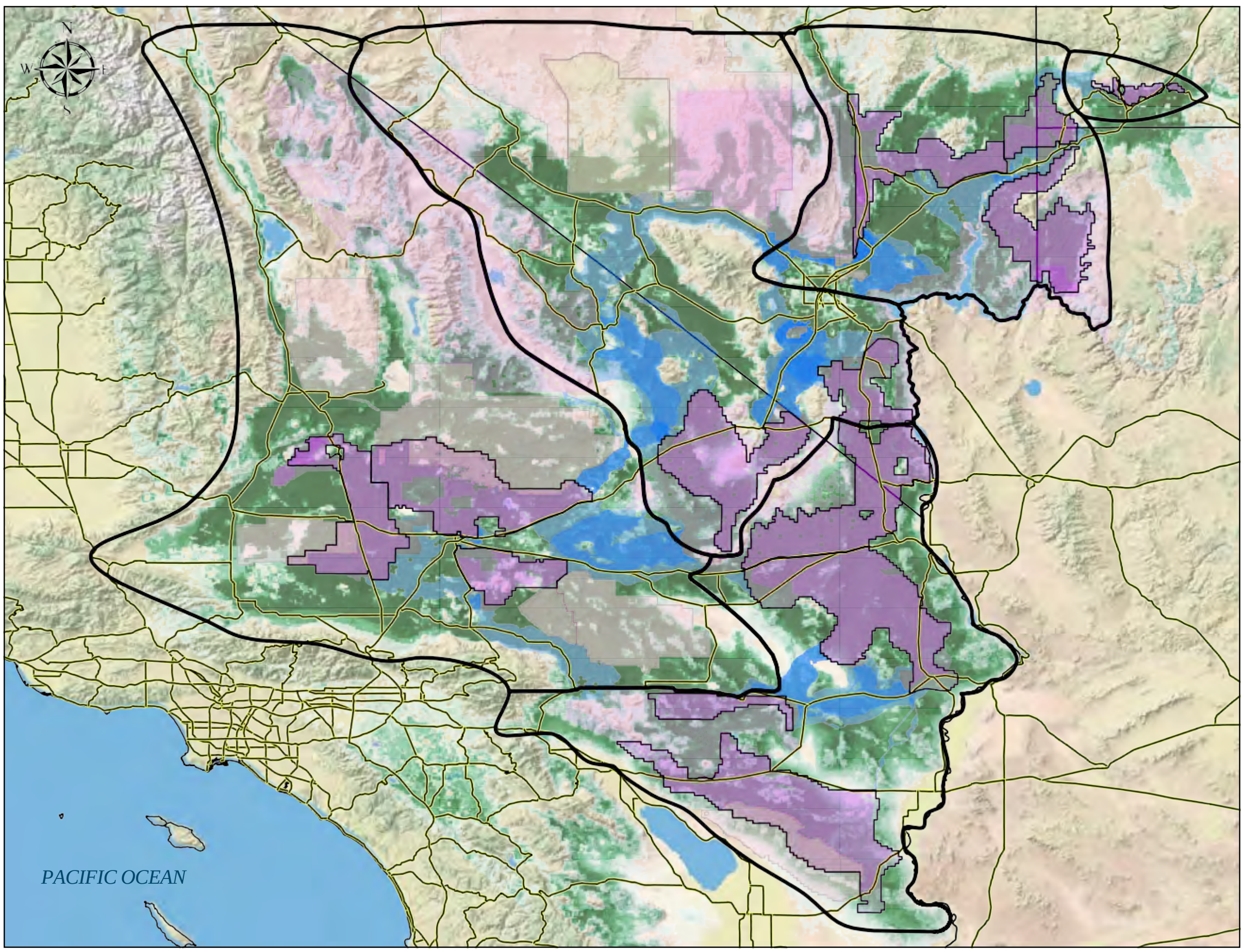

Image source: National Geographic Society. Copyright:© 2013 National Geographic Society, i-cubed.

0 50 100 MILES

0 50 100 KILOMETERS

EXPLANATION

USFWS linkage model

2009 USGS habitat model

High probability

Low probability

Tortoise conservation areas

Department of Defense

Nevada National Security Site

Recovery units

Critical habitat

Highways

Figure 1.1. Range-wide Mojave desert tortoise habitat probability model (Nussear and others, 2009) overlain by the U.S. Fish and Wildlife Service (USFWS) linkage model (Averill-Murray and others, 2013) that connects designated tortoise conservation areas. The color ramp from white to green represents the probability of tortoise presence from low to high, respectively.

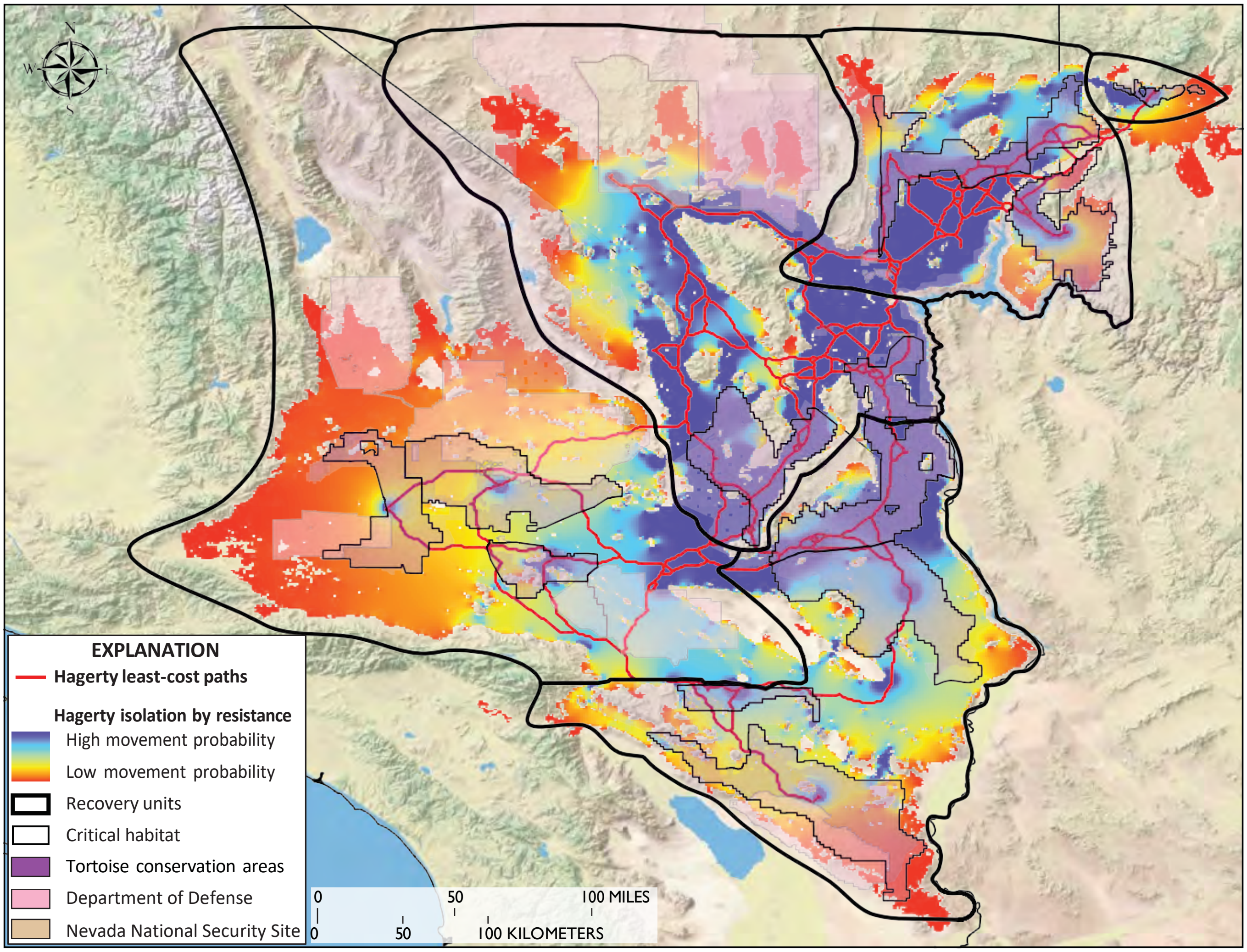

Image source: National Geographic Society. Copyright:© 2013 National Geographic Society, i-cubed.

Figure 1.2. Mojave desert tortoise landscape genetics modeled by Hagerty and others (2011) showing least-cost paths between sampled population centroids overlying an isolation-by-resistance surface.

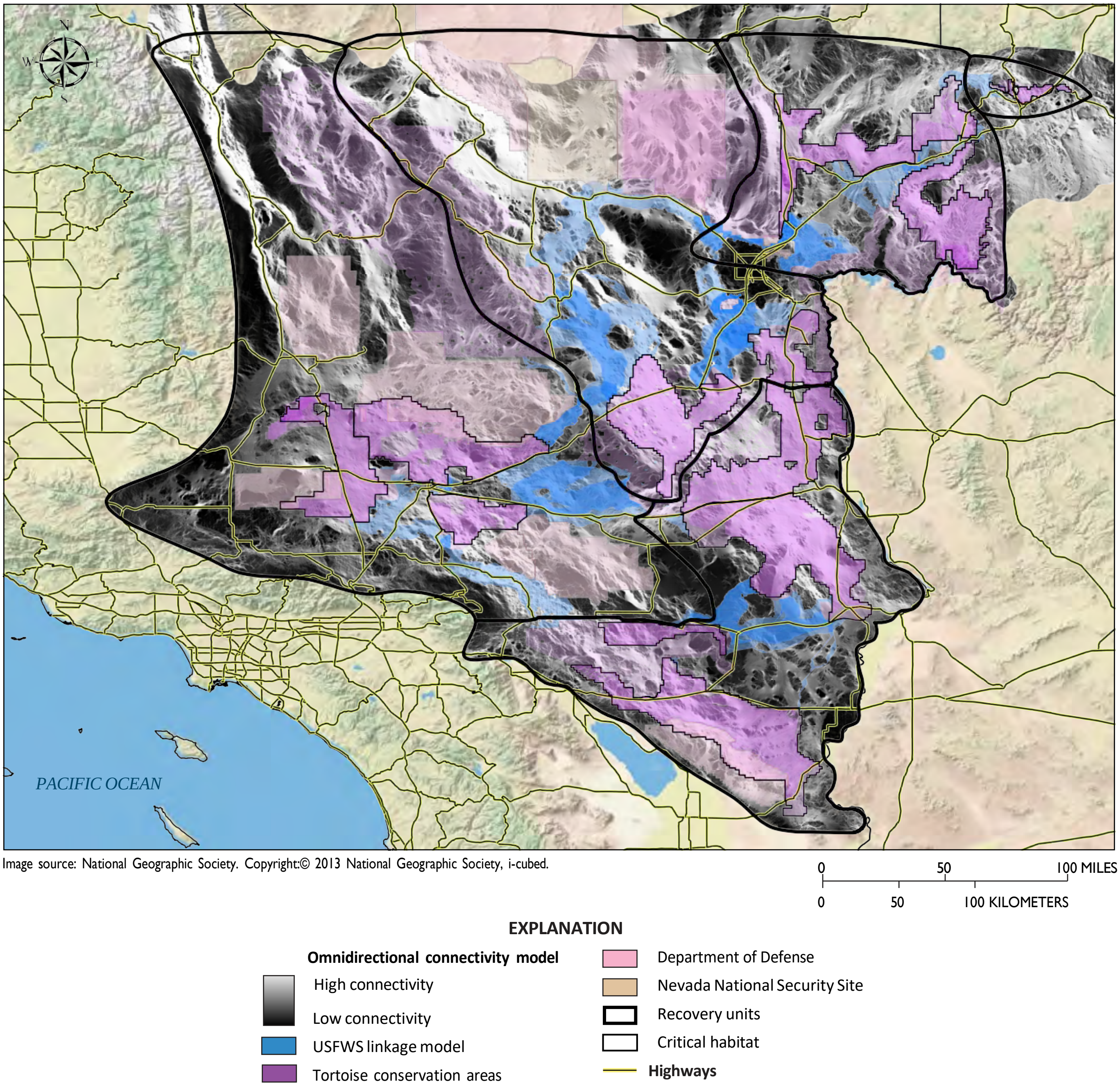

Figure 1.3. Range-wide omnidirectional connectivity model (Gray and others, 2019) for the Mojave desert tortoise overlain by the U.S. Fish and Wildlife Service (USFWS) linkage model (blue) that connects designated tortoise conservation areas (Averill-Murray and others, 2013).

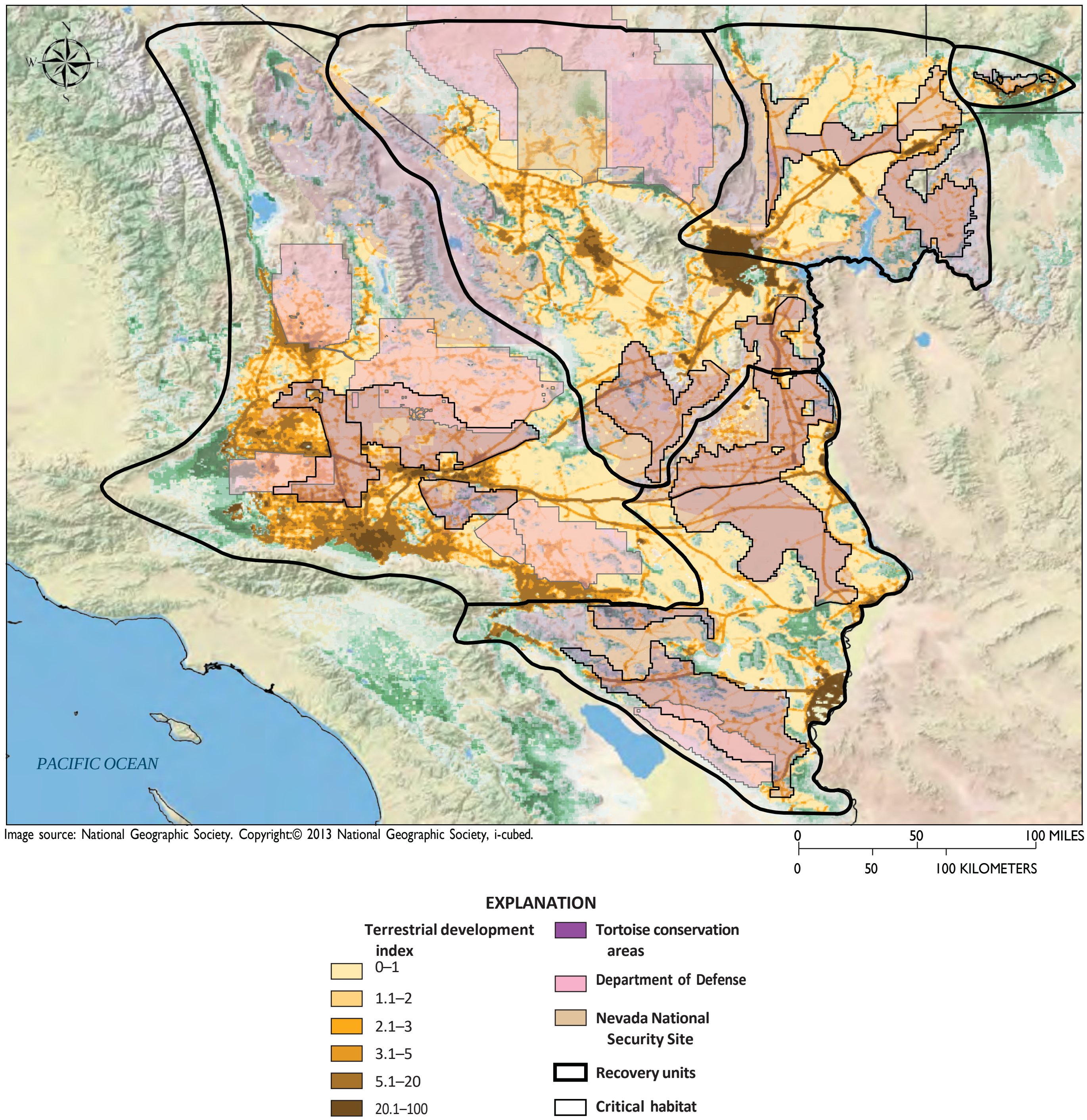

Figure 1.4. Terrestrial development index modeled by Carter and others (2020).

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August 4th, 2022

To: Bureau of Land Management Southern Nevada District Office
Attn: Golden Currant Solar Project Variance
4701 N. Torrey Pines Drive
Las Vegas, NV 89130

Email sent to: BLM_NV_SND_EnergyProjects@blm.gov

Re: Comments on the Golden Currant Solar Project Variance Process

To Whom it May Concern,

Basin and Range Watch is a nonprofit working to conserve the Mojave and Great Basin deserts and to educate the public about the diversity of life, culture, and history of the ecosystems and wild lands of the desert.

The mission of **Western Watersheds Project** is to protect and restore western watersheds and wildlife through education, public policy initiatives, and legal advocacy.

Mojave Green combines art and activism to draw attention to issues of environmental injustice and highlights viable solutions.

Wildlands Defense works to inspire and empower the preservation of wild lands, wildlife and biodiversity in the West.

The Desert Tortoise Council is a non-profit organization comprised of hundreds of professionals and laypersons who share a common concern for wild desert tortoises and a commitment to advancing the public's understanding of desert tortoise species. Established in 1975 to promote conservation of tortoises in the deserts of the southwestern United States and Mexico, the Council routinely provides information and other forms of assistance to individuals, organizations, and regulatory agencies on matters potentially affecting desert tortoises within their geographic ranges.

Morongo Basin Conservation Association advocates for the healthy desert environment that nurtures the region's rural character, cultural wealth and economic well-being.

Shoshone Village is situated in the beautiful Death Valley and Amargosa River region of Inyo County California, and is an ecotourism hub.

Desert Survivors is a non-profit organization founded in 1981 with the mission of experiencing, sharing and protecting desert wilderness. We recognize the places we love to explore will not remain wild unless we give others the opportunity to experience them and unless we remain vigilant and active in our efforts to monitor and preserve them.

Together known as 'Conservation Groups.'

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The proposed Golden Currant Solar Project is undergoing a Variance Review process and the Bureau of Land Management (BLM) has recently segregated mineral rights for 2 years to consider an application for a 4,300-acre solar project.

Noble Solar, LLC applied for a right-of-way grant for the construction, operation and eventual decommissioning of a proposed 400 megawatt (MW) alternating current solar facility and battery energy storage system on BLM managed public land.

During the Virtual Variance Meeting on July 19^{th} and 20^{th}, 2022, several issues were raised by participants.

These issues include:

1. Desert Tortoise – In 2021, biologists removed nearly 3 times the amount of desert tortoise predicted to be on the adjacent Yellow Pine Solar Project site on a record-breaking drought year, many of which were killed by predators. Eleven additional tortoises were located on the site since the original translocation—one of which was run over by a vehicle (personal communication, July 29, 2022, BLM).
2. Fugitive Dust – Large-scale solar developers can't seem to ever control fugitive dust emissions caused by their projects. This is very difficult in arid regions and the projects develop four to ten square miles of land at a time. In addition to being a visual eyesore, the human health risks stemming from disturbed topsoils/blowing dirt and dust events, is a rising problem. According to numerous studies *Coccidioides immitis* is a fungus found in the soil; clinical infections have a strong association with blowing dust events in the Southwestern United States. Blowing dust events can cause significant morbidity and

mortality in the general population causing acute respiratory failure and exacerbations of chronic respiratory diseases, such as asthma and COPD[1].

3. Old Spanish National Historic Trial – the project would be located about 2 miles away from the Old Spanish Trail. A large industrial project would destroy the historic view-scape of the area as well as cause desecration to this national historic treasure.
4. Important Mojave Desert Habitat – The project would impact high quality Mojave Desert habitat and remove several thousand Mojave yucca plants. It would also impact mesquite woodlands and associated species. The rare Pahrump buckwheat has been found on the project site.
5. Water – the project would need over 1,000 acre-feet of water for construction and 200-acre feet a year for operation for 30 years which is 6,000 acre feet. All basins are over-allocated.
6. Public Land Access – Large areas of public lands (up to 7 square miles) would be blocked off by fences and solar panels.
7. Visual Impacts – The project would be visible for several miles and from wilderness areas in Nevada and California, and even from high elevations in Death Valley National Park.
8. Paleontological Resources – the project possibly contains Plio-Pleistocene megafaunal fossils, such as mammoth.
9. Pahrump Paiute Ethnography – The Golden Currant Site is adjacent to both Stump Springs and Brown's Spring. The mesquite areas throughout this valley constitute an important part of the Pahrump Paiute's cultural landscape.

Please pause the Golden Currant Solar Project Variance Review until the Resource Management Plan can be Revised.

The BLM is basing the variance review on an old and outdated Resource Management Plan (RMP) called the Las Vegas Resource Management Plan that was completed in 1997. The plan is 25 years old. In the meantime, the listed population of the desert tortoise has experienced drastic declines (Allison and McLuckie 2018) and the International Union for Conservation of Nature's (IUCN) Species Survival Commission, Tortoise and Freshwater Turtle Specialist Group, now considers the Mojave desert tortoise to be Critically Endangered (Berry et al. 2021).

The 25-year-old plan has designated most of the project site as a Visual Resource Management Class IV which encourages developments like this, but this was before June 5, 2003, when the Secretary of the Interior assigned joint administrative responsibility for the Old Spanish National Historic Trail to the Bureau of Land Management and the National Park Service.

The 25-year-old plan also predates the Clark County Multi Species Habitat Conservation Plan (MSHCP) which was established in 2000 to conserve a wide variety of species and their habitats throughout the county. The MSHCP has been prepared pursuant to Section 10(a) of the

[1] See for example https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8962906/

Endangered Species Act of 1973, as amended (Act). The MSHCP identifies those actions necessary to maintain the viability of natural habitats in the county for approximately 232 species residing in those habitats. Some of those species and habitats are present on the Golden Currant Solar Energy project site.

We have learned through personal communication with the BLM that they are planning a Nevada-wide Resource Management Plan revision in 2023. Land use planning can help define the latest values and issues involving these public lands. An RMP revision would require an updated analysis of these values and help the agency better decide the importance of this area. It appears that BLM is using a loophole trying to review this project with an outdated RMP.

We would like to request that all Variance and future NEPA review for this proposed project be paused until the Resource Management Plan can be revised.

The Federal Land Policy and Management Act (FLPMA) requires the BLM to maintain on a continuing basis an inventory of all public lands and their resources and other values (Inventories, Section 201). Planning, per FLPMA Section 202, instructs that the Secretary of the Interior shall, with public involvement and consistent with the terms and conditions of the Act, develop, maintain, and, when appropriate, revise land use plans which provide tracts or areas for the use of the public lands.

The purpose of a Resource Management Plan (RMP) is to:

1. Allocate resources and determine appropriate multiple uses for the public lands;

2. Provide a strategy to manage and protect resources;

3. Establish systems to monitor and evaluate the health of resources and effectiveness of practices.

RMPs are like a public lands version of municipal zoning.

The Bureau of Land Management evaluates and amends or revises its land-use plans in response to changing conditions and demands on the public lands, or when new components are added to the National Conservation Lands that it manages. Keeping a plan up-to-date helps ensure that the BLM manages the public lands in ways that meet the multiple-use and sustained yield goals that Congress has set for these lands.

Examples of situations that may require new or changed land-use plan decisions include:

- New information or scientific knowledge about the environmental health of an area.
- Failure to meet the land health standards set out in the original plan.
- Requests for land uses that were not considered in the original plan. Many older land-use plans, for example, did not consider the possible land-use needs of emerging renewable energy resources.

The Las Vegas RMP is 25 years old, and in that timeframe, values, visitation and use of the area have changed.

Old Spanish National Historic Trial

The project would be located within the 5-mile trail corridor that both NPS and BLM consider important to protect.

The jurisdiction of the Old Spanish National Historic Trail is now shared by both the BLM and National Park Service, and this happened 6 years after the Las Vegas Resource Management Plan was established.

After the feasibility study was completed and submitted, Congress passed a bill creating the Old Spanish National Historic Trail and sent it to the White House on November 15, 2002. President George W. Bush signed the bill into law

Both the BLM and NPS prepared the Old Spanish National Historic Trail Comprehensive Administrative Strategy (OSNHTCAS) in 2003. In the strategy, they outline the purpose of the Old Spanish National Historic Trail. [2]

In 2015, the BLM started to revise the Southern Nevada Resource Management Plan, but would later cancel the review for unknown reasons. In the revision for all alternatives, BLM's objectives were to reduce and consider threats to the cultural and visual resources.

"Nature and Purpose of the Old Spanish National Historic Trail –

Many of the more than 2,700 miles of the Old Spanish Trail are characterized by stark landscapes that recall those described by early users of the trail. The trail corridor is informally considered by the NPS to lie five miles on either side of the centerline of the trail alignment to include the nearest elements of the view shed, parts of the cultural landscapes, landmarks, and traditional cultural properties near the trail. The BLM follows direction from their trail administration manual to establish a trail corridor.

Administrative responsibilities include overall trail-wide leadership, such as coordination, planning, and signing; resource preservation and protection (such as protection of high potential sites and segments); review of trail site and segment development; trail-wide resource inventories and mapping (including developing and maintaining geographic information systems); certification, interpretation, and visitor use cooperative/ interagency agreements; and limited financial assistance to other government agencies, landowners, interest groups, and individuals."

Was the National Park Service present for the Variance meetings for this project? It appeared that only the BLM was there running the show.

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[2] https://oldspanishtrail.org/wp-content/uploads/2019/01/Comprehensive-Management-Strategy-2017.pdf

Under Section 5(e)(1) of the National Trails System Act, it is the responsibility of the administering agencies to identify high potential sites and segments as part of the comprehensive planning process for a national historic trail.

High potential sites are those historic sites related to the route or sites in close proximity, which provide opportunity to interpret the historic significance of the trail during the period of its major use. Criteria for consideration as high potential sites include historic significance, presence of visible historic remnants, scenic quality, and relative freedom from intrusion.

High potential segments are those segments of a trail that afford high-quality recreation experiences along a portion of the route having greater-than-average scenic values or affording an opportunity to share vicariously the experience of the original users of a historic route.

Stump Spring, about 2 miles from the site, was identified as a High Potential Segment.

Cultural landscapes are identified as "a geographic area (including both cultural and natural resources and the wildlife or domestic animals therein) associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Department of the Interior 1996).

The National Park Service defines a cultural landscape as a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person, or exhibiting other cultural or aesthetic values.

According to the Old Spanish National Historic Trail Comprehensive Administrative Strategy in 2003:

"Four main types of cultural landscapes have been defined: historic designed landscape, ethnographic landscape, historic site, and historic vernacular landscape (note: these four types are not mutually exclusive). The Old Spanish Trail is essentially a linear cultural landscape significant for its "association with a historic event, activity, or person" (ibid.), and comprised of numerous historic sites and defining features. An outstanding characteristic of the Old Spanish National Historic Trail is the presence of extensive cultural landscape elements that still retain integrity. For the Old Spanish National Historic Trail, cultural landscapes are intricately related to the essential nature of the trail. Trail administration considers them essential for trail administration and management"

"The Old Spanish National Historic Trail, characterized by open stretches of western terrain somewhat free of modern intrusions, offers exceptional opportunities for the public to enjoy and appreciate both the natural and cultural environment. In general, few physical traces remain that can be directly linked to the period of significance identified in the legislation. In other places, the original traces have been superseded by wagon roads, cattle drive traces, and other later uses. However, the natural landmarks that guided travelers still can be seen today."

The OSNHTCAS strategies for protecting the cultural resources of the trail include:

- agree and systematically address the importance of protecting these landscapes in order to reach some degree of consensus,
- protect the visual characteristics of a landscape and other sensory components that make important contributions to their historic significance and help us make sense and value of what we see.

Upgrading the VRM Class With a Resource Management Plan Revision

The majority of the landscape of the proposed Golden Currant Solar Project was designated as Visual Resource Management (VRM) Class IV during the last revision of the RMP. This did not consider the future designation of the Old Spanish National Historic Trail and the NPS involvement. This was 6 years before the Interior Department designated co-management with BLM and NPS.

The BLM has developed a Visual Resource Inventory (VRI)[3]. VRI is a systematic process for:

- *Assessing and rating the intrinsic scenic quality of a particular tract of land, through the Scenic Quality Rating process;*
- *Measuring the public concern for the scenic quality of the tract, through the Sensitivity Level Analysis; and*
- *Classifying the distance from which the landscape is most commonly viewed, through delineation of Distance Zones.*

Scenic Quality Rating

Within the VRI process, public lands are evaluated with regard to their scenic quality, defined as the visual appeal of a particular tract of land. Scenic quality is determined systematically by

1. *dividing the landscape into Scenic Quality Rating Units (SQRUs) based on conspicuous changes in physiography or land use, and*
2. *ranking scenic quality within each SQRU based on the assessment of seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications.*

The ratings are made in the field by trained observers who evaluate the landscape view from inventory observation points, which are either important viewpoints or points with views that are representative of the SQRU. Based on the outcome of this assessment, lands within each SQRU are assigned a scenic value rating of A (high scenic value), B (moderate scenic value), or C (low scenic value). Generally, those areas with the most variety and most harmonious composition have the highest scenic value ratings, while *areas with less variety and greater levels of disturbance from human activities have the lowest scenic value ratings.*

Sensitivity Level Analysis:

[3] Bureau of Land Management Visual Resource Management Classes (anl.gov)

Visual sensitivity is defined as a measure of public concern for scenic quality. Sensitivity is determined by evaluating the types and numbers of potential viewers of a specified area (this area is referred to as a Sensitivity Level Rating Unit or SLRU), the level of public interest in the SLRU, adjacent land uses, and the presence of special areas. The Sensitivity Level Analysis (SLA) is completed in two steps:

1. *delineation of SLRUs, and*
2. *rating visual sensitivity within each SLRU. Public sensitivity is determined through analyzing various indicators including user types, amount of use, public interest, adjacent land uses, special areas and other factors unique to the SLRU.*

Distance Zone Delineation

Within the VRI process, distance zones are assigned based on the distance of lands from places where people are known to be present on a regular basis, such as highways, waterways, trails, or other key locations. They include the following:

- ***Foreground-middle ground –*** *This zone includes visible areas from 0 to 5 mi.*
- ***Background –*** *This zone includes visible areas from 5 to 15 mi.*
- ***Seldom seen –*** *This zone includes lands visible beyond 15 mi or lands hidden from view from key locations.*

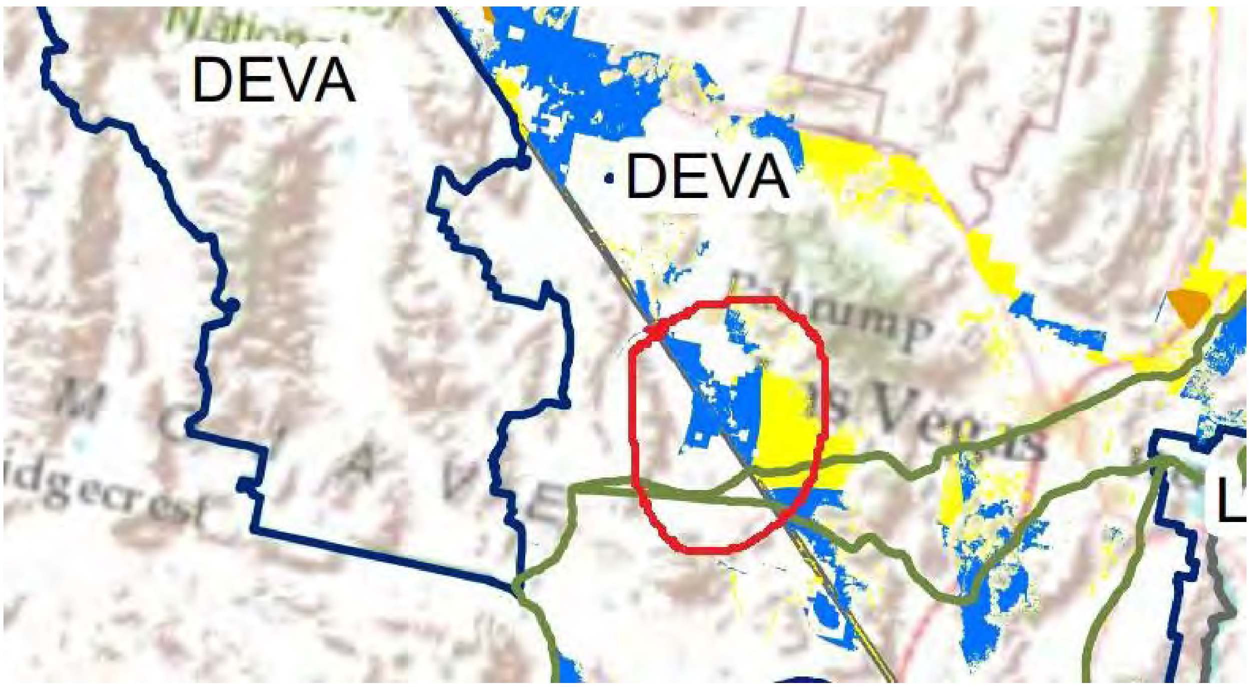
The VRM classes set VRM objectives for lands in each class, as well as the level of visual change in the landscape character that is allowed as a result of proposed management activities. The objectives and allowed levels of change for each of the four VRM classes are as follows:

- ***VRM Class I Objective****: To preserve the existing character of the landscape. Allowed Level of Change: This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.*
- ***VRM Class II Objective****: To retain the existing character of the landscape. Allowed Level of Change: The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.*
- ***VRM Class III Objective****: To partially retain the existing character of the landscape. Allowed Level of Change: The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.*
- ***VRM Class IV Objective****: To provide for management activities which require major modification of the existing character of the landscape. Allowed Level of Change: The level of change to the characteristic landscape can be high. Management activities may dominate the view and may be the major focus of viewer attention. However, the impact*

of these activities should be minimized through careful siting, minimal disturbance, and repeating the basic elements of form, line, color, and texture within the existing setting.

For unknown reasons, BLM designated most of the Golden Currant Project site as VRM Class IV. A new Resource Management Plan could potentially protect the view-scape associated with the Old Spanish National Historic Trial.

In 2012, the Western Solar Plan was established for 6 western states and certain areas near national parks were designated High Conflict Areas. In the case of the Golden Currant Solar Project, BLM has stated that 2,000 acres of the 4,300-acre application fall into a "High Conflict Area" as determined by the Solar Programmatic Environmental Impact Statement.[4] The PEIS was approved 15 years after the last revision of the RMP.



^Red circle shows High Conflict area described in the solar PEIS.

There are two ways to change an RMP:

- **Plan revisions**: Plan revisions involve a complete or near-complete rewrite of an existing land-use plan. A plan revision always requires a full Environmental Impact Statement.

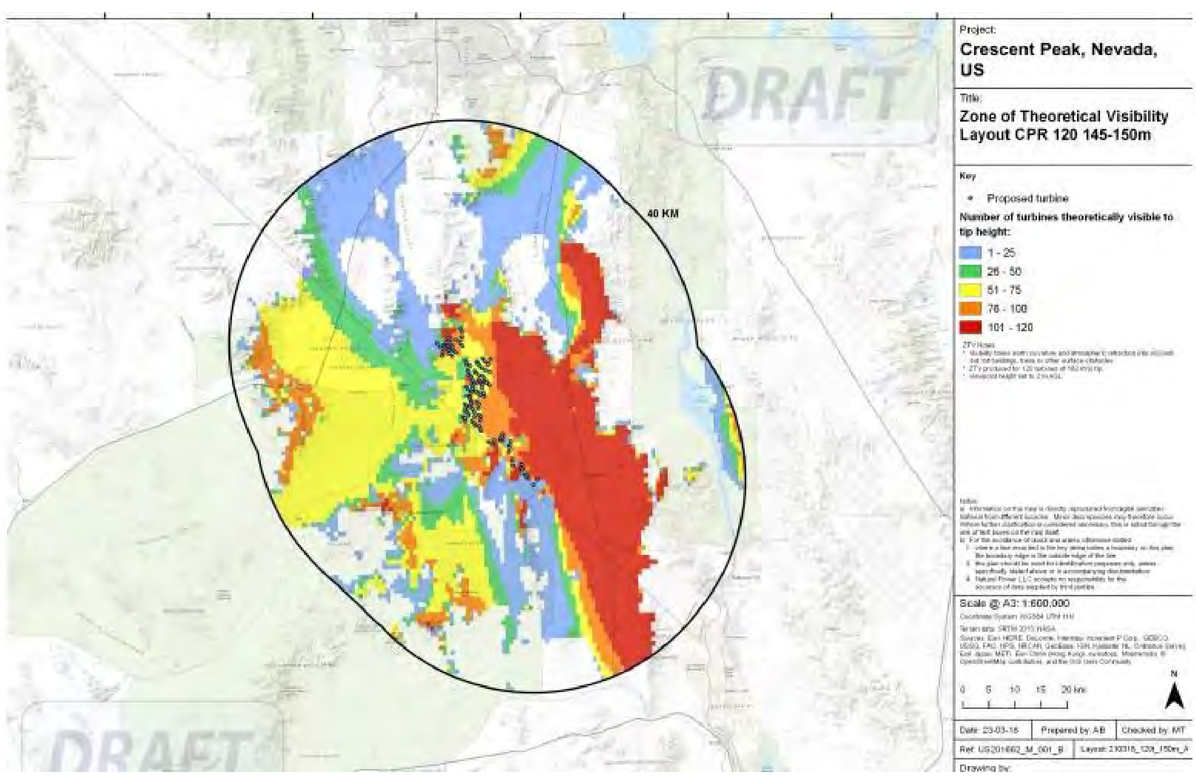
[4] NPS_Identified_Areas_of_High_Potential_for_Resource_Conflict_Regional.pdf (anl.gov)

- **Plan amendments**: Plan amendments modify one or more parts of an existing land-use plan, for example, allowing the development of wind energy resources where they had not previously been considered. Depending on how wide-ranging the effects of an amendment would be, the BLM will prepare either an Environmental Assessment or a full Environmental Impact Statement to accompany a plan amendment.

The BLM is planning on amending the Las Vegas RMP to approve two other solar applications near the Golden Currant proposal. These two projects are called Rough Hat Clark County at 2,400 acres and Copper Rays Solar at 5,100 acres. Both are in the Pahrump Valley northeast of Golden Currant. The reason for the amendment is that the projects are being proposed for VRM Class III lands. The BLM knows that large-scale solar does not conform to the VRM Class III objectives.

If the BLM reevaluates the Golden Currant site and factors in the more recent designations such as the Old Spanish National Historic Trail, the Golden Currant site or parts of it could even be upgraded to VRM Class II.

The landscape is characterized by sweeping vistas, scenic, eroded badlands and is visible from wilderness and national park service areas. The Tecopa Road has seen increased traffic and visitation since the 1997 RMP was released. The Sensitivity level has increased at this time.



^A viewshed analysis should be created and distributed for the Golden Currant Solar Project like this one created for the proposed and now cancelled Crescent Peak Wind Project in Southern Nevada.

The BLM also issued a Medium Priority status latter (see attached) for this project under the *Code of Federal Regulations 2804.35 - How will the BLM prioritize my solar or wind energy application?*

The BLM will prioritize a solar application by placing it into one of three categories – Low Priority, Medium Priority or High Priority and may re-categorize the application based on new information received through surveys, public meetings, or other data collection, or after any changes to the application. The BLM will generally prioritize the processing of leases awarded under subpart 2809 before applications submitted under subpart 2804. For applications submitted under subpart 2804, the BLM will categorize an application as High Priority based on the following screening criteria: (a) High-priority applications are given processing priority over medium- and low-priority applications and may include lands that meet the following criteria:

If the RMP were amended, the project could potentially fall into the Low Priority category

Low-priority applications may not be feasible to authorize. These applications may include lands that meet the following criteria:

(1) Lands near or adjacent to lands designated by Congress, the President, or the Secretary for the protection of sensitive viewsheds, resources, and values (**e.g.*****, units of the National Park System, Fish and Wildlife Service Refuge System, some National Forest System units, and the BLM National Landscape Conservation System), which may be adversely affected by development;***

(2) Lands near or adjacent to Wild, Scenic, and Recreational Rivers and river segments determined suitable for Wild or Scenic River status, if project development may have significant adverse effects on sensitive viewsheds, resources, and values;

(3) Designated critical habitat for federally threatened or endangered species, if project development may result in the destruction or adverse modification of that critical habitat;

(4) Lands currently designated as Visual Resource Management Class I or Class II;

(5) Right-of-way exclusion areas; *or*

(6) Lands currently designated as no surface occupancy for oil and gas development in BLM land use plans.

Area of Critical Environmental Concern

An RMP revision could designate the Golden Currant proposed project site as an Area of Critical Environmental Concern. Ideally, this could be an expansion of the Stump Spring ACEC.

The resources on the site that could potentially qualify for an ACEC would be:

1. Close proximity to the Old Spanish National Historic Trail
2. Desert tortoise habitat
3. Habitat for mesquite and associated species (like the phainopepla)
4. Fossils of Plio-Pleistocene megafauna and other paleontological resources located in badlands topography.

As the BLM states: *"Areas of Critical Environmental Concern or "ACEC" designations highlight areas where special management attention is needed to protect important historical, cultural, and scenic values, or fish and wildlife or other natural resources. ACECs can also be designated to protect human life and safety from natural hazards. ACECs can only be designated during the land-use planning process."*[5]

An ACEC can be nominated by anyone. It would be evaluated through land use planning using the best available information and public outreach.

BLM states:

If a nominated area meets the criteria, an interdisciplinary planning team develops potential management options and incorporates the proposed ACEC into a draft land use plan. Members of the public have the opportunity to review and comment on proposed ACEC and the associated management options during a 90-day public comment period.[6]

The point is, using a resource management plan that is outdated by 25 years eliminates much of the opportunity for the public and stakeholders to be involved. Resource Management Planning should not be viewed as an obstacle by the BLM but rather a tool to make the most informed decisions managing our public lands.

Other Impacts

Significant cumulative impacts are not avoidable if the BLM maintains plans to permit 18,000 acres of solar projects in the area. At this point BLM has approved the 3,000-acre Yellow Pine Solar Project and is considering Rough Hat Clark at 2,400 acres, Rough Hat Nye at 3,500 acres, Copper Rays at 5,100 acres and Mosey Solar at 3,500 acres. BLM has approved the Trout Canyon substation with the intention of developing the area and sacrificing the resources in the area.

A grassroots effort is underway to nominate an Amargosa National Monument in California, which would encompass the Shoshone, Death Valley Junction, and Tecopa region, the Wild and Scenic Amargosa River and other reaches, as well as the unique wildlands and open desert spaces from Amargosa Valley, the California portion of Pahrump Valley, to the Kingston Range and Shadow Valley. The diverse history and ecology of the region has attracted many visitors seeking soft recreational opportunities. Developing industrial energy-sprawl projects adjacent to

[5] ACEC | Bureau of Land Management (blm.gov)

[6] ACEC | Bureau of Land Management (blm.gov)

the proposed monument would ruin the views and historic character of the region. The Golden Currant Solar Project is proposed to be built right along Tecopa Road, which would be a main entrance road and scenic route to enter the proposed National Monument.

Desert Tortoise

We have not seen any results from the April desert tortoise surveys for the Golden Currant Solar Project, but data from surveys from the 4 other sites (Rough Hat Clark, Rough Hat Nye, Copper Rays and Yellow Pine) predicted that all 4 of the sites had a low density of desert tortoises at 3.04 per square mile. As BLM is aware, the tortoise numbers were undercounted and nearly 3 times the predicted number of desert tortoises were located and moved on the Yellow Pine Solar site during the Spring 2021 desert tortoise clearance. It is also quite possible that the biologists did not locate all the adult tortoises because the clearance was conducted on a record-breaking drought year.

The numbers of desert tortoises found on the Yellow Pine site exceeded the predicted total by both the Bureau of Land Management and the U.S. Fish and Wildlife Service. The Final Environmental Impact Statement for the Yellow Pine Solar Project predicted that based on population estimates, approximately 53 adult desert tortoises, 276 subadults or juveniles, and 69 hatchlings are anticipated to be displaced by project-related construction activities via translocation. [7]

The Biological Opinion predicted that the Phase I Tortoise Clearance Area would enclose an area of 3,233.5 acres from which an estimated 39 adults (95% CI = 27 to 59) would need to be translocated from the Yellow Pine Solar Project, and 1 adult (95% CI = 0 to 2) would be translocated by GLW. In addition to adult tortoises, it was estimated that many more juvenile tortoises would also require translocation.

Starting in April of 2021, Boulevard Associates LLC hired tortoise biologists to clear the Yellow Pine site of every tortoise they could find. In spite of record-breaking dry conditions, biologists found and moved 139 desert tortoises from the site. In a personal communication with the BLM, the final numbers were reported as:

Adults = 85 (33 Females, 52 Males)
Juveniles 110-179 mm = 30
Juveniles 110 mm = 24

This is over double the predicted number of adults that were found. In fact, biologists for Candela Renewables, applicants for the two Rough Hat projects, recently stated in a public meeting that the desert tortoise density for the Yellow Pine Solar Project site in now believed to be 11 per square mile.

We also found out though personal communication with federal agencies that 26 to 30 of the relocated adults were killed by predators – mostly badgers. That is about a 30 percent mortality for the adults found. On Page 88, the Biological Opinion for Yellow Pine Solar states *"we*

[7] Yellow Pine Solar Project Final Environmental Impact Statement, Volume I: Chapters 1-4 (blm.gov)

anticipate that survival rates of adult desert tortoises moved from the project sites will not significantly differ from that of animals that have not been moved. We expect that desert tortoises would be at greatest risk during the time they are spending more time aboveground than resident animals. We cannot precisely predict the level of risk that will occur after moving desert tortoises ***because regional factors that we cannot control or predict (e.g., drought, predation related to a decreased prey base during drought, etc.) would likely exert the strongest influence on the mortality rates".***

This record-breaking drought year may have been the cause of the high mortality and there is no evidence that the resident tortoises experienced the same mortality as the relocated ones killed by predators.

The Mojave Population of the Agassiz's desert tortoise was listed as Threatened by the US Fish and Wildlife Service (USFWS) in 1990 followed by the designation of critical habitat in 1994. In 2000, the USFWS began systematically surveying tortoise populations in critical habitat and recovery unit areas to determine population trends. Based on their findings (USFWS 2015), which are briefly summarized in the chart, we convinced that the Mojave Population of the Agassiz's desert tortoise should be federally listed as Endangered rather than Threatened.

Recovery Unit: Designated Critical Habitat Unit/Tortoise Conservation Area	Surveyed area (km^2)	% of total habitat area in Recovery Unit & CHU/TCA	2014 density/km^2 (SE)	% 10-year change (2004–2014)
Western Mojave, CA	**6,294**	**24.51**	**2.8 (1.0)**	**–50.7 decline**
Fremont-Kramer	2,347	9.14	2.6 (1.0)	–50.6 decline
Ord-Rodman	852	3.32	3.6 (1.4)	–56.5 decline
Superior-Cronese	3,094	12.05	2.4 (0.9)	–61.5 decline
Colorado Desert, CA	**11,663**	**45.42**	**4.0 (1.4)**	**–36.25 decline**
Chocolate Mtn AGR, CA	713	2.78	7.2 (2.8)	–29.77 decline
Chuckwalla, CA	2,818	10.97	3.3 (1.3)	–37.43 decline
Chemehuevi, CA	3,763	14.65	2.8 (1.1)	–64.70 decline
Fenner, CA	1,782	6.94	4.8 (1.9)	–52.86 decline
Joshua Tree, CA	1,152	4.49	3.7 (1.5)	+178.62 increase
Pinto Mtn, CA	508	1.98	2.4 (1.0)	–60.30 decline
Piute Valley, NV	927	3.61	5.3 (2.1)	+162.36 increase
Northeastern Mojave	**4,160**	**16.2**	**4.5 (1.9)**	**+325.62 increase**
Beaver Dam Slope, NV, UT, AZ	750	2.92	6.2 (2.4)	+370.33 increase
Coyote Spring, NV	960	3.74	4.0 (1.6)	+ 265.06 increase
Gold Butte, NV & AZ	1,607	6.26	2.7 (1.0)	+ 384.37 increase
Mormon Mesa, NV	844	3.29	6.4 (2.5)	+ 217.80 increase
Eastern Mojave, NV & CA	**3,446**	**13.42**	**1.9 (0.7)**	**–67.26 decline**
El Dorado Valley, NV	999	3.89	1.5 (0.6)	–61.14 decline
Ivanpah, CA	2,447	9.53	2.3 (0.9)	–56.05 decline
Upper Virgin River	***115***	***0.45***	***15.3 (6.0)***	***–26.57 decline***
Red Cliffs Desert	*115*	*0.45*	*15.3 (6.0)*	*–26.57 decline*
Range-wide Area of CHUs - TCAs/Range-wide Change in Population Status	**25,678**	**100.00**		**–32.18 decline**

The table includes the area of each Recovery Unit and Tortoise Conservation Area (TCA), percent of total habitat, density (number of breeding adults/km2 and standard errors = SE), and the percent change in population density between 2004 and 2014. Populations below the viable level of 3.9 breeding individuals/km2 (10 breeding individuals per mi2) (assumes a 1:1 sex ratio) and showing a decline from 2004 to 2014 are in red.

^One of the translocated desert tortoises killed by badgers in 2021 for the Yellow Pine Solar Project. (photo from BLM Freedom of Information Act Request)

An Analysis of Storm Water should be made

The applicant should develop a detailed erosion and sedimentation control plan, and a flood risk control plan now for public review. Proposed project sites are often located on an alluvial fan that acts as an "active stormwater conveyance" between mountains and valleys. Widespread bajada flooding events and sheetwash deposition occurs. The consequences of allowing flooding through the project would be too great. How does the project propose to maintain the solar fields if floodwaters jump the banks of the washes? In addition, alluvial fans often have shifting flow channels and pathways, so there is no guarantee that washes will not shift over 30 years.

Fugitive Dust

Nevada's large-scale solar projects have recently had a poor record in violating air quality controls, as we have recorded in photographs such as at the 800-acre Sunshine Valley Solar Project in Amargosa Valley. This mowed-vegetation project repeatedly had fine particulate whirlwinds, and dust clouds emerging from disturbed desert surfaces in construction zones. Despite water trucks attempting to water-down loose dirt, the solar project was too large to control all dust. Construction continued on windy days, yet even on mild breezy days we saw wind-blown dust and clouds of fine particulates from disturbed ground in the construction site. Construction, especially on windy days, would create huge dust black-outs and greatly impact visibility. Removal of stabilized soils and biological soil crust creates a destructive cycle of airborne particulates and erosion. As more stabilized soils are removed, blowing particulates from recently eroded areas act as abrasive catalysts that erode the remaining crusts, thus resulting in more airborne particulates.

The Golden Currant site is nearly 40 percent clay-based badlands topography and will create a very big dust issue if it is crushed for this kind of development.

We are concerned that industrial construction in the region will compromise the air quality to the point where not only visual resources, but public health will be impacted. Epidemiologists investigated an outbreak of valley fever that had sickened 28 workers at two large solar power construction sites in San Luis Obispo County[8]

^Photo of the fugitive dust caused by the Sunshine Valley Solar Project, Amargosa Valley, Nevada in summer of 2019.

Avian impacts

Placing up to 30 square miles of solar panels in this area from 5 projects will have avian impacts. The avian impacts are documented in several solar projects. It is thought that the projects mimic water and cause birds to hit the solar panels. Data from 7 solar projects in California has revealed 3,545 bird kills from 183 species from 2012 to 2016. This can be referenced from the 2016 Multi-Agency Avian Solar Working Group conference from 2016.[9]

The area is close to the Stump Spring wetland and only about 30 miles from the Tecopa/ Shoshone Amargosa River area. It is quite possible this project could cause avian mortality.

Other Wildlife and Plants

The project will impact:

Burrowing owls

American badgers

Kit foxes

Pahrump buckwheat -- Pahrump Valley buckwheat (*Eriogonum bifurcatum*), a BLM Sensitive Species. Alkaline sand flats and slopes, within saltbush communities at elevations of 1,969–2,700 feet. Associated with Corncreek-Badland-Pahrump soils due to its salinity and association

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[8] https://www.latimes.com/archives/la-xpm-2013-may-01-lame-ln-valley-fever-solar-sites-20130501- story.html
[9] http://blmsolar.anl.gov/program/avian-solar/docs/Avian Solar_CWG_May_2016_Workshop_Slides.pdf

with relict lakebeds and lake terraces. **Pahrump Valley buckwheat has been observed on this project site.** We request that the project be completely moved off this soil type to avoid potential for destroying populations of this species that did not flower during 2018 and 2019. Pahrump Valley buckwheat is a BLM Sensitive species, meaning population or distribution of the wildlife is in a significant decline, the population is threatened as a result of disease or predation or ecological or human causes, and/or the primary habitat of the wildlife is deteriorating.

Other rare plants possibly impacted:

Aven Nelson Phacelia (*Phacelia anelsonii*)

Rosy Twotone Beardtongue (*Penstemon bicolor ssp. roseus*)

Yellow Twotone Beardtongue (*Penstemon bicolor* ssp.*bicolor*) (deserving of ESA protection)

White-Margined Beardtongue (*Penstemon albomarginatus*) (deserving of ESA protection)

Death Valley Ephedra (*Ephedra funerea)*

New York Mountains *Catseye (Cryptantha tumulosa*)

Spring Mountains Milk-Vetch (*Astragalus remotus*)

Nye Milk-Vetch (*Astragalus nyensis*)

Mojave Milk-Vetch (*Astragalus mohavensis* var. *mohavensis)*

White Bear Poppy (*Arctomecon merriamii*)

Cacti and Yucca are considered Forest Products under 43 CFR 5420.0-6. Even with a site plan that avoids washes, the majority of these plants would be destroyed.

Possible mule deer and bighorn sheep.

And a host of other species. Construction will kill millions of living organisms.

Sensitive Birds Will Be Impacted Bendire's thrasher (*Toxostoma bendirei)* may occur. Joshua trees are present in areas near the project, and Mojave yuccas are abundant. Therefore, the project may impact suitable breeding or foraging habitat for this species. Targeted surveys should be undertaken for this species. Le Conte's thrasher (*Toxostoma lecontei)* is also present.

The project may impact suitable breeding or foraging habitat for this species Phainopepla (*Phainopepla nitens*) which inhabits Stump Spring. There are stands of mesquite located within the project area; therefore, the project will impact suitable breeding or foraging habitat for this species. Scott's oriole *(Icterus parisorum)* was recorded by Nevada Division of Wildlife (NDOW) within 10 miles of the project area. The project may impact suitable breeding or foraging habitat for this species.

Large Mammal Habitat Will Be Fragmented

A Mountain lion was recorded within the analysis area from NDOW records. We have seen mule deer in Mojave yucca and creosote scrub on alluvial fans within a few miles of the project site in Pahrump Valley.

Bats May Be Impacted A diversity of bats may feed in the project area, migrate through, and roost in yuccas: Allen's big-eared bat (*Idionycteris phyletism),* Big brown bat (*Eptesicus fuscus),* Big free-tailed bat (*Nyctinomops macrotis*), Brazilian free-tailed bat (*Tadarida 30 brasiliensis*), Brazilian free-tailed bat (*Tadarida brasiliensis*), Canyon bat (formerly western pipistrelle) (*Parastrellus hesperus*), Fringed myotis (*Myotis thysanodes*), Hoary bat (*Lasiurus cinereus*), Long-eared myotis (*Myotis evotis*), Long-legged myotis (*Myotis volans*), Pallid bat (*Antrozous pallidus*), Silver-haired bat (*Lasionycteris noctivagans*), Spotted bat (*Euderma maculatum*), Townsend's big-eared bat (*Corynorhinus townsendii*), Western red bat (*Lasiurus blossevillii),* Western small-footed myotis (*Myotis ciliolabrum*), and Yuma myotis (*Myotis yumanensis*). Night-lighting installed for safety purposes may create light pollution in bat foraging areas, which may disorient foraging bats.

Soils and Biological Soil Crusts Will Be Significantly Impacted

Biotic soils and desert pavement commonly occur as a mosaic on the project site. Desert pavements are a matrix of rock fragments that form smooth, pavement-like surfaces. Biotic soils are living surface features comprised of soil particles enmeshed in a complex web of cyanobacteria, mosses, lichens, bacteria, algae, and fungi that send roots and filaments deep into the soil, helping to sequester Carbon. Both desert pavements and biotic soils provide a protective soil covering that reduces wind and water erosion potential and further impact soil moisture dynamics. Disruption of fragile biotic soils or removal of desert pavements generally increase wind and water erosion potential.

Cultural Resources

BLM needs to undertake full consultation with the Pahrump Paiute, Timbisha Shoshone, and other tribal entities with interest in the area.

The area was conceived as a Cultural Landscape during the California Energy Commission Evidentiary Hearing in Shoshone CA for the proposed Hidden Hills Solar Electric Generating System in March 2013[10]. Southern Paiute and Chemehuevi elders described the Salt Song Trail area passing through this region. This needs further analysis.

Paleontological Resources

The clay-based badlands on the site could potentially contain fossils. The badlands are Quaternary basin fill formed as groundwater discharge deposits at the base of the alluvial fan. The site could contain fossils of Plio-Pleistocene megafauna. How many paleontological resources would be damaged by the project? Is there an inventory of any large mammal fossils on the site?

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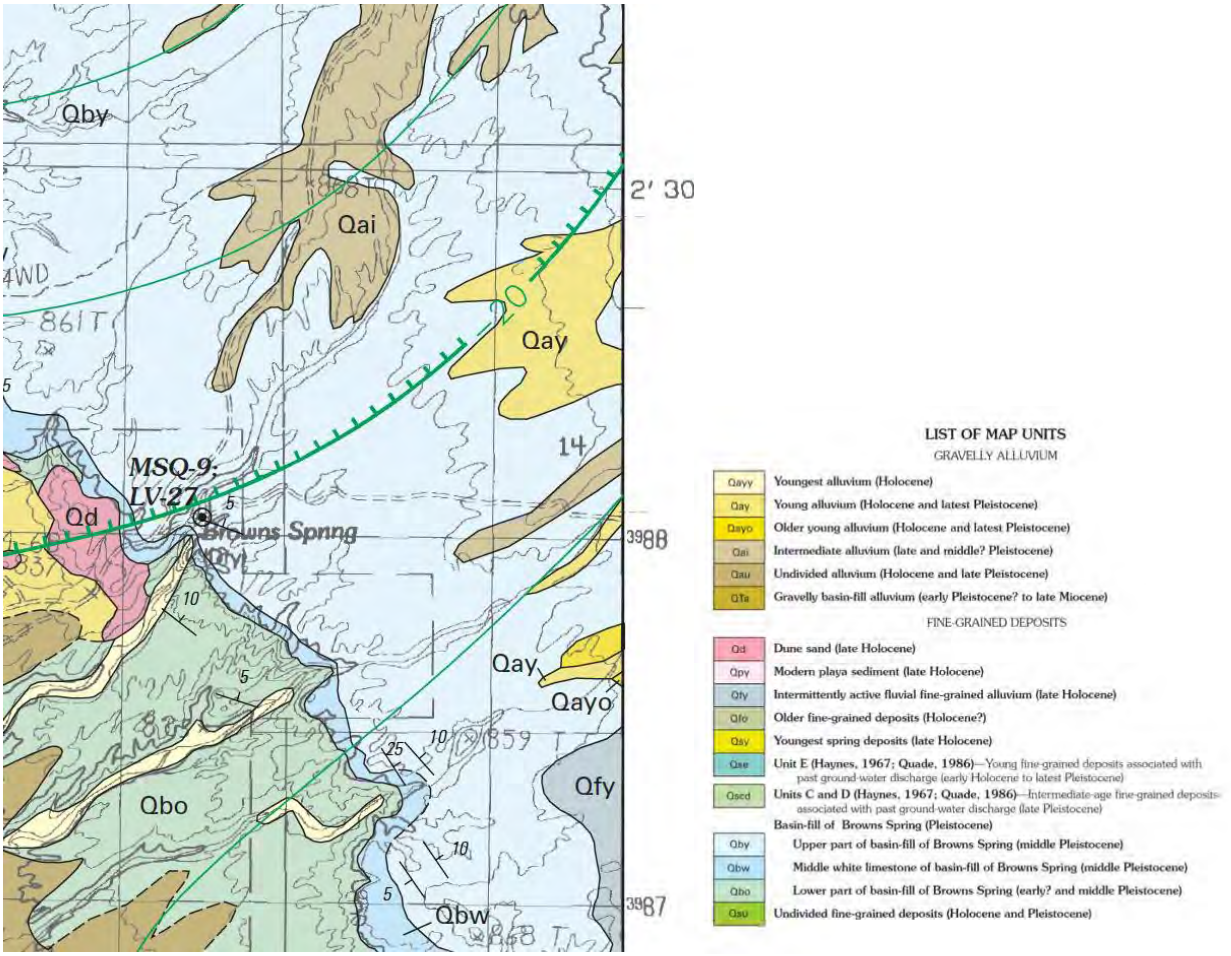
[10] http://basinandrangewatch.org/HiddenHills-hearing.html

The following geologic map of the Mound Spring Quadrangle, Nye and Clark Counties, Nevada, shows a portion of the proposed solar project site on top of mid and early Pleistocene Brown's Spring basin fill which could hold fossils. Brown's Spring is at the end of the Front Site Road.



From: https://pubs.usgs.gov/mf/2002/mf-2339/mf-2339.pdf

These sites are protected by the Paleontological Resources Preservation Act of 2009 (PRPA) (16 U.S.C. § 470aaa 1-11). This law was established 12 years after the last revision of the RMP.

The primary legislation pertaining to fossils from NPS and other federal lands is the Paleontological Resources Preservation Act of 2009 (PRPA) (16 U.S.C. § 470aaa 1- 11) which was enacted on March 30, 2009 within the Omnibus Public Land Management Act of 2009. PRPA directs the Department of Agriculture (U.S. Forest Service) and the Department of the Interior (National Park Service, Bureau of Land Management, Bureau of Reclamation, and Fish and Wildlife Service) to manage and protect paleontological resources on Federal land using scientific principles and expertise. The Secretary shall develop appropriate plans for inventory, monitoring, and the scientific and educational use of paleontological resources, in accordance with applicable agency laws, regulations, and policies. These plans shall emphasize interagency *coordination and collaborative efforts where possible with non-Federal partners, the scientific community, and the general public.* (see Paleontological Resources Preservation Act.pdf (blm.gov))

A diverse assemblage of fossil megafauna was recovered from the Las Vegas Valley in southern Nevada, providing opportunities for paleontologists to study the paleoecology of these deposits. Vetter (2007) undertook isotopic reconstruction of diet in extinct large herbivores: *Mammuthus, Equus, Bison,* and *Camelops* from the Late Pleistocene assemblage of megaherbivore teeth recovered from the Gilcrease spring mound.

The Tule Springs fauna was recovered from the northwestern Las Vegas Valley and provides the most complete Pleistocene faunal record for the area. The Tule Springs excavation in the 1960s yielded fossil material of invertebrates (primarily molluscs), amphibians, reptiles, birds, small mammals, and large carnivores and herbivores.

The formations are similar to those located in the Tule Springs Fossil Beds National Monument. The Bureau of Land Management needs to coordinate with the National Park Service to ensure that Best Management Practices are used to protect any fossil on the Golden Currant Site.

Indeed, *Mammuthus columbi* fossils have been found in Pahrump Valley, NV. Conin et al (1998) found two mammoth tooth fragments in Pahrump Valley, held in the author's collection.

Paleontological surveys need to be undertaken in these deposits before any solar project is approved here.

Western Honey Mesquite

There are Western Honey Mesquite (*Prosopis glandulosa)* located on the project site. These trees have been impacted by water drawdown but still are a unique ecological part of this desert that should be avoided. They provide habitat to several BLM Sensitive and Special Status Species[11]

Mesquite trees furnish shade and wildlife habitat where other trees will not grow. They will often be found in alkaline soils near water holes.

Although a single flower of the blossom is only a few millimeters long, they are clustered into a yellow creamy blossom attracting many different types of pollinators.

At the Golden Currant virtual meeting, the BLM stated that not all mesquite habitat would be avoided.

Topography

About 40 percent of the site is composed of badlands cut by canyons with vertical walls. The area would have to be leveled to build a solar project. Much of the site is steeper than the 5 percent or under slope required for solar on public lands in the Western Solar Plan:

[11] 2017 Final BLM NV Sensitive and Special Species Status List .pdf

*"The geographic boundaries for exclusion categories 13, 14, 28, 29, 31, and 32 are explicitly defined through the Solar PEIS ROD and its associated maps, and these boundaries will not be updated in the future**. The geographic boundaries for exclusion category 1 (lands with slope greater than 5%)** and exclusion category 2 (lands with solar insolation levels less than 6.5 kWh/m2) will not be updated in the future; they may, however, be refined at the individual project level as necessary based on site-specific information."* [12]

^Eroded badlands topography on the site, early to mid Pleistocene in age.

Public Access/Multiple Use

The project would surround the Front Site Road and be built close to scenic Cathedral Canyon. The project would potentially close off over 7 square miles of public lands with barbed wire fences. This directly conflicts with BLM's mission of Multiple Use. No other uses could be compatible in this area.

"Congress tasked the BLM with a mandate of managing public lands for a variety of uses such as energy development, livestock grazing, recreation, and timber harvesting while ensuring natural, cultural, and historic resources are maintained for present and future use. [13]

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[12] Exclusion Areas under the BLM Solar Energy Program (anl.gov)
[13] Our Mission | Bureau of Land Management (blm.gov)

Clark County Multi-Species Conservation Plan

BLM should give the history of the Wheeler Wash Allotment that overlaps the solar project proposal, and give the reason that the allotment is no longer active. Was the allotment designated as non-active in order to protect desert tortoise, phainopepla, and other species covered in the Clark County Multi-Species Habitat Conservation Plan[14]?

Reasonable Alternatives to this Project: Distributed Energy

In 2020, the nation of Vietnam installed 9 GW of solar energy on rooftops[15] . They simply don't have volumes of land to sacrifice for large-scale solar projects, so they utilized their built environment, proving that significant amounts of solar energy can be generated from rooftops and other built structures.

Researchers from Vibrant Clean Energy found the cheapest way to reduce emissions actually involves building 247 gigawatts of rooftop and local solar power (equal to about one-fifth of the country's entire generating capacity today). In this scenario, consumers would save $473 billion, relative to what electricity would otherwise cost.[16]

In September 2016, Dr. Rebecca Hernandez of University of California, Davis published a study, Solar Energy Potential on the Largest Rooftops in the United States. This study was conducted on the rooftops of 5,418 elementary schools in Korea to determine the feasibility of achieving net-zero energy solar buildings through rooftop PV systems (Hernandez et al. 2013)

Conclusion

If the Golden Currant Solar Project is approved, it will result in the destruction of many irreplaceable resources located on public lands managed by the BLM including wildlife, plants, cultural sites and public access. The project is being reviewed through a BLM Resource Management Plan that has not been updated for 25 years. Many changes have occurred including the designation of the Old Spanish National Historic Trail. We believe this is a very inappropriate location for a solar energy project and request that the BLM not only reject the application but pause the entire review until the Southern Nevada Resource Management Plan can be revised. A revision would allow both the public and the BLM provide better management that would protect this valuable site for future generations.

Sincerely.

(Groups/Organizations)

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14 https://files.clarkcountynv.gov/clarknv/Environmental%20Sustainability/Desert%20Conservation/MSHCP/ccfeis.pdf

15 Scaling up Rooftop Solar in Vietnam – More than 9GW installed in 2020 – pv magazine International (pv-magazine.com)

16 https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_ES_Final.pdf

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Tracy Stone-Manning, Director, Bureau of Land Management

Deb Haaland, Interior Secretary

Clark County Commissioner Justin Jones

Senator Jacky Rosen

Senator Catherine Cortez-Masto

Nevada State Senator Pete Goicoechea

Nevada State Assemblyman Gregory Hafen

Land-Use Efficiency of Big Solar

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Land-Use Efficiency of Big Solar

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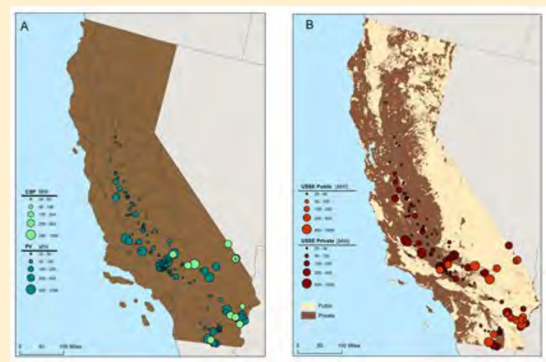
ABSTRACT: As utility-scale solar energy (USSE) systems increase in size and numbers globally, there is a growing interest in understanding environmental interactions between solar energy development and land-use decisions. Maximizing the efficient use of land for USSE is one of the major challenges in realizing the full potential of solar energy; however, the land-use efficiency (LUE; Wm^{-2}) of USSE remains ambiguous. We quantified the capacity-based LUE of 183 USSE installations (>20 MW; planned, under construction, and operating) using California as a case study. In California, USSE installations are concentrated in the Central Valley and interior regions of southern California and have a LUE of 35.0 Wm^{-2}. The installations occupy approximately 86 000 ha and more land is allocated for photovoltaic schemes (72 294 ha) than for concentrating solar power (13 604 ha). Photovoltaic installations are greater in abundance (93%) than concentrating solar power, but technology type and nameplate capacity has no impact on capacity-based LUE. More USSE installations are on private land (80%) and have a significantly greater LUE (35.8 Wm^{-2}) than installations on public land (25.4 Wm^{-2}). Our findings can be used to better understand and improve the LUE of USSE, thereby maximizing economic, energetic, and environmental returns on investments.



INTRODUCTION

In the past decade, the capacity of photovoltaic (PV) and concentrating solar power (CSP) energy has risen exponentially and globally; notably in Germany, Spain, Japan, Italy, and the United States[1] (Figure 1). The expansion of solar energy development, particularly for utility-scale solar energy (USSE)—solar energy systems that exceed one megawatt (MW) in capacity—has increased interest in understanding ecological interactions with solar energy development, and how impacts may augment, reduce, or interact with drivers of global environmental change,[2−4] including land-use change.[2,3,5−9] Like cost and generation intermittency, maximizing the efficient use of land for USSE projects is one of the major challenges in realizing the full potential of solar energy development.[5,10,11]

All solar energy systems can be classified as either distributed or utility-scale, with the distinction determined by a project's size and location. Although this distinction can be tenuous, distributed systems are typically sized to meet a small, localized energy demand and may function independent of the grid (Figure 1a). These systems usually require little to no ancillary facilities, often utilizing pre-existing infrastructure within the built environment[11,12] (e.g., residential, governmental, and commercial rooftop photovoltaic systems; solar water heating systems; portable battlefield and tent shield devices). In contrast, USSE installations are large, centralized enterprises with large economies of scale. As such, they necessitate large swaths of flat space, creating trade-offs in places where development may compromise the sustainability of natural resources and reduce the provision of ecosystem services (Figure 1b). Such trade-offs can reduce or negate the overall return on investment, if one integrates across economic, energetic, and environmental returns.[2,5] Utility-scale solar energy systems that exceed 20 MW are becoming increasingly common and very large-scale installations, one gigawatt in size or greater, have been proposed.[13]

Within an installation site, the footprint of a solar energy system includes all areas directly transformed or impacted by the installation during its life-cycle from construction to decommission. Areas that are indirectly affected by solar energy systems (e.g., extraction or mining of raw materials offsite) are separate from this life-cycle analysis. Fthenakis and Kim[14] reported that the total land area that is indirectly transformed for multi-, mono-, and ribbon-Si systems (over a 30 year period using an insolation of 1800 KWh m^{-2} $year^{-1}$) is minor compared to direct land-use at 18.4, 18, and 15 m^2 GWh^{-1}, respectively. Photovoltaic panels and CSP mirrors are distributed uniformly across space—typically double the panel area[15]—and in rows, to preclude self-shading and allow for easy access and service (often by vehicles), but increasing the footprint. For example, PV arrays are not arranged flat, but are typically installed on tilted (fixed-tilt) or moving (e.g., single-axis or dual-axis tracking) frames to increase solar interception up to 50% more than flat arrays, but creating a

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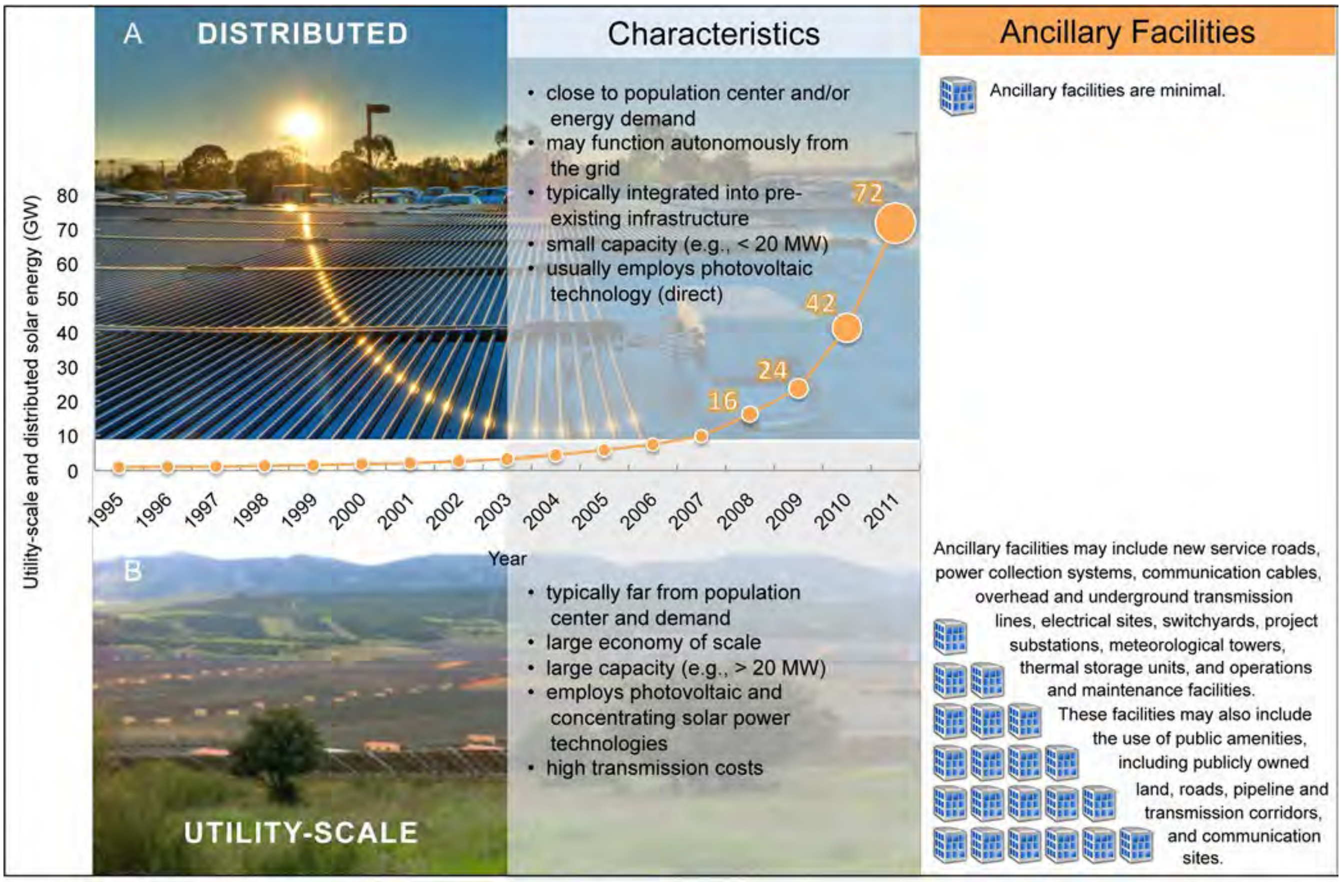

Figure 1. Graph shows utility-scale and distributed solar energy global installed capacity in gigawatts (GW) over time. Characteristics and ancillary facilities required of distributed (A) and utility-scale (B) solar energy systems. Photo credits: (top) Doug Kop; (bottom) Rebecca R. Hernandez.

trade-off between the cost of land and maximizing energetic yield.[6] The use of ancillary facilities adds to the land area required (see Figure 1 for complete list) and when appropriate may include publicly owned roads, pipelines, transmission corridors, and communication sites.

Consequently, maximizing the capacity and land-use efficiency (LUE) of USSE installations globally may serve to mitigate atmospheric CO_2 levels by reducing both direct and indirect emissions. Indirect emissions may be reduced by (1) reductions in land-use change, and (2) where solar energy substitutes for existing energy infrastructure, such land may transition into uses that increase carbon uptake (e.g., afforestation). Incorporating sustainable practices and conservation-compatibility into USSE development can further mitigate or obviate adverse environmental effects beyond those related to land-use impacts.[5,9,11,16]

The capacity-based (or nominal) LUE is the USSE installation's power by area (e.g., Wm^{-2}) and is therefore a function of the project's spatial design and nameplate capacity. Capacity-based LUE data are useful for estimating land and cost requirements, and such data are useful as efficiency targets for new projects.[8] When realized generation data are available, some studies have reported generation-based LUE (e.g., m^2 GWh^{-1}), which is a function of a plant's location (e.g., climatic conditions and solar resources), technological efficiency, and thermal energy storage, the latter enabling the instantaneous capacity to exceed the nameplate (turbine) capacity.[8,17] Generation-based LUE data provides the greatest accuracy for more detailed comparisons, such as those between subtechnology types, and technology and storage options, despite the fact that generation may vary from one year to the next. Studies vary in the type of LUE they report, the data and methods they use to derive it, and the units they use to report their findings (e.g., m^2 GWh^{-1},(m^2−year) MWh^{-1}), which adds some confusion across studies (see Horner and Clark 2013)[18] and difficulty in deriving synthetic and comparative conclusions.

To date, studies quantifying LUE using specifications of more than one installation,[7,19] exploring the effects of land tenure, and using official records and documents[8] are few and the results, overall, are ambiguous.[18] However, quantifying the relationship between solar energy and land use is critical for understanding: (1) how USSE power plant configuration and design impact LUE; (2) effects on radiative forcing and the atmospheric boundary layer resulting from changes in surface roughness and albedo caused by USSE infrastructure;[20] (3) ecological consequences of the construction, operation, and decommissioning of USSE power plants; and (4) USSE power plant configuration and design necessary to integrate/colocate different energy systems for efficient use of land and water resources.

In this study, our goal was to quantify the capacity-based LUE (i.e., watts in nameplate capacity, per meter squared) and spatial distribution of USSE installations using California as a case study. We also report how LUE of USSE in California interacts with technology type, capacity, and land ownership (publicly or privately owned), as well as the implications of this land ownership type for land-use change. Lastly, we discuss mechanisms for increasing LUE and return on investment of

USSE development, including examples that integrate environmental cobenefits.

MATERIALS AND METHODS

California As a Case Study. We use California as a case study for assessing the land-use properties of USSE. California is interesting not only because it has been a leader in adoption of renewable energy systems and adaptation strategies,[21] but also for its increasing population, unique constraints on land availability, immense energy demand,[22] and vulnerability to climate change.[23,24] California has been at the vanguard of global USSE deployment since the early 1980s and a center of focus over solar energy-related land use decisions.[3,25] For example, California:

- is the site of the largest concentrating solar power plant in the world[26] (the 354 MW Solar Energy Generating Systems);
- is the site of the first multimegawatt concentrating solar power plant[26] (the 14 MW SolarOne power tower plant);
- is where 25 000 ha of USSE projects are required in the Desert Renewable Energy Conservation Plan area to meet 2040 greenhouse gas reduction goals;[27]
- if a country, would rank seventh for PV and includes over 2500 MW of installed solar energy capacity;[28] and
- leads the total installed capacity for U.S. military installations with over 47 MW.[12]

California includes, in part, the Mojave, Sonoran, Great Basin, and San Joaquin Deserts[29]—areas notable for high levels of solar resources and biodiversity—and approximately 90% of the California Floristic Province, a biodiversity hotspot known for high levels of species richness and endemism threatened by environmental change.[30] Energy demand in California may exceed 67 GW by 2016,[31] while energy reliability may be adversely impacted by climate change-related events, such as extreme heat waves.[22] Despite land conservation priorities and energy demands, spatially strategic penetration of USSE into the grid can be employed to meet both conservation and energy-related goals. For example, Cameron et al.[5] found 200 000 ha of low conservation value land within the Mojave Desert Ecoregion that could meet California's renewable energy goals 1.8 times over. These characteristics render the understanding of USSE and its associated land-use in California instructive, especially for other global regions that share similar resource demands and limitations.

Land-Use Efficiency of Big Solar and Technology. To derive an empirical estimate of USSE footprint and LUE, we collected data on 200 USSE installations in California, ranging in capacity from 20 to 1000 MW. Data were synthesized exclusively from official government documents (e.g., public county documents, the Bureau of Land Management records, environmental impact reports or statements).[32−34] Press and news releases, project fact sheets, developer Web sites, news articles, and other secondary sources were not used. For each installation, we recorded several characteristics including nominal capacity (generation under ideal conditions in MW), land footprint (km^2), technology type, location (latitude, longitude), and land ownership (i.e., public or private).

In our data sources, authors used various terms to describe the total footprint of an installation (e.g., "total acreage", "area impacted", "footprint", and "land needed"). In accordance, we define the land footprint as the land encompassing the entire power plant facility excluding land required for raw material acquisition and the generation of energy necessary for manufacturing. Other studies have explicated the raw material and manufacturing life-cycle stages (e.g., Fthenakis and Kim 2009; Burkhardt et al., 2012; Hsu et al., 2012; Kim et al., 2012) and this is beyond the scope of this study.[14−37] The footprint was delineated in our sources—sources that were paired with a respective environmental impact report or statement—and therefore can also be defined as the area where most, if not all, direct impacts from construction, operation, and decommissioning occur. As mentioned above, panels and heliostats do not cover the entire footprint, but direct impacts from development are likely not restricted exclusively to the land under panels and heliostats. For example, we anecdotally observed that developers often modify a large fraction, if not all, of the installation's footprint through the implementation of various activities, including vegetation removal, herbicide application, surface grading, gravel application, concrete production, and road and facility construction. Existing transmission corridors were not included in the site's footprint. To the best of our knowledge, compulsory or voluntary environmental set-asides (i.e., land for conservation typically equal to the area of land disturbed) were not included in the footprint, as such areas were explicitly and separately defined from the total footprint when described in our sources.

Data on technology subtype for PV (e.g., flat, fixed-tilt, single-axis, dual-axis) and CSP (e.g., solar power tower, parabolic trough, dish Stirling, Fresnel reflectors) were not typically described in our data sources. Additionally, subtypes specified for planned installations are highly subject to change due to market price fluctuations, reducing confidence in derived statistics. For CSP schemes, we used the reported capacity of the installation, as details regarding the presence and use of thermal energy storage were not provided. The effect of thermal energy storage on the LUE of CSP is beyond the scope of this paper, but see Sioshansi and Denholm.[17] Any installation that showed a range of values for capacity or area was deemed premature and was excluded (n = 17) from analyses, for a total of 183 power plants. We standardized all reported energy-area data to units of watts (W) per meter squared (m^2) and calculated the mean LUE, including the mean LUE by technology type (i.e., CSP and PV). We did not calculate capacity-based LUE for PV or CSP technology subtypes, but this may be feasible—and certainly informative for both capacity- and generation-based LUE—in the future as more installations become operational.

Land-Use Efficiency of Big Solar and Land Tenure. To explore how land ownership may influence capacity-based LUE, we mapped our geo-referenced data set in ArcGIS (10.x; Redlands, CA) and layered it with a land ownership data set.[23] Any installation that showed a discrepancy in land ownership type between public records and the location of the point in accordance with the NLCD was excluded (n = 23) from the land ownership analysis. We then calculated descriptive statistics on USSE projects by technology and land ownership type, and conducted a Wilcoxon rank-sum test (nonparametric) to determine significant differences between types. We used a linear model to test for a relationship between nameplate capacity and capacity-based LUE, however, no significant relationship was found. Nonetheless, we report the proportion and LUE of unique size classes (i.e., 20, 21−50, 51−100, 101−500, and 501−1000 MW); however, we caution that these classes are arbitrarily defined. All data processing and statistics

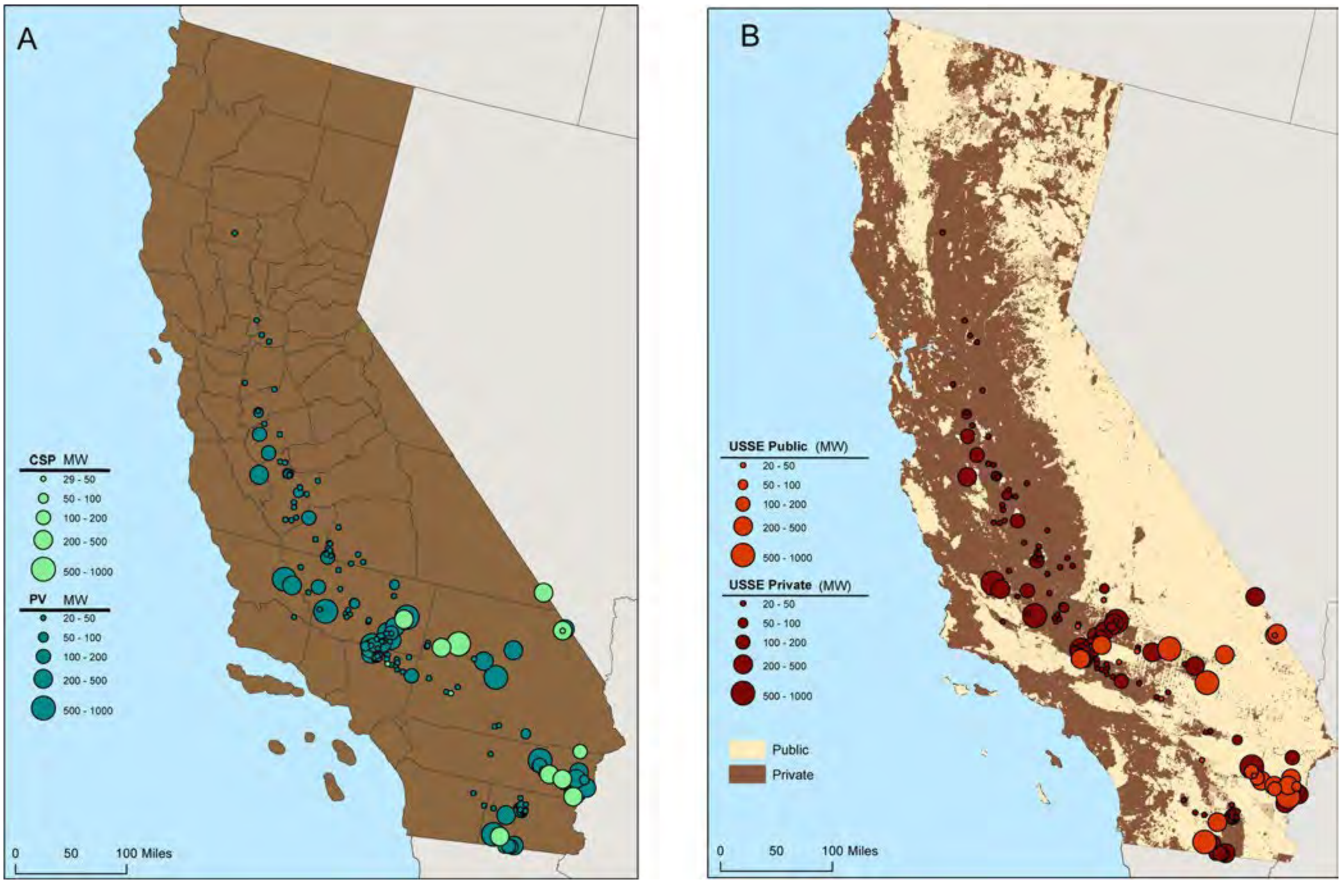

Figure 2. (A) The distribution of utility-scale solar energy installations in California (operating, under construction, and planned) by technology type: concentrating solar power (CSP) and photovoltaic (PV) with county lines shown. (B) The distribution of utility-scale solar energy installations in California by location: public or privately owned land. Larger capacity installations (in megawatts, [MW]) have relatively greater point size.

were performed in R (R: A Language and Environment for Statistical Computing). We mapped each USSE power plant as a function of technology and land ownership type in ArcGIS (10.x; Redlands, CA). The installations we evaluated varied in development stage—from in planning to operating—and our data set may therefore incorporate some power plants that never become operational.

Data Quality and Comparative Analysis. To gain access to public sites and facilities, an environmental impact statement and ROW (right-of-way) application is required and is made publicly available. To verify that the reported footprint in public records included all land impacted by the power plant, including ROW on public land, we compared publicly available footprint records with values reported by each installation's environmental impact statement or grant record of decision. We did this for a subset (n = 13) of USSE power plants—eight were located on public land and five on private land—and performed a Pearson's correlation to quantify the consistency between these two data sets. Lastly, we searched the literature for studies and reports that estimated the LUE of USSE. In general, these estimates were either based on industry standards, single power plant specifications, or back-of-the-envelope approximations. Due to the paucity of available research, we included both peer-reviewed literature and technical reports.

RESULTS

On the basis of records from 183 installations, we found that USSE in California is concentrated particularly in the Central Valley and the interior of southern California and with a capacity-based LUE of 35.0 Wm^{-2} ± 2.2 (95% CI; Figure 2a and 3a). Of these installations, PV-type installations are the majority (n = 171) and have a LUE of 35.1 Wm^{-2} ± 2.3. The smaller fraction comprises CSP installations (n = 12) with a LUE of 33.9 Wm^{-2} ± 7.9, which is not significantly different from the LUE of PV installations (p-value =0.5237, W = 1139.5). Concentrating solar power plants are located exclusively in inland southern California (i.e., San Bernardino, Riverside, and Imperial counties). The total capacity for the 183 installations that are planned, under construction, and operating in California is 24 156 MW; of these, 20 237 MW is PV and 3919 MW is CSP.

Of the 184 USSE installations, 160 met our criteria for analyzing the relationship between land ownership type and capacity-based LUE. Installations on private land, which are the great majority (n = 128 versus n = 32 on public land), have a significantly greater LUE at 35.8 Wm^{-2} ± 2.7 (95% CI) than installations on public land (25.4 Wm^{-2} ± 3.5; p-value < 0.001, W = 1157.5; Figure 2b). We found that publicly available records of USSE footprints and footprint values as reported by environmental impact statements or grant records of decision, are in good accord, i.e., highly positively correlated (r = 0.996786, p-value < 0.0001, r^2 = 0.993 584).

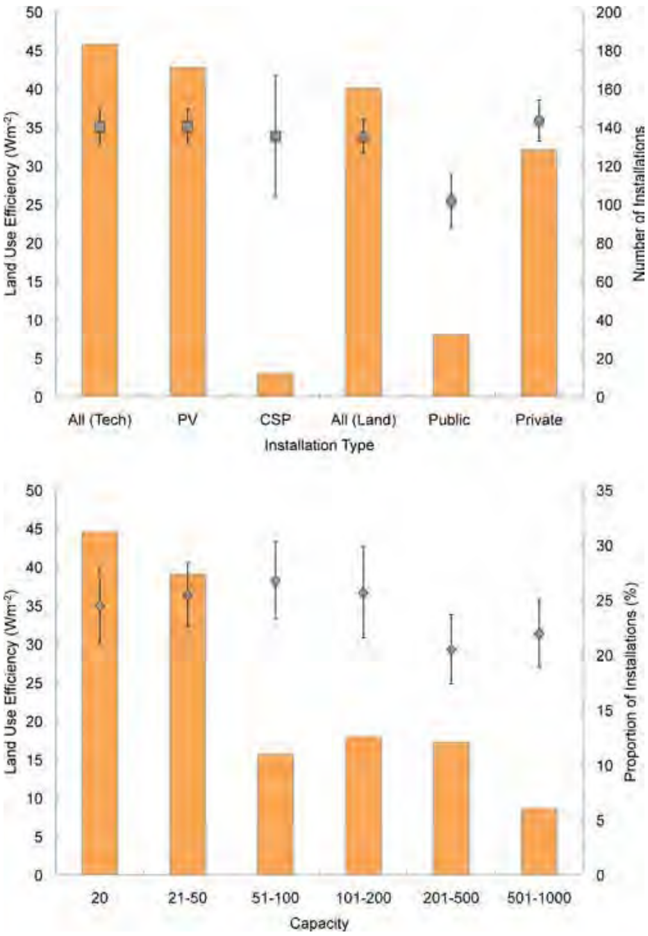

Figure 3. (A) The land-use efficiency (Wm^{-2}) of utility-scale solar energy (USSE) in California as a function of technology and land ownership type (points) and the number of installations in each category (bars),(B) The land-use efficiency (Wm^{-2}) of USSE in California as a function of capacity (MW; points) and the proportion of the total number of installations in each capacity range (bars). Error bars are 95% confidence intervals.

In California, USSE installations on private land are located particularly in the Central Valley and the Basin and Range province (Figure 2b). USSE installations on public lands are roughly confined to the Basin and Range province of southern California.

The total land area planned, under construction, and in use for USSE in California is 85 899 ha (Table 1; Figure 4). More land is allocated for PV (84.2%, 72,294 ha) than for CSP (15.8%, 13,604 ha). The amount of land allocated for USSE and PV is approximately equally divided between private (41 307 and 36 000 ha, respectively) and public (44 592 and 36 295 ha, respectively) land; however, approximately 22% more land for CSP is allocated on public land than privately owned land.

Table 1. Total Land Area (Hectares) Planned, Under Construction, And in Use for Utility-Scale Solar Energy (>20 MW) Power Plants, By Technology and Land-Ownership Type

type	all	private	public
all	85 899	41 307	44 592
PV	72 295	36 000	36 295
CSP	13 604	5 307	8297

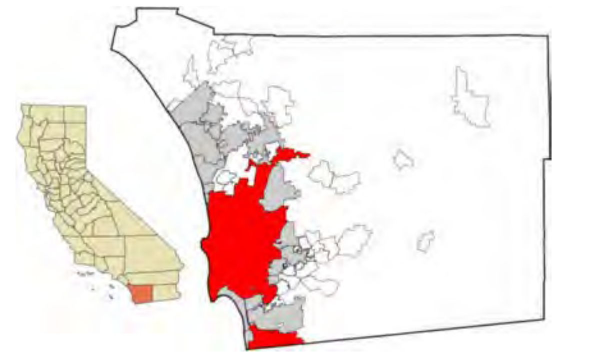

Figure 4. Map showing the city of San Diego (red, incorporated; gray/white, unincorporated; CA, U.S.). The city's area (84 220 ha) is approximately equal to the land planned, under construction, and in use for utility-scale solar energy (n = 160) in California.

The nominal capacity of installations included in our study ranges from 20 to 1000 MW. The plurality (n = 57, 31.1%) of these installations are 20 MW in capacity and average 35.0 Wm^{-2} ± 4.8 (95% CI) in capacity-based LUE (Figure 3b). Installations between 51 and 100 and 101−200 MW have the lowest LUE at 29.3 Wm^{-2} ± 4.5 and 31.3 Wm^{-2} ± 4.4, respectively. Numerically, the greatest LUE (38.2 Wm^{-2} ± 5.1) was found for installations between 201 and 500 MW in capacity. Installations over 500 MW in capacity comprise a minor proportion (6.0%) of all power plants. Overall, there is no significant effect of nameplate capacity on capacity-based LUE (Multiple r-squared = 2.724, df = 181, p-value = 0.1006). Estimations of capacity-based LUE as reported in 13 peer-reviewed studies and technical reports (Table 2) averaged 34.6 and 29.7 Wm^{-2}, for CSP and PV respectively. In total, estimates from these studies ranged over 2 orders of magnitude, from <1.0 Wm^{-2} to 74.8 Wm^{-2}, with a mean LUE of 31.3 Wm^{-2}. The LUE of individual USSE installations in our database showed a comparable range from 5.2 to 100.9 Wm^{-2}.

DISCUSSION

In this study, we found that capacity-based LUE is 35.0 Wm^{-2} based on actual footprints of over 180 USSE installations spanning the state of California. Prior to this study, the LUE of solar power plants were typically based on back-of-the envelope approximations, industry standards, data from uncertain sources, or data from a single facility, which has resulted in highly variable results (Table 2; also see Horner and Clark 2013).[18] For example, in a meta-analysis, Horner and Clark (2013) found that generation-based estimates varied by as much as 4 orders of magnitude (0.042−64 m^2/MWh) and by 2 orders of magnitude (5−55 m^2/MWh) after applying a harmonization.[18] Consequently, we provide greater accuracy for understanding capacity-based LUE and land-use characteristics of solar energy development in California, which is a consequence of the high number of installations analyzed and the high quality of data employed in this study.

The predicted rise in global energy demand and atmospheric CO_2 levels underscores the importance of understanding the nexus of energy, land, and the environment.[38] Understanding the efficient use of land for energy systems, particularly large-scale renewable energy systems, is critical to quantifying the complete energy conversion chain,[39] but studies quantifying

Table 2. Land Area (m^2) Required to Produce One Watt (W) of Energy Using Utility-Scale Solar Energy (USSE) Technologies, Including Photovoltaics (PV) and Concentrating Solar Power (CSP), as Reported in Primary Literature and Technical Reports[a−n]

N/means	type-subtype	authors	date	capacity (MW)	area (ha)	ha/MW	Wm-2
1	CSP	Block et al.	2007	1	3	2.83	35.30076878
2	CSP	Dahle et al.	2008	1	2	2.02	49.42127685
3	CSP	DOE 2012	2012	1	3	3.00	33.33333333
4	CSP	Fluri	2009	1000	2800	2.80	35.71428571
5	CSP	Schillings et al.	2007	50	100	2.00	50
6	CSP	Simons and McCabe	2005	56	75	1.34	74.7995106
7	CS-tower	Bravo et al.	2007	324 300	42 762 315	131.86	0.758378026
8	CSP-trough	Bravo et al.	2007	2 739 000	43 433 293	15.86	6.30622232
9	CSP-trough	Pimentel et al.	2002	114	1100	9.64	10.37086843
10	CSP/PV	Allen and McHughen	2012	1000	2833	2.83	35.3007688
11	CSP/PV	Karstaedt et al.	2005	1	2	2.02	49.42127685
mean CSP						16.02	34.61
10	CSP/PV	Allen and McHughen	2012	1000	2833	2.83	35.3007688
11	CSP/PV	Karstaedt et al.	2005	1	2	2.02	49.42127685
12	PV	Copeland et al.	2011	31 689	1 000 000	31.56	3.168876464
13	PV	Pimentel et al.	2002	114	2800	24.54	4.074269739
14	PV	Webster and Potter	2010	5	12	2.43	41.18446522
15	PV-w/tracking	Bravo et al.	2007	708 400	45 656 533	64.45	1.551585197
16	PV-25°(fixed tilt)°	Denholm and Margolis	2007	na	na	na	65
17	PV-1-axis	Denholm and Margolis	2007	na	na	na	48
18	PV-2-axis	Denholm andMargolis	2007	na	na	na	20
mean PV						21.31	29.74
mean ALL						19.95	31.32

[a]Allen M and McHughen A. 2012. Solar Power in the Desert: Are the current large-scale solar developments really improving California's environment?. Riverside, CA: University of California Riverside, Desert Development Issues. [b]Block S, Cummer K, Gilton K, Hunsaker M, O'Connell R, Pletka R, Roush B, Stoddard L, Tilley S, and Woodward D. 2007. Arizona Renewable Energy Assessment. Overland. [c]Park, KS: Black and Veatch. [d]Bravo JD, Casals AG, and Pascua IP. 2007. GIS approach to the definition of capacity and generation ceilings of renewable energy technologies. *Energy Policy* 35: 4879−4892. Copeland HE, Kiesecker JM, Pocewicz A. 2011. Geography of energy development in Western North America: Potential impacts to terrestrial ecosystems. Pages 7−22 in D. [e]Naugle editor "Energy development and wildlife conservation in Western North America" Island Press. [f]Dahle D, Elliott D, Heimiller D, Mehos M, Robichaud R, Schwartz M, Stafford B, and Walker A. 2008. Assessing the Potential for Renewable Energy Development on DOE Legacy Management Lands. Golden, CO: National Renewable Energy Laboratory. [g]Denholm P, Margolis R. 2007. The Regional Per-Capita Solar Electric Footprint for the United States. National Renewable Energy Laboratory. Technical Report: NREL/TP-670- [h]42463, Accessed: http://www.nrel.gov/docs/fy08osti/42463.pdf, Accessed on: 8 September 2013. [i]Fluri TP. 2009. The Potential of Concentrating Solar Power in South Africa. *Energy Policy* 37: 5075−5080. [j]Karsteadt R, Dahle D, Heimiller D, and Nealon T. 2005. Assessing the Potential for Renewable Energy on National Forest System Lands. National Renewable Energy Laboratory and USDA Forest Service. [k]Pimentel D, Herz M, Glickstein M, Zimmerman M, Allen R, Becker K, Evans J, Hussain B, Sarsfeld R, Grosfeld A, and Seidel T. 2002. Renewable Energy: Current and Potential. [l]Issues. *American Institute of Biological Sciences* 52:1111−1120. [m]Schillings C, Mannstein H, and Meyer R. 2004. Operational Method for Deriving High Resolution Direct Normal Irradiance from Satellite Data. *Solar Energy* 76: 475−484. Simons G, McCabe J. 2005. California Solar Resources. California Energy Commission. [n]Webster IA, Potter R. 2010. Solar Power on Brownfields Sites. Brea, CA: Project Navigator, Ltd.

such systems in this manner are few and ambiguous.[3,5,25,14,40,41] In a comprehensive life-cycle comparison of a wide range of energy systems, Fthenakis and Kim[14] used a nominal packing factor for various PV technology subtypes (based on a single footprint specifications) to determine the land transformation required by installations. Their estimates ranged between 229 and 552 m^2 GWh^{-1}. These values are comparable to our results□approximately 500 m^2 GWh^{-1} assuming a capacity factor of 13% for PV.

A few studies have compared the LUE of solar with other energy systems[7,25,14] and some use solar LUE data from individual power plants. Compared to other energy systems, Fthenakis and Kim (2009)[14] found that direct and indirect (i.e., energy for materials and energy use) generation-based LUE of PV and CSP was smaller relative to other renewable energy systems including wind, hydroelectric, and biomass and our results corroborate this finding. They also determined that ground-mounted PV systems in favorable locations have a higher generation-based LUE than the coal-fuel cycle coupled with surface mining. In the U.S., 70% of all coal is extracted at the surface, removing mountaintops and altering landscape topography.[42] McDonald et al. (2009)[7] found that CSP and PV had intermediate land-use efficiency□ower than natural gas, coal, geothermal, and nuclear power but greater than bioenergy, wind, hydropower, and petroleum. In regions where land is limited, these results and ours underscore the potential for solar energy systems, over other renewable schemes, to meet relatively greater energetic demands.

Total land-cover change as a result of USSE activities is likely smaller relative to other energy systems, owing to its recent deployment compared to long-standing activities of other energy systems, its inherent land-use efficiency, and the option to deploy installations in the built environment where no additional land-cover change occurs. For example, in the western United States, oil and gas energy systems have impacted approximately 2 orders of magnitude more land

(∼21 million ha) than solar (∼100 000 ha), but given the region's vast solar resources, solar energy development could impact up to 18.6 million hectares of land.[26] An accurate understanding of LUE is needed to determine net land-cover and land-use change impacts at large scales. Consequently, in this region and elsewhere, capacity- and generation-based LUE estimates such as ours can be used to determine if meeting renewable energy goals through solar energy development will necessitate relatively small or large land transformations.[7]

We found no significant difference in capacity-based LUE between different sized power plants or in plants employing PV or CSP technology (although CSP showed a rather large variance in LUE; Figure 3). Ong et al. (2013)[8] also found no relationship between capacity size and capacity-based LUE for PV and additionally found no relationship between capacity size and generation-based LUE. Given that certain geographic factors (e.g., slope, ambient temperature, water availability, and infrastructure cost) will render PV more favorable than CSP, or vice versa, our results suggest that a comparable level of capacity-based LUE may be achieved regardless of technology type. That is, differences in the capacity factor are more important in determining LUE than technology type.

Land-use efficiency is significantly different for USSE power plants located on publicly and privately owned plants. Installations located on private lands potentially generate over 10 more watts per m^{-2} more than those located on public lands. Possible reasons for this contrast include (1) public lands may be cheaper, conferring greater spatial lenience in the design of installations, whereas private USSE power plants are spatially maximized to be cost-effective; (2) public installations may be, on average, older in the development process and therefore may have lower nominal capacity due to technological lags; and (3) installations on public lands are impacted by their unique geographic attributes (e.g., installations are farther from existing transmission infrastructure and therefore require longer or new corridors). Future research should be conducted to identify the cause underlying this disparity.

If spatial elasticity in public installations contributes to a greater footprint, then there may be an opportunity to improve array design and layout such that the least amount of public land is utilized. Array design is a multifaceted problem that involves optimizing the nominal capacity, capacity factor, structural design, series/parallel circuit design, thermal and shading site characteristics, and ecological features of the land used. However, understanding of how USSE infrastructure impacts an ecosystem, especially impacts related to land-use, are still limited.[5,9] For example, do installations in previously undisturbed environments with lower LUE necessitate less environmental recovery upon their decommission than those with greater efficiency? Future research should be conducted to determine the effect of (1) LUE, (2) shape and layout properties of array design, and (3) different USSE infrastructure on ecological impacts and time to recovery from USSE activities.

By reducing the land used by USSE infrastructure, increasing the LUE can reduce environmental impacts of USSE development related to biodiversity,[3,5,43] water use and consumption,[41,44−46] and human health and air quality.[3,47−49] Improving LUE (i.e., for nameplate capacity) will require (1) maximizing the number of panels, mirrors, or heliostats in the space available for solar capture; (2) minimizing the size and/or number of ancillary facilities; (3) maximizing the density of ancillary facilities; and (4) minimizing new transmission corridors, which can augment the footprint. For example, Denholm and Margolis (2008)[6] state that USSE installers often maximally space arrays to solely increase yield, but that actual shading impacts may not justify the large array spacing, given realized weather conditions and the lower value of off-peak time periods. More research should be done to understand the relationships among spacing, energetic efficiency, and LUE.

In addition to practices that maximize LUE, USSE power plants can maximize their return on investment by integrating ecological cobenefit opportunities. Such opportunities include brightfields□when brownfields are utilized for solar energy development, the colocation of solar and agriculture, hybrid energy systems, floatovoltaics (i.e., PV installed on top of bodies of water), photovoltaic noise barriers, rooftop solar, and the use of salt-contaminated, agricultural, and other degraded lands. Co-benefits include but are not limited to obviating land-use (m^2) and land occupation ($m^2 \times$ year); reducing land deficits for energy, food, and fiber production;[6] creating novel job opportunities; stabilizing degraded soil; enhanced electrical generation; and water conservation. Reducing adverse environmental impacts of USSE and incorporating cobenefit opportunities while concomitantly practicing energy conservation may reduce rates of global warming.[4,38]

Our results are based on nominal capacity and therefore realized LUE will be different for each power plant given its unique capacity factor (e.g., the technological efficiency of the power plant and site-specific weather conditions) and thermal energy storage facilities, where solar-derived energy is converted and stored as thermal energy in a heat-transfer medium for use later.[17,50] To illustrate, a capacity factor of 13% and 33% would engender a realized LUE of approximately 4.6 Wm^{-2} and 11.2 Wm^{-2} for PV and CSP, respectively. Sources providing real time data for the total number of USSE installations online in California are lacking making it difficult to estimate the percentage of planned, under construction, and operating installations in our data set. In 2012, the cumulative installed capacity of solar energy in California was 25 560 MW, where 49.6% of the total MW installed in 2012 were USSE enterprises.[28] Future studies should explore the generation-based LUE of PV and CSP technologies and technology subtypes of USSE using large data sets like ours, especially as more installations come online.

Our results can be employed as inputs for future studies such as those modeling ecological impacts resulting from USSE construction, operation, and decommissioning activities and those quantifying land-atmosphere interactions that integrate effects of USSE infrastructure. Several studies have attempted to project the future land-use impacts of USSE under specific renewable energy goals (e.g., Copeland et al. 2011, Margolis et al. 2012)[25,51] and our study may provide accurate land-related inputs into these projection models. Lastly, our findings provide a baseline against which developers may strive to improve and better understand the LUE of USSE. Overall, our study provides greater clarity to a broader understanding of big solar development, especially the impact of technology, capacity, and land ownership on land-use practices.

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Notes

The authors declare no competing financial interest.

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Paleoecology of Pleistocene megafauna in southern Nevada, Usa: Isotopic evidence for browsing on halophytic plants

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PALEOECOLOGY OF PLEISTOCENE MEGAFAUNA IN SOUTHERN NEVADA, USA: ISOTOPIC EVIDENCE FOR BROWSING ON HALOPHYTIC PLANTS

by

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ABSTRACT

Paleoecology of Pleistocene megafauna in southern Nevada, USA: isotopic evidence for browsing on halophytic plants

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Stable isotopic techniques are emergent as a powerful reconstructive tool in Neogene paleoecology. The Las Vegas Valley in southern Nevada contains one of few diverse Late Pleistocene fossil assemblages in the Mojave Desert. This study investigates the diet of four megafaunal genera (*Mammuthus*, *Equus*, *Bison*, and *Camelops*) using $\delta^{13}C$ signatures preserved in tooth enamel. Results from serial sampling are also presented as a subannual record of dietary variation and seasonality. During the Last Glacial Maximum, the three grazing genera (*Mammuthus*, *Equus*, and *Bison*) consumed C_3 and C_4 grasses in the naturally occurring proportion, which consisted primarily of C_3 grasses. *Camelops* $\delta^{13}C$ values indicate the highest dietary proportion of C_4 plants; I interpret that these animals consumed browse material with a high proportion of the halophytic C_4 shrub *Atriplex*, a substantial component of modern Mojave Desert vegetation. This study provides new insight into stable isotopic applications for reconstruction of arid paleoenvironments.

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CHAPTER 1

INTRODUCTION

Overview

The end of the Pleistocene Epoch (11,500 calendar years before present, or 11.5 ka) marked the extinction of a unique "megafauna" of large mammals on almost every continent (Barnosky et al., 2004). The precise causes of this extinction have long been debated, and are still controversial. Current research suggests that both rapid climate change and human hunting may have played a significant role (Barnosky et al., 2004; Grayson and Meltzer, 2002, 2003; Martin, 1984; Mosiman and Martin, 1975).

The preferential extinction of large mammals, in concert with rapid climate change during deglaciation, suggests that nutritional stress may have had effects on multiple trophic levels and possibly played a role in extinction (Guthrie, 1984). Numerous recent studies have explored niche partitioning and dietary variation in taxa of extinct megafauna using stable isotopic variation (Feranec and MacFadden, 2000; Hoppe et al., 1999; Koch et al., 1998; MacFadden et al., 1996). Traditional paleontological reconstructions of diet rely primarily on dental morphology. In herbivores, grazing and browsing habits are delineated by hypsodonty (high-crowned teeth) versus brachydonty (low-crowned teeth), and further identified by the shape of the occlusal or chewing surface (Webb, 1974). Bison, mammoths, and horses all have hypsodont teeth with relatively flat occlusal surfaces, and are interpreted as grazers; mastodons and antilocaprids have low-crowned teeth and are interpreted as browsers (Webb, 1974).

Isotopic discrimination between C_4 grasses and C_3 browse material permits more detailed reconstruction of the dietary preferences of herbivores. In some cases, as with equids, the evolution of hypsodonty mirrors the expansion of C_4 grasslands in the Late Miocene, as revealed by stratigraphic isotopic data (Cerling et al., 1989; Quade et al., 1989; Quade et al., 1992). These studies permit paleoecological reconstructions in mammalian diet and behavior at a level of complexity previously unattainable for the fossil record.

In low latitudes with sufficient moisture, browse plants are almost entirely C_3 and grasses are almost exclusively C_4, and isotopic values in tooth enamel can be directly correlated to dietary preferences. Because of the simplicity of assigning isotopic end-members to corresponding dietary end-members, most of these studies focused on low-latitude paleoecosystems with abundant rainfall. As a result, little work has produced reconstructions of this type in western North America. In the absence of these customary isotopic end-members for diet, other paleoecological questions may still be addressed and answered using isotopic data.

A diverse assemblage of fossil megafauna was recovered from the Las Vegas Valley in southern Nevada, located in the Central Basin and Range. Previous work has been primarily descriptive (de Narvaez, 1995; Haynes, 1967; Mawby, 1967), although some studies have analyzed species assemblages in an attempt to reconstruct population dynamics (de Narvaez, 1995; Vetter et al., 2005).

Objectives and Predictions

The Late Pleistocene assemblage of megaherbivore teeth recovered from the Gilcrease spring mound, Las Vegas Valley, Nevada, provided an opportunity to test hypotheses about isotopic reconstruction of diet in different taxa and seasonal variability within individual animals. In addition, absolute dating tests provided a means of evaluating the taphonomy of the site, and whether the fossils represent a time-averaged accumulation or a single mass death event. This project evaluated four genera of extinct large herbivores: *Mammuthus*, *Equus*, *Bison*, and *Camelops*.

This project evaluated the relative proportions of C_3 and C_4 vegetation in herbivore diets using stable carbon isotope values. Modern bison are obligate grazers and consume almost no browse material. Bison do not exhibit preference for C_3 or C_4 grasses and consume grass in the naturally-occurring C_3/C_4 ratio, and are thus passive recorders of the relative abundances of C_3 and C_4 grasses (Hoppe et al., 2006). I measured the carbon isotopic values from bison teeth and used these values, in conjunction with independent vegetation records, to approximate a baseline abundance of each type of grass. Recent evidence suggests that Pleistocene *Equus* and *Mammuthus* were both facultative grazers; Pleistocene *Camelops* was putatively a browser. I predicted that the carbon isotopic values of these three taxa would differ from values from bison, indicating differences in diet.

I also measured several serial samples along the growth axis of a single tooth for each individual. I predicted cyclic variability in both carbon and oxygen isotope values measured along the growth axis. These cyclic variations are interpreted as seasonal variation in diet. Since vegetation is highly variable on small spatial scales in the Basin and Range, I predicted a broader range of intra-species carbon isotopic values between individuals than has been demonstrated for other Pleistocene herbivores.

Radiocarbon tests were performed on six *Mammuthus* molars from six individuals. I predicted that the absolute dates obtained from these analyses would span a range of values, indicating that these fossils accumulated over several thousand years.

Significance

The modern Mojave Desert is extremely arid and has a low vegetation density; as a result, it supports a very low density of modern large animals. The Pleistocene-to-Holocene transition in the Mojave Desert was a particularly dramatic climatic shift: the mean annual temperature approximately doubled, while the mean annual precipitation decreased by about a factor of two (Thompson et al., 1999). Data from the relatively small number of Quaternary fossil localities in the Mojave Desert indicate that a diverse fauna was present in the Late Pleistocene.

Southwestern North America is the historic location of megafaunal kill sites that unequivocally indicate interactions between human Paleoindian hunters and animals that are now extinct (Haury, 1953; Haury et al., 1959; Stock and Bode, 1937; Warnica, 1966). Recent evidence indicates the presence of humans in the Las Vegas Valley and surrounding area during the early Holocene (Heidi Roberts, 2006 personal comm. to S. Rowland). Interaction between human hunters and extinct megafauna in the Las Vegas Valley has been suggested based on stratigraphic association of archaeological artifacts with fossil remains (Harrington, 1933; Haynes, 1967). Although human-megafaunal interactions have not been conclusively proven, these interactions could have increased the considerable environmental stress that resulted from changing climate and vegetation regimes.

In the Late Pleistocene faunal assemblage from the La Brea tar pits in southern California, studies have inferred environmental and nutritional stress from dietary shifts, indicated by both morphological (Van Valkenburgh and Hertel, 1993) and isotopic data (Fox-Dobbs and Koch, 2003). Faunal records from the Las Vegas Valley span the time interval from the Last Glacial Maximum to the end-Pleistocene megafaunal extinction, and thus record the paleoecology and paleoenvironmental interactions of these animals immediately prior to their extinction. In this study, I reconstruct resource partitioning and seasonal variability in dietary habits of Pleistocene herbivores in the Mojave Desert immediately prior to their extinction, and test for potential resource competition and environmental sources of nutritional stress.

CHAPTER 2

PREVIOUS RESEARCH

Geologic Background

The Las Vegas Valley is one of several fault-bounded intermontane basins in the Basin and Range, a region of continental extension in western North America (Longwell et al., 1965). Extension in the Central Basin and Range was initiated in the Late Miocene, and the Neogene sedimentary record extends into the Holocene (Faulds et al., 2001). Pleistocene sediments in the Las Vegas Valley consist primarily of coarse alluvial fans and fan remnants adjacent to mountain fronts; areas more distal from range fronts are characterized by finer sands and silts (Haynes, 1967). Drainage in the Las Vegas Valley runs generally from northwest to southeast, and terminates in Lake Mead and the Colorado River (Figure 1; Longwell et al., 1965).

The Pleistocene Epoch (~1.8 Ma to 10 ka) was characterized by frequent alternation between glacial and interglacial conditions, resulting from cyclical variation in orbital patterns (Hays et al., 1976). During glacial stages, pluvial conditions were prevalent in the Basin and Range, with considerably more precipitation than in the modern interglacial stage (Smith and Street-Perrott, 1983). Many closed intermontane basins were filled with lakes during Pleistocene pluvial intervals, and multiple pluvial events are recorded in thick lacustrine sedimentary sequences within some basins (Snyder et al., 1964). Other hydrologically open basins accumulated interbedded coarse and fine

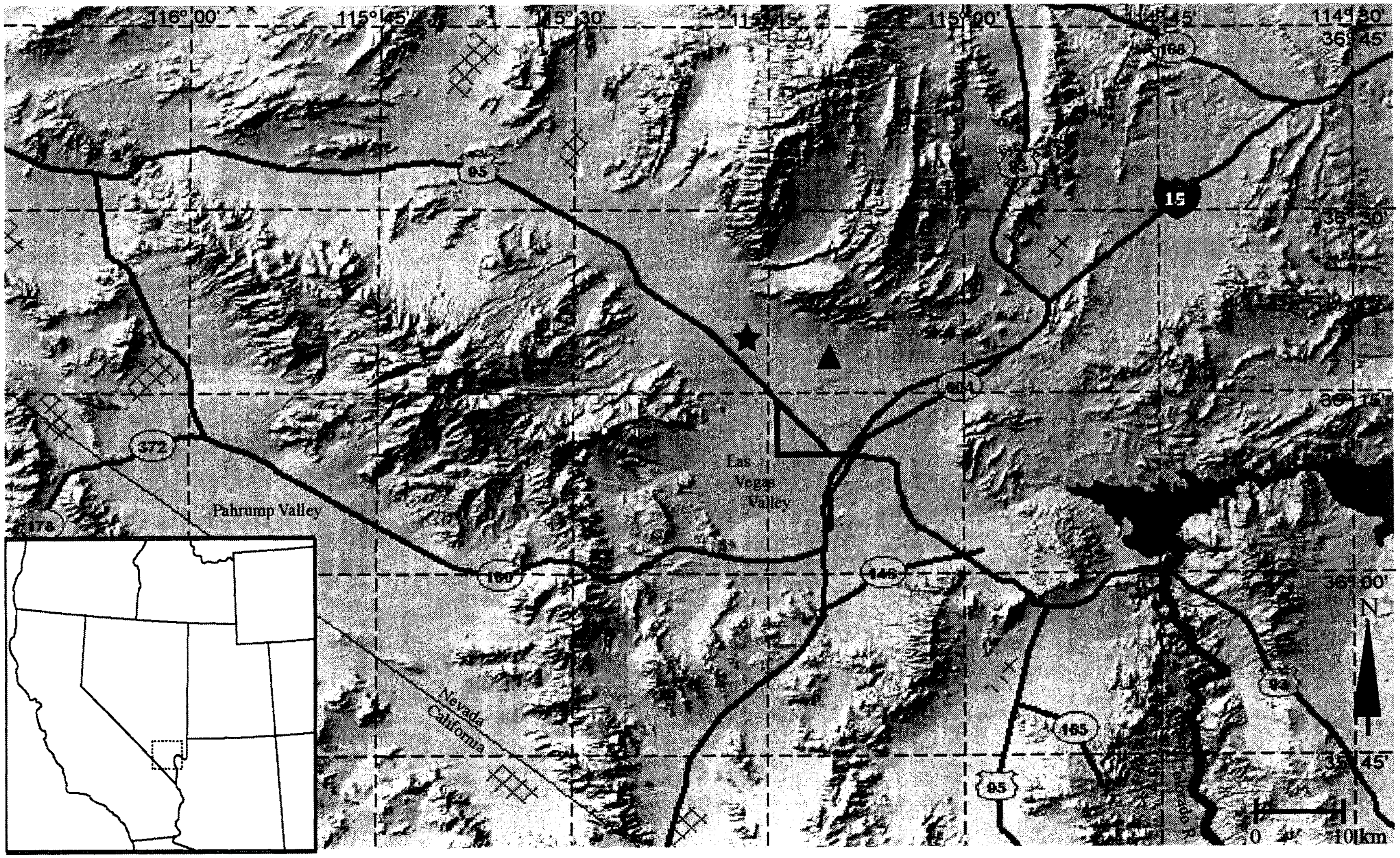

Figure 1. Map of the Las Vegas Valley, southern Nevada. ▲ = Tule Springs excavation, ★ = Gilcrease property and spring mound (modified from USGS, 2007).

deposits that reflect disparate precipitation and weathering between pluvial and interpluvial climatic regimes (Mifflin and Wheat, 1979). Pleistocene sediments in the Las Vegas Valley consist of interbedded gravels, sands, silt and mudstones, and paleosols (Quade, 1983). Reconstructed depositional environments are fluvial during drier intervals and paludal or marsh systems during wetter intervals (Quade, 1986).

The Tule Springs excavation, an interagency research effort that took place in 1962-63, mechanically exposed Late Pleistocene sediments (Haynes, 1967). Haynes (1967) identified and described seven stratigraphic units, labeled A through G, which provide context and continuity for Quaternary sediments in the region. Stratigraphic age control for these units was determined using radiocarbon dates from a variety of materials, including wood, mollusc shells, tufa carbonates, organic-rich tufa deposits, and bone material (Table 1; Haynes, 1967). Units A and C are primarily coarse-grained fluvial facies. Units B and D consist of greenish calcareous mudstone (Haynes, 1967); these two units are interpreted as paludal or marsh facies, deposited during wetter pluvial intervals (Quade, 1986). These mudstone units are also characterized by abundant burrows from cicada larvae, which in modern environments are linked with wetter conditions and a vegetation regime with abundant sagebrush (*Artemisia* spp.) (Quade, 1986). Unit D, which is correlative with the Last Glacial Maximum, is marked by the presence of abundant nodules of secondary soil carbonate (Quade, 1986). Subunit E_1 consists of cross-bedded alluvium, organic-rich black mats, and areally restricted green clays; subunit E_2 is interpreted as a drier environment consisting of hardpan and occasional marshes of limited extent. Units F and G consist primarily of fine-grained deposits and are interpreted as aeolian sediments deposited under very arid conditions; within these units, black organic-rich mats and green clays are found only in association with modern springs (Quade, 1986).

Table 1. Selected stratigraphic units and ages of Quaternary sediments in the Las Vegas Valley; units from (Haynes, 1967; Mehringer, 1967; Quade, 1986). Absolute ages are inferred from radiocarbon dates of various interbedded materials.

Unit	Age range (ka)	Description	Features
G	1.0 – present	Fine-grained Aeolian deposits	
F_2	4.0 – 1.5	Fine-grained Aeolian deposits	
F_1	5.0 – 4.0	Fine-grained Aeolian deposits	
E_2	11.0 – 6.0	Cross-bedded alluvium	Hardpan
E_1	14.0 – 11.5	Cross-bedded alluvium	Black mats, occasional green clays
D	30.0 – 16.0	Greenish calcareous mudstone	Cicada larvae, carbonate nodules
B_2	> 40	Greenish calcareous mudstone	Cicada larvae

The Gilcrease Flat and Kyle Canyon alluvial fan are located ~4 km west of the Tule Springs excavation (Figure 1). Units C and D extend into the subsurface of the Kyle Canyon fan. The surface of the fan is correlative with the upper part of Unit D, and local paleosols are believed to be correlative with Unit E (de Narvaez, 1995). Several active springs have deposited topographic mounds (~100 to 500 m across and 4 to 15 m in height; Haynes, 1967). The Gilcrease and Stilwell alignments are parallel, north-south trending traces of a normal fault at the base of the Spring Mountains; these are marked by linear occurrence of a series of these spring mounds (Haynes, 1967). Spring discharge initiates when fan drainage is interrupted by impermeable, fine-grained fault gouge along the active fault (Haynes, 1967). Placement of these springs above local erosional surfaces at the top of Unit D, below Unit E_1, constrains initiation of movement along these faults to 22 ka to 14 ka, when spring discharge began (Haynes, 1967). More detailed examination of spring stratigraphy indicates that these springs were vigorously active beginning in the Late Pleistocene (~18 ka) and that discharge declined into the Holocene

(Quade, 1986). Several of the springs were active into historical time and discharge ceased in response to groundwater extraction from urban development in the Las Vegas Valley (Quade et al., 1995). The spring mounds measure approximately 30-150 m in diameter and 3-7 m in height, and accumulated a high diversity of megafaunal remains (Haynes, 1967).

Faunal Records

There is an overall paucity of published Pleistocene vertebrate localities in the Mojave Desert region. The modern abundance of large mammals is low due to resource limitation, and abundances may have been low in the Pleistocene as well. In addition, preservation potential is poor in arid environments, and much of the region is undeveloped or used for rangeland. A high diversity of large and small vertebrates and invertebrates is preserved at a few sites, but most published faunal records tend to describe isolated individual fossils. In contrast to most Pleistocene faunal localities in the Mojave Desert, the Las Vegas Valley contains a diverse fossil assemblage (de Narvaez, 1995; Glowiak, 2007; Mawby, 1967).

The Tule Springs fauna was recovered from the northwestern Las Vegas Valley and provides the most complete Pleistocene faunal record for the area (Haynes, 1967). The Tule Springs excavation yielded fossil material of invertebrates (primarily molluscs), amphibians, reptiles, birds, small mammals, and large carnivores and herbivores. Some pollen was also recovered from the Tule Springs excavation (Mehringer, 1967); these palynological data are discussed with other vegetation records below. The faunal assemblage is composed primarily of large mammals, in part due to large-scale methods of excavation and inattention to smaller fossil material (Haynes, 1967). Most of these large mammals are herbivores, with few representatives of the carnivore guild (Table 2; Mawby, 1967).

Table 2. Large mammals from the Tule Springs fossil assemblage (Mawby, 1967). G = grazer, B = browser, C = carnivore. See Table 1 for correlation with stratigraphic units.

Family	Taxon	Common name	Diet	Stratigraphic unit
Proboscidea	*Mammuthus columbi*	Columbian mammoth	G	B_2, D, E_1
Equidae	*Equus* sp. (large morph—*E. occidentalis?*)	Horse	G	B_2, E_1
	E. conversidens	Horse	G	B_2, E_1
Camelidae	*Camelops hesternus*	Yesterday's camel	B	B_2, D, E_1
Bovidae	*Bison antiquus*	Antique bison	G	B_2
Cervidae	*Odocoileus* sp.	Deer	B	E_1
Ovidae	*Ovis Canadensis*	Mountain sheep	B	
Antilocapridae	*Tetrameryx* sp.	Pronghorn	B	E_1
Xenarthra	*Megalonyx* sp.	Giant ground sloth	B	B_2, E_1
	Nothrotheriops shastensis	Shasta ground sloth	B	B_2
Carnivora	*Felis* or *Lynx*	Small predatory cat	C	B_2
	Panthera atrox	American lion	C	B_2
	Puma sp.	Puma	C	E_1
	Canis latrans	Coyote	C	E_1

Additional Pleistocene vertebrate material in the Las Vegas Valley was recovered from Gypsum Cave, 22 km east of the Tule Springs locality. Initial excavations yielded the remains of several extinct and extant large mammals (Harrington, 1933). Radiocarbon analyses of dung samples of the Shasta ground sloth (*Nothrotheriops shastensis*) from

Gypsum Cave produced a range of ages from 8,400 to 11,700 yr BP (Heizer and Berger, 1970). Subsequent identification and analysis of the Gypsum Cave assemblage has yielded a minimum number of individuals for each taxon (Table 3; Glowiak, 2007), consistent with the distribution within the Tule Springs assemblage.

A specimen of *Nothrotheriops shastensis* was also recovered from a pitfall cave trap at Devil Peak in the Spring Mountains, ~80 km south of the Las Vegas Valley (Gromny, 2003). Isolated proboscidean and ungulate fossils are also reported from the region. Various localities include *Mammuthus columbi* from Pahrump Valley (NV), Cactus Springs (NV), and Valley Wells (CA); *Equus* sp. and *Camelops* sp. from Corn Creek Flat (NV); *Equus* sp. from Lathrop Wells (NV) and Kokoweef Cave (CA); and *Camelops* sp. from Sunshine Lake (NV) (Connin et al., 1998).

Table 3. Large mammals from the Gypsum Cave assemblage (Glowiak, 2007).

Order	Taxon	Common Name	Status	MNI (Juvenile/Adult)
Artiodactyla	*Hemiauchenia macrocephala*	Stilt-legged llama	Extinct	1/2
	Camelops hesternus	Yesterday's camel	Extinct	1/1
	Ovis canadensis	Bighorn sheep	Extant	1/8
	Odocoileus hemionus	Mule deer	Extant	1/6
Perissodactyla	*Equus* sp. 1	Horse	Extinct	1/4
	Equus sp. 2	Horse	Extinct	
Xenarthra	*Nothrotheriops shastensis*	Shasta ground sloth	Extinct	2/4
Carnivora	*Urocyon cinereoargenteus*	Gray fox	Extant	0/1
	Vulpes macrotus	Kit fox	Extant	0/4
Felidae (Family)	*Lynx rufus*	Bobcat	Extant	1/0

Vegetation Records

Plants can be categorized by either functional type (e.g., shrubs, herbaceous plants, grasses, etc.) or by photosynthetic mechanism. The C_3 photosynthetic pathway is utilized by most plants, including trees, shrubs, herbaceous plants, and some cool-season bunch grasses (e.g., *Amphipogon*, *Festuca*). The C_4 photosynthetic pathway is utilized by warm-season grasses (e.g., *Spartina*, *Sorghum*, *Bouteloua*; Watson and Dallwitz, 2005). The presence of C_3 or C_4 plants is discernible from isotopic analysis of organic matter, soil carbonate, and mammalian tooth enamel. Modern vegetation in the Las Vegas Valley consists primarily of C_3 shrubs and C_3 grasses (Mehringer, 1967; Quade et al., 1987). Components of the modern Mojave Desert plant community that utilize the C_4 photosynthetic pathway include occasional warm-season (C_4) grasses and *Atriplex* spp. (shadscale or saltbush), one of few C_4 shrubs (Quade et al., 1987). Modern vegetation in the Las Vegas Valley is composed of approximately 93-95% C_3 plants; this is corroborated by isotopic measurements of soil carbonate (Quade et al., 1987).

Temperature and moisture regimes in the Basin and Range are delimited by altitude. Extreme topographic relief in the Basin and Range results in high variability in plant communities on small spatial scales (Vasek and Barbour, 1977). Fluctuations in climatic conditions thus result in both altitudinal and latitudinal shifts in vegetation ranges. Modern vegetation in the Las Vegas Valley consists in part of taxa that exploit and colonize disturbed areas, so pre-disturbance analogs are necessary to evaluate modern plant species distributions based on climate variables alone. Reconstruction of plant species distribution during the different climatic conditions of the LGM and late glacial time is difficult using any single vegetation record or proxy. Multiple vegetation records are discussed below; consideration of all of these records provides a more detailed basis for evaluation of Pleistocene herbivore diet.

Conventionally preserved plant macrofossils are infrequently recovered from coarse-grained terrestrial sedimentary sequences. However, arid environments contain plant macrofossils with a unique mode of preservation. Rodents of the species *Neotoma* sp. (packrats) colonize rocky habitats, acquire plant material from their surroundings, and incorporate the material into middens or nests (Finley, 1958).

Material in the middens is desiccated and preserved, and radiocarbon dates may be obtained from fecal pellets within the middens (Wells and Jorgensen, 1964). Packrats only collect material from a distance of approximately 100 m from their nests. Middens thus provide a site-specific record of vegetation that may be precisely dated, although the geographic and temporal range of any single midden is limited in scope. However, some evidence suggests that midden contents may not accurately represent total floral diversity at a given site, and that packrats may exhibit selectivity when collecting material for middens (e.g., Dial and Czaplewski, 1990).

Vegetation reconstructions using packrat middens demonstrate significant change in the composition of plant communities in the Basin and Range throughout the Pleistocene (Spaulding, 1983; Spaulding and Graumlich, 1986; van Devender and Spaulding, 1979). However, because packrats preferentially dwell in upland habitats, midden records are not directly applicable to reconstructions of valley floor vegetation in the Las Vegas Valley. Climate-induced range shifts were specific to individual plant species, so the overall species composition of plant communities fluctuated throughout the Pleistocene. The LGM and late glacial plant communities represented by macrofossils are fundamentally different from modern communities (van Devender and Spaulding, 1979). Midden analyses suggest a minimum downward vertical shift in plant communities of 1065 m to 1200 m and indicate that a rapid transition to present-day desert scrub vegetation was underway by ~14 ka (Spaulding, 1985).

Preservation of pollen is generally poor in sediments deposited in arid environments. Some well-preserved Pleistocene palynological records for the Basin and Range exist in lacustrine sequences (Mensing, 2001), but palynological data are generally sparse in the Mojave Desert. The Tule Springs excavation yielded some pollen records from both alluvial and spring deposits, although poor preservation may result in a biased representation of Pleistocene vegetation communities (Mehringer, 1967). *Pinus* spp. pollen is overrepresented with respect to absolute abundance in pollen spectra due to the preferential long-distance transport of *Pinus* pollen (Solomon and Silkworth, 1986). The pine problem is potentially a confounding factor in determining absolute relative abundances of plant taxa from the Tule Springs pollen assemblage (Mehringer, 1967).

No single vegetation proxy supplies sufficient information for a complete reconstruction of Pleistocene plant communities. Because of the incomplete information provided by each vegetation proxy, I used packrat midden analyses and pollen data in conjunction with a stepwise regression model based on climate parameters to produce estimates of the percent abundance of C_4 grasses and other vegetation (Appendix 1). On the basis of these analyses I concluded that during the LGM in southern Nevada, C_4 grass abundance was approximately 4 to 13%, the abundance of non-grass C_4 plants (e.g. *Atriplex* spp., *Amaranthus*) was approximately 5%, and total C_4 biomass during the LGM ranged from 9 to 18%.

Previous Study of the Gilcrease Ranch Spring Mound

The Gilcrease Ranch spring mound (Cauldron 2; de Narvaez, 1995) is one of the fault-bounded springs located along the Gilcrease alignment on the Kyle Canyon fan (Haynes, 1967). Cauldron 2 (hereinafter referred to as "the spring mound") is located at 36.309°N/115.271°W, on the present site of the Gilcrease Nature Sanctuary, 8103 Racel Road, Las Vegas, Nevada. Active spring discharge is reported from historical times and ceased in approximately 1955 in response to urban development and groundwater extraction in the Las Vegas Valley. Fossil material was initially recovered from the site by the property owner, Mr. Bill Gilcrease, in 1985. From 1990 to 1995 the Fossil Club of Las Vegas excavated an area approximately 20 m in diameter to a depth of 6.5 m (de Narvaez, 1995).

The spring mound is located on a surface of the Kyle Canyon fan that is correlative with the Tule Springs Unit D (Quade, 1986). The sedimentology and stratigraphy of Cauldron 2 were described during the excavation (de Narvaez, 1995). Several black organic-rich mats are interbedded with spring deposits. Radiocarbon ages for the lower black mats are 12,727 to 12,178 cal yr BP and 11,801 to 10,963 cal yr BP (de Narvaez, 1995). A black mat from approximately the middle of the spring strata was dated to 9,615 to 9,582 cal yr BP, and a mat near the top of the spring mound was dated to 1,183 to 939 cal yr BP (de Narvaez, 1995). The placement of these dates implies that most deposition of sediments in the spring occurred during the latest Pleistocene and early Holocene.

An extensive collection of faunal material that consisted almost entirely of teeth from extinct large mammals was recovered from the spring mound (de Narvaez, 1995). Vigorous spring discharge resulted in a complex depositional pattern, precluding stratigraphic age correlation of fossil material (de Narvaez, 1995). The dental assemblage recovered from the site consists of *Mammuthus columbi*, *Equus* sp. (one large and one small morph), *Camelops* sp., *Hemiauchenia* sp., *Bison antiquus*, and one small and one large unidentified carnivore. Seven partial *Mammuthus* tusks were also recovered, although preservation is extremely poor and this material is not well articulated (de Narvaez, 1995). Some skeletal material is present but has not been identified and is not demonstrably Pleistocene in age; it may instead be from modern fauna, since the spring was active into historic time (Haynes, 1967).

The unusual taphonomy of this site is likely a result of high pH in spring water from dissolved $CaCO_3$ (Paul Koch, 2006 personal comm.). Regional bedrock consists primarily of Paleozoic carbonates; aeolian dust is predominantly carbonate material, and groundwater also passes through carbonate aquifers, increasing sodium and calcium cation concentration and groundwater alkalinity. Deposition in aerobic environments with high pH is not conducive to preservation of organic material (e.g., bone collagen) (Nicholson, 1998). Tooth apatite is a more robust biogenic mineral and is thus preserved in the spring mound.

Radiocarbon (^{14}C) Dating

Radiocarbon (^{14}C) is a naturally-occurring cosmogenic isotope of carbon formed by interaction of N_2 in the troposphere with incoming cosmic rays. ^{14}N undergoes an n,p reaction to produce ^{14}C, and ^{14}C decays by β emission to ^{14}N with a half-life of 5730 yr (Bradley, 1999). Radiocarbon in organic matter from living organisms is equilibrated with the environment; when an organism dies, enzymatic equilibration ceases and net radiocarbon decay begins. Abundances of radiocarbon in Pleistocene materials are measurable using accelerator mass spectrometry (AMS) techniques and provide absolute ages up to approximately 50 ka (van der Plicht et al., 2004).

Organic materials are rich in carbon. The high concentration of carbon allows precise AMS measurements of trace amounts of ^{14}C to produce a radiocarbon age. Soft animal tissues are rarely fossilized; radiocarbon ages are typically measured from the collagen-rich inner layer of fossil bones. The outer (cortical) bone is a denser, inorganic mineral matrix that is less organic rich, and is more difficult to date. Tooth apatite $[Ca_5(PO_4,CO_3,OH)_3(F,OH)]$ is a phosphatic biogenic mineral with ~4% carbonate in the mineral lattice. This inherently low concentration of carbon in apatite leads to difficulty and the potential for significant error in measurement of trace amounts of ^{14}C in tooth enamel.

Stable Isotope Fractionation

Carbon and oxygen both have multiple naturally occurring stable isotopes. Carbon has two stable isotopes, ^{12}C and ^{13}C. On Earth, ^{12}C comprises 98.9% and ^{13}C comprises 1.1% of all stable carbon (Faure and Mensing, 2005). Oxygen has three stable isotopes: ^{16}O, ^{17}O, and ^{18}O. ^{16}O and ^{18}O are the two most abundant isotopes: ^{16}O accounts for 99.76%, and ^{18}O comprises approximately 0.20% (Faure and Mensing, 2005). The relative abundances of each of these isotopic species are fixed on the Earth's surface. Since light elements have a relatively high mass difference between isotopes, these elements are subject to isotopic mass fractionation by different geochemical processes, including evaporation, condensation, photosynthesis, and metabolism. Records of stable isotope fluctuations provide key insight into the roles of various processes in biological and geochemical systems in the geologic past. Stable isotope abundance is expressed in per mil notation, relative to a standard. For example,

$$\delta^{18}O = \left(\frac{(^{18}O/^{16}O)_{sample}}{(^{18}O/^{16}O)_{standard}} - 1 \right) \times 1000$$

Carbon isotopic composition and the oxygen isotopic composition of carbonate solids are both typically reported with respect to the Vienna Pee Dee Belemnite (VPDB).

Oxygen isotopic values in different materials are primarily influenced by the $\delta^{18}O$ value of various water sources. Evaporation is the primary mechanism for isotopic differentiation of individual water bodies, although several different effects are observed within the realm of evaporative differentiation. The oxygen isotopic value of the modern ocean is defined as $\delta^{18}O$ = 0‰ VSMOW (-29.94‰ VPDB). Water evaporated from the ocean is isotopically lighter (has a lower $\delta^{18}O$) with respect to the ocean (Dansgaard, 1964). Subsequent rainout is isotopically heavy with respect to the producing vapor (Dansgaard, 1964). In continental environments with significant topographic relief, the "orographic effect" results in isotopically heavier water precipitating on windward sides of mountain ranges (Dansgaard, 1964).

The oxygen isotopic composition of modern rainfall in southern Nevada varies from about -13 to -1‰ (Friedman et al., 2002b). Geographic and temporal variation in $\delta^{18}O$ values of precipitation occurs as along spatial and altitudinal gradients, as well as seasonally (Friedman et al., 1992; Friedman et al., 2002b; Smith et al., 1992; Smith et al., 2002). Oxygen isotopic values of rainfall vary by about 2-3‰ from summer to winter (Friedman et al., 2002b). Over local changes in altitude >450m, precipitation $\delta^{18}O$ values decrease 2-3‰/km (Friedman et al., 2002b). There is little isotopic variation from west to east across the Great Basin (Friedman et al., 2002a; Ingraham and Taylor, 1991), although a systematic isotopic depletion from south to north occurs regionally; this is interpreted as evidence of most precipitation for the region originating in the subtropical Pacific (Friedman et al., 2002a). Smith et al. (2002) conclude that the isotopic compositions of groundwater and precipitation in southern Nevada do not vary more than 1-2‰ for oxygen isotopes (~20‰, δD values), and that recharge is rapid on geologic timescales. Modern surface water $\delta^{18}O$ values are similar to values from precipitation and groundwater, and exhibit similar ranges of variability (Coplen and Kendall, 2000).

Mammalian tooth enamel $\delta^{18}O$ values are equilibrated with environmental signals and provide a record of the $\delta^{18}O$ of ingested water in tooth enamel phosphate (Bryant and Froelich, 1995; Kohn, 1996). The $\delta^{18}O$ values of structural carbonate (CO_3) in apatite are offset from phosphate $\delta^{18}O$ values and also record a faithful signal of environmental $\delta^{18}O$ (Bryant et al., 1996). Water sources include surface water, groundwater, and leaf water from ingested plants; for large mammals, the isotopic signal of leaf water is a negligible contributor to tooth enamel $\delta^{18}O$ (Bryant and Froelich, 1995). Variation in $\delta^{18}O$ values in tooth enamel structural carbonate thus record environmentally-mediated changes in the oxygen isotopic value of water ingested by an animal.

In terrestrial environments, carbon is fractionated by plants during photosynthesis; different photosynthetic mechanisms result in different fractionations and resultant $\delta^{13}C$ values (O'Leary, 1981). Plants that use the C_3 pathway produce organic matter with $\delta^{13}C$ values ranging from -24‰ to -31‰ (Figure 2; O'Leary, 1988). C_4 plants are more efficient at photosynthesis and thus fractionate carbon to a lesser extent; typical $\delta^{13}C$

values for C_4 plants are about -13‰ (Figure 2; O'Leary, 1988). Atmospheric $\delta^{13}C$ values have varied on glacial/interglacial timescales, producing an offset of +0.5‰ for the LGM and up to +1.3‰ for late glacial times (Marino et al., 1992). However, this offset was relatively constant over the span of mineralization time (years) of a single tooth, and is small compared to dietary variation. The isotopic composition of vegetation ingested by herbivores is recorded in trace carbonate in the tooth enamel with a metabolic offset of +13.5‰ to +14‰ (Bocherens et al., 1996).

Use of Stable Isotopes in Paleoecological Reconstruction

Carbon isotopic values preserved in fossil tooth enamel permit reconstruction of the relative proportion of C_3 and C_4 vegetation in the diets of individual herbivores (DeNiro and Epstein, 1978). The same isotopic data in faunal assemblages may be used to evaluate different paleoecological questions by interpreting two primary types of information: information about paleoenvironment and vegetation as recorded in tooth enamel (e.g., Connin et al., 1998; Higgins and MacFadden, 2004), and information about the diet and behavior of individual animals and clades (Koch, 1998).

Analyses of $\delta^{13}C$ values from individuals of several different taxa permit dietary reconstruction for animals that lived contemporaneously in the same ecosystem (Figure 2); because of the potential range in values between individuals, at least five specimens of the same taxon are necessary to provide corroboration of $\delta^{13}C$ values (Clementz and Koch, 2001). Niche spaces occupied by different clades of animals in an ancient ecosystem can be discerned from clustering of $\delta^{13}C$ and $\delta^{18}O$ values in related individuals and taxa. Browsers are identified by lighter, more negative carbon isotopic values, which

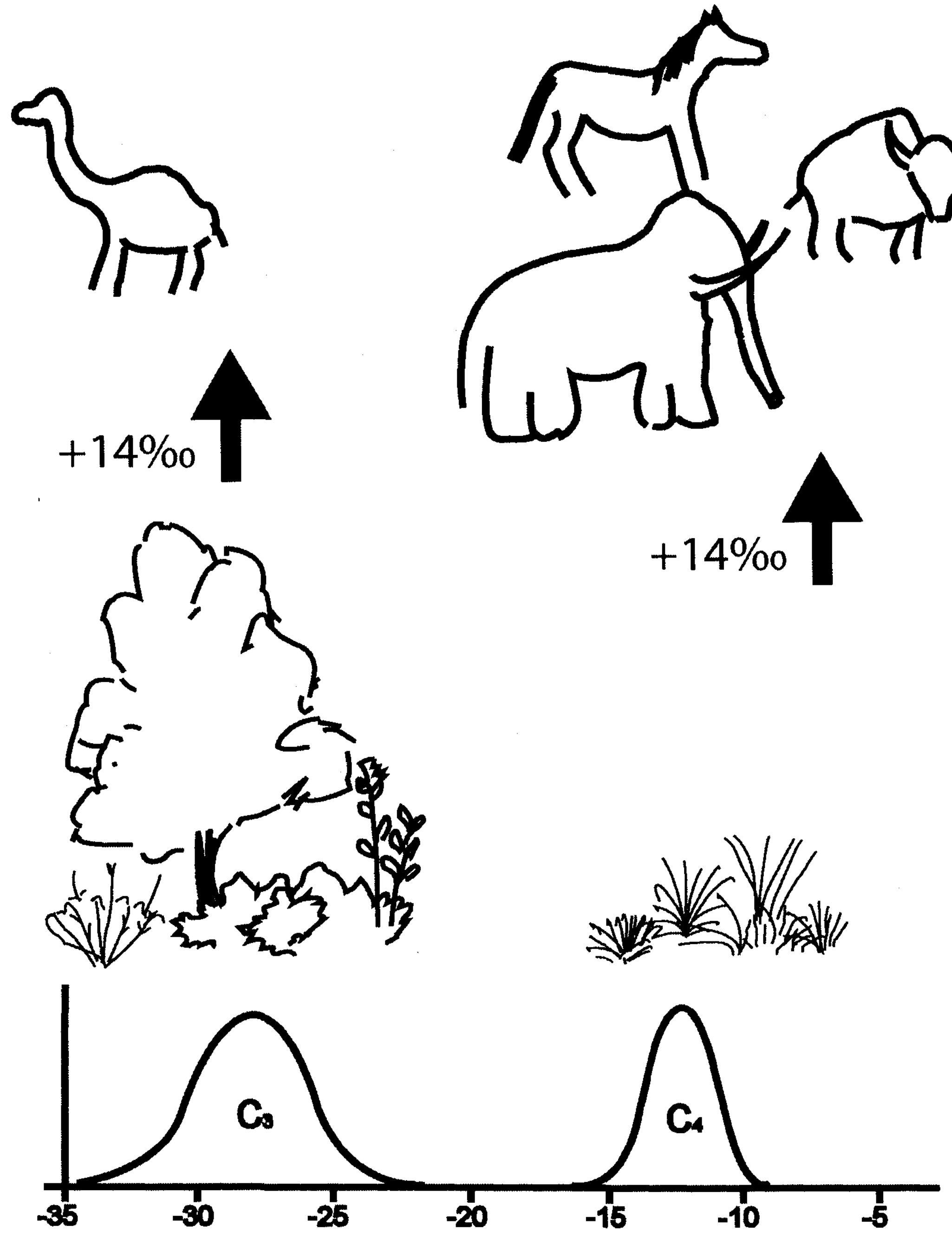

Figure 2. Stable isotope fractionation in C_3 and C_4 plants. Bimodal distribution of $\delta^{13}C$ values is recorded in the organic matter of plants with different photosynthetic mechanisms. Herbivores consume C_3 plants, C_4 plants, or a mixture of both, and $\delta^{13}C$ values from plants are recorded in the tooth enamel with a constant offset of +14‰.

correspond with ingestion of C_3 browse material. Further isotopic differentiation is possible between open, savanna-like habitats with C_3 plants (~ -27‰) and closed-canopy forests (~ -31‰)(Ehleringer et al., 1987), and in corresponding herbivory and forage habits of animals in these habitats (Ambrose and DeNiro, 1986).

Clustering of $\delta^{13}C$ values is usually interpreted as a taxon-specific dietary preference for a certain proportion of grass and browse material. Intra-generic $\delta^{13}C$ variation has been interpreted in two ways: as an adaptive response to resource limitation, or as an indication of variation in the geographic range of unrelated individuals within a fossil assemblage. High variability in $\delta^{13}C$ values in mammoths, with respect to contemporaneous browsers, is interpreted as ecological generalization and C_3/C_4 dietary mixing; this anomalous behavior is interpreted as a potential response to resource limitation (Koch et al., 1998). Hoppe (2004) found that demonstrable mammoth family groups from catastrophic death assemblages exhibited very low variability in $\delta^{13}C$ values between individuals. Deposits with time-averaged accumulations of fossils showed higher $\delta^{13}C$ value variability between individuals (Hoppe, 2004).

A variety of hypotheses about herbivore diet and resource partitioning in ancient ecosystems have been tested using stable isotopic analysis (Feranec and MacFadden, 2000; Koch et al., 1998; MacFadden, 2000; MacFadden et al., 1996). Examination of Cenozoic herbivore assemblages documents a shift in dietary habits in response to the evolution of C_4 grasses in the Late Miocene (MacFadden et al., 1996). Isotopic studies also demonstrate geographic variation in mammalian diet as both ecological adaptations to new habitats (Sánchez et al., 2004) and passive response to ecological change in the composition of plant communities (Fox and Koch, 2003). Another study of a Late

Pleistocene assemblage in Florida demonstrated no inter- or intra-generic differences in diet and feeding strategy in any herbivore taxa in response to ecological pressure from the arrival of *Bison*, a grazer (Feranec and MacFadden, 2000).

Although most isotopic reconstructions of Pleistocene ecosystems in North America focused on the eastern and central United States, Connin et al. (1998) analyzed the $\delta^{13}C$ and $\delta^{18}O$ values of several Late Pleistocene herbivore teeth from the American southwest and used these values to reconstruct paleovegetation. Some specimens from the Tule Springs excavation in the Las Vegas Valley were included in this dataset and provide a basis for interpretation of the isotopic values of other Late Pleistocene fossils from this area (Table 4; Connin et al., 1998). A qualitative assessment of these data suggests a shift from a C_4-rich plant community during B_2 deposition to a mixed C_3/C_4 vegetation regime during E_1 deposition.

Intra-generic $\delta^{18}O$ values from fossil herbivores often exhibit a higher σ than the level of variability recorded in modern ecosystems (e.g., Feranec and MacFadden, 2000). In modern, non-migrating herbivores, intra-generic variation in $\delta^{18}O$ values does not exceed a standard deviation (σ) of 1.1‰; for grazers, $\sigma < 0.9$‰, while for browsers $\sigma < 1.3$‰ (Bocherens et al., 1996). In fossil assemblages, $\delta^{18}O$ variability and σ may be interpreted in two ways. The pattern of fossil isotopic data could represent temporal mixing of individuals from different time periods that ingested meteoric water with different isotopic values; fossil assemblages with poor age constraints could thus be time-averaged accumulations (Koch et al., 1998). Alternatively, this intra-generic isotopic variation could represent geographic mixing of individuals whose tooth enamel mineralized in different contemporaneous climates, with one or more individuals migrating over large distances (Koch et al., 1998). Intra-tooth variability in $\delta^{18}O$ values is demonstrated to either match the amplitude of local seasonal variation or to be damped due to a time lag from a hydrologic process with a longer residence time (Sharp and Cerling, 1998).

Table 4. $\delta^{13}C$ and $\delta^{18}O$ data for large extinct herbivores from the Tule Springs assemblage (Connin et al., 1998).

Taxon	Unit	Age (ka)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
Antilocapridae	E_1	14.0-11.5	-10.8	29.5
Tetrameryx spp.	E_1	14.0-11.5	-10.9	24.2
Tetrameryx spp.	E_1	14.0-11.5	-9.9	28.4
Equus spp.	E_1	14.0-11.5	-6.3	25.1
Equus spp.	E_1	14.0-11.5	-8.8	24.0
Camelops spp.	E_1	14.0-11.5	-9.6	24.8
Camelops spp.	E_1	14.0-11.5	-8.0	25.8
Mammuthus spp.	E_1	14.0-11.5	-8.3	20.6
Mammuthus spp.	E_1	14.0-11.5	-9.0	20.6
Mammuthus spp.	D	22.0-17.0	-6.4	22.8
Bison spp.	B_2	≥40.0	-4.9	20.3
Bison spp.	B_2	≥40.0	-3.4	25.0
Mammuthus spp.	B_2	≥40.0	-6.4	19.3
Equus spp.	B_2	≥40.0	-1.6	22.5

Recovery of Isotopic Time-Series from Tooth Enamel

Isotopic analyses from teeth sampled serially along the primary growth axis produce an isotopic record of seasonality (Cerling and Sharp, 1996; Fricke and O'Neil, 1996). Mineralization time for tooth enamel varies between taxa, but generally takes 1 to 3 years for large ungulates and proboscideans (Kohn et al., 1998). As with bulk isotopic values from fossil mammals, serial sampling of fossil mammal teeth is used to address two primary types of questions: paleoenvironmental and paleobiological (Fricke and O'Neil, 1996). Paleoenvironmental reconstructions based on serially sampled teeth provide a subannual record of climate and vegetation change (Fricke et al., 1998; Fricke and

O'Neil, 1996; Sharp and Cerling, 1998). Intra-tooth isotopic variation also provides insight into subannual cyclicity in the habits of individual animals and may be used to infer seasonal or cyclic behavior and other biological aspects of extinct animals (Feranec and MacFadden, 2000; Hoppe, 2004; Koch et al., 1998). Several serial sampling studies have examined seasonal variability in fossil ungulate and proboscidean teeth (Feranec and MacFadden, 2000; Fricke et al., 1998; Koch et al., 1998; MacFadden, 2000). For example, Koch et al. (1998) identified $\delta^{18}O$ minima concurrent with tightly spaced growth structures and interpreted these minima to correspond with a winter season of slow growth and drinking water that was less evaporatively enriched in ^{18}O.

Koch et al. (1998) measured intratooth isotopic variation in a mammoth molar and showed a $\delta^{13}C$ range of only 0.5‰. They concluded that low within-individual variability made bulk samples particularly well-suited to faithfully tracking the average $\delta^{13}C$ value of an individual animal. However, Feranec and MacFadden (2000) measured intra-tooth variation and found that $\delta^{13}C$ value ranges within individuals varied considerably more. Their results show $\delta^{13}C$ ranges of 1.7‰ to 1.8‰ for *Mammuthus* and 0.9‰ to 3.1‰ for *Equus*. The range in intratooth $\delta^{13}C$ values for *Bison* was less than 0.8‰ for three specimens and 4.8‰ for a fourth *Bison* specimen (Feranec and MacFadden, 2000).

Use of isotopic microsamples to infer paleoenvironmental or paleobiological conditions has raised important questions about the validity of isotopic time series recovered from a single tooth, and whether these time series faithfully record a true environmental signal (Hoppe et al., 2004a; Sharp and Cerling, 1998). Recent studies of intra-tooth isotopic variation indicate that the process of enamel mineralization (amelogenesis) can take up to two weeks, potentially damping the record of a primary environmental signal of isotopic variation (Passey and Cerling, 2002). Other studies suggest that total amelogenesis in modern equids may continue for 6 to 12 months after eruption (Hoppe et al., 2004b). Furthermore, individual enamel layers form at a 5° to 10° angle with the enamel-dentine junction (EDJ) and then rotate to become parallel to the growth axis (Figure 3b; Hoppe et al., 2004b); sampling methods that bore deeply into the outer enamel surface are then perpendicular to the mineralization front and may average isotopic signatures. Modeling of attenuation of isotopic signals in ever-growing teeth demonstrates a faithful record of intra-tooth isotopic variation, although the primary signal is damped (Passey and Cerling, 2002).

Sampling strategy is thus of crucial importance when addressing paleoenvironmental and paleobiological questions with serial enamel samples. Initial attempts to recover primary isotopic time series from teeth were sampled along the outer surface of the enamel at regular intervals (Feranec and MacFadden, 2000; Fricke and O'Neil, 1996; MacFadden, 2000). However, this method does not account for averaging of the isotopic signal along the outer enamel surface due to rotation of the mineralization front. Zazzo et al. (2005) demonstrated that serial sampling along the enamel-dentine junction produced the least-attenuated signal with respect to primary isotopic variability (Figure 3a).

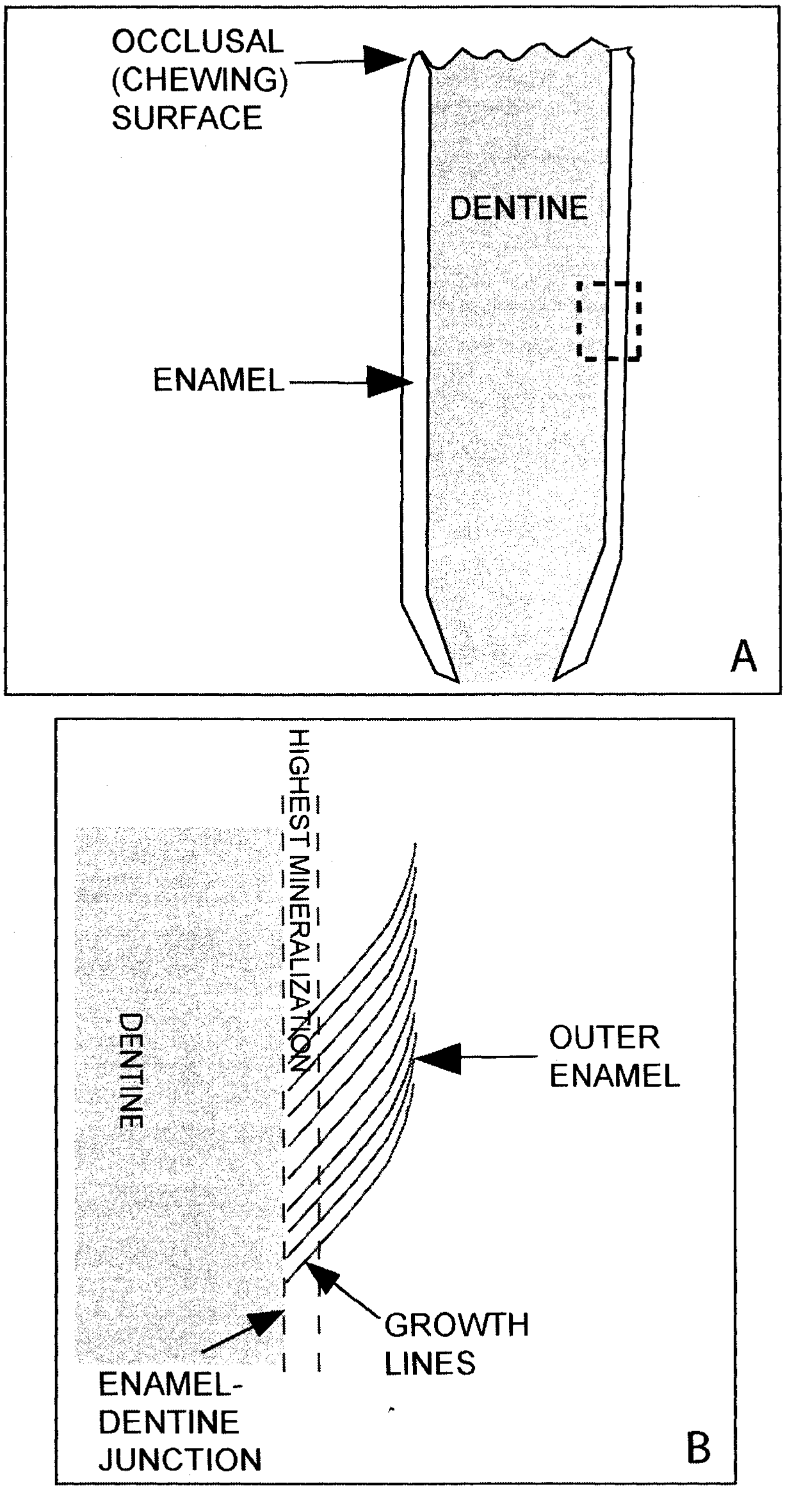

Figure 3. A) Cross-section of a typical ungulate tooth (box is shown magnified in B). B) Cross-section of enamel-dentine junction, showing highest degree of mineralization where growth lines are most perpendicular to growth direction.

CHAPTER 3

METHODS

Radiocarbon Dating

Six total *M. columbi* molars were selected for radiocarbon analysis (Table 5). Proboscideans grow six deciduous sets of molars over the course of their life spans; at any given time, one or two molars are present in each quadrant of the mouth. To avoid duplication between individuals, five of the teeth selected for analysis were right mandibular molars of M1 to M3 designation (fourth through sixth of six deciduous molars)(Haynes, 1991). One selected tooth (GIL MT-78) was a left mandibular molar of dP3 to M1 designation; this range encompasses the second through fourth of the set of deciduous molars, and this individual is thus of a different age (Haynes, 1991). Dentine samples were mechanically removed from between enamel plates.

Table 5. *Mammuthus columbi* molars selected for radiocarbon analysis. GIL numbers are from original excavation of the Gilcrease spring mound. Sample numbers correspond to numbering for stable isotopic analyses performed in this study.

GIL #	Sample #	Size	Quadrant
MT 65	MAM 1	M1-M2	R Mandible
MT 72	MAM 2	M1-M2	R Mandible
MT 8103	MAM 3	M1-M2	R Mandible
MT 73	MAM 4	M3	R Mandible
MT 78	MAM 5	dP3-M1	L Mandible
MT 7	--	M1	R Mandible

For each specimen, one dentine and two enamel samples were analyzed for radiocarbon dates. The dentine samples were prepared using a method developed for bone (dos Santos, 2006). Samples were treated with 0.5N HCl for 24 hours. Visual inspection indicated that no humic contaminants were present, so an alkali treatment step was omitted. Samples were hydrolyzed with 0.01N HCl at 70°C for 10 hours; the resulting gelatinized solution was then centrifuged through ultra-filters to remove excess water. The gelatinized solution was freeze-dried and centrifuged in an evacuated chamber for 8 hours. After cryogenic treatment and freeze-drying, no collagen remained for further analysis. This is consistent with the taphonomic properties of the Gilcrease site and the poor preservation of organic-rich skeletal components.

Enamel samples were leached with 0.01N HCl at 80°C to remove secondary carbonates. Samples were then acidified with 85% H_3PO_4 in vacuum tubes and heated to produce CO_2. The CO_2 from each sample was graphitized at 550°C using a hydrogen reduction method with Fe powder as a catalyst. Graphite samples were analyzed for radiocarbon on an NEC 0.5MV 1.5SDH-2 AMS particle accelerator. Initial enamel samples from each specimen consisted of approximately 15 mg of apatite and yielded very little CO_2 after acidification. Additional enamel samples from the same specimens were prepared with approximately 50 to 60 mg of initial apatite material. All sample preparation and analysis took place at the Keck Carbon Cycle AMS facility at the University of California, Irvine. Results are in radiocarbon years (RCyBP); calendar year age calibrations were performed using CALIB software version 5.0.1 (Stuiver and Reimer, 1993). Calendar year ages are calibrated for post-nuclear testing ages to the IntCal04 curve for terrestrial radiocarbon ages 26 ka to present (Reimer et al., 2004).

Stable Isotope Analysis

Five molars each were selected from four genera: *Mammuthus*, *Equus*, *Bison*, and *Camelops*. *Mammuthus* molars were selected from the radiocarbon analyses described above; for the other three genera, specimens were selected on the basis of disparate size to decrease the potential of repeated sampling of the same individual. Each tooth was mechanically prepared for serial sampling along the growth axis at the enamel-dentine junction (EDJ). Dentine was removed with a Dremel tool and the enamel surface was cleaned with alcohol. *M. columbi* molars were sampled with a Sherline 5410 microdrill at 5 mm interval along the EDJ. Other ungulate teeth were sampled with a Foredom rotary tool and a dental burr along the EDJ at sampling intervals that varied from 2 to 3 mm (Figure 4).

From tooth enamel carbonate-apatite $[Ca_5(PO_4,CO_3,OH)_3(F,OH)]$, the carbonate component was analyzed for $\delta^{13}C$ and $\delta^{18}O$ values. For each sample, 3-5 mg powdered enamel was treated with 30% H_2O_2 overnight to remove organic material. Samples were rinsed with deionized water and treated with 0.1N acetic acid to remove diagenetic carbonate, then rinsed with ethanol and air-dried. Apatite samples were then pre-roasted in a vacuum at 75°C for 30 minutes. For stable isotope analysis, 400-1000 μg of sample were reacted in a phosphoric acid bath at 90°C and analyzed on the directly coupled dual inlet of a GV Instruments Optima isotope ratio mass spectrometer at the University of California, Davis. Isotopic ratios are reported in VPDB values. One σ error is +/- 0.04 per mil for $\delta^{13}C$ and +/-0.06 per mil for $\delta^{18}O$.

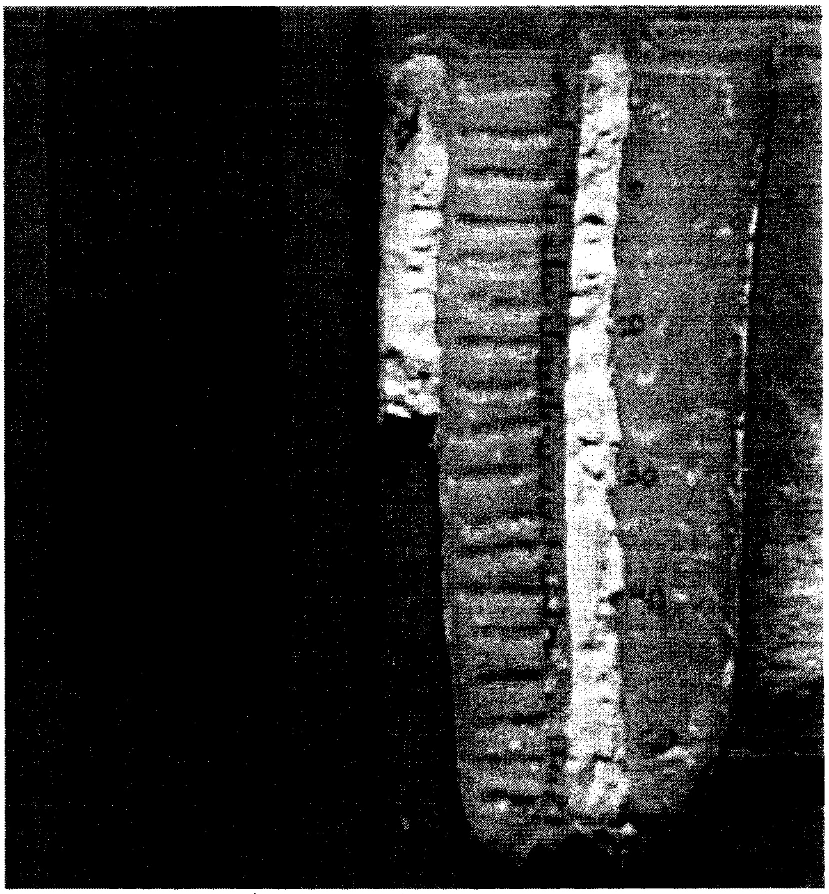

Figure 4. Photograph of sampling technique for ungulate teeth. Dentine was mechanically removed from interior of tooth; samples were collected at 2 to 3 mm intervals along the enamel-dentine junction.

The mean differences between genera were compared using ANOVA. The Student-Newman-Keuls multiple comparisons test was used to compare means between different genera. The GraphPad InStat 3 Macintosh version was used to calculate the statistics.

Methods for Vegetation Reconstruction

Vegetation records are available for the Pleistocene in the form of macroscopic fossils (packrat middens) and pollen data (from both sedimentary deposits and packrat middens). Packrats usually colonize rocky, upland habitats. Thus, packrat middens preferentially record vegetation from high-altitude, mountainous regions, and are less suitable for reconstructions of valley vegetation (Finley, 1990). Pollen data are available from sediments at the Tule Springs site (Mehringer, 1967) and from low-elevation packrat middens at other Mojave Desert localities (Koehler et al., 2005). However, identification of grass pollen at the genus level is difficult and rarely attempted, and pollen spectra usually only report percent abundance of the grass family (Poaceae or Gramineae). Determination of the percent abundance of C_3 and C_4 grasses is therefore not possible from palynological analyses alone.

In addition to some grasses, a few other plants utilize the C_4 pathway, and may affect the isotopic value of vegetation as a whole. Pollen spectra record the presence of plants in the family Chenopodiaceae. In southwestern North America, this group is primarily represented by *Atriplex* spp. (shadscale), a shrub that uses the C_4 pathway. Pollen records also indicate the presence of *Amaranthus* (Amaranthaceae), another C_4 plant. Isotopic reconstructions of the absolute proportion of C_3 and C_4 plants for this region should also account for the presence of these non-grass C_4 plants. Interpretations of herbivore diet and feeding strategy from isotopic data in this study thus incorporate the estimated abundances of C_3 and C_4 plants of several different functional types.

Plants that utilize the Crassulacean Acid Metabolism (CAM) have $\delta^{13}C$ values intermediate between C_3 and C_4 plants; these include *Yucca* spp. and other succulent plants common in modern vegetation assemblages in southwestern North America. However, palynological records indicate that CAM plants were not present north of 36°N latitude in the Mojave Desert during the LGM (Koehler et al., 2005). Furthermore, CAM plants are not a demonstrable component of the diets of modern large herbivores; since there is little reason to assume that these plants were preferentially selected by Pleistocene herbivores, CAM plants are not discussed further here.

Several workers have presented predictive models for C_4 abundance. These models were formulated by testing the dependence of C_4 abundance on several different climatic variables, statistically identifying the variables with the most influence, and then producing a model based on these variables. Most of these models were calculated for a much lower mean annual temperature (MAT) and much higher mean annual precipitation (MAP) than observed in modern-day southern Nevada. Predictive models must be used with some caution, although calculations from modern climate data do concur with vegetation results for some models.

To estimate the percentage of C_4 plants present in the Las Vegas Valley during the Last Glacial Maximum, I used a predictive statistical model that calculated an estimate using independent paleoclimatic data. First, I present a model commonly used in association with isotopic studies of herbivore diet in wetter climates (Teeri and Stowe, 1976). This method produces an estimate of C_4 grasses for the modern climate in southern Nevada that is not consistent with modern vegetation assemblages, and is thus a poor estimator of C_4 grass abundance in the Pleistocene. I then present a second method that incorporates different climate parameters, including precipitation, and provides an estimate of modern C_4 grass abundance consistent with observed vegetation.

The estimate from the Paruelo and Lauenroth (1996) model is then combined with palynological data from the Tule Springs assemblage to estimate the total percentage of C_4 grass in the Las Vegas Valley during the LGM. In addition, I used the Tule Springs pollen spectra to calculate percent abundance of plants in the Chenopodiaceae family and of the genus *Amaranthus*, and used this value as an estimate for the abundance of non-grass C_4 plants. The combined percentage of C_4 grasses and C_4 shrubs provide the total C_4 plant biomass for the Las Vegas Valley during the LGM.

Calculation of %C_4 Grass from Reconstructed Climate Parameters

Teeri and Stowe (1976) used a multiple stepwise regression to determine the roles of various climatic variables in determining the relative abundance of C_3 and C_4 grasses. They found that the abundance of C_4 grasses in modern ecosystems was dependent on three primary climatic variables, all functions of temperature, and produced the following equation:

$$\%C4 = (1.60 \times TJM) + (0.0086 \times D\mu) - (8.98 \times \log F\mu) - 22.44$$

where T_{JM} = normal July minimum temperature (°F)

D_μ = mean annual degree days above 65°F

F_μ = mean annual freeze-free period (days)

Modern climate data for the Las Vegas Valley have values for these variables of T_{JM} = 73.2°F, D_μ = 2968, and F_μ = 302 days (WRCC, 2007); this produces an estimate of 97% C_4 grass abundance using the Teeri and Stowe (1976) model. Modern vegetation surveys do not support the value produced by this model (Quade et al., 1987).

Initial estimates of mean annual temperature (MAT) for the LGM range from 6.5°C to 7.5°C, a 6 to 7°C drop from present MAT values (Spaulding, 1985). These estimates were based on data compiled from several packrat midden analyses, using the modern ranges of plant taxa observed in the middens. More recent analysis of these data using new techniques yields MAT values of 7.9°C to 8.5°C for the LGM, a 4.9 to 5.5°C drop from the present MAT value (Thompson et al., 1999). I used both estimates of temperature change in my reconstruction of paleoclimatic variables for this exercise to produce a range of possible $\%C_4$ values (Table 6).

Table 6. Calculated climate variables for the Las Vegas Valley during the LGM using estimates of MAT from various datasets, and predicted %C4 values.

Reference	Time	Temp. drop °C	Temp. drop °F	T_{JM} (°F)	D_μ	F_μ	$\%C_4$
WRCC, 2007	Modern	0	0	73.2	2903	302	97
Thompson et al., 1999	LGM max	4.9	8.82	64.4	1443	238	72
Thompson et al., 1999	LGM min	5.5	9.9	63.3	1291	231	69
Spaulding, 1985	LGM max	6	10.8	62.4	1169	227	66
Spaulding, 1985	LGM min	7	12.6	60.6	948	208	62

Several studies have used the Teeri and Stowe (1976) model to estimate or calculate percent C_4 grass abundance. However, this method accounts for only two functional types of vegetation: C_3 and C_4 grasses. In pure grasslands, this model is appropriate and applicable (Fox and Koch, 2003); in areas with mixed plant communities, other vegetation types may dominate that are not accounted for by this model. In addition, the model is based solely on temperature. In the Mojave Desert, where aridity is a substantial factor in determining vegetation communities, the predictive power of this model is poor.

Paruelo and Lauenroth (1996) developed a model for the abundance of several plant functional types in western North America that predicted percent productivity and absolute productivity. They identified five plant functional types: C_3 grasses, C_4 grasses, shrubs, herbaceous plants, and succulents. They then used a multiple stepwise regression to determine the relationship between the abundance of each plant functional type and several climatic variables. The climatic factors that were most influential were MAT, mean annual precipitation (MAP), and the proportion of MAP that occurred during the summer months (JJA/MAP). According to this model, C_4 grass abundance is determined by the following equation:

$$\%\mathbf{C4} = -0.9837 + (0.000594 \times \mathrm{MAP}) + (1.3528 \times \mathrm{JJA/MAP}) + (0.2710 \times \ln(\mathrm{MAT}))$$

where MAP = Mean annual precipitation (mm)

JJA/MAP = Proportion of mean annual precipitation that occurs during June, July, and August

MAT = Mean annual temperature (°C)

Modern climate data for the Las Vegas Valley have values for these variables of MAT = 19.2°C, MAP = 125 mm, and JJA/MAP = 0.16 (WRCC, 2007); this produces an estimate of 9% C_4 grass abundance using the Paruelo and Lauenroth (1996) model. Modern vegetation surveys are in approximate agreement with this estimate (Quade et al., 1987). To assess a range of possible values for %C_4 vegetation, I used a range of estimates of MAP, and of net decreases in MAT (Table 7; Spaulding, 1985; Thompson et al., 1999). Climate circulation models for the LGM are highly debated, and reconstructions of seasonality of precipitation for this interval are controversial (Connin et al., 1998). I estimated the proportion of summer precipitation to be approximately equal to modern precipitation (Paruelo and Lauenroth, 1996).

Table 7. Calculated climate variables for the Las Vegas Valley during the LGM using estimates of MAT, MAP, and seasonality of precipitation. Predicted %C4 abundance is also reported, using the Paruelo and Lauenroth (1996) model.

Reference	Interval	MAT (°C)	MAP (mm)	JJA/MAP	%C_4
WRCC, 2007	Modern	19.2	125	0.15	9
Thompson et al., 1999	LGM max T	14.3	266	0.15	10
Thompson et al., 1999	LGM max T	14.3	321	0.15	13
Thompson et al., 1999	LGM min T	13.7	266	0.15	9
Thompson et al., 1999	LGM min T	13.7	321	0.15	12
Spaulding, 1985	LGM max T	13.2	246	0.15	6
Spaulding, 1985	LGM max T	13.2	265	0.15	8
Spaulding, 1985	LGM min T	12.2	246	0.15	4
Spaulding, 1985	LGM min T	12.2	265	0.15	5

This model for prediction of vegetation using several plant functional types is more inclusive of potential shrub, succulent, and forb components; I therefore use the range of

$\%C_4$ abundance calculated here to estimate the abundance of C_4 grasses in the Las Vegas Valley during the LGM.

Correlation with Other Vegetation Data

Mehringer (1967) identified pollen types from various stratigraphic levels within the Tule Springs excavation that were correlated with radiocarbon dates. Fossil pollen spectra were reported for Unit D (31,300 to 22,600 yr BP) and Unit E_1 (9920 yr BP and younger). Spring Mound 4A is correlated between Units D and E_1, and also provides a pollen spectrum for the interval between the top of Unit D and the base of Unit E_1. The high volume of *Pinus* pollen from preferential aerial transport (up to 80% in Unit D and 60% in Spring Mound 4A) may result in an underrepresentation of other taxa (Solomon and Silkworth, 1986). The percent abundance of grass pollen ranged from 0 to 8% in Unit D, had a value of ~10% in Spring Mound 4A, which correlates between Units D and E_1, and had a value of 8% at the base of Unit E. These values estimate the total abundance of C_3 and C_4 grasses combined, and may underestimate this abundance. Given the potential for underrepresentation of grass abundance from pollen data alone, and since palynologically-derived abundance values are approximately equal to C_4 abundances predicted by the Paruelo and Lauenroth (1996) model, I used estimates from the model of 4 to 13% C_4 grass at the LGM.

Modern "Cheno-am" pollen rain (from the family Chenopodiaceae and the genus *Amaranthus*) is approximately 8% on the Kyle Canyon fan; this value fluctuates in an altitudinal transect of the Spring Mountains and reaches a peak abundance of 20% at 1500 m (Mehringer, 1967). Cheno-am pollen counts ranged from 1 to 6% in Unit D, had a value of ~3% in Spring Mound 4A, and had a value of 5% at the base of Unit E_I. Cheno-am abundances of 10% are reported from pollen spectra in LGM-age packrat middens for other nearby Mojave Desert localities (Koehler et al., 2005). As with all data recovered from pollen spectra, the abundances of non-*Pinus* taxa may be under-reported.

I used a conservative estimate of 5% abundance of non-grass C_4 taxa for the LGM to late glacial transition. With the inclusion of estimated abundance of C_4 grasses of 4 to 13%, estimates of total $\%C_4$ plant abundance for the LGM therefore range from 9 to 18%. These abundances of C_4 plants of various functional types are used in conjunction with interpretations of feeding habits from dental morphology to interpret Pleistocene mammal diet from $\delta^{13}C$ values.

CHAPTER 4

RESULTS

Radiocarbon Dates

The radiocarbon ages of mammoth molars from enamel samples are summarized in Table 8. The lack of collagen in pre-treatment of dentine for radiocarbon analysis is consistent with the poor or nonexistent preservation of bones in the spring deposit. Two samples from each tooth were analyzed, except in cases of sample loss. Radiocarbon ages are reported in both ^{14}C yr BP and as ranges in thousands of years ago (ka) (Reimer et al., 2004).

Table 8. Radiocarbon ages of mammoth molars from analysis of enamel samples. Both radiocarbon ages (BP) and calibrated ages (ka) are reported.

Sample	UCIAMS #	^{14}C age (BP)	IntCal04 CAL range (ka)
MAM 1	28539	13960 ± 80	16424 – 16852
MAM 1	28548	15270 ± 35	18621 – 18724
MAM 2	28540	15880 ± 110	18951 – 19176
MAM 2	28549	17630 ± 45	20618 – 20950
MAM 3	28542	14210 ± 80	16730 – 17182
MAM 3	28551	14975 ± 40	18113 – 18381
MAM 4	28538	13360 ± 70	15654 – 16046
MAM 5	28541	15290 ± 110	18595 – 18774
MAM 5	28550	15015 ± 35	18141 – 18359
MT 7	28537	18350 ± 160	21572 – 22119
MT 7	28547	18200 ± 50	21499 – 21885

Duplicate samples from the same tooth fail to yield consistent radiocarbon ages within one standard deviation; therefore, these data are suspect. Low carbon content in tooth enamel carbonate-apatite resulted in significantly lower precision in AMS dates, and these data demonstrate that high-resolution dating is difficult if not impossible using tooth enamel alone. However, the span of radiocarbon ages from 22.2 ka to 16.4 ka is consistent with the hypothesis that these fossils are a time-averaged accumulation, and provides a range of ages for context of further paleoenvironmental interpretations.

Mean $\delta^{13}C$ and $\delta^{18}O$ Values

Mean isotopic data from tooth enamel analyses are displayed in Table 9 and Figure 5. Values displayed are the calculated means of intra-tooth analyses for each individual animal, and are reported with respect to VPDB. The $\delta^{13}C$ and $\delta^{18}O$ values of individuals from each genus are displayed in Figures 6 through 9 with one σ error bars for each individual. The average $\delta^{13}C$ value for *Mammuthus* is -8.45‰ with a standard deviation of 0.54‰, and the range of $\delta^{13}C$ values is -9.18‰ to -8.00‰. The average $\delta^{13}C$ value for *Equus* is -8.14‰ with a standard deviation of 0.48‰. The range of $\delta^{13}C$ values for *Equus* is -8.83‰ to -7.42‰.

Table 9. Mean isotopic values for carbon and oxygen isotopes and percent C_4 plants in the diet from tooth enamel samples, Gilcrease spring mound, Las Vegas Valley, Nevada.

		$\delta^{13}C$ VPDB (‰)			$\delta^{18}O$ VPDB (‰)			
Taxon	n	Average	S.D.	Range	Average	S.D.	Range	% C_4
Mammuthus	5	-8.44	0.54	-9.18 to -8.00	-14.42	0.54	-15.32 to -13.96	12 – 23
Equus	5	-8.16	0.59	-8.83 to -7.42	-11.07	0.61	-11.71 to -10.08	15 – 28
Bison	5	-8.72	1.70	-10.22 to -5.97	-13.21	1.56	-15.42 to -11.13	3 – 41
Camelops	5	-6.54	1.24	-8.49 to -5.23	-11.65	0.82	-12.54 to -10.67	18 – 48

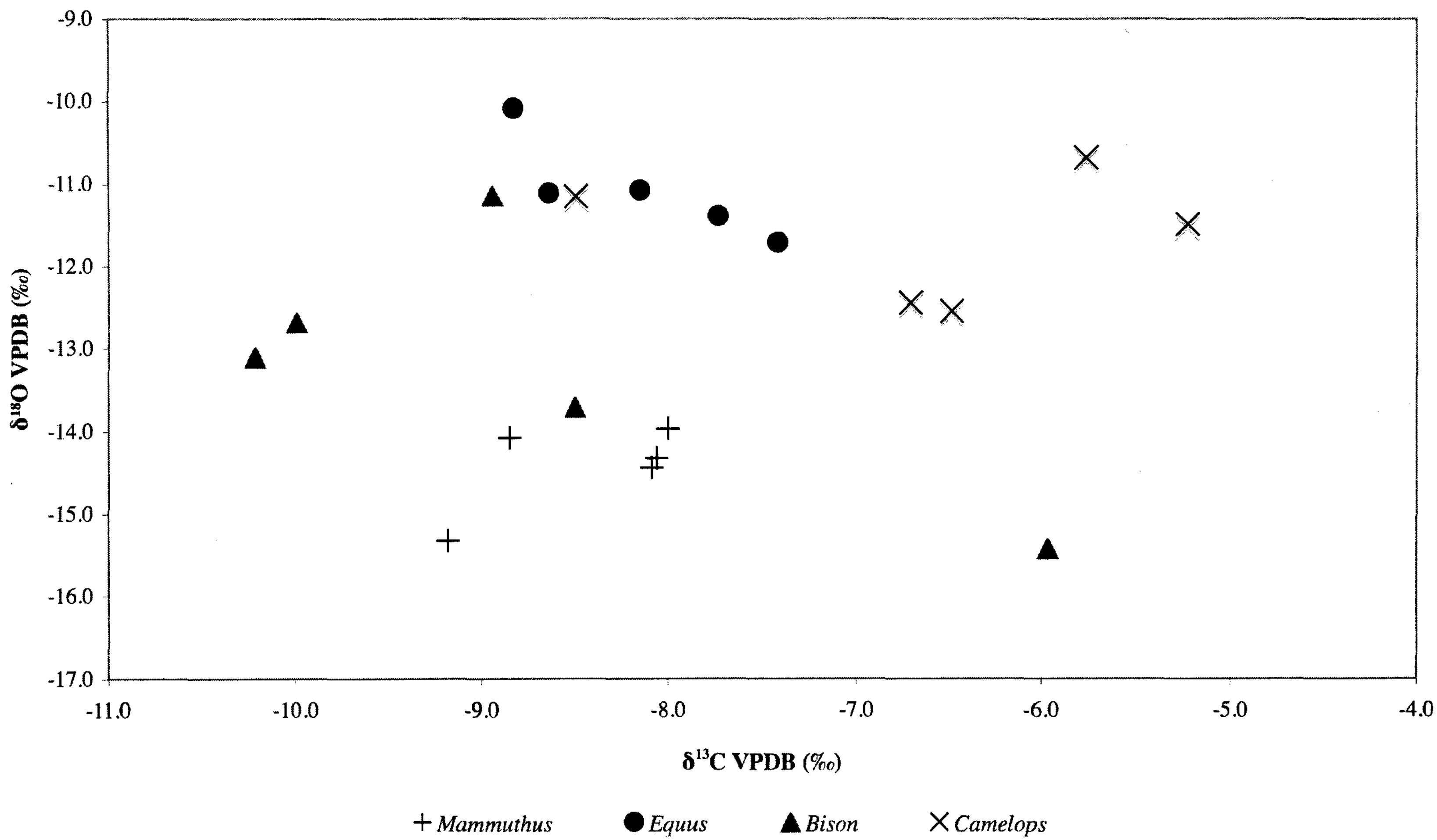

Figure 5. Bulk carbon and oxygen isotope values for *Mammuthus*, *Equus*, *Bison*, and *Camelops*. Dietary variation between taxa is indicated by differences in carbon isotopic values.

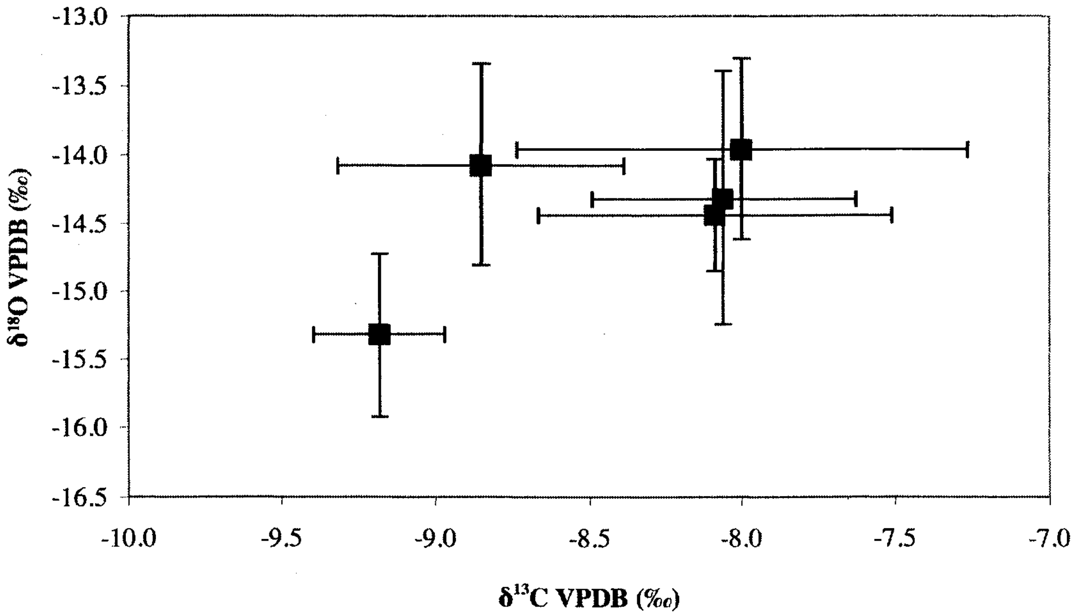

Figure 6. Mean $\delta^{13}C$ and $\delta^{18}O$ values for *Mammuthus*. Error bars show one standard deviation as calculated using the range of intratooth values from each individual.

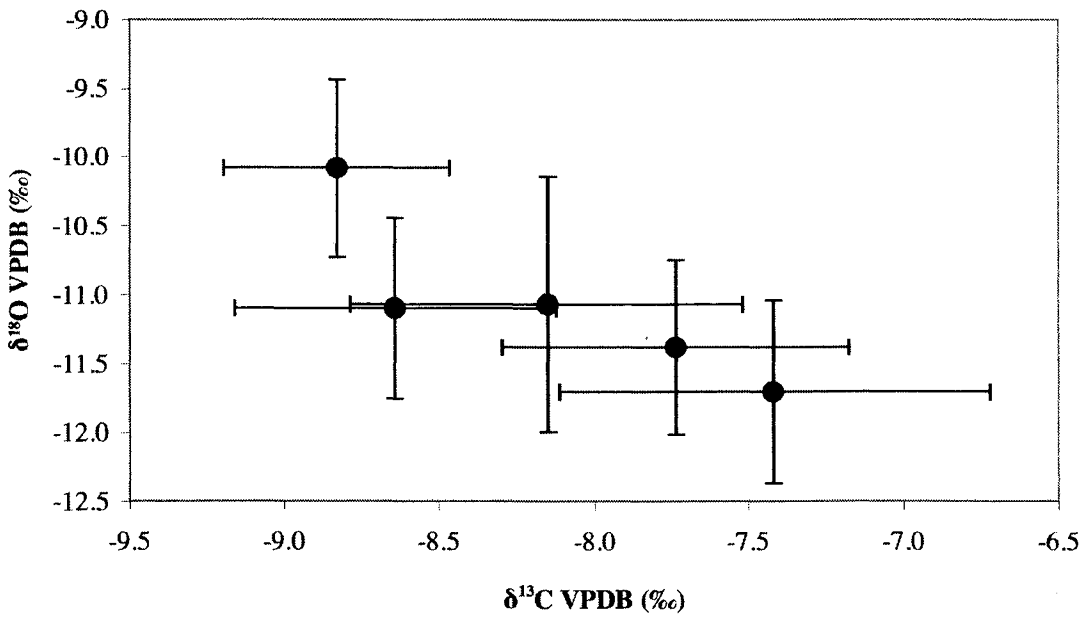

Figure 7. Mean $\delta^{13}C$ and $\delta^{18}O$ values for *Equus*. Error bars show one standard deviation as calculated using the range of intratooth values from each individual.

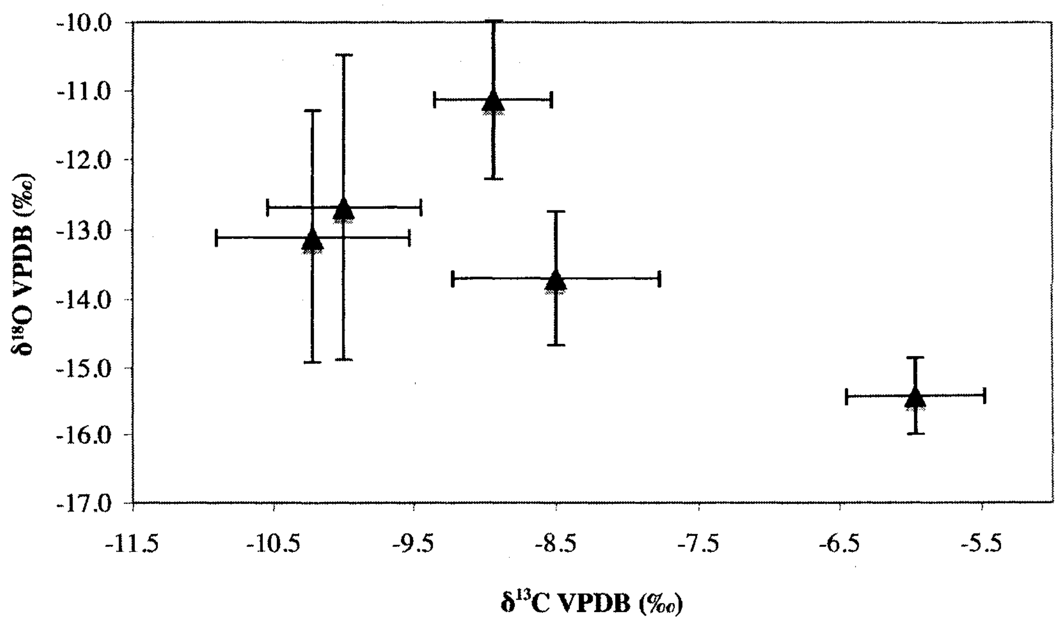

Figure 8. Mean $\delta^{13}C$ and $\delta^{18}O$ values for *Bison*. Error bars show one standard deviation as calculated using the range of intratooth values from each individual.

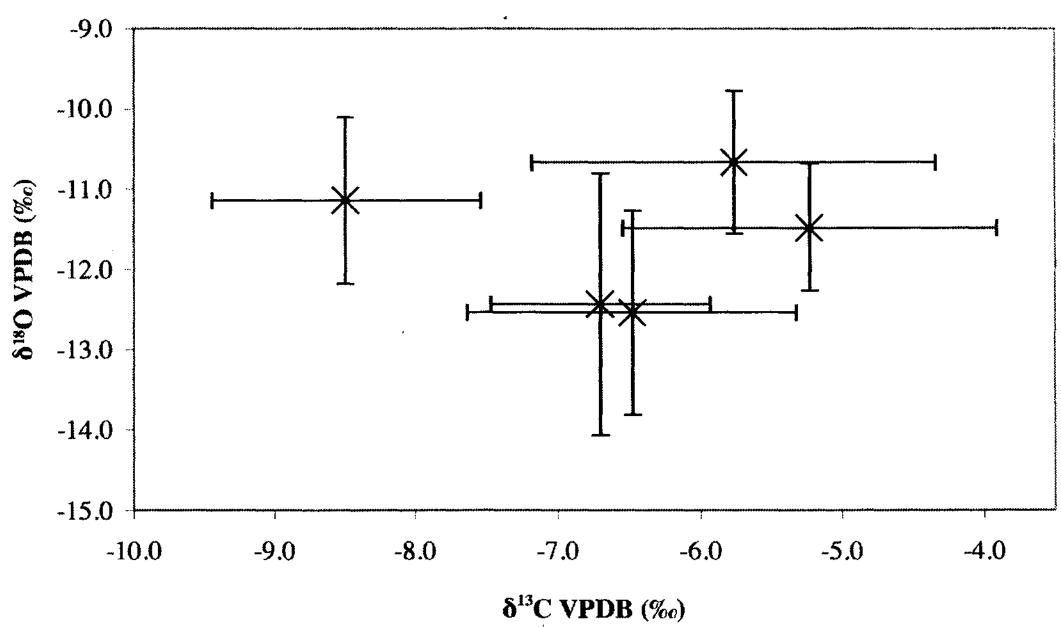

Figure 9. Mean $\delta^{13}C$ and $\delta^{18}O$ values for *Camelops*. Error bars show one standard deviation as calculated using the range of intratooth values from each individual.

Carbon isotope values vary considerably more between individuals for the *Bison* and *Camelops* specimens analyzed (Figure 5). The average $\delta^{13}C$ value for *Bison* is -8.72‰ with a standard deviation of 1.70‰, and the range of $\delta^{13}C$ values for *Bison* is -10.22‰ to -5.97‰. The average $\delta^{13}C$ value for *Camelops* is -6.53‰ with a standard deviation of 1.24‰, and the range of $\delta^{13}C$ values for *Camelops* is -8.49‰ to -5.23‰.

Oxygen isotope values are also reported as the calculated means of all intra-tooth analyses for each individual animal; values are reported here with respect to VPDB (Table 9). The average $\delta^{18}O$ value for *Mammuthus* is -14.42‰ with a standard deviation of 0.54‰; values range from -15.32‰ to -13.96‰. The average $\delta^{18}O$ value for *Equus* is -11.07‰ with a standard deviation of 0.61‰; values range from -11.17‰ to -10.08‰. The average $\delta^{18}O$ value for *Bison* is -13.21‰ with a standard deviation of 1.56‰; values range from -15.42‰ to -11.13‰. The average $\delta^{18}O$ value for *Camelops* is -11.65‰ with a standard deviation of 0.82‰; values range from -12.54‰ to -10.67‰.

Statistical Analysis of Bulk Isotopic Data

Statistical analysis of differences in $\delta^{13}C$ values between genera was performed using ANOVA; the Student-Newman-Keuls post-test was used to evaluate differences in $\delta^{13}C$ values between individual pairs of genera. Significant differences in $\delta^{13}C$ values are observed between genera ($P<0.03$). Paired comparisons between *Mammuthus*, *Equus*, and *Bison* show that there are no significant differences between any two of these taxa. *Mammuthus*, *Equus*, and *Bison* all exhibit average $\delta^{13}C$ values that indicate ≤20% proportion of C_4 plants in the diet. Individual paired comparisons between *Camelops* and each of these three taxa show significant differences ($P<0.05$). The carbon isotopic values for *Camelops* indicate that this taxon had the highest proportion of C_4 plants in its diet.

Intra-Tooth Variation in Isotopic Values

Serial tooth enamel samples were collected from five individuals from each genus (Tables 10 and 11). Average values from each individual were treated as bulk samples and are reported in the Mean $\delta^{13}C$ and $\delta^{18}O$ Values section above. The serial sample isotopic data display some intra-tooth cyclicity; this pattern is more pronounced for some genera than others (Figures 10 through 29).

Variation in carbon and oxygen isotopes in *Mammuthus* is displayed in Figures 10 through 14. All intratooth $\delta^{13}C$ variations in *Mammuthus* have similar means (Table 10). The range of $\delta^{13}C$ values for a single individual varies from 0.85‰ to 2.58‰; the average range is 1.71‰. The average within-individual standard deviation is 0.49‰. For all *Mammuthus* specimens, $\delta^{13}C$ values show little correlation with $\delta^{18}O$ values. MAM 4 shows approximately two cycles of isotopic variation in carbon and oxygen (Figure 13). Specimens MAM 1, MAM 2, and MAM 5 show two to three cycles of variation (Figures 10, 11, and 14). MAM 3 shows three to four cycles of variation (Figure 12).

Carbon and oxygen isotope variations for *Equus* are displayed in Figures 15 through 19. Mean values of intratooth variations are similar between individual *Equus* specimens (Tables 10 and 11). Ranges of $\delta^{13}C$ values for individuals vary from 1.27‰ to 2.65‰, with an average range of 1.95‰. The average within-individual standard deviation is 0.55‰. Most *Equus* specimens show some inverse correlation between $\delta^{13}C$ and $\delta^{18}O$ values. Specimens EQS 2, EQS 4, and EQS 5 all show one to two cycles of variation

(Figures 16, 18, and 19). EQS 3 shows approximately four complete cycles of isotopic variation (Figure 17). Intratooth isotopic data for EQS 1 follow no particular trend (Figure 15).

Intratooth measurements of carbon and oxygen isotope values for *Bison* are displayed in Figures 20 through 24. Mean values of intratooth $\delta^{13}C$ variation vary considerably between individuals, from -10.22‰ to -5.97‰ (Table 10). The range of $\delta^{13}C$ values in a single individual varies from 1.44‰ to 2.24‰, with an average range of 1.80‰. The average intratooth standard deviation is 0.57‰. The total span of $\delta^{13}C$ values between individuals is much greater than the $\delta^{13}C$ range for any given individual. All *Bison* specimens show inverse variation between $\delta^{13}C$ and $\delta^{18}O$ values; r^2 values range from 0.41 to 0.91 for four specimens (BIS 2, BIS 3, BIS 4, and BIS 5). BIS 1 displays two to three potential cycles in carbon and oxygen isotope variation (Figure 20). BIS 2, BIS 4, and BIS 5 all show one to two cycles (Figures 21, 23, and 24). BIS 3 shows less than one full cycle of variation (Figure 22).

Variation in carbon and oxygen isotopic values in *Camelops* is displayed in Figures 25 through 29. Mean values of intratooth $\delta^{13}C$ variation vary from -8.49‰ to -5.23‰, although with the exception of CAM 5 ($\delta^{13}C_{mean}$= -8.49‰), mean values for *Camelops* are > -7‰. Ranges of $\delta^{13}C$ values for individuals vary from 2.35‰ to 4.78‰, with an average range of 3.30‰. The average within-individual standard deviation is 1.12‰. Although the range of intratooth $\delta^{13}C$ values for any given individual is relatively high with respect to other taxa in this study, these ranges overlap within the span of mean values for each individual (Figure 9). Some *Camelops* specimens show approximate inverse variation between $\delta^{13}C$ and $\delta^{18}O$ values. CAM 1 and CAM 2 display greater than one cycle in oxygen and carbon isotope variation (Figures 25 and 26). CAM 4 displays one to two cycles (Figure 28); CAM 3 displays two complete cycles (Figure 27). CAM 5 displays one complete cycle in $\delta^{18}O$ values, but no apparent cyclicity in $\delta^{13}C$ values (Figure 29).

Table 10. Serial sample results for carbon isotope values in tooth enamel of *Mammuthus*, *Equus*, *Bison*, and *Camelops*.

		δ^{13}C VPDB (‰)					Averages of individual intratooth values		
Specimen	n	Mean	S.D.	Max.	Min.	Range	Mean	S.D.	Range
MAM 1	21	-8.00	0.74	-6.88	-9.46	2.58			
MAM 2	19	-8.06	0.43	-7.34	-8.93	1.59			
MAM 3	21	-8.09	0.58	-7.20	-15.29	1.90	-8.44	0.49	1.71
MAM 4	22	-9.18	0.21	-8.77	-9.62	0.85			
MAM 5	17	-8.85	0.46	-7.76	-9.40	1.64			
EQS 1	16	-7.74	0.56	-6.04	-8.25	2.21			
EQS 2	17	-8.15	0.63	-7.36	-9.33	1.97			
EQS 3	24	-8.83	0.36	-8.12	-9.39	1.27	-8.16	0.55	1.95
EQS 4	18	-7.42	0.70	-5.84	-8.49	2.65			
EQS 5	15	-8.64	0.52	-7.83	-9.49	1.66			
BIS 1	18	-8.94	0.41	-7.99	-9.44	1.44			
BIS 2	16	-9.99	0.55	-9.16	-10.82	1.66			
BIS 3	15	-8.50	0.72	-7.78	-10.03	2.24	-8.72	0.57	1.80
BIS 4	15	-5.97	0.49	-5.21	-6.79	1.57			
BIS 5	16	-10.22	0.69	-9.47	-11.57	2.09			
CAM 1	15	-6.48	1.16	-4.92	-7.94	3.01			
CAM 2	13	-5.23	1.32	-3.45	-7.21	3.75			
CAM 3	20	-6.70	0.77	-5.17	-7.77	2.60	-6.54	1.12	3.30
CAM 4	16	-5.76	1.42	-3.16	-7.94	4.78			
CAM 5	18	-8.49	0.95	-7.20	-9.55	2.35			

Table 11. Serial sample results for oxygen isotope values in tooth enamel of *Mammuthus*, *Equus*, *Bison*, and *Camelops*

		$\delta^{18}O$ VPDB (‰)					Averages of individual intratooth values		
Specimen	n	Mean	S.D.	Max.	Min.	Range	Mean	S.D.	Range
MAM 1	21	-13.96	0.65	-11.86	-15.07	3.21			
MAM 2	19	-14.32	0.92	-12.66	-16.09	3.44			
MAM 3	21	-14.44	0.41	-13.68	-15.29	1.61	-14.42	0.67	2.73
MAM 4	22	-15.32	0.60	-14.11	-16.50	2.38			
MAM 5	17	-14.08	0.73	-12.59	-15.60	3.01			
EQS 1	16	-11.38	0.63	-10.52	-12.78	2.26			
EQS 2	17	-11.07	0.92	-8.96	-12.34	3.38			
EQS 3	24	-10.08	0.65	-9.02	-11.32	2.29	-11.07	0.70	2.55
EQS 4	18	-11.71	0.66	-10.67	-12.79	2.12			
EQS 5	15	-11.10	0.66	-10.17	-12.87	2.71			
BIS 1	18	-11.13	1.12	-9.72	-13.73	4.01			
BIS 2	16	-12.68	2.13	-7.89	-15.01	7.12			
BIS 3	15	-13.70	0.94	-11.78	-14.90	3.12	-13.21	1.30	4.34
BIS 4	15	-15.42	0.55	-14.09	-16.22	2.13			
BIS 5	16	-13.11	1.76	-10.00	-15.33	5.33			
CAM 1	15	-12.54	1.23	-11.27	-14.62	3.35			
CAM 2	13	-11.48	0.77	-9.46	-11.98	2.52			
CAM 3	20	-12.44	1.58	-9.96	-14.68	4.72	-11.65	1.09	3.45
CAM 4	16	-10.67	0.86	-9.22	-11.94	2.72			
CAM 5	18	-11.14	1.01	-9.01	-12.94	3.93			

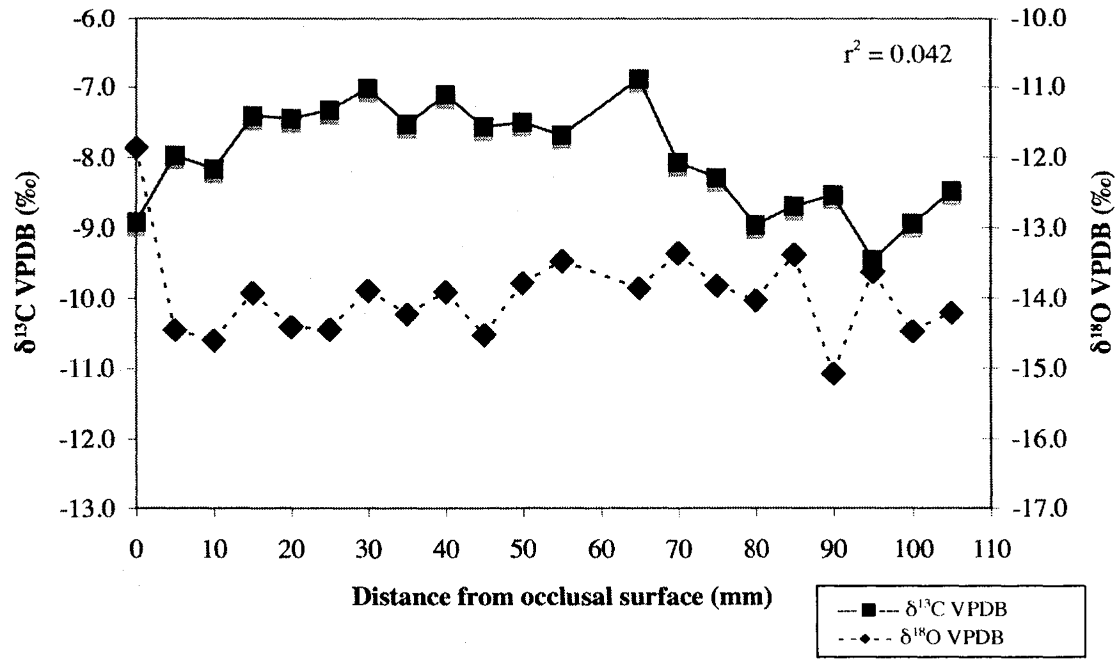

Figure 10. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Mammuthus* specimen MAM 1.

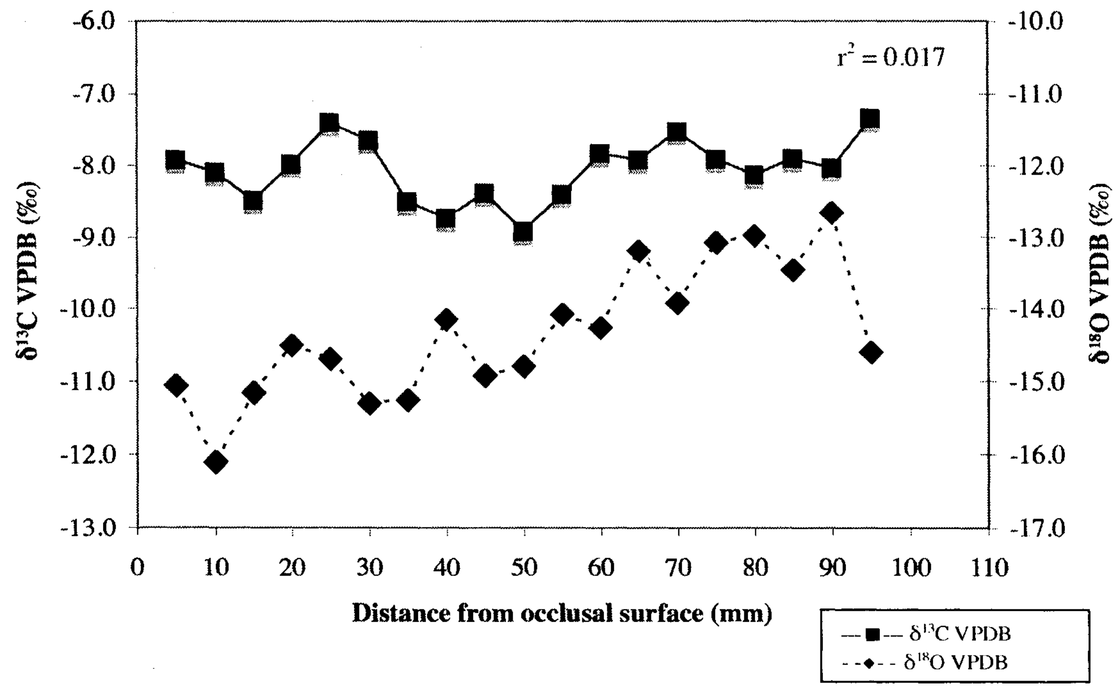

Figure 11. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Mammuthus* specimen MAM 2.

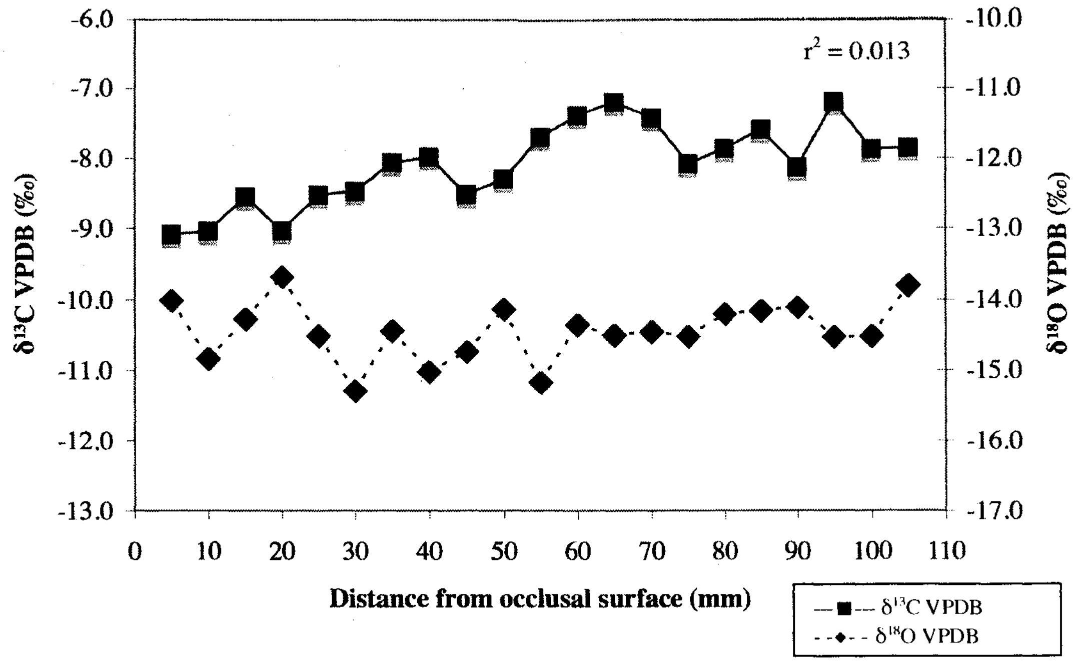

Figure 12. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Mammuthus* specimen MAM 3.

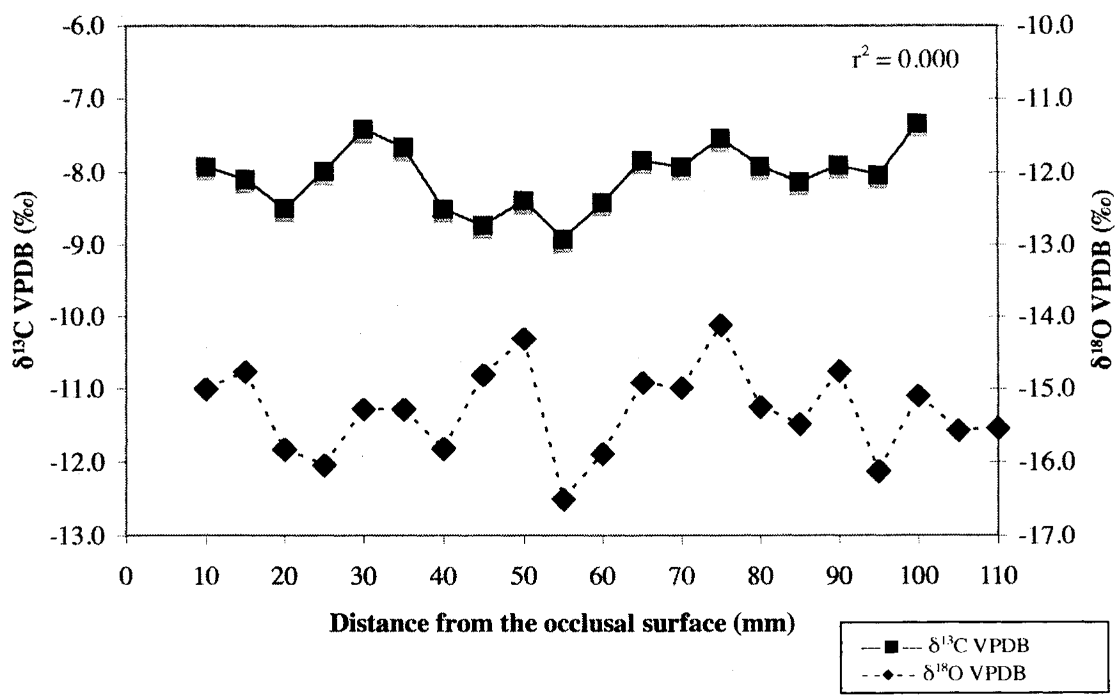

Figure 13. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Mammuthus* specimen MAM 4.

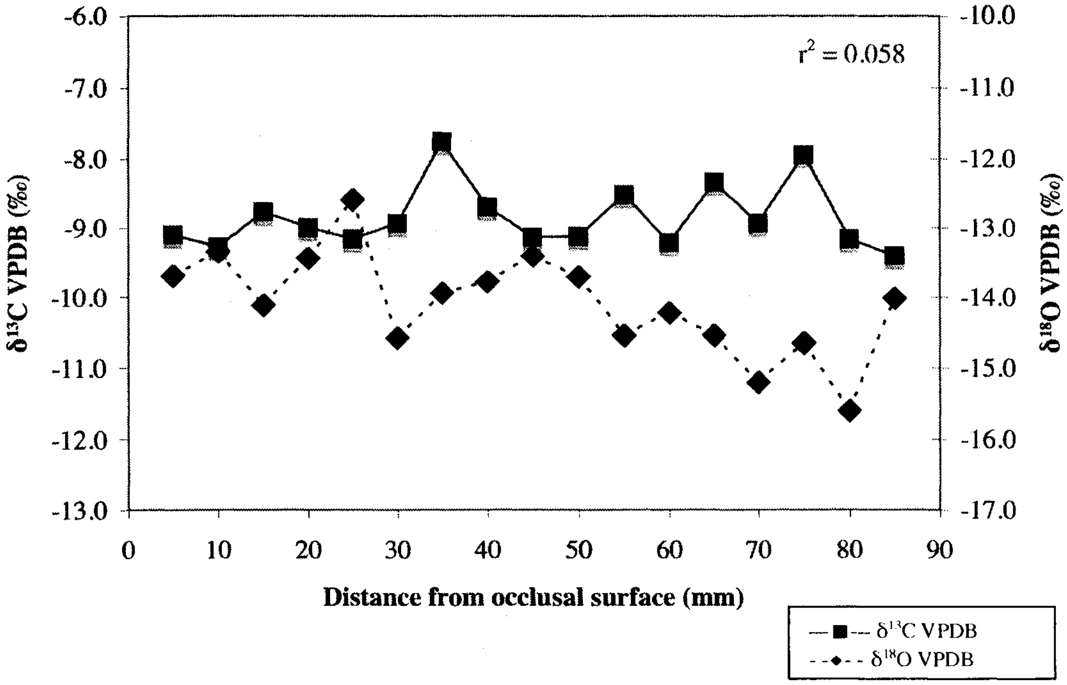

Figure 14. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Mammuthus* specimen MAM 5.

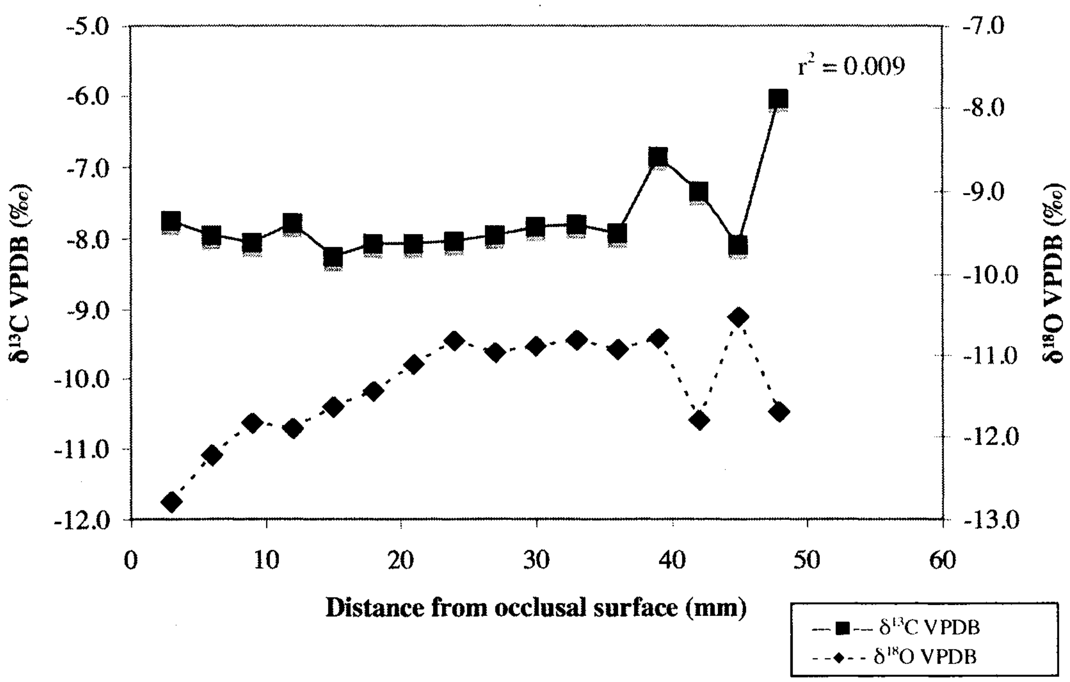

Figure 15. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Equus* specimen EQS 1.

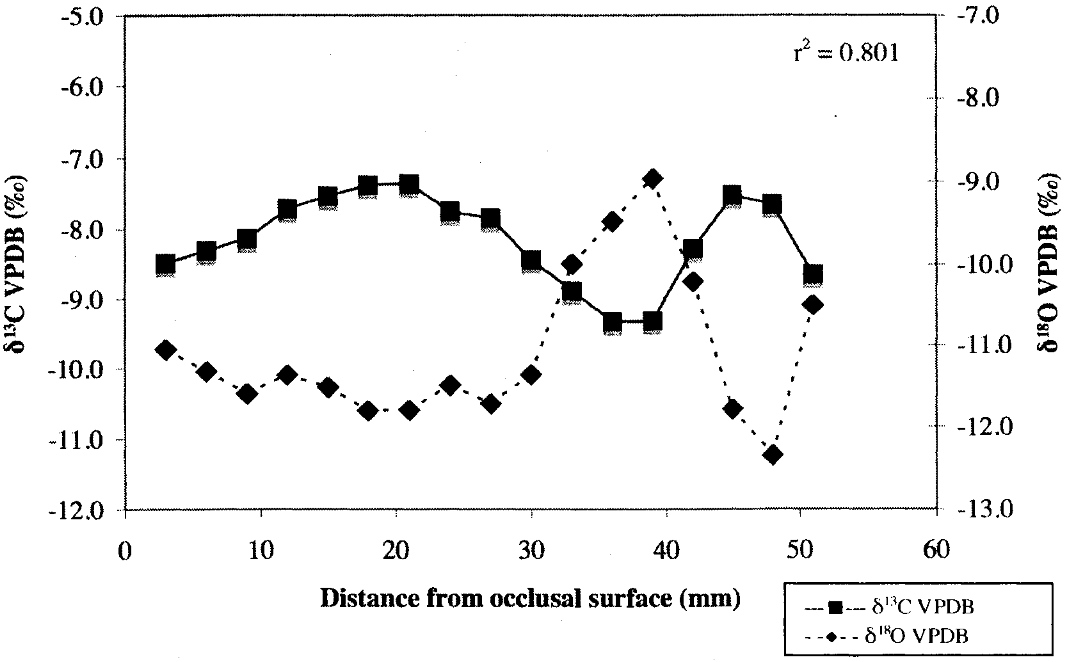

Figure 16. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Equus* specimen EQS 2.

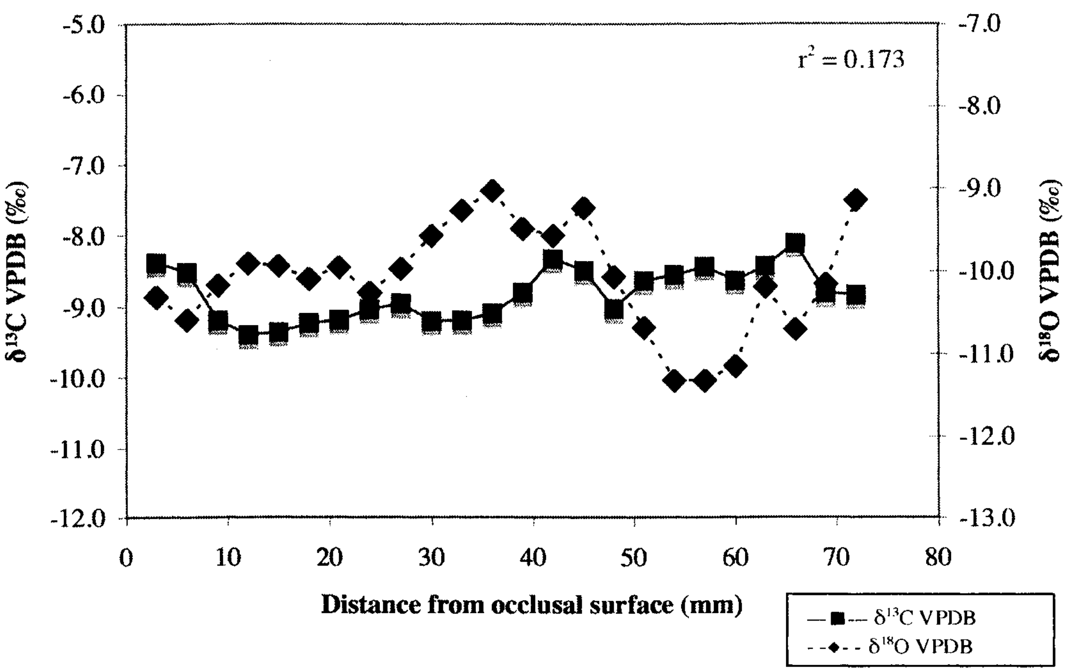

Figure 17. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Equus* specimen EQS 3.

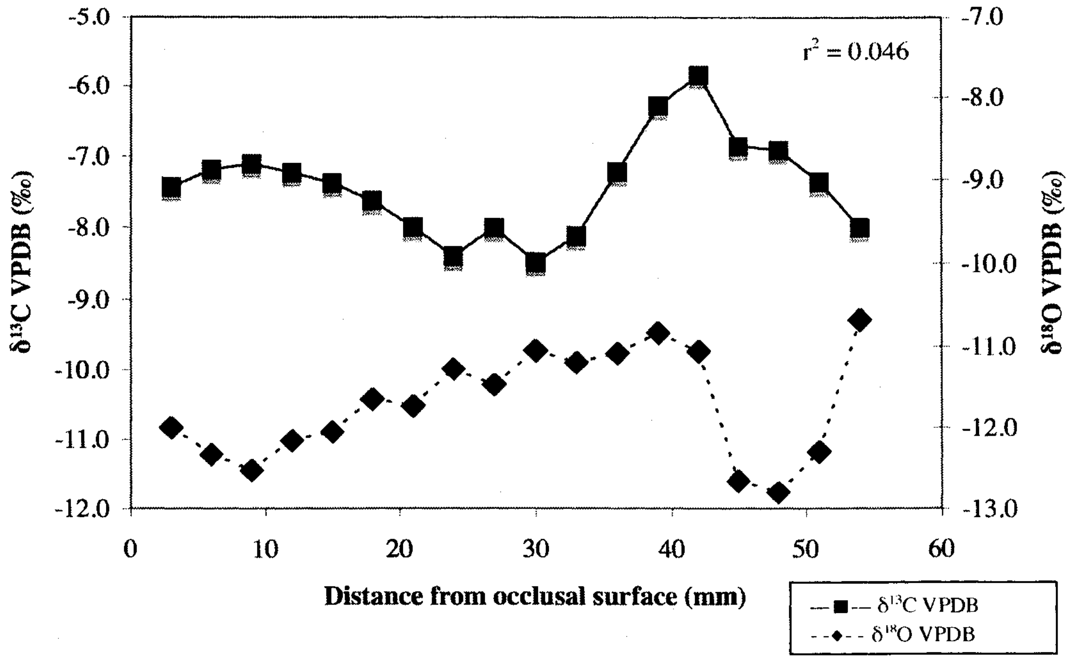

Figure 18. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Equus* specimen EQS 4.

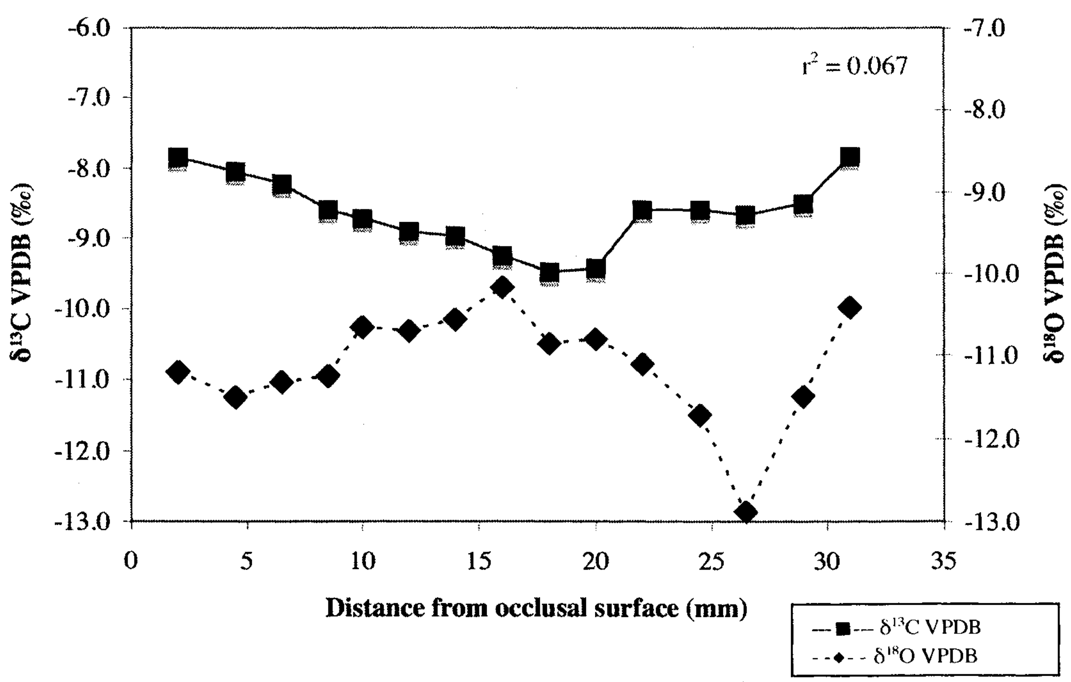

Figure 19. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Equus* specimen EQS 5.

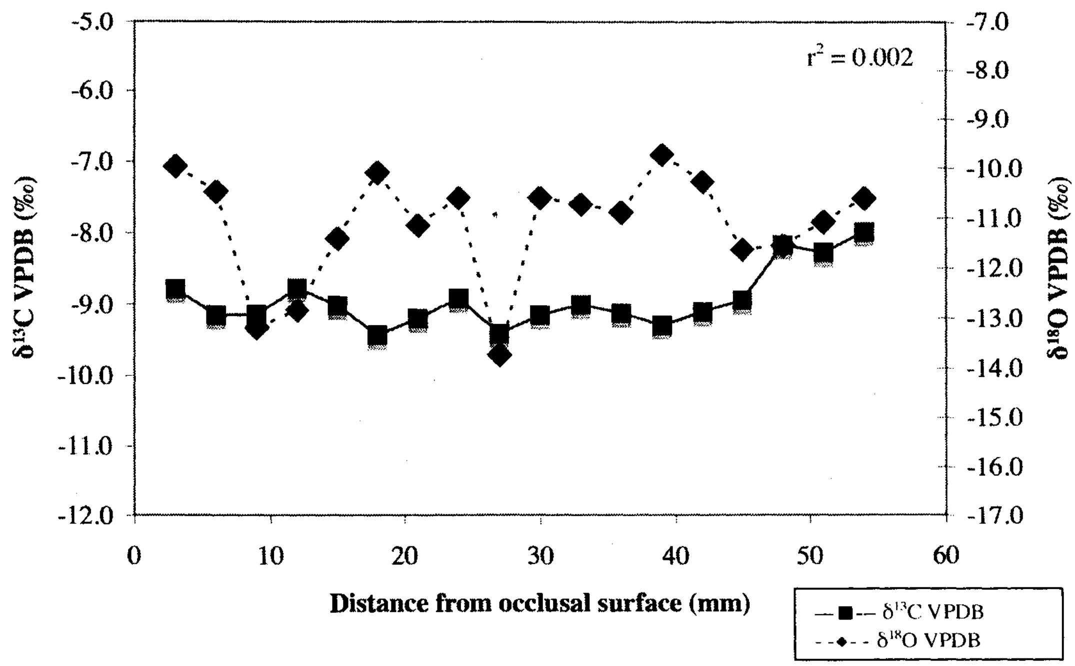

Figure 20. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Bison* specimen BIS 1.

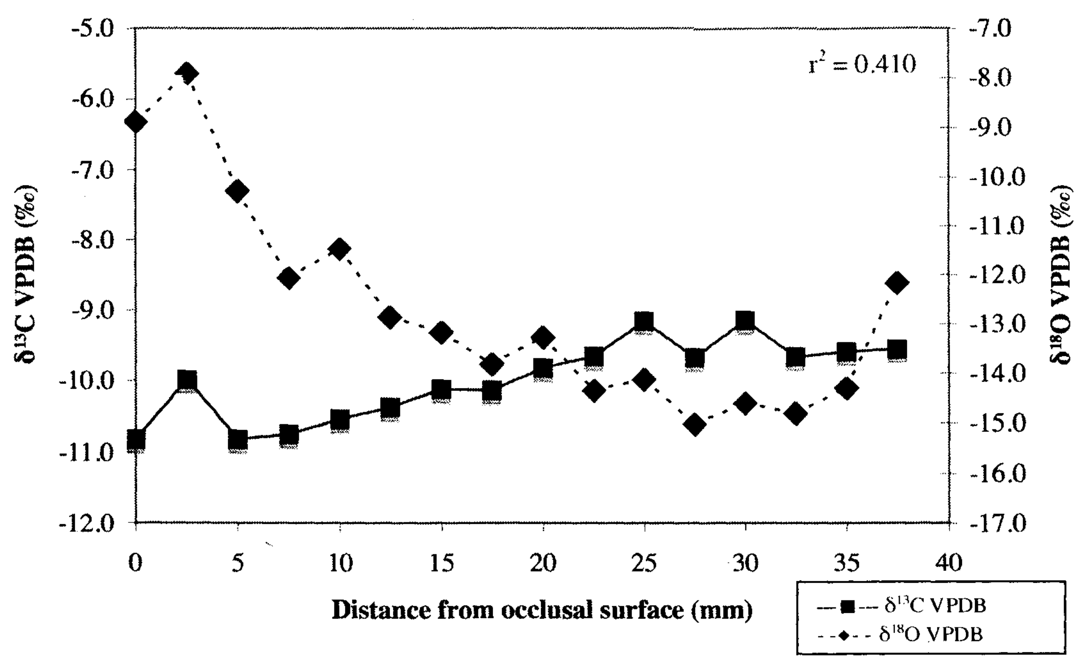

Figure 21. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Bison* specimen BIS 2.

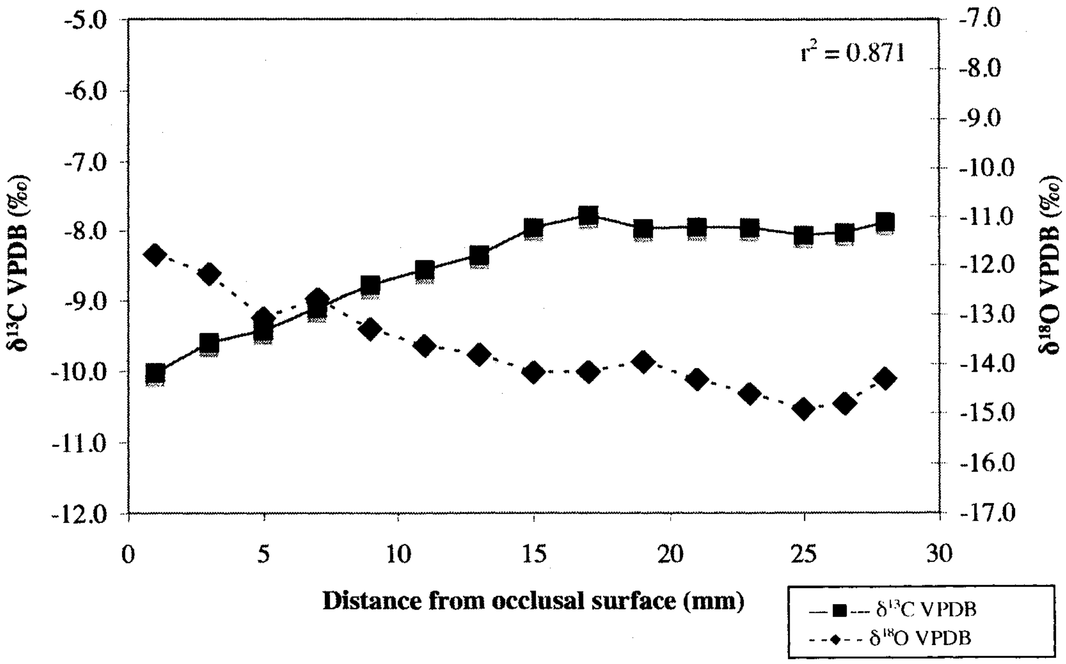

Figure 22. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Bison* specimen BIS 3.

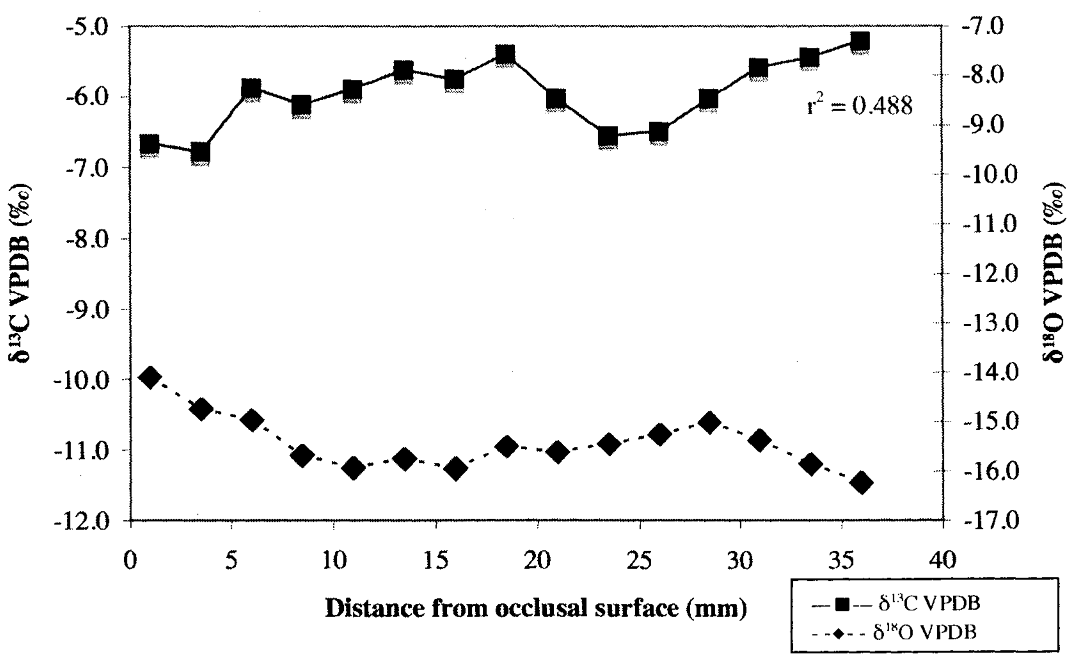

Figure 23. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Bison* specimen BIS 4.

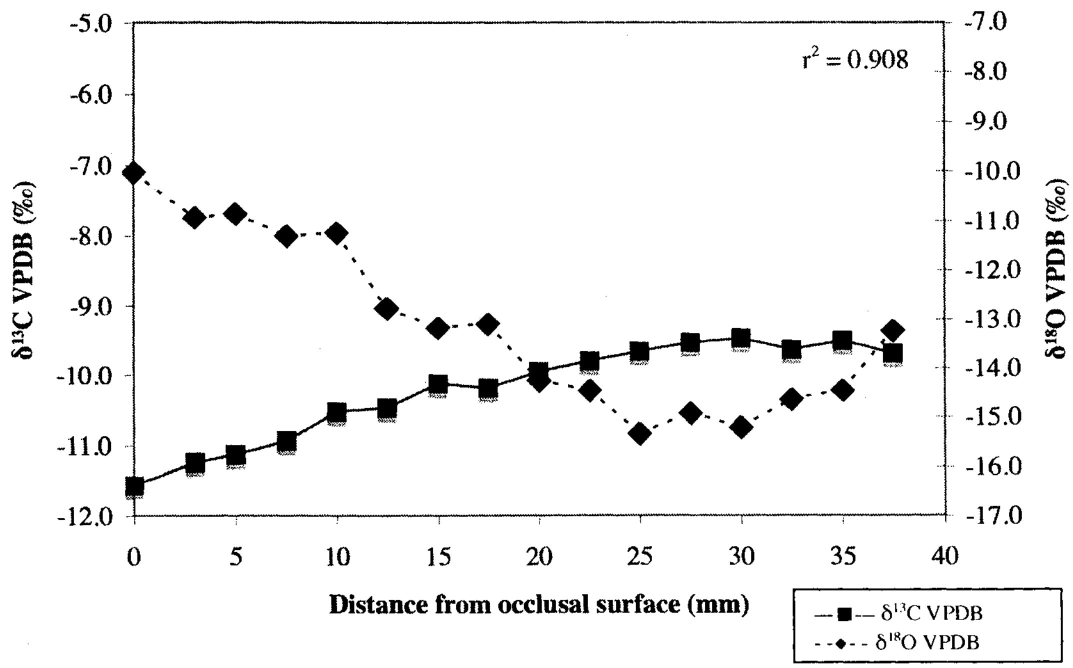

Figure 24. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Bison* specimen BIS 5.

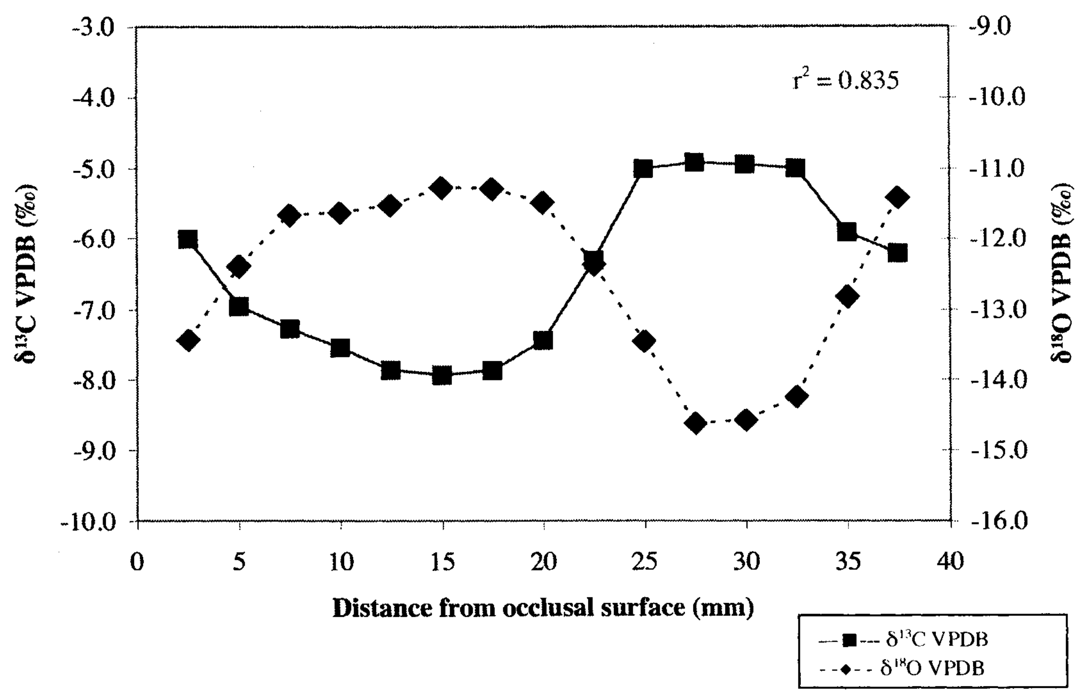

Figure 25. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Camelops* specimen CAM 1.

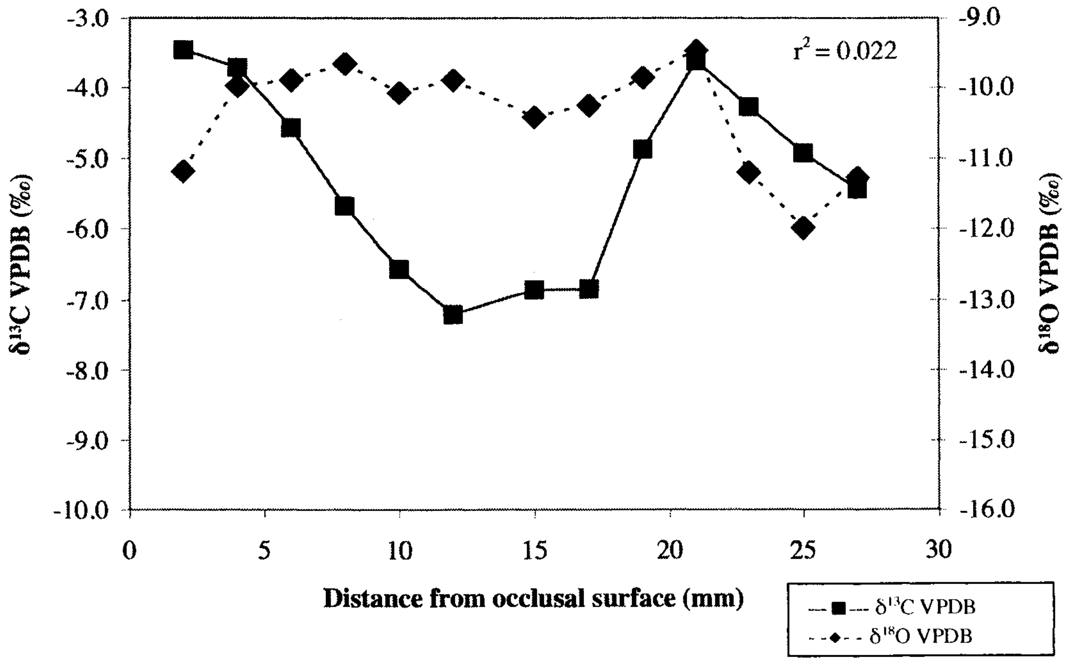

Figure 26. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Camelops* specimen CAM 2.

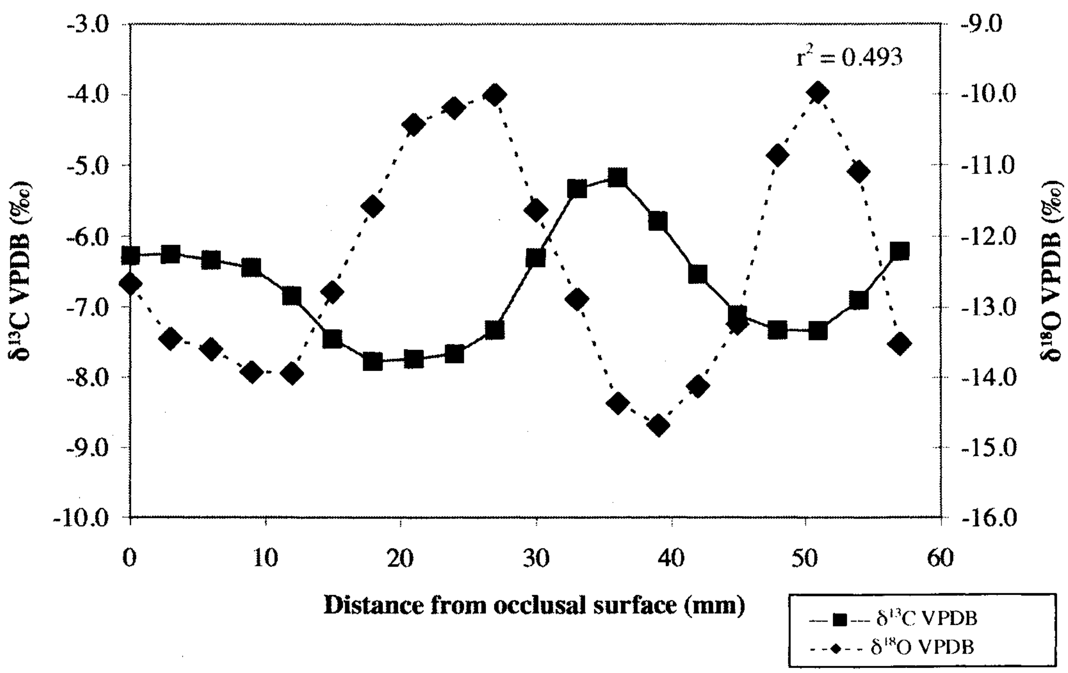

Figure 27. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Camelops* specimen CAM 3.

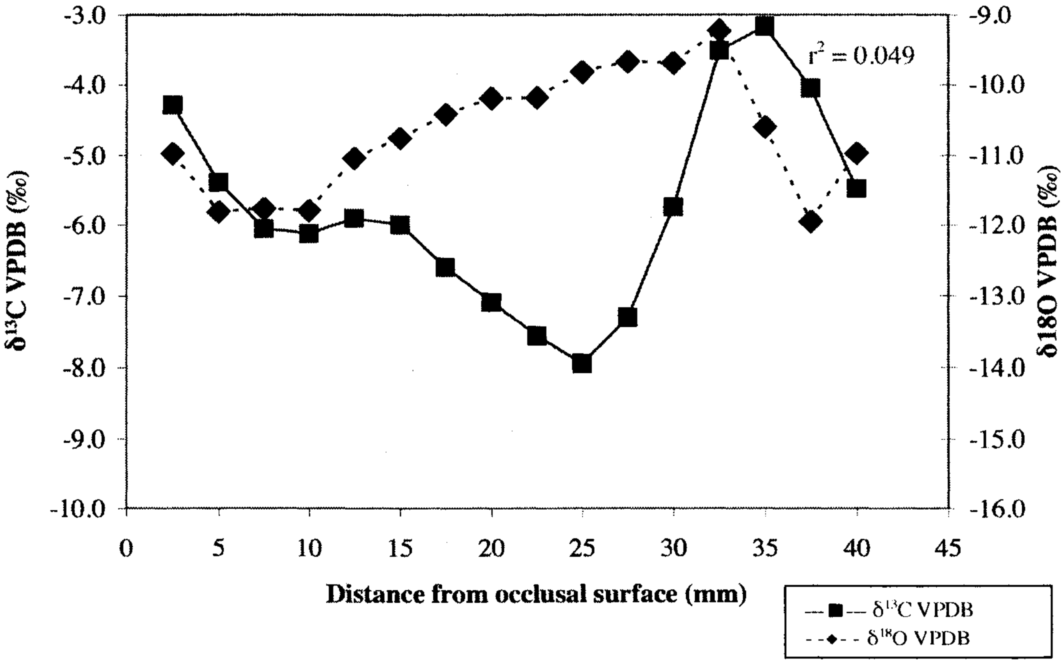

Figure 28. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Camelops* specimen CAM 4.

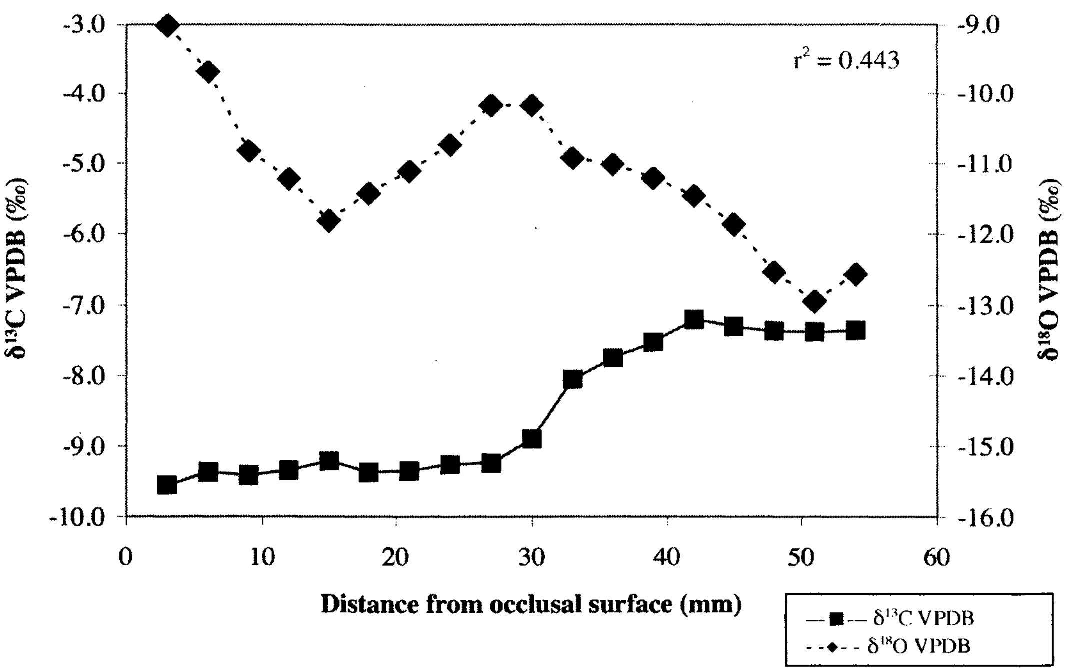

Figure 29. Intra-tooth variation in $\delta^{13}C$ and $\delta^{18}O$ values, *Camelops* specimen CAM 5.

CHAPTER 5

DISCUSSION

Isotopic Reconstruction of Diet and Range

The relative proportions of C_3 and C_4 plants in the diets of each individual were calculated using isotopic end-member values for tooth enamel of pure C_3 and pure C_4 feeders. The average $\delta^{13}C$ value for *Mammuthus* was -8.45‰, which suggests that it was primarily a C_3 feeder with an average proportion of 19% C_4 plants (Figure 5). Similarly, the average $\delta^{13}C$ value for *Equus* was -8.14‰, which suggests that it was also primarily a C_3 feeder, with an average proportion of 21% C_4 plants (Figure 5).

Both *Bison* and *Camelops* exhibit a broader range of $\delta^{13}C$ values between individuals than *Mammuthus* or *Equus*. The $\delta^{13}C$ values for *Bison* range from -10.22‰ to -5.97‰, and the calculated proportion of C_4 material in the diet is 16%, ranging from 3% to 41% (Table 9; Figure 5). Results from *Camelops* exhibit similar variability: $\delta^{13}C$ values range from -8.49‰ to -5.23‰, and the calculated proportion of C_4 plants in *Camelops* diet is 36%, ranging from 18% to 48% (Table 9; Figure 5).

Of all taxa analyzed in this study, bison have the highest preference for grazing, and indiscriminately consume C_3 and C_4 grasses in the proportion in which they occur on the landscape (Hoppe et al., 2006). Evaluation of *Bison* $\delta^{13}C$ values, excluding the outlier BIS 4, indicate ingestion of 3 to 18% C_4 material. Since *Bison* is an obligate grazer and a passive recorder of the relative C_3/C_4 grass abundance, the results from this study suggest an abundance of C_4 grasses of 3 to 18% at the LGM in southern Nevada. This value is also consistent with estimated abundances of C_4 grasses from other vegetation data.

The feeding habits of *Bison* from the Gilcrease spring mound vary considerably between individuals, as inferred from isotopic values (Figure 8). Average $\delta^{13}C$ values for this taxon generally indicate ≤20% C_4 plants in the diet. The single individual with a greater proportion of C_4 grasses in its diet (BIS 4; Figure 5) was possibly migrating to areas further to the south (e.g., Arizona) where a higher percentage of C_4 grasses have been documented for the LGM (Connin et al., 1998; Liu et al., 1996). An alternative, more likely explanation lies in the intermittent activity of the Gilcrease spring through late glacial and Holocene times. A higher percentage of C_4 grass has been documented in the area for later intervals (Connin et al., 1998; Mehringer, 1967; Spaulding, 1985); BIS 4 could represent an individual from this later time period. This is also confirmed by isotopic data from late glacial herbivores from Unit E_1 of the Tule Springs assemblage (Connin et al., 1998).

The $\delta^{13}C$ values recorded in *Camelops* tooth enamel indicate that the average individual diet contained a higher proportion of C_4 plant material than any of the other herbivores analyzed (Table 9; Figure 5). Conventional interpretations of camelids place them in a browsing or mixed-feeding niche, although they have hypsodont teeth (Dompierre and Churcher, 1996). Recent isotopic studies allow more detailed reconstruction of diet and suggest ecological generalization in intermediate feeding with a preference for browse (Feranec, 2003). Of all taxa analyzed in this study, *Camelops* has the highest preference for browsing, although $\delta^{13}C$ values here indicate the greatest consumption of C_4 plant material.

Modern camels are highly adapted for survival in arid environments. Nutritional studies of modern camels demonstrate that they show a strong preference for salty plants (halophytes) (Farid, 1989; Wardeh, 2004; Wilson, 1989), and identify *Atriplex* spp. and other halophytic taxa among their most preferred browse plants (Farid, 1989; Wilson, 1989). *Atriplex*, a C_4 shrub, is a member of the Chenopodiaceae family, and is abundant in the modern Great Basin in several forms, including *A. confertifolia* (shadscale) and *A. canescens* (fourwing saltbush) (Mozingo, 1987). *Atriplex* spp. provides an important source of winter browse material for a variety of modern large mammals, including both livestock and range animals (Blaisdell and Holmgren, 1984; Cook and Harris, 1968; Tipton, 1994). Chenopod pollen is present in sedimentary records from this interval, although it is not abundant (Mehringer, 1967). However, other vegetation records from the Mojave Desert indicate a high percentage of chenopods (Koehler et al., 2005). Because of the browsing feeding habit demonstrated for both modern and fossil camelids and the preference of modern Old World camels for the salty browse plant *Atriplex*, I interpret that the high $\delta^{13}C$ values in *Camelops* teeth record preferential browsing on the C_4 shrub *Atriplex*.

The $\delta^{13}C$ values for each of two grazers, *Mammuthus* and *Equus*, are approximately consistent with reconstructed abundances of C_4 vegetation on the landscape during the LGM to late glacial transition. The $\delta^{13}C$ values of *Mammuthus* and *Equus* are slightly higher than those of *Bison* from this study, indicating a slightly higher percentage of C_4 plants ingested. Some evidence has suggested a mixed-feeding habit for *Mammuthus* and *Equus*, in contrast to traditional interpretations of pure grazing (Koch et al., 1998). I interpret that the diets of *Mammuthus* and *Equus* were composed primarily of C_3 grasses, with a preference for a small percentage of browse, composed of the C_4 shrub *Atriplex*. This is consistent both with interpretations for *Camelops* and with newer evidence from other studies suggesting facultative grazing in these taxa.

Oxygen isotopic variability between individuals can be used to evaluate whether individual fossils accumulated over a short or long time span. In modern large herbivores in Africa, the average within-species standard deviation of $\delta^{18}O$ is ±1.3‰ for browsers, ±0.9‰ for pure grazers, and ±1.1‰ for mixed feeders (Bocherens et al., 1996). Koch et al. (1998) concluded that within-species variability exceeding 1.1‰ to 1.3‰ should be considered significant, and interpreted as an assemblage composed of individuals from different geographic or temporal populations. The within-clade standard deviations of $\delta^{18}O$ in *Mammuthus* (0.54‰), *Equus* (0.61‰), and *Camelops* (0.82‰) do not approach this critical limit. The $\delta^{18}O$ standard deviation in *Bison* is 1.56‰, which indicates that in this assemblage, individual animals most likely came from different populations.

Low intra-taxon ranges of $\delta^{18}O$ values for both *Mammuthus* and *Equus* suggest that these individuals did not migrate considerable distances over the time interval of tooth growth. It is possible that these individuals represent an accumulation over a long time span. However, coincident low variability in $\delta^{13}C$ values for both taxa suggests either an accumulation of individuals over a short time span or no change in diet concurrent with the increase in C_4 plants during the transition to late glacial flora. A broader range of $\delta^{18}O$ values in *Bison* suggests a broader geographic range for individuals, or that *Bison* accumulated in the spring mound over a longer time span than *Mammuthus* or *Equus*. A wide range of $\delta^{18}O$ values for *Camelops* suggests a wider range that could reflect either geographic or altitudinal variation. The interpretation of preferential feeding on *Atriplex* may have led *Camelops* to range farther up slopes in search of forage.

Isotopic Records of Seasonal Variations

Intra-tooth variation in $\delta^{13}C$ values for *Mammuthus*, *Equus*, and *Bison* all exhibit ranges similar to previously documented ranges in these Pleistocene taxa in other locations. The low intra-tooth variability for each individual of these taxa suggests less seasonal variation in diet, and little seasonal partitioning of resources discernible from isotopic analysis. Instead, individuals consumed grass in the naturally occurring C_3/C_4 proportion. *Mammuthus* and *Equus* may have consumed a small amount of C_4 browse, as discussed above; this preference for a small amount of browse does not vary notably between individuals. The ranges of intra-tooth variation in *Camelops* are consistently higher, suggesting a more seasonally varied diet. A browsing habit with a high proportion of seasonally available halophytic C_4 species would produce an isotopic pattern with higher seasonal variability in $\delta^{13}C$ values.

The high range of $\delta^{18}O$ values in modern seasonal precipitation (Friedman et al., 2002b) makes distinction of secular or seasonal trends in ^{18}O difficult for any single individual. In general, $\delta^{18}O$ values of precipitation are higher in the summer because of ^{18}O enrichment through evaporation (Dansgaard, 1964). In the Basin and Range, summer $\delta^{18}O$ values are additionally higher because the dominant source of summer precipitation, the summer monsoon, originates in the ^{18}O-enriched Gulf of California (Friedman et al., 2002a). Over seasonal timescales, $\delta^{13}C$ and $\delta^{18}O$ values should covary: an increase in warm-season grasses should correspond to an increase in temperature. In the taxa analyzed in this study that do show demonstrable correlation, $\delta^{13}C$ values vary inversely with $\delta^{18}O$ values, which is contrary to the expected pattern. *Atriplex* is a preferred winter browse plant for modern rangeland herbivores (Monzigo, 1987; Tipton, 1994) and livestock (Blaisdell and Holmgren, 1984; Cook and Harris, 1968). Increased winter consumption of nondeciduous browse such as *Atriplex* may have produced the inverse relationship between $\delta^{13}C$ and $\delta^{18}O$ exhibited by *Mammuthus*, *Equus*, *Bison*, and *Camelops*. The amplitude and pattern of seasonality is strongest in *Camelops*, which I interpret consumed the highest proportion of *Atriplex*.

Implications for Interpretation of Isotopic Data

This study underscores the importance of correlating isotopic data with independent records of paleovegetation. Isotopic values from tooth enamel have been used to reconstruct changes in vegetation through time. Studies of this type often use $\delta^{13}C$ values from grazers to approximate the percent C_4 grass on the landscape, and assume passive recording of the naturally-occurring abundance of C_3 and C_4 grasses. These results demonstrate that isotopic values indicative of C_4 plants may not always correlate to the grass functional type, depending on the feeding habits of the animal. Reconstructions of vegetation in the Mojave Desert and other arid regions should approach interpretation of tooth enamel isotopic values with caution, and consider both the abundance of drought-tolerant C_4 shrubs and the feeding habits of the animal.

High intra-tooth variability is also documented here for the browser *Camelops*. While this provides high-resolution paleobiological information, it calls into question the use of bulk tooth enamel samples, rather than a mean of values mineralized over the course of one or several years. Interpretation of vegetation regimes from bulk isotopic sampling alone should consider potential intra-tooth variability as a significant source of error or bias. Intratooth samples provide high-resolution data of subannual variation in vegetation and potentially in climate; mean values calculated from intratooth samples provide a more accurate representation of the vegetation consumed by an individual.

CHAPTER 6

SUMMARY

This study uses stable isotopic methods to reconstruct the paleoecology and resource partitioning of megafauna in southern Nevada at the LGM and during the LGM-late glacial transition. Radiocarbon data are suspect, but the dates obtained confirm stratigraphic placement of the spring mound fossils in the LGM and late glacial intervals. These dates corroborate the hypothesis that these fossils accumulated over several thousand years during the LGM and late glacial time. High variability in $\delta^{18}O$ values further suggests that individual animals preserved at the site lived during different time intervals.

Resource partitioning between Late Pleistocene herbivores is demonstrated here between grazer taxa and one browsing taxon. Potential resource partitioning between obligate grazers (*Bison*) and facultative grazers (*Equus* and possibly *Mammuthus*) is demonstrated isotopically through small amounts of seasonal $\delta^{13}C$ variation in *Equus* coupled with more positive mean $\delta^{13}C$ values than the naturally-occurring proportion of C_3 and C_4 grasses would predict. Results indicate that *Camelops* ingested the highest proportion of C_4 plants, interpreted as a preference for browsing on the C_4 shrub *Atriplex*. Vegetation records indicate the presence of *Atriplex*; studies of modern camels indicate a strong preference for this plant, here discernible in fossil taxa as well.

The results of this study highlight the importance of detailed knowledge of the diets and feeding preferences of modern herbivores in reconstructions of the paleodiet of extinct animals. Isotopic values of herbivore tooth enamel are traditionally interpreted with respect to end-member plant functional types. Here, the C_4 isotopic signal may come from multiple plant functional types; the dietary preferences of each animal provide a basis for interpretation of isotopic data from herbivore tooth enamel. The selective feeding habits of some animals, such as the preferential grazer *Bison*, permit the naturally-occurring abundance of C_4 grasses to be passively recorded in *Bison* teeth. This provides a basis for evaluation of enrichment of C_4 plants in the diets of other herbivores, which may be interpreted as an indication of feeding on non-grass C_4 plants. Furthermore, selective or preferential herbivory on specific plants may enhance the isotopic signal of diet preserved in mammalian tooth enamel, depending on the feeding habits of the animal. This may affect interpretations of paleovegetation using herbivore tooth enamel alone.

The identification of the isotopic signature of *Atriplex*, in conjunction with its association with arid, alkaline growing conditions, combine into an isotopically distinct paleoenvironmental indicator with many potential applications. In arid environments too dry and too cold to support C_4 grasses, the presence of *Atriplex* may be discerned through isotopic analyses; in areas with a low proportion of C_4 grasses, such as southern Nevada during the LGM, careful use of isotopic analysis in conjunction with herbivore feeding habits may be used to demonstrate the presence of *Atriplex* and associated alkali desert scrub vegetation. Several avenues of future research are possible using this proxy: in paleobiological dietary reconstructions, vegetation reconstructions using tooth enamel isotopic values, and as potential paleoenvironmental indicators of soil chemistry, aridity, and other variables.

APPENDIX 1

STABLE ISOTOPE DATA

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
MAM 1-01	0	-8.92	-11.86	18.64
MAM 1-02	5	-7.97	-14.45	15.97
MAM 1-03	10	-8.17	-14.59	15.82
MAM 1-04	15	-7.41	-13.92	16.52
MAM 1-05	20	-7.44	-14.40	16.02
MAM 1-06	25	-7.33	-14.44	15.98
MAM 1-07	30	-7.02	-13.88	16.56
MAM 1-08	35	-7.53	-14.22	16.21
MAM 1-09	40	-7.11	-13.91	16.53
MAM 1-10	45	-7.57	-14.52	15.89
MAM 1-11	50	-7.50	-13.78	16.66
MAM 1-12	55	-7.69	-13.47	16.98
MAM 1-13	65	-6.88	-13.86	16.58
MAM 1-14	70	-8.08	-13.36	17.09
MAM 1-15	75	-8.29	-13.81	16.63
MAM 1-16	80	-8.97	-14.02	16.41
MAM 1-17	85	-8.70	-13.37	17.08
MAM 1-18	90	-8.55	-15.07	15.33
MAM 1-19	95	-9.46	-13.62	16.82
MAM 1-20	100	-8.95	-14.47	15.95
MAM 1-21	105	-8.49	-14.20	16.23
MAM 2-01	5	-7.92	-15.05	15.35
MAM 2-02	10	-8.10	-16.09	14.27
MAM 2-03	15	-8.49	-15.14	15.25
MAM 2-04	20	-7.98	-14.50	15.91
MAM 2-05	25	-7.40	-14.69	15.72
MAM 2-06	30	-7.65	-15.29	15.10
MAM 2-07	35	-8.51	-15.24	15.15
MAM 2-08	40	-8.73	-14.14	16.28
MAM 2-09	45	-8.39	-14.92	15.49
MAM 2-10	50	-8.93	-14.80	15.61

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
MAM 2-11	55	-8.41	-14.07	16.35
MAM 2-12	60	-7.84	-14.26	16.16
MAM 2-13	65	-7.93	-13.19	17.26
MAM 2-14	70	-7.53	-13.92	16.51
MAM 2-15	75	-7.91	-13.07	17.38
MAM 2-16	80	-8.13	-12.98	17.48
MAM 2-17	85	-7.91	-13.45	16.99
MAM 2-18	90	-8.03	-12.66	17.81
MAM 2-19	95	-7.34	-14.60	15.81
MAM 3-01	5	-9.09	-14.01	16.42
MAM 3-02	10	-9.05	-14.83	15.57
MAM 3-03	15	-8.55	-14.28	16.14
MAM 3-04	20	-9.03	-13.68	16.76
MAM 3-05	25	-8.52	-14.51	15.90
MAM 3-06	30	-8.47	-15.29	15.10
MAM 3-07	35	-8.06	-14.44	15.98
MAM 3-08	40	-7.98	-15.02	15.38
MAM 3-09	45	-8.51	-14.74	15.67
MAM 3-10	50	-8.30	-14.14	16.28
MAM 3-11	55	-7.70	-15.17	15.22
MAM 3-12	60	-7.38	-14.35	16.06
MAM 3-13	65	-7.20	-14.50	15.92
MAM 3-14	70	-7.42	-14.45	15.96
MAM 3-15	75	-8.08	-14.52	15.90
MAM 3-16	80	-7.86	-14.20	16.22
MAM 3-17	85	-7.59	-14.16	16.26
MAM 3-18	90	-8.13	-14.11	16.31
MAM 3-19	95	-7.20	-14.53	15.88
MAM 3-20	100	-7.87	-14.52	15.89
MAM 3-21	105	-7.86	-13.81	16.63
MAM 4-01	10	-9.62	-15.00	15.40
MAM 4-02	15	-9.07	-14.76	15.64
MAM 4-03	20	-9.10	-15.82	14.55
MAM 4-04	25	-9.27	-16.03	14.33
MAM 4-05	30	-9.42	-15.28	15.11
MAM 4-06	35	-9.44	-15.27	15.11
MAM 4-07	40	-9.38	-15.82	14.55
MAM 4-08	45	-9.09	-14.80	15.60
MAM 4-09	50	-8.86	-14.30	16.11
MAM 4-10	55	-8.77	-16.50	13.85
MAM 4-11	60	-9.26	-15.89	14.48
MAM 4-12	65	-9.28	-14.91	15.49
MAM 4-13	70	-9.07	-14.98	15.42

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
MAM 4-14	75	-9.36	-14.11	16.31
MAM 4-15	80	-9.02	-15.25	15.14
MAM 4-16	85	-9.40	-15.48	14.90
MAM 4-17	90	-8.94	-14.76	15.65
MAM 4-18	95	-9.32	-16.12	14.24
MAM 4-19	100	-9.06	-15.09	15.30
MAM 4-20	105	-9.16	-15.57	14.81
MAM 4-21	110	-8.94	-15.54	14.84
MAM 4-22	115	-9.15	-15.82	14.55
MAM 5-01	5	-9.10	-13.68	16.75
MAM 5-02	10	-9.27	-13.34	17.11
MAM 5-03	15	-8.77	-14.11	16.31
MAM 5-04	20	-8.99	-13.43	17.01
MAM 5-05	25	-9.16	-12.59	17.88
MAM 5-06	30	-8.94	-14.57	15.84
MAM 5-07	35	-7.76	-13.94	16.49
MAM 5-08	40	-8.70	-13.78	16.66
MAM 5-09	45	-9.14	-13.40	17.05
MAM 5-10	50	-9.13	-13.70	16.73
MAM 5-11	55	-8.53	-14.53	15.88
MAM 5-12	60	-9.21	-14.22	16.20
MAM 5-13	65	-8.35	-14.54	15.88
MAM 5-14	70	-8.93	-15.20	15.19
MAM 5-15	75	-7.95	-14.65	15.77
MAM 5-16	80	-9.16	-15.60	14.78
MAM 5-17	85	-9.40	-14.01	16.42
EQS 1-01	3	-7.75	-12.78	17.69
EQS 1-02	6	-7.96	-12.22	18.26
EQS 1-03	9	-8.05	-11.83	18.67
EQS 1-04	12	-7.78	-11.90	18.60
EQS 1-05	15	-8.25	-11.63	18.87
EQS 1-06	18	-8.07	-11.44	19.07
EQS 1-07	21	-8.07	-11.11	19.41
EQS 1-08	24	-8.03	-10.81	19.72
EQS 1-09	27	-7.95	-10.96	19.56
EQS 1-10	30	-7.84	-10.88	19.65
EQS 1-11	33	-7.80	-10.81	19.72
EQS 1-12	36	-7.93	-10.92	19.60
EQS 1-13	39	-6.86	-10.78	19.75
EQS 1-14	42	-7.34	-11.80	18.70
EQS 1-15	45	-8.08	-10.52	20.02
EQS 1-16	48	-6.04	-11.70	18.81
EQS 2-01	3	-8.49	-11.04	19.48

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
EQS 2-02	6	-8.31	-11.31	19.20
EQS 2-03	9	-8.13	-11.59	18.92
EQS 2-04	12	-7.72	-11.36	19.15
EQS 2-05	15	-7.54	-11.51	18.99
EQS 2-06	18	-7.38	-11.80	18.70
EQS 2-07	21	-7.36	-11.79	18.71
EQS 2-08	24	-7.75	-11.49	19.02
EQS 2-09	27	-7.84	-11.71	18.79
EQS 2-10	30	-8.43	-11.35	19.16
EQS 2-11	33	-8.88	-9.99	20.57
EQS 2-12	36	-9.33	-9.47	21.10
EQS 2-13	39	-9.32	-8.96	21.63
EQS 2-14	42	-8.28	-10.21	20.34
EQS 2-15	45	-7.53	-11.77	18.73
EQS 2-16	48	-7.65	-12.34	18.14
EQS 2-17	51	-8.65	-10.50	20.04
EQS 3-01	3	-8.38	-10.31	20.24
EQS 3-02	6	-8.52	-10.58	19.96
EQS 3-03	9	-9.19	-10.17	20.38
EQS 3-04	12	-9.39	-9.90	20.66
EQS 3-05	15	-9.36	-9.94	20.62
EQS 3-06	18	-9.23	-10.09	20.46
EQS 3-07	21	-9.18	-9.95	20.60
EQS 3-08	24	-9.04	-10.26	20.29
EQS 3-09	27	-8.96	-9.96	20.59
EQS 3-10	30	-9.20	-9.57	21.00
EQS 3-11	33	-9.19	-9.26	21.31
EQS 3-12	36	-9.10	-9.02	21.56
EQS 3-13	39	-8.80	-9.49	21.08
EQS 3-14	42	-8.33	-9.57	21.00
EQS 3-15	45	-8.50	-9.24	21.34
EQS 3-16	48	-9.03	-10.06	20.49
EQS 3-17	51	-8.64	-10.67	19.86
EQS 3-18	54	-8.56	-11.32	19.20
EQS 3-19	57	-8.44	-11.31	19.20
EQS 3-20	60	-8.64	-11.14	19.38
EQS 3-21	63	-8.43	-10.19	20.35
EQS 3-22	66	-8.12	-10.70	19.83
EQS 3-23	69	-8.81	-10.16	20.39
EQS 3-24	72	-8.84	-9.14	21.44
EQS 4-01	3	-7.44	-11.99	18.50
EQS 4-02	6	-7.19	-12.33	18.15
EQS 4-03	9	-7.11	-12.52	17.96

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
EQS 4-04	12	-7.23	-12.15	18.34
EQS 4-05	15	-7.38	-12.04	18.45
EQS 4-06	18	-7.62	-11.64	18.86
EQS 4-07	21	-8.00	-11.72	18.78
EQS 4-08	24	-8.40	-11.27	19.25
EQS 4-09	27	-8.01	-11.46	19.05
EQS 4-10	30	-8.49	-11.04	19.48
EQS 4-11	33	-8.12	-11.19	19.33
EQS 4-12	36	-7.23	-11.08	19.44
EQS 4-13	39	-6.28	-10.83	19.70
EQS 4-14	42	-5.84	-11.05	19.47
EQS 4-15	45	-6.87	-12.65	19.62
EQS 4-16	48	-6.92	-12.79	17.68
EQS 4-17	51	-7.38	-12.29	18.19
EQS 4-18	54	-8.01	-10.67	19.86
EQS 5-01	2	-7.84	-11.19	19.33
EQS 5-02	4.5	-8.04	-11.49	19.02
EQS 5-03	6.5	-8.22	-11.31	19.20
EQS 5-04	8.5	-8.59	-11.24	19.28
EQS 5-05	10	-8.71	-10.64	19.89
EQS 5-06	12	-8.91	-10.70	19.84
EQS 5-07	14	-8.97	-10.55	19.99
EQS 5-08	16	-9.25	-10.17	20.38
EQS 5-09	18	-9.49	-10.85	19.68
EQS 5-10	20	-9.43	-10.79	19.74
EQS 5-11	22	-8.59	-11.10	19.42
EQS 5-12	24.5	-8.59	-11.71	18.79
EQS 5-13	26.5	-8.66	-12.87	17.59
EQS 5-14	29	-8.50	-11.48	19.03
EQS 5-15	31	-7.83	-10.41	20.14
BIS 1-01	3	-8.78	-9.95	20.60
BIS 1-02	6	-9.16	-10.45	20.09
BIS 1-03	9	-9.14	-13.19	17.27
BIS 1-04	12	-8.78	-12.84	17.63
BIS 1-05	15	-9.02	-11.38	19.13
BIS 1-06	18	-9.44	-10.07	20.48
BIS 1-07	21	-9.20	-11.13	19.40
BIS 1-08	24	-8.92	-10.58	19.95
BIS 1-09	27	-9.42	-13.73	16.70
BIS 1-10	30	-9.16	-10.59	19.95
BIS 1-11	33	-9.02	-10.72	19.81
BIS 1-12	36	-9.13	-10.87	19.66
BIS 1-13	39	-9.30	-9.72	20.84

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
BIS 1-14	42	-9.11	-10.26	20.28
BIS 1-15	45	-8.95	-11.62	18.88
BIS 1-16	48	-8.18	-11.54	18.97
BIS 1-17	51	-8.28	-11.06	19.46
BIS 1-18	54	-7.99	-10.59	19.94
BIS 2-01	0	-10.82	-8.89	21.70
BIS 2-02	2.5	-9.99	-7.89	22.73
BIS 2-03	5	-10.82	-10.27	20.28
BIS 2-04	7.5	-10.75	-12.05	18.44
BIS 2-05	10	-10.55	-11.45	19.06
BIS 2-06	12.5	-10.38	-12.85	17.62
BIS 2-07	15	-10.12	-13.15	17.31
BIS 2-08	17.5	-10.15	-13.81	16.63
BIS 2-09	20	-9.83	-13.27	17.19
BIS 2-10	22.5	-9.67	-14.33	16.09
BIS 2-11	25	-9.17	-14.11	16.32
BIS 2-12	27.5	-9.68	-15.01	15.39
BIS 2-13	30	-9.16	-14.59	15.82
BIS 2-14	32.5	-9.68	-14.80	15.61
BIS 2-15	35	-9.60	-14.30	16.12
BIS 2-16	37.5	-9.57	-12.16	18.33
BIS 3-01	1	-10.03	-11.78	18.72
BIS 3-02	3	-9.60	-12.17	18.32
BIS 3-03	5	-9.43	-13.06	17.40
BIS 3-04	7	-9.12	-12.68	17.79
BIS 3-05	9	-8.79	-13.29	17.17
BIS 3-06	11	-8.57	-13.63	16.82
BIS 3-07	13	-8.36	-13.80	16.64
BIS 3-08	15	-7.96	-14.16	16.27
BIS 3-09	17	-7.78	-14.15	16.28
BIS 3-10	19	-7.97	-13.94	16.49
BIS 3-11	21	-7.95	-14.31	16.12
BIS 3-12	23	-7.96	-14.59	15.82
BIS 3-13	25	-8.07	-14.90	15.51
BIS 3-14	26.5	-8.03	-14.80	15.61
BIS 3-15	28	-7.88	-14.29	16.13
BIS 4-01	1	-6.67	-14.09	16.34
BIS 4-02	3.5	-6.79	-14.73	15.68
BIS 4-03	6	-5.88	-14.96	15.44
BIS 4-04	8.5	-6.11	-15.68	14.70
BIS 4-05	11	-5.90	-15.92	14.45
BIS 4-06	13.5	-5.63	-15.74	14.64
BIS 4-07	16	-5.76	-15.94	14.43

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
BIS 4-08	18.5	-5.40	-15.50	14.89
BIS 4-09	21	-6.04	-15.62	14.77
BIS 4-10	23.5	-6.56	-15.45	14.94
BIS 4-11	26	-6.49	-15.25	15.14
BIS 4-12	28.5	-6.03	-15.01	15.39
BIS 4-13	31	-5.59	-15.37	15.02
BIS 4-14	33.5	-5.45	-15.85	14.53
BIS 4-15	36	-5.21	-16.22	14.14
BIS 5-01	0	-11.57	-10.00	20.56
BIS 5-02	3	-11.24	-10.91	19.62
BIS 5-03	5	-11.13	-10.83	19.70
BIS 5-04	7.5	-10.94	-11.28	19.23
BIS 5-05	10	-10.52	-11.22	19.30
BIS 5-06	12.5	-10.47	-12.76	17.71
BIS 5-07	15	-10.12	-13.16	17.30
BIS 5-08	17.5	-10.18	-13.08	17.38
BIS 5-09	20	-9.96	-14.25	16.17
BIS 5-10	22.5	-9.80	-14.45	15.97
BIS 5-11	25	-9.67	-15.33	15.07
BIS 5-12	27.5	-9.54	-14.92	15.48
BIS 5-13	30	-9.47	-15.20	15.19
BIS 5-14	32.5	-9.64	-14.64	15.78
BIS 5-15	35	-9.51	-14.45	15.96
BIS 5-16	37.5	-9.69	-13.23	17.23
CAM 1-01	2.5	-6.01	-13.42	17.02
CAM 1-02	5	-6.95	-12.38	18.10
CAM 1-03	7.5	-7.28	-11.66	18.84
CAM 1-04	10	-7.55	-11.63	18.88
CAM 1-05	12.5	-7.87	-11.51	19.00
CAM 1-06	15	-7.94	-11.27	19.25
CAM 1-07	17.5	-7.87	-11.28	19.23
CAM 1-08	20	-7.45	-11.48	19.03
CAM 1-09	22.5	-6.32	-12.37	18.11
CAM 1-10	25	-5.01	-13.45	17.00
CAM 1-11	27.5	-4.92	-14.62	15.79
CAM 1-12	30	-4.94	-14.57	15.84
CAM 1-13	32.5	-5.00	-14.23	16.19
CAM 1-14	35	-5.92	-12.81	17.65
CAM 1-15	37.5	-6.21	-11.41	19.11
CAM 2-01	2	-3.45	-11.17	19.35
CAM 2-02	4	-3.71	-9.97	20.58
CAM 2-03	6	-4.57	-9.88	20.68
CAM 2-04	8	-5.68	-9.65	20.92

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
CAM 2-05	10	-6.57	-10.06	20.49
CAM 2-06	12	-7.21	-9.88	20.68
CAM 2-07	15	-6.86	-10.41	20.14
CAM 2-08	17	-6.84	-10.24	20.31
CAM 2-09	19	-4.88	-9.85	20.71
CAM 2-10	21	-3.61	-9.46	21.11
CAM 2-11	23	-4.26	-11.19	19.33
CAM 2-12	25	-4.93	-11.98	18.51
CAM 2-13	27	-5.44	-11.27	19.25
CAM 3-01	0	-6.27	-12.67	17.80
CAM 3-02	3	-6.25	-13.45	17.00
CAM 3-03	6	-6.33	-13.60	16.85
CAM 3-04	9	-6.44	-13.92	16.51
CAM 3-05	12	-6.84	-13.94	16.50
CAM 3-06	15	-7.45	-12.78	17.69
CAM 3-07	18	-7.77	-11.56	18.94
CAM 3-08	21	-7.74	-10.41	20.13
CAM 3-09	24	-7.66	-10.17	20.37
CAM 3-10	27	-7.32	-10.00	20.56
CAM 3-11	30	-6.29	-11.61	18.89
CAM 3-12	33	-5.33	-12.87	17.59
CAM 3-13	36	-5.17	-14.36	16.05
CAM 3-14	39	-5.78	-14.68	15.73
CAM 3-15	42	-6.53	-14.11	16.31
CAM 3-16	45	-7.11	-13.24	17.21
CAM 3-17	48	-7.33	-10.86	19.67
CAM 3-18	51	-7.34	-9.96	20.59
CAM 3-19	54	-6.91	-11.09	19.43
CAM 3-20	57	-6.22	-13.52	16.92
CAM 4-01	2.5	-4.28	-10.96	19.56
CAM 4-02	5	-5.39	-11.81	18.69
CAM 4-03	7.5	-6.05	-11.76	18.73
CAM 4-04	10	-6.12	-11.79	18.71
CAM 4-05	12.5	-5.91	-11.03	19.49
CAM 4-06	15	-6.00	-10.75	19.78
CAM 4-07	17.5	-6.59	-10.40	20.14
CAM 4-08	20	-7.10	-10.18	20.37
CAM 4-09	22.5	-7.57	-10.17	20.38
CAM 4-10	25	-7.94	-9.81	20.75
CAM 4-11	27.5	-7.31	-9.66	20.90
CAM 4-12	30	-5.75	-9.68	20.88
CAM 4-13	32.5	-3.51	-9.22	21.36
CAM 4-14	35	-3.16	-10.59	19.95

Sample	Dist. from occlusal surface (mm)	$\delta^{13}C$ VPDB (‰)	$\delta^{18}O$ VPDB (‰)	$\delta^{18}O$ VSMOW (‰)
CAM 4-15	37.5	-4.05	-11.94	18.55
CAM 4-16	40	-5.49	-10.96	19.56
CAM 5-01	3	-9.55	-9.01	21.58
CAM 5-02	6	-9.37	-9.67	20.89
CAM 5-03	9	-9.41	-10.82	19.71
CAM 5-04	12	-9.34	-11.22	19.30
CAM 5-05	15	-9.21	-11.81	18.69
CAM 5-06	18	-9.37	-11.42	19.09
CAM 5-07	21	-9.35	-11.11	19.41
CAM 5-08	24	-9.26	-10.73	19.81
CAM 5-09	27	-9.24	-10.16	20.39
CAM 5-10	30	-8.91	-10.16	20.39
CAM 5-11	33	-8.05	-10.92	19.61
CAM 5-12	36	-7.74	-11.01	19.51
CAM 5-13	39	-7.52	-11.21	19.31
CAM 5-14	42	-7.20	-11.46	19.05
CAM 5-15	45	-7.30	-11.86	18.64
CAM 5-16	48	-7.37	-12.53	17.95
CAM 5-17	51	-7.37	-12.94	17.53
CAM 5-18	54	-7.36	-12.56	17.91

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FEB 2 4 2022

In Reply Refer To:
N-100225
2800 (NVS0100)

CERTIFIED MAIL

DECISION

Noble Solar, LLC	:	
1901 Harrison Street, Suite 1600	:	Right-of-Way N-100225
Oakland, California 94612	:	Sagittarius Solar Project

Priority Determination

On November 9, 2020, the Bureau of Land Management (BLM) received an application for the Sagittarius Solar Project on public lands. The application was assigned the case number N-100225. Please refer to this number for all future correspondence relating to this case.

The BLM has reviewed and prioritized your application in accordance with the screening criteria in 43 CFR § 2804.35 and has determined your application to be a Medium priority. The rationale for the priority determination of your application is provided in the enclosed Priority Determination Worksheet. Regulations found at 43 CFR §2804.35(a) state that "High-priority applications are given processing priority over medim- and -low-priority applications…"

You may request the BLM re-categorize your application based on new information obtained through surveys, public meetings, or other data collection, or after any changes to the application. Staff time to review the new information will be limited and based on higher priority workload demands. If you submit a request for BLM to re-categorize your priority level, the BLM will determine the schedule on which we will review the information provided.

This decision may be appealed to the Interior Board of Land Appeals, Office of the Secretary, in accordance with the regulations contained in 43 CFR, Part 4 and the enclosed Form 1842-1. If an appeal is taken, your notice of appeal must be filed in this office (at the above address) within 30 days from receipt of this decision. The appellant has the burden of showing that the decision appealed from is in error.

If you wish to file a petition (request) pursuant to regulation 43 CFR 2801.10 or 2881.10 for a stay (suspension) of the effectiveness of this decision during the time that your appeal is being reviewed by the Board, the petition for a stay must accompany your notice of appeal. A petition for a stay is required to show sufficient justification based on the standards listed below. Copies of the notice of appeal and petition for a stay must also be submitted to each party named in this decision and to the Interior Board of Land Appeals and to the appropriate Office of the Solicitor (see 43 CFR 4.413) at the same time the original documents are filed with this office. If you request a stay, you have the burden of proof to demonstrate that a stay should be granted.

<u>Standards for Obtaining a Stay</u>

Except as otherwise provided by law or other pertinent regulation, a petition for a stay of a decision pending appeal shall show sufficient justification based on the following standards:

(1) The relative harm to the parties if the stay is granted or denied,

(2) The likelihood of the appellant's success on the merits,

(3) The likelihood of immediate and irreparable harm if the stay is not granted, and

(4) Whether the public interest favors granting the stay.

Acting For:
Shonna Dooman
Field Manager
Las Vegas Field Office

Enclosures

cc: Toby Butterfield (tb@primergysolar.com)

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Interested Parties

SNDO Renewable Energy
Project Priority Determination Worksheet

Project Name: Sagittarius Solar **Date:** February 22, 2022
BLM Serial Number: N-100225

Purpose: The purpose of this worksheet is to identify landscape level constraints for Solar and Wind project proposals in the Bureau of Land Management (BLM) Southern Nevada District Office (SNDO) and to prioritize the solar or wind proposal based on known resource conflicts.

This worksheet is divided into four sections. These sections evaluate each proposed solar or wind project submitted to the Southern Nevada District Office (SNDO). The sections in this worksheet are as follows:

- Section 1 identifies the prioritization of projects based on regulations (43 CFR §2804.35).
- Section 2 are local (SNDO) considerations.
- Section 3 identifies specific resources issues.
- Section 4 identifies the priority decision.

Section 1 – Regulation Compliance

The regulatory compliance criteria below come from 43 CFR §2804.35. When completing the following form, if something is marked present or further clarification is needed please note it in the table at the end of Section 2 or if resource specific within Section 3 notes.

	Low-Priority Criteria[1]	Present	Not Present
1)	Lands near or adjacent to lands designated by Congress, the President, or the Secretary for the protection of sensitive viewsheds, resources, and values (e.g., units of the National Park System, Fish and Wildlife Service Refuge System, some National Forest System units, and the BLM National Landscape Conservation System), which may be adversely affected by development.	X	
2)	Lands near or adjacent to Wild, Scenic, and Recreational Rivers and river segments determined suitable for Wild or Scenic River status, if project development may have significant adverse effects on sensitive viewsheds, resources, and values.		X
3)	Designated critical habitat for federally threatened or endangered species, if project development may result in the destruction or adverse modification of that critical habitat.		X
4)	Lands currently designated as Visual Resource Management Class I or Class II.		X
5)	Right-of-way exclusion areas.		X

[1] Lands currently designated as no surface occupancy for oil and gas development in BLM land use plans was removed from the low-priority criteria. This removal is due to the vagueness in the Las Vegas 1998 RMP.

Medium-Priority Criteria:		Present	Not Present
6)	BLM special management areas that provide for limited development, including recreation sites and facilities.		X
7)	Areas where a project may adversely affect conservation lands, including lands with wilderness characteristics that have been identified in an updated wilderness characteristics inventory.		X
8)	Right-of-way avoidance areas.	X	
9)	Areas where project development may adversely affect resources and properties listed nationally such as the National Register of Historic Places, National Natural Landmarks, or National Historic Landmarks.	X	
10)	Sensitive habitat areas, including important species use areas, riparian areas, or areas of importance for Federal or State sensitive species.	X	
11)	Lands currently designated as Visual Resource Management Class III.	X	
12)	Department of Defense operating areas with land use or operational mission conflicts.		X
13)	Projects with proposed groundwater uses within groundwater basins that have been allocated by State water resource agencies.	X	

High-Priority Criteria:		Present	Not Present
14)	Lands specifically identified as appropriate for solar or wind energy development, other than designated leasing areas.		X
15)	Previously disturbed sites or areas adjacent to previously disturbed or developed sites.	X	
16)	Lands currently designated as Visual Resource Management Class IV.	X	
17)	Lands identified as suitable for disposal in BLM land use plans.		X

Section 2 – Local Considerations

The following considerations are specific to the Southern Nevada District. The selection of "present" for any of the local considerations can change the project priority. These local considerations take into account, but are not limited to, the following secretarial orders, policy, regulation, and laws, and BLM priorities.

- 43 CFR §2804.35
- Approved Resource Management Plan Amendments/Record of Decision for Solar Energy Development in Six Southwestern States[i]
- 1998 Las Vegas Resource Management Plan[ii]
- Department of the Interior Priorities[iii]
- Bureau of Land Management Leadership Priorities[iv]
- United States Fish and Wildlife Species List[v]
- Nevada State Species List[vi]
- BLM Sensitive Species List[vii]

Local Considerations		Present	Not Present
18)	Development is located in the Southern Nevada Public Land Management Area (SNPLMA) Boundary		X
19)	Development is located near the proposed Southern Nevada Supplemental Airport		X

20)	There is a Solar Energy Zone or Designated Leasing Area within the district that could be used.	X	
21)	Development is located in areas where project development may adversely affect lands acquired for conservation (e.g., SNPLMA Environmentally Sensitive Land Acquisitions such as the Perkins Ranch acquisition near the Moapa, Nevada).		X
22)	The proposed project supports economies of local Tribes		X
23)	The proposed project supports the economy of Nye County		X
24)	Development is located within an area identified for disposal		X
25)	Development is located within a utility corridor	X	
26)	Development is located within lands withdrawn from ROW authorizations		X
27)	Development is located within lands segregated from ROW authorizations.		X
28)	Development is located over another Solar or Wind Application		X see note
29)	Development may not be compatible with an existing grant, easement, lease, license, or permit.		
30)	Development is located outside of BLM jurisdiction		X
31)	Development is located on private lands		X
32)	Development is located in a USFWS least cost desert tortoise corridor.		X
33)	Development is located in or adjacent to desert tortoise translocation areas	X	
34)	Development is located over existing or active mining claims or community pit		X
35)	Development is located over or within 1000 meters of natural surface water, springs, riparian areas or wetlands	X	
36)	Development is located within a hydrogeographic basin where groundwater withdrawal could potentially impact groundwater dependent natural resources.	X	
37)	Development is located over lands containing sensitive soil resources.	X	

When completing Sections 1 and 2, if something is marked present or further clarification is needed please include here. Please place the number in the first column that corresponds to the number in Sections 1 and 2. If the presence or clarification is resource specific provide the justification or clarification in Section 3.

Clarifications/Justifications	
1	The Old Spanish National Historic Trail (Designated December 2002) is located less than two miles south of the proposed project area. Associated with the OSNHT, the Stump Spring high potential site is also within two miles of the proposed project area. High potential sites are those historic sites related to the route or sites near the route, which provide opportunity to interpret the historic significance of the trail during the period of its major use; criteria for consideration as high potential sites include historic significance, presence of visible historic remnants, scenic quality, and relative freedom from intrusion. The trail corridor is informally considered by the BLM and the NPS to lie five miles on either side of the centerline of the trail alignment to include the nearest elements of the viewshed, parts of the cultural landscapes, landmarks, and traditional cultural properties near the trail. (Old Spanish National Historic Trail Comprehensive Administrative Strategy, 2017) Additional information on the potential conflicts with the OSNHT are found in the resources section. The National Park Service has identified Areas of High Potential for Resource Conflict near Death Valley National Park which overlap approximately 2,000 acres of the 4,400 proposed project area. (Variance Factor in Solar PEIS)

8	This project is located within Solar Avoidance/Variance areas. The project is not located in an area designated as avoidance for other site type rights-of-way.
9	The project is 2.6 km north of a recorded segment of the National Register Listed Old Spanish Trail/Mormon Road Historic District and may have adverse indirect effects to the site.
10	There is riparian habitat occurring within the current proposed project area boundary, but this could be excluded as part of boundary adjustments.
11	The project area is located partially within BLM VRM Class III (designated in the Resource Management Plan), including approximately 40 acres of the current proposed project area boundary.
13	The proposed project area is located within the Pahrump Valley Basin, which is three times over appropriated in terms of water rights. No new water rights are available. There may be a need to purchase existing water rights and water rights to relinquish to the basin for the project to obtain water within the Pahrump Valley Basin.
15	The project area would be adjacent to Yellow Pine Solar (N-90788) approved and currently being developed ROW. The rest of the project area looks to be undisturbed based on Google imagery.
16	The project area is located almost entirely within BLM VRM Class IV (designated in the Resource Management Plan), including approximately 4,400 acres of the current proposed project area boundary.
20	The Amargosa SEZ and the Dry Lake East DLA are both available for Solar Energy Development. While there is space in both an SEZ and a DLA in the Southern Nevada District, neither of those located are sufficiently sized to accommodate all of the interest that is present in the district for Renewable Energy.
25	The SNDO 1998 RMP Amargosa-Roach Designated Corridor runs through sections 7,8,17,16, and 21 of the project area. The West Wide Energy Corridor (WEC 224-225) runs through sections 7, 17,18,19,20, and 21 of the project area.
28	This application overlaps one of the Rough Hat Nye (N-99407) gen-tie line route.
32	Project is located in Priority 2 connectivity habitat as identified in the Solar PEIS (Variance Factor).
33	Located adjacent to the Stump Springs translocation area (across Tecopa Springs Road), which will be fenced preventing any tortoises from moving into the project area.
35	Sensitive riparian areas, including mesquite bosques, are located within the proposed project footprint. These mesquite woodlands provide important habitat for migratory bird species. Mesquite in southern Nevada have been impacted by development, illegal woodcutting, and ground water withdrawal throughout the district. The BLM would coordinate with the applicant to adjust the proposed project area to remove mesquite bosques and reduce potential direct impacts.
36	The Pahrump Valley Basin is overallocated in water use permits. Any additional pumping is likely to impact groundwater dependent natural resources within the valley and adjacent valley to the southeast, depending on the depth of wells. There are several springs in the vicinity and downstream from the project area that may be impacted. BLM has water rights to some of these springs. Local riparian areas may also be impacted by additional groundwater pumping. Until additional information is gathered on proposed ground water pumping, this information is not contributing to the project priority level. If the proponent decides to include ground water pumping in the plan of development, coordination with the State Water Engineer will be required.
37	Biocrust and desert pavement is known to exist in the general vicinity. Detailed surveys would be required to determine the density of biocrust.

Section 3 – Resource Considerations

This section identifies the proposed projects resources conflicts. This section is to be completed by BLM resource specialists using existing data and knowledge of the area. The resource conflicts identified in this section can change the priority of the project.

Desert Tortoise
Considerations: • Based on vegetation, soil type, and/or previous surveys, whether the project is proposed in areas expected to occur in low, medium or high density tortoise habitat. • Whether the project is proposed in relatively undisturbed habitat. • Whether the project is located in a tortoise genetic connectivity corridor (least cost tortoise corridor) • The availability of an area to translocate desert tortoise within the same recovery unit from the proposed project site.
Description of Issues: • Desert tortoise (*Gopherus agassizii*) is a BLM sensitive species and classified as threatened by the USFWS. • Without new tortoise surveys, the density of tortoises within the project area is unknown. However, there are 10 historic tortoise surveys within 3 km of the project area that were conducted "prior to 1987" or "1987 to 1990". The density results of those surveys vary but are classified as "very low" (3), "low" (6), and "very high" (1). • Recent tortoise surveys for the Rough Hat Nye solar project, which is located west and north of the proposed Sagittarius project, has similar habitat quality and an estimated adult tortoise density of 3.5 tortoises per km^2. In comparison, Rough Hat Clark solar, which is located north and east of the proposed Sagittarius project, has an estimated tortoise density of 14 tortoise per km2. • The project is proposed in relatively undisturbed habitat. • The project is located in high value contiguous habitat as modeled by the DTRO with the second highest conservation value in order to maintain desert tortoise connectivity on a landscape scale. The project is also located in Desert Tortoise Priority 2 habitat designated in the Solar PEIS. Even though this project is located in high value contiguous habitat, and Desert Tortoise Priority 2 habitat, the desert tortoise connectivity is being maintained in this area through limiting development north of State Route 160 and east of Tecopa Road, which are part of the BLM's regional tortoise augmentation areas (Stump Springs and Trout Canyon Translocation Areas). The project is not located within the recently outlined priority tortoise connectivity habitat and is instead located just east of Pahrump, south of State Route 160, west of Tecopa Road, and southwest of the proposed Yellow Pine Solar Project. • The project is located in the Eastern Mojave Recovery Unit, and this recovery unit is estimated to have a decreasing tortoise density. Tortoise translocation can follow existing USFWS established protocols. Tortoise could be translocated into the Stump Springs Regional Translocation Area, which is located directly across Tecopa Road.

Other Federally Listed, State Listed, and BLM Sensitive Species Constraints
Considerations: • Whether there are other Federally Listed, State Listed, and BLM Sensitive Species expected to occur at the site or have the potential to be directly or indirectly affected by the proposed project.
• Besides desert tortoise, there are no other known listed species in the project area. • Other BLM sensitive species most likely occur within the project area including Phainopepla, Golden Eagle, LeConte's Thrasher, Loggerhead Shrike, Prairie Falcon, Scott's Oriole, Western Burrowing Owl, Desert Horned Lizard, Long-nosed Leopard Lizard, and Sidewinder. Impacts can be addressed through the normal NEPA process. • Mesquite bosques within the project area support migratory and resident bird communities including the BLM sensitive Phainopepla.

Botany
Considerations: • Whether the project will occur in or adjacent to habitat for any sensitive or state or federally listed species or Clark County MSHCP protected plant species. • Whether the project occurs in major portion (>10% of any population group) of habitat for BLM sensitive plant species or MSHCP protected plant species • Whether the project occurs in any habitat for federally endangered plant species OR Project occurs in habitat (> 5% of any population group) for state endangered plant species.
Description of Issues: • Pahrump Valley buckwheat (*Eriogonum bifurcatum*) is a BLM sensitive species and is covered by the Clark County MSHCP. This species has a high likelihood of occurring within the project area – a population was recorded immediately at the southern edge of the project boundary, and the project area has not been previously surveyed for this species. • Because the project area has not been surveyed it is unclear what percentage of overall habitat for the Pahrump Valley buckwheat occurs within the project boundaries. However, given the density of proposed projects in this area, cumulative impacts to this species should be analyzed, as multiple adjacent projects have footprints that could impact habitat for this species. • The project does not occur in habitat for any federally threatened or endangered plant species or in habitat for state endangered plant species. • The project boundary does overlap mesquite bosques, which are important vegetation communities in southern Nevada and important habitat patches for BLM sensitive bird species. Proximity to the Stump Springs ACEC, which supports dense mesquite bosques and is an important stopover location for migratory birds, should also be considered in prioritization of this project.

Weed Constraints
Considerations: • Whether there are non-native and/or noxious weed species present or adjacent to the project area. • Whether the project activity is likely to result in the establishment of noxious/invasive weed species. • Whether the spread of non-native and/or noxious weed species would result in impacts to the surrounding areas and whether that would have impacts to important areas such as Critical Habitat Units, ACECs, sensitive plant habitat, NCA's, National Monuments, etc.
Description of Issues: • Comprehensive weed surveys have not been done in this area, but Mediterranean grass (*Schismus* barbatus) is a non-native species that is pervasive in the area. • The project will contribute to weed proliferation in the area, but this can be managed through a thorough weed management plan and BMPs. The likelihood of weed invasion decreases when there is decreased soil disturbance. • The project is across the road from the Stump Springs ACEC, which protects cultural and natural resources. There are currently no novel weed problems, but introduction of new weed species by the project and subsequent weed spread could lead to detrimental effects in the ACEC.

Cultural and Native American
Considerations: • Whether there are isolated documented sites and sites within 1000 meters of the project area. • Whether there are ineligible archaeological sites and possible Native American cultural or religious sites, including high potential areas like river terraces or springs. • Whether there are eligible archaeological resources that require treatment and known Native American Cultural or religious sites. • Whether there are significant eligible intact sites and undisturbed human burials.
Description of Issues: • The majority of the proposed project area has not been inventoried for cultural resources. If the results for this project are like the Yellow Pine Project, or the Clark and Nye County Rough Hat Projects, which are adjacent to or near this project area, there is a very low probability of locating historic properties. A Class III Cultural Resource Inventory would be required for this project. • There are no documented Isolated Objects within the project area nor within 1000 m of the project boundary. • There are three documented ineligible archaeological sites within the project area. • There are no documented eligible archaeological or Native American cultural or religious sites within the project area. • There is one documented isolated cemetery that appears to be approximately 10 meters outside the proposed project area. Though it was recommended ineligible, it was recommended that the site be specially managed by the BLM as an "Indian Burial Site," which is protected under the Nevada Antiquities Law of 1889 and the Native American Graves Repatriation Act (NAGPRA). • The project is 2 km north of the Stump Springs ACEC, which contains an eligible multi-component archaeological site. Indirect effects to the site may be a concern.

• The project is 2.6 km north of a recorded segment of the National Register Listed Old Spanish Trial/Mormon Road Historic District and could pose indirect effects to the site.

Recreation
Considerations: • The level of casual use recreation. • Types and numbers of special recreation permits in the area. • Whether the proposed project area occurs within a Special Recreation Management Area identified in a Land Use Plan that is managed specifically for recreation opportunities. • The proposed project area occurs within a Special Recreation Management Area identified in a Land Use Plan that is managed specifically for recreation opportunities, and has developed recreation facilities (trailheads, kiosks, staging areas), in addition to having special recreation permitted activities.
Description of Issues: • The area has casual use in the form of camping and OHV riding. Generally, the OHV use is moderate in the northwest portion of the boundary. Dispersed camping has a low level of use in that area. • There is currently one potential commercial OHV SRP administered by the Pahrump Field Office that has proposed operations on existing routes across the proposed project area. • The proposed project area does not occur within a Special Recreation Management Area.

Range / Grazing
Considerations • Whether the project area is located in any active grazing allotment. • Whether the development of the solar facility make grazing impossible within the active allotment (development of key forage areas or key water sites). • Whether the project is in an allotment where Clark County has purchased the grazing preference to protect desert tortoise under the MSHCP (Arrow Canyon, Arrow Canyon in Battleship Wash, Beacon, Bunkerville, Crescent Peak, Christmas Tree Pass, Gold Butte, Hen Springs, Ireteba Peaks, Jean Lake, McCullough Mountain, Mesa Cliff, Roach Lake, Table Mountain, Toquop Sheep, Upper Mormon Mesa, White Basin).
Description of Issues: • The project is not located in an active grazing allotment. • Because the project is not within an active grazing allotment, it will not influence the ability of any current permittees to graze within their allotment. • The project is not within an allotment where Clark County has purchased the grazing preference to protect desert tortoise under the MSHCP.

Section 4 - Priority Decision

Priority Decision	
Based on the BLM screening criteria found in 43 CFR 2804.35, and additional resource considerations, the project priority category has been determined to be:	**Medium**

Justification: The Priority Decision documented above is made given the following considerations.

There are several other applications in the same geographic vicinity as this project. This project is located south of and adjacent to the Yellow Pine Solar Project which is currently authorized and beginning construction. The Final EIS for the Yellow Pine Solar Project disclosed resource conflicts with issues that could be largely resolved through best management practices and mitigation measures. Work will need to be done with the Sagittarius applicant to avoid certain impacts, such as removing areas with mesquite bosques from the proposed development area.

The Stump Springs Regional Translocation Site for desert tortoise would be available to accept tortoises from this project area. The Stump Springs Regional Long-term Monitoring Plan has already been approved by the USFWS and can be used by solar projects that translocate tortoises within the Eastern Mojave Recovery Unit.

The project area is located within two miles of the Old Spanish National Historic Trail, and is entirely within the informal trail corridor, and coordination and consultation with the National Park Service, the co-administrator of the trail, and the Old Spanish Trail Association will be required. Development of a BLM Manual 6280 Inventory and Impacts Analysis report will also be required.

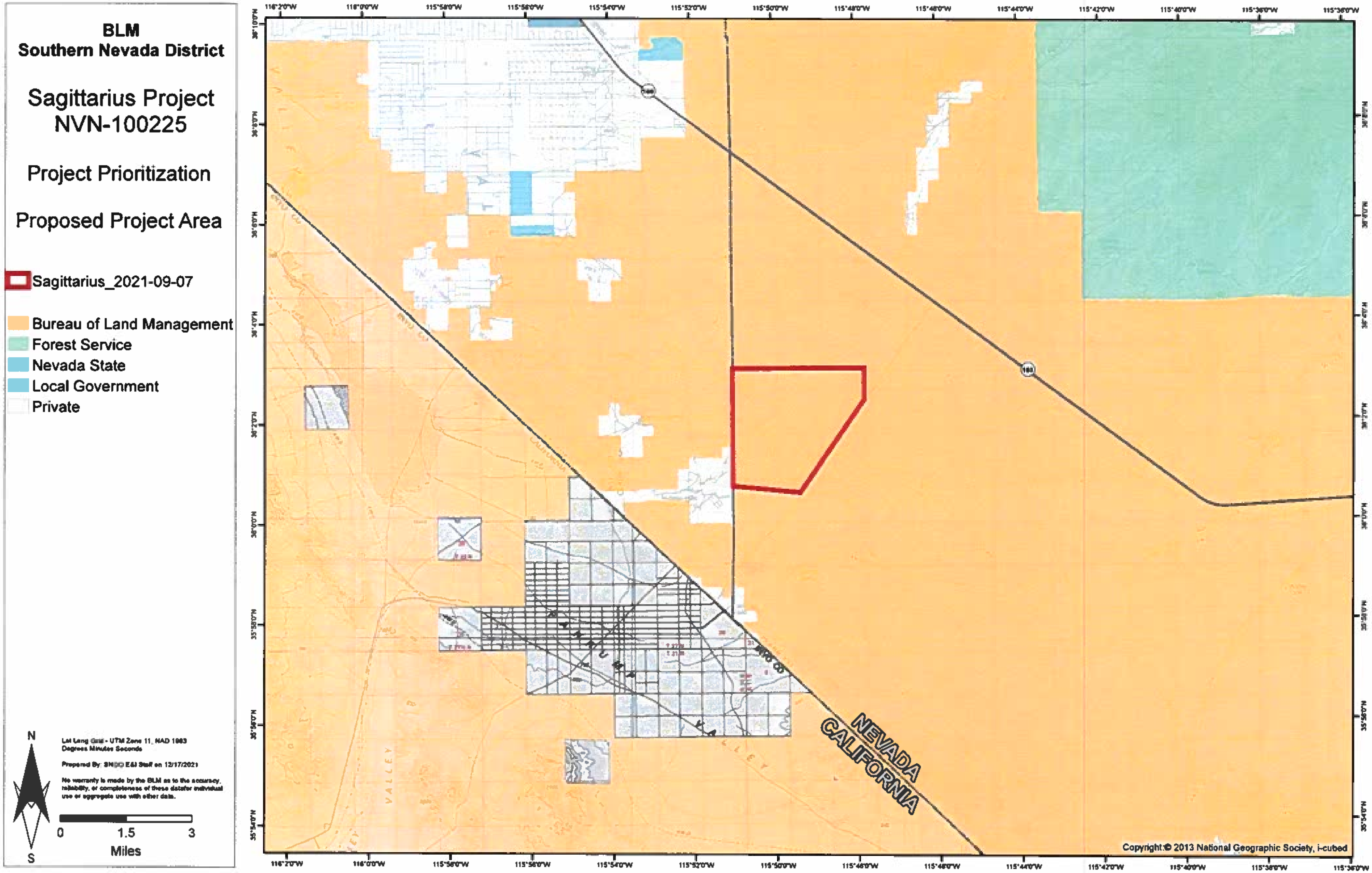
The presence of Areas of High Potential for Resource Conflict near Death Valley National Park on approximately half of the proposed project area will require additional review and consideration during the variance process.

After reviewing the information provided above, this project has several potential resource conflicts across the three regulatory compliance criteria categories. Therefore, the project is determined to be a Medium Priority for processing.

Shonna Dooman — 2/22/2022
Field Manager — Date
Las Vegas Field Office

Concurrence / Non-Concurrence — Angelita S. Bulletts — 2/23/2022
District Manager — Date
Southern Nevada District

[i] BLM. 2012a. "Approved Resource Management Plan Amendments/Record of Decision for Solar Energy Development in Six Southwestern States." October.
[ii] BLM. 1998. "Record of Decision for the Approved Las Vegas Resource Management Plan and Final Environmental Impact Statement." October.
[iii] https://www.doi.gov/ourpriorities
[iv] https://blmspace.blm.doi.net/wo/600/commtools/SitePages/Leadership%20Priorities.aspx
[v] https://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=NV&status=listed
[vi] http://heritage.nv.gov/species/process.php
[vii] https://www.blm.gov/policy/nv-im-2018-003



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Sagittarius Project
NVN-100225
Project Prioritization
Proposed Project Area
Sagittarius_2021-09-07
Bureau of Land Management
Forest Service
Nevada State
Local Government
Private
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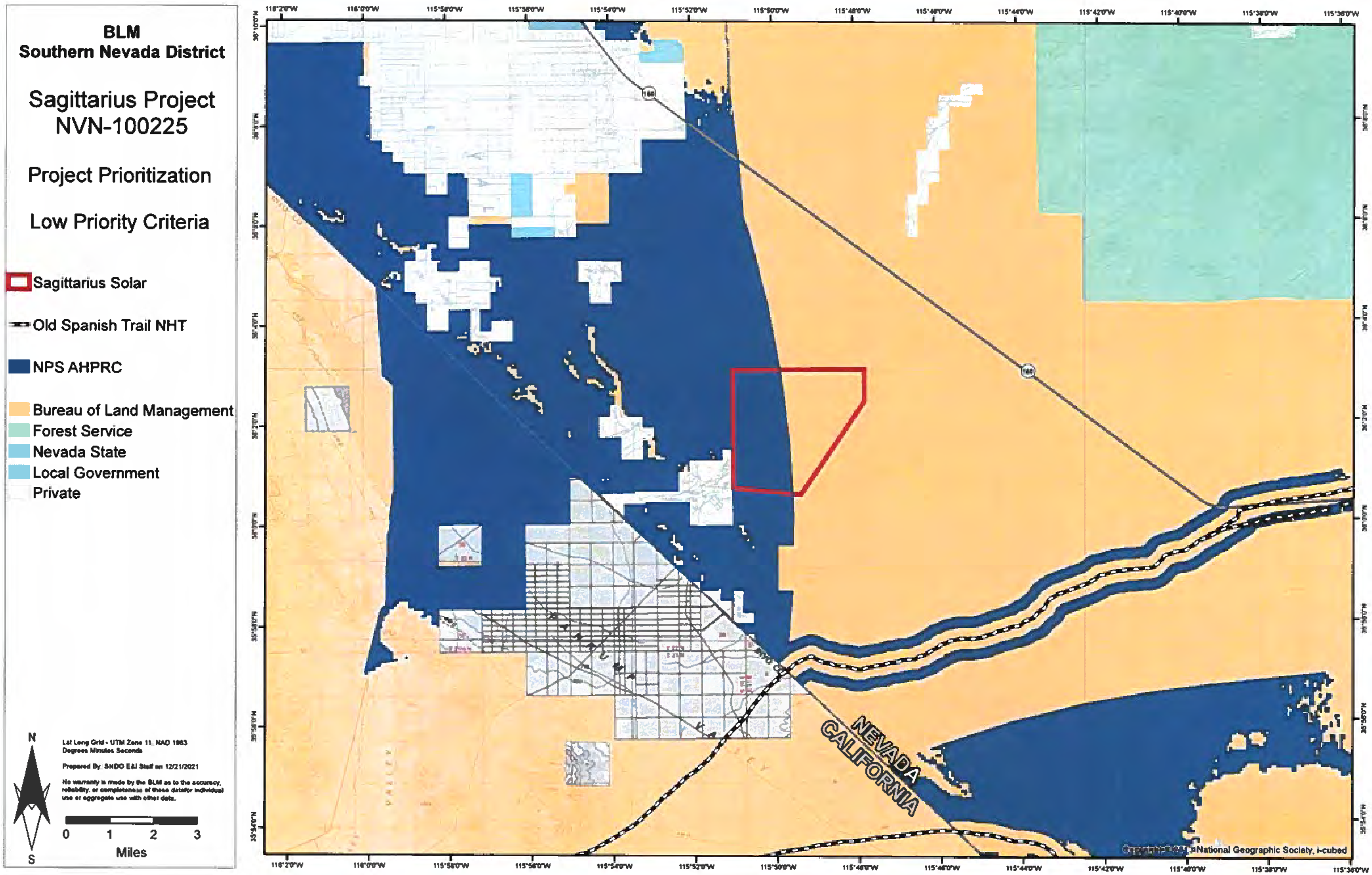
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NVN-100225
Project Prioritization
Low Priority Criteria
Sagittarius Solar
Old Spanish Trail NHT
NPS AHPRC
Bureau of Land Management
Forest Service
Nevada State
Local Government
Private
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Lat Long Grid - UTM Zone 11, NAD 1983
Degrees Minutes Seconds
Prepared By: SNDO E&I Staff on 12/21/2021
No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data.
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BLM
Southern Nevada District

Sagittarius Project
NVN-100225

Project Prioritization

Medium Priority Criteria

- Sagittarius Solar
- Mesquite
- NV Groundwater Basin 162
- VRM Class 3
- Variance Areas
- Bureau of Land Management
- Forest Service
- Nevada State
- Local Government
- Private

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Lat Long Grid - UTM Zone 11, NAD 1983
Degrees Minutes Seconds

Prepared By: SNDO E&J Staff on 12/21/2021

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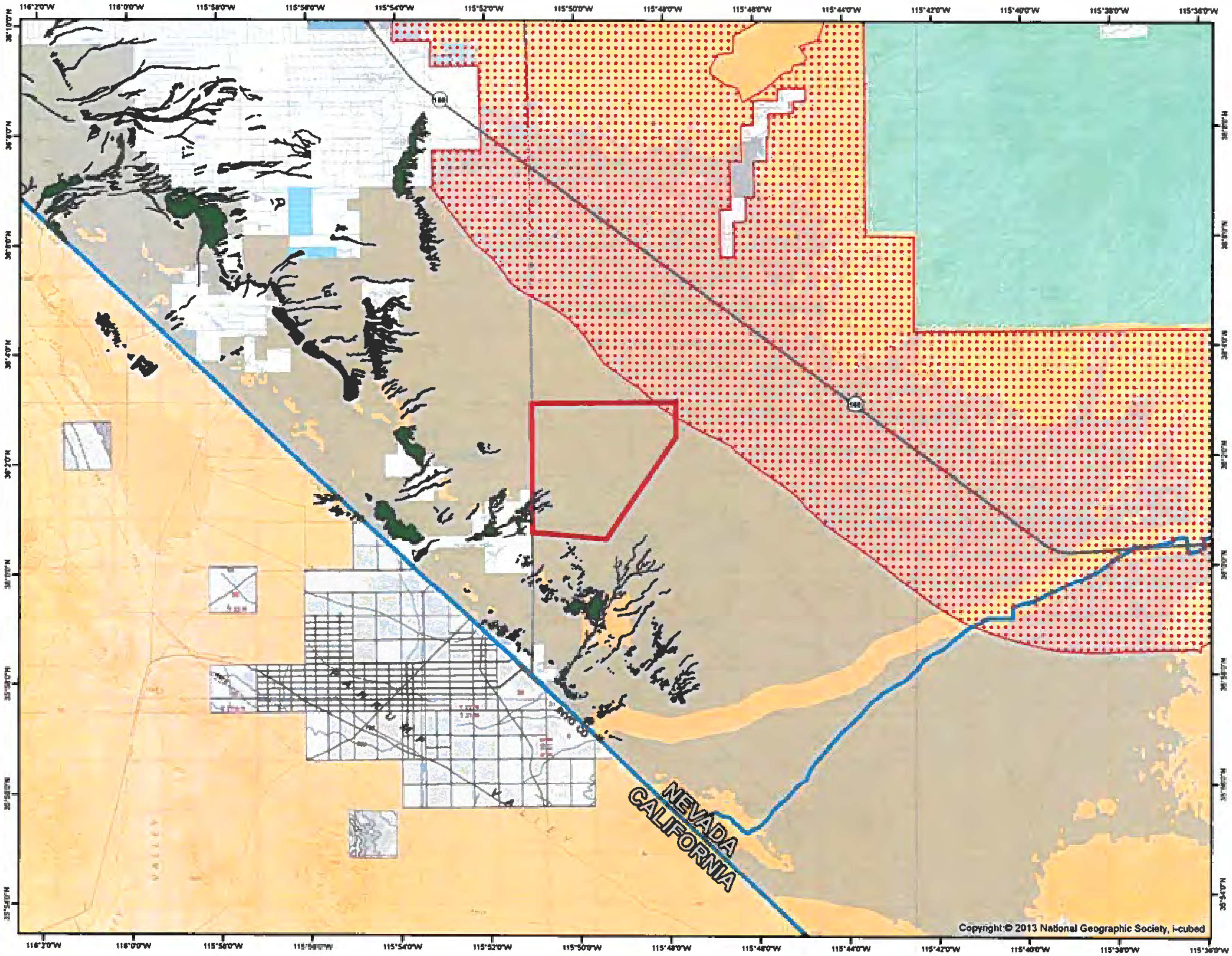


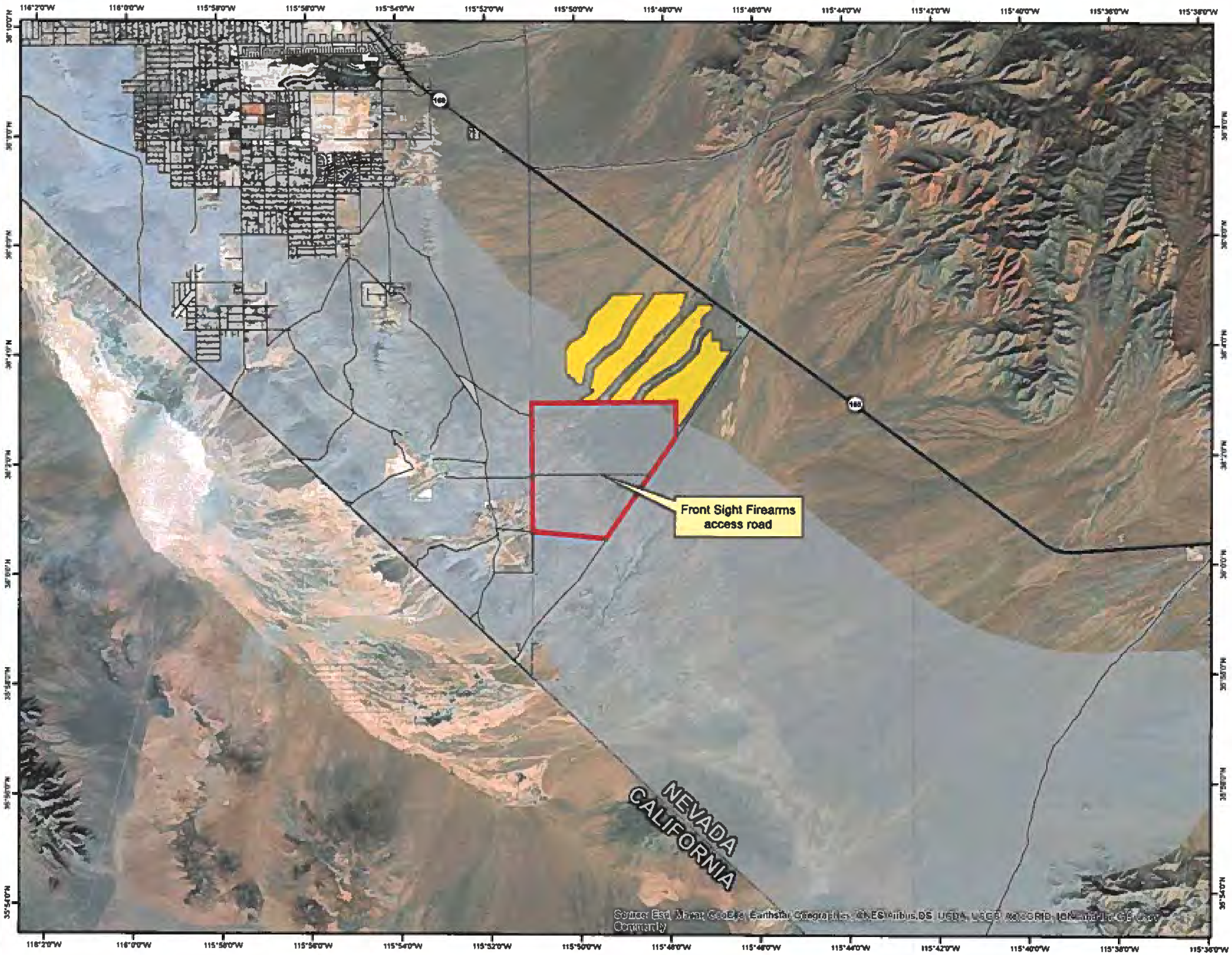
BLM
Southern Nevada District

Sagittarius Project
NVN-100225

Project Prioritization

High Priority Criteria

- Sagittarius Solar
- Yellow Pine Solar Project
- VRM Class 4



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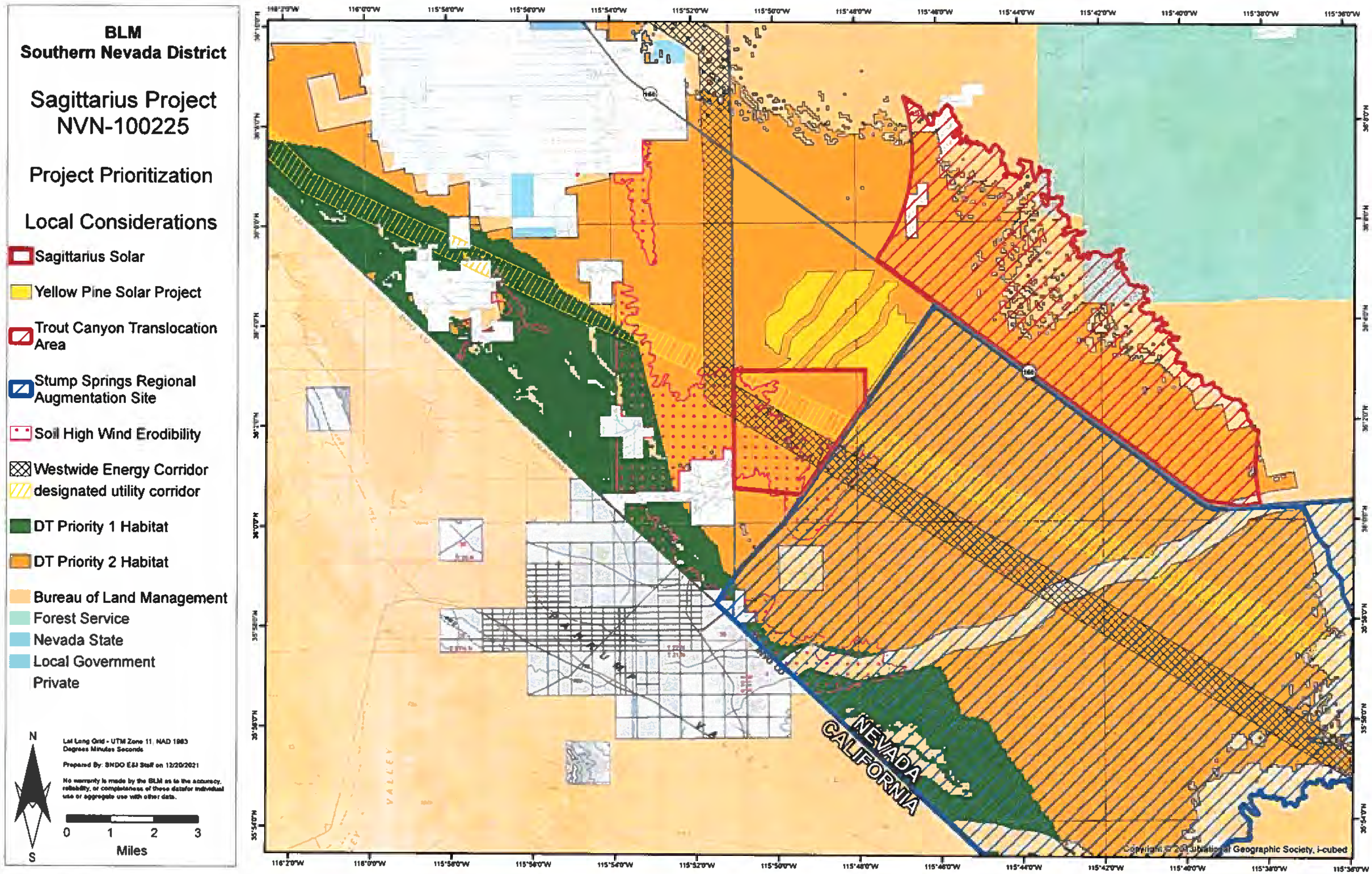
BLM
Southern Nevada District
Sagittarius Project
NVN-100225
Project Prioritization
Local Considerations
Sagittarius Solar
Yellow Pine Solar Project
Trout Canyon Translocation Area
Stump Springs Regional Augmentation Site
Soil High Wind Erodibility
Westwide Energy Corridor
designated utility corridor
DT Priority 1 Habitat
DT Priority 2 Habitat
Bureau of Land Management
Forest Service
Nevada State
Local Government
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Lat Long Grid - UTM Zone 11, NAD 1983
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CALIFORNIA
VALLEY

[EXTERNAL] Opposition to Golden Currant Solar Project Variance

[redacted]

Thu 8/4/2022 5:26 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Hello,

This project would destroy thousands of acres of precious desert habitat. I am also concerned about the impact this project would have to the plants, animals, and geology of the region. This would endanger our friend the Desert Tortoise as well. We also need to consider the health of the rural communities that will be impacted by this. Air quality will suffer in Pahrump and the Las Vegas Valley as a result of construction and this will degrade the health of our communities.

Don't sell our desert to big solar! Please protect fragile desert ecosystems and public health. We need solar power and other renewables, but this should be concentrated in disturbed areas. Rooftop solar and parking lot solar would be better alternatives than this project.

Best,
[redacted]

[EXTERNAL] Golden Curant Solar Project Variance

[redacted]

Thu 8/4/2022 8:48 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

Please consider this email as a comment against Golden Currant Solar. The mesquite bosques are imperiled in the southwest. Please protect the mesquite and their natural drainage patterns. Also, this is the home of your tortoise relocation and should remain unbladed.

[redacted]

Fw: [EXTERNAL] Opposition letter to the Golden Currant Solar Project

Ransel, Beth E <bransel@blm.gov>
Fri 8/5/2022 4:36 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

1 attachments (1 MB)
Golden Currant Variance Comments final2.pdf;

Beth Ransel
Southern Nevada District Energy & Infrastructure Team
Bureau of Land Management, Interior Regions 8 & 10
bransel@blm.gov / 702-280-5938

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From: Shepherd, Alan B <ashepher@blm.gov>
Sent: Friday, August 5, 2022 2:43 PM
To: Ransel, Beth E <bransel@blm.gov>; Dooman, Shonna <sdooman@blm.gov>
Subject: FW: [EXTERNAL] Opposition letter to the Golden Currant Solar Project

Angie may have forwarded this to you but just in case

Thanks,
Alan

Alan Shepherd
DSD – Resources, Lands, and Planning (NV930)
Nevada State Office
Bureau of Land Management
Reno, NV 89502
Office: 775-861-6767
Gov Mobile: 775-530-2784
ashepher@blm.gov

From: [redacted]
Sent: Friday, August 5, 2022 6:34 AM
To: Stone-Manning, Tracy M <tstonemanning@blm.gov>; Deb_Haaland@ios.doi.gov; Culver, Nada L <nculver@blm.gov>; Hudson, Dane (Rosen) <Dane_Hudson@rosen.senate.gov>; Zaragoza, Zach <Zach_Zaragoza@cortezmasto.senate.gov>; Goicoechea, Pete Senator <Pete.Goicoechea@sen.state.nv.us>; DistrictF@clarkcountynv.gov; Gregory.Hafen@asm.state.nv.us; Raby, Jon K <jraby@blm.gov>; Shepherd, Alan B <ashepher@blm.gov>; Bulletts, Angelita S <abulletts@blm.gov>
Subject: [EXTERNAL] Opposition letter to the Golden Currant Solar Project

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

Hello,

Several groups and individuals sent in the attached letter to BLM opposing the Golden Currant Solar Project variance review proposed for public lands in Southern Nevada.

Impacts to the Old Spanish National Historic Trial, desert tortoise, paleontological resources, public access and air quality have all been raised.

Please take a look at this letter and help us reject the Golden Currant Solar Project.

Thank you,

[redacted]

August 4th, 2022

To: Bureau of Land Management Southern Nevada District Office
Attn: Golden Currant Solar Project Variance
4701 N. Torrey Pines Drive
Las Vegas, NV 89130

Email sent to: BLM_NV_SND_EnergyProjects@blm.gov

Re: Comments on the Golden Currant Solar Project Variance Process

To Whom it May Concern,

Basin and Range Watch is a nonprofit working to conserve the Mojave and Great Basin deserts and to educate the public about the diversity of life, culture, and history of the ecosystems and wild lands of the desert.

The mission of **Western Watersheds Project** is to protect and restore western watersheds and wildlife through education, public policy initiatives, and legal advocacy.

Mojave Green combines art and activism to draw attention to issues of environmental injustice and highlights viable solutions.

Wildlands Defense works to inspire and empower the preservation of wild lands, wildlife and biodiversity in the West.

The Desert Tortoise Council is a non-profit organization comprised of hundreds of professionals and laypersons who share a common concern for wild desert tortoises and a commitment to advancing the public's understanding of desert tortoise species. Established in 1975 to promote conservation of tortoises in the deserts of the southwestern United States and Mexico, the Council routinely provides information and other forms of assistance to individuals, organizations, and regulatory agencies on matters potentially affecting desert tortoises within their geographic ranges.

Morongo Basin Conservation Association advocates for the healthy desert environment that nurtures the region's rural character, cultural wealth and economic well-being.

Shoshone Village is situated in the beautiful Death Valley and Amargosa River region of Inyo County California, and is an ecotourism hub.

Desert Survivors is a non-profit organization founded in 1981 with the mission of experiencing, sharing and protecting desert wilderness. We recognize the places we love to explore will not remain wild unless we give others the opportunity to experience them and unless we remain vigilant and active in our efforts to monitor and preserve them.

Together known as 'Conservation Groups.'

———

The proposed Golden Currant Solar Project is undergoing a Variance Review process and the Bureau of Land Management (BLM) has recently segregated mineral rights for 2 years to consider an application for a 4,300-acre solar project.

Noble Solar, LLC applied for a right-of-way grant for the construction, operation and eventual decommissioning of a proposed 400 megawatt (MW) alternating current solar facility and battery energy storage system on BLM managed public land.

During the Virtual Variance Meeting on July 19th and 20th, 2022, several issues were raised by participants.

These issues include:

1. Desert Tortoise – In 2021, biologists removed nearly 3 times the amount of desert tortoise predicted to be on the adjacent Yellow Pine Solar Project site on a record-breaking drought year, many of which were killed by predators. Eleven additional tortoises were located on the site since the original translocation—one of which was run over by a vehicle (personal communication, July 29, 2022, BLM).
2. Fugitive Dust – Large-scale solar developers can't seem to ever control fugitive dust emissions caused by their projects. This is very difficult in arid regions and the projects develop four to ten square miles of land at a time. In addition to being a visual eyesore, the human health risks stemming from disturbed topsoils/blowing dirt and dust events, is a rising problem. According to numerous studies *Coccidioides immitis* is a fungus found in the soil; clinical infections have a strong association with blowing dust events in the Southwestern United States. Blowing dust events can cause significant morbidity and

mortality in the general population causing acute respiratory failure and exacerbations of chronic respiratory diseases, such as asthma and COPD[1].

3. Old Spanish National Historic Trial – the project would be located about 2 miles away from the Old Spanish Trail. A large industrial project would destroy the historic view-scape of the area as well as cause desecration to this national historic treasure.
4. Important Mojave Desert Habitat – The project would impact high quality Mojave Desert habitat and remove several thousand Mojave yucca plants. It would also impact mesquite woodlands and associated species. The rare Pahrump buckwheat has been found on the project site.
5. Water – the project would need over 1,000 acre-feet of water for construction and 200-acre feet a year for operation for 30 years which is 6,000 acre feet. All basins are over-allocated.
6. Public Land Access – Large areas of public lands (up to 7 square miles) would be blocked off by fences and solar panels.
7. Visual Impacts – The project would be visible for several miles and from wilderness areas in Nevada and California, and even from high elevations in Death Valley National Park.
8. Paleontological Resources – the project possibly contains Plio-Pleistocene megafaunal fossils, such as mammoth.
9. Pahrump Paiute Ethnography – The Golden Currant Site is adjacent to both Stump Springs and Brown's Spring. The mesquite areas throughout this valley constitute an important part of the Pahrump Paiute's cultural landscape.

Please pause the Golden Currant Solar Project Variance Review until the Resource Management Plan can be Revised.

The BLM is basing the variance review on an old and outdated Resource Management Plan (RMP) called the Las Vegas Resource Management Plan that was completed in 1997. The plan is 25 years old. In the meantime, the listed population of the desert tortoise has experienced drastic declines (Allison and McLuckie 2018) and the International Union for Conservation of Nature's (IUCN) Species Survival Commission, Tortoise and Freshwater Turtle Specialist Group, now considers the Mojave desert tortoise to be Critically Endangered (Berry et al. 2021).

The 25-year-old plan has designated most of the project site as a Visual Resource Management Class IV which encourages developments like this, but this was before June 5, 2003, when the Secretary of the Interior assigned joint administrative responsibility for the Old Spanish National Historic Trail to the Bureau of Land Management and the National Park Service.

The 25-year-old plan also predates the Clark County Multi Species Habitat Conservation Plan (MSHCP) which was established in 2000 to conserve a wide variety of species and their habitats throughout the county. The MSHCP has been prepared pursuant to Section 10(a) of the

[1] See for example https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8962906/

Endangered Species Act of 1973, as amended (Act). The MSHCP identifies those actions necessary to maintain the viability of natural habitats in the county for approximately 232 species residing in those habitats. Some of those species and habitats are present on the Golden Currant Solar Energy project site.

We have learned through personal communication with the BLM that they are planning a Nevada-wide Resource Management Plan revision in 2023. Land use planning can help define the latest values and issues involving these public lands. An RMP revision would require an updated analysis of these values and help the agency better decide the importance of this area. It appears that BLM is using a loophole trying to review this project with an outdated RMP.

We would like to request that all Variance and future NEPA review for this proposed project be paused until the Resource Management Plan can be revised.

The Federal Land Policy and Management Act (FLPMA) requires the BLM to maintain on a continuing basis an inventory of all public lands and their resources and other values (Inventories, Section 201). Planning, per FLPMA Section 202, instructs that the Secretary of the Interior shall, with public involvement and consistent with the terms and conditions of the Act, develop, maintain, and, when appropriate, revise land use plans which provide tracts or areas for the use of the public lands.

The purpose of a Resource Management Plan (RMP) is to:

1. Allocate resources and determine appropriate multiple uses for the public lands;
2. Provide a strategy to manage and protect resources;
3. Establish systems to monitor and evaluate the health of resources and effectiveness of practices.

RMPs are like a public lands version of municipal zoning.

The Bureau of Land Management evaluates and amends or revises its land-use plans in response to changing conditions and demands on the public lands, or when new components are added to the National Conservation Lands that it manages. Keeping a plan up-to-date helps ensure that the BLM manages the public lands in ways that meet the multiple-use and sustained yield goals that Congress has set for these lands.

Examples of situations that may require new or changed land-use plan decisions include:

- New information or scientific knowledge about the environmental health of an area.
- Failure to meet the land health standards set out in the original plan.
- Requests for land uses that were not considered in the original plan. Many older land-use plans, for example, did not consider the possible land-use needs of emerging renewable energy resources.

The Las Vegas RMP is 25 years old, and in that timeframe, values, visitation and use of the area have changed.

Old Spanish National Historic Trial

The project would be located within the 5-mile trail corridor that both NPS and BLM consider important to protect.

The jurisdiction of the Old Spanish National Historic Trail is now shared by both the BLM and National Park Service, and this happened 6 years after the Las Vegas Resource Management Plan was established.

After the feasibility study was completed and submitted, Congress passed a bill creating the Old Spanish National Historic Trail and sent it to the White House on November 15, 2002. President George W. Bush signed the bill into law

Both the BLM and NPS prepared the Old Spanish National Historic Trail Comprehensive Administrative Strategy (OSNHTCAS) in 2003. In the strategy, they outline the purpose of the Old Spanish National Historic Trail. [2]

In 2015, the BLM started to revise the Southern Nevada Resource Management Plan, but would later cancel the review for unknown reasons. In the revision for all alternatives, BLM's objectives were to reduce and consider threats to the cultural and visual resources.

"Nature and Purpose of the Old Spanish National Historic Trail –

Many of the more than 2,700 miles of the Old Spanish Trail are characterized by stark landscapes that recall those described by early users of the trail. The trail corridor is informally considered by the NPS to lie five miles on either side of the centerline of the trail alignment to include the nearest elements of the view shed, parts of the cultural landscapes, landmarks, and traditional cultural properties near the trail. The BLM follows direction from their trail administration manual to establish a trail corridor.

Administrative responsibilities include overall trail-wide leadership, such as coordination, planning, and signing; resource preservation and protection (such as protection of high potential sites and segments); review of trail site and segment development; trail-wide resource inventories and mapping (including developing and maintaining geographic information systems); certification, interpretation, and visitor use cooperative/ interagency agreements; and limited financial assistance to other government agencies, landowners, interest groups, and individuals."

Was the National Park Service present for the Variance meetings for this project? It appeared that only the BLM was there running the show.

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[2] https://oldspanishtrail.org/wp-content/uploads/2019/01/Comprehensive-Management-Strategy-2017.pdf

Under Section 5(e)(1) of the National Trails System Act, it is the responsibility of the administering agencies to identify high potential sites and segments as part of the comprehensive planning process for a national historic trail.

High potential sites are those historic sites related to the route or sites in close proximity, which provide opportunity to interpret the historic significance of the trail during the period of its major use. Criteria for consideration as high potential sites include historic significance, presence of visible historic remnants, scenic quality, and relative freedom from intrusion.

High potential segments are those segments of a trail that afford high-quality recreation experiences along a portion of the route having greater-than-average scenic values or affording an opportunity to share vicariously the experience of the original users of a historic route.

Stump Spring, about 2 miles from the site, was identified as a High Potential Segment.

Cultural landscapes are identified as "a geographic area (including both cultural and natural resources and the wildlife or domestic animals therein) associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Department of the Interior 1996).

The National Park Service defines a cultural landscape as a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person, or exhibiting other cultural or aesthetic values.

According to the Old Spanish National Historic Trail Comprehensive Administrative Strategy in 2003:

"Four main types of cultural landscapes have been defined: historic designed landscape, ethnographic landscape, historic site, and historic vernacular landscape (note: these four types are not mutually exclusive). The Old Spanish Trail is essentially a linear cultural landscape significant for its "association with a historic event, activity, or person" (ibid.), and comprised of numerous historic sites and defining features. An outstanding characteristic of the Old Spanish National Historic Trail is the presence of extensive cultural landscape elements that still retain integrity. For the Old Spanish National Historic Trail, cultural landscapes are intricately related to the essential nature of the trail. Trail administration considers them essential for trail administration and management"

"The Old Spanish National Historic Trail, characterized by open stretches of western terrain somewhat free of modern intrusions, offers exceptional opportunities for the public to enjoy and appreciate both the natural and cultural environment. In general, few physical traces remain that can be directly linked to the period of significance identified in the legislation. In other places, the original traces have been superseded by wagon roads, cattle drive traces, and other later uses. However, the natural landmarks that guided travelers still can be seen today."

The OSNHTCAS strategies for protecting the cultural resources of the trail include:

- agree and systematically address the importance of protecting these landscapes in order to reach some degree of consensus,
- protect the visual characteristics of a landscape and other sensory components that make important contributions to their historic significance and help us make sense and value of what we see.

Upgrading the VRM Class With a Resource Management Plan Revision

The majority of the landscape of the proposed Golden Currant Solar Project was designated as Visual Resource Management (VRM) Class IV during the last revision of the RMP. This did not consider the future designation of the Old Spanish National Historic Trail and the NPS involvement. This was 6 years before the Interior Department designated co-management with BLM and NPS.

The BLM has developed a Visual Resource Inventory (VRI)[3]. VRI is a systematic process for:

- *Assessing and rating the intrinsic scenic quality of a particular tract of land, through the Scenic Quality Rating process;*
- *Measuring the public concern for the scenic quality of the tract, through the Sensitivity Level Analysis; and*
- *Classifying the distance from which the landscape is most commonly viewed, through delineation of Distance Zones.*

Scenic Quality Rating

Within the VRI process, public lands are evaluated with regard to their scenic quality, defined as the visual appeal of a particular tract of land. Scenic quality is determined systematically by

1. *dividing the landscape into Scenic Quality Rating Units (SQRUs) based on conspicuous changes in physiography or land use, and*
2. *ranking scenic quality within each SQRU based on the assessment of seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications.*

The ratings are made in the field by trained observers who evaluate the landscape view from inventory observation points, which are either important viewpoints or points with views that are representative of the SQRU. Based on the outcome of this assessment, lands within each SQRU are assigned a scenic value rating of A (high scenic value), B (moderate scenic value), or C (low scenic value). Generally, those areas with the most variety and most harmonious composition have the highest scenic value ratings, while *areas with less variety and greater levels of disturbance from human activities have the lowest scenic value ratings.*

Sensitivity Level Analysis:

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[3] Bureau of Land Management Visual Resource Management Classes (anl.gov)

Visual sensitivity is defined as a measure of public concern for scenic quality. Sensitivity is determined by evaluating the types and numbers of potential viewers of a specified area (this area is referred to as a Sensitivity Level Rating Unit or SLRU), the level of public interest in the SLRU, adjacent land uses, and the presence of special areas. The Sensitivity Level Analysis (SLA) is completed in two steps:

1. *delineation of SLRUs, and*
2. *rating visual sensitivity within each SLRU. Public sensitivity is determined through analyzing various indicators including user types, amount of use, public interest, adjacent land uses, special areas and other factors unique to the SLRU.*

Distance Zone Delineation

Within the VRI process, distance zones are assigned based on the distance of lands from places where people are known to be present on a regular basis, such as highways, waterways, trails, or other key locations. They include the following:

- ***Foreground-middle ground –** This zone includes visible areas from 0 to 5 mi.*
- ***Background –** This zone includes visible areas from 5 to 15 mi.*
- ***Seldom seen –** This zone includes lands visible beyond 15 mi or lands hidden from view from key locations.*

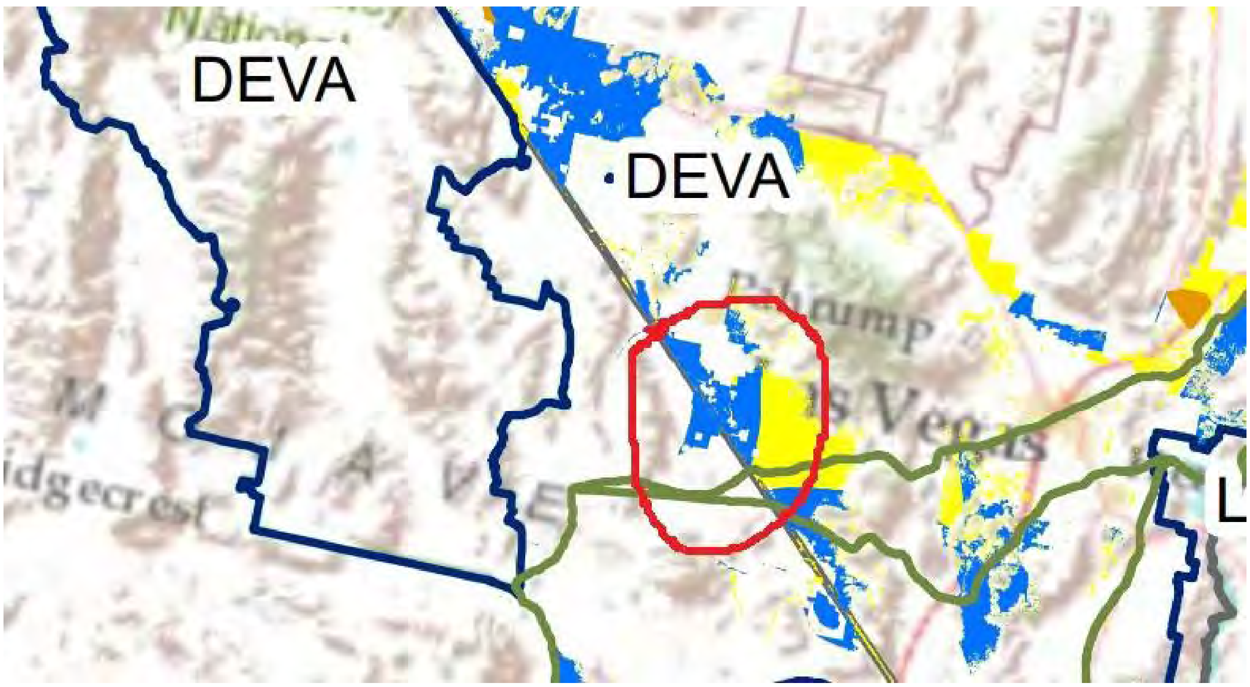
The VRM classes set VRM objectives for lands in each class, as well as the level of visual change in the landscape character that is allowed as a result of proposed management activities. The objectives and allowed levels of change for each of the four VRM classes are as follows:

- ***VRM Class I Objective**: To preserve the existing character of the landscape. Allowed Level of Change: This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.*
- ***VRM Class II Objective**: To retain the existing character of the landscape. Allowed Level of Change: The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.*
- ***VRM Class III Objective**: To partially retain the existing character of the landscape. Allowed Level of Change: The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.*
- ***VRM Class IV Objective**: To provide for management activities which require major modification of the existing character of the landscape. Allowed Level of Change: The level of change to the characteristic landscape can be high. Management activities may dominate the view and may be the major focus of viewer attention. However, the impact*

of these activities should be minimized through careful siting, minimal disturbance, and repeating the basic elements of form, line, color, and texture within the existing setting.

For unknown reasons, BLM designated most of the Golden Currant Project site as VRM Class IV. A new Resource Management Plan could potentially protect the view-scape associated with the Old Spanish National Historic Trial.

In 2012, the Western Solar Plan was established for 6 western states and certain areas near national parks were designated High Conflict Areas. In the case of the Golden Currant Solar Project, BLM has stated that 2,000 acres of the 4,300-acre application fall into a "High Conflict Area" as determined by the Solar Programmatic Environmental Impact Statement.[4] The PEIS was approved 15 years after the last revision of the RMP.



^Red circle shows High Conflict area described in the solar PEIS.

There are two ways to change an RMP:

- **Plan revisions**: Plan revisions involve a complete or near-complete rewrite of an existing land-use plan. A plan revision always requires a full Environmental Impact Statement.

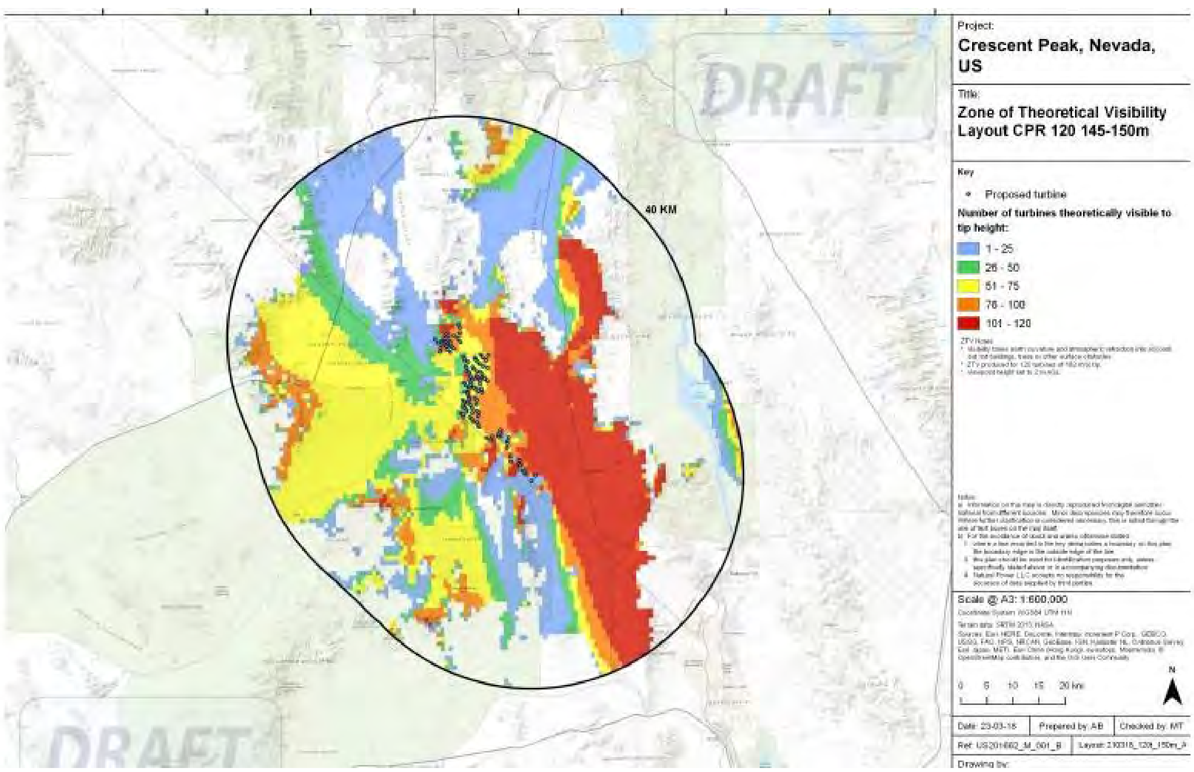
[4] NPS_Identified_Areas_of_High_Potential_for_Resource_Conflict_Regional.pdf (anl.gov)

- **Plan amendments**: Plan amendments modify one or more parts of an existing land-use plan, for example, allowing the development of wind energy resources where they had not previously been considered. Depending on how wide-ranging the effects of an amendment would be, the BLM will prepare either an Environmental Assessment or a full Environmental Impact Statement to accompany a plan amendment.

The BLM is planning on amending the Las Vegas RMP to approve two other solar applications near the Golden Currant proposal. These two projects are called Rough Hat Clark County at 2,400 acres and Copper Rays Solar at 5,100 acres. Both are in the Pahrump Valley northeast of Golden Currant. The reason for the amendment is that the projects are being proposed for VRM Class III lands. The BLM knows that large-scale solar does not conform to the VRM Class III objectives.

If the BLM reevaluates the Golden Currant site and factors in the more recent designations such as the Old Spanish National Historic Trail, the Golden Currant site or parts of it could even be upgraded to VRM Class II.

The landscape is characterized by sweeping vistas, scenic, eroded badlands and is visible from wilderness and national park service areas. The Tecopa Road has seen increased traffic and visitation since the 1997 RMP was released. The Sensitivity level has increased at this time.



^A viewshed analysis should be created and distributed for the Golden Currant Solar Project like this one created for the proposed and now cancelled Crescent Peak Wind Project in Southern Nevada.

The BLM also issued a Medium Priority status latter (see attached) for this project under the *Code of Federal Regulations 2804.35 - How will the BLM prioritize my solar or wind energy application?*

The BLM will prioritize a solar application by placing it into one of three categories – Low Priority, Medium Priority or High Priority and may re-categorize the application based on new information received through surveys, public meetings, or other data collection, or after any changes to the application. The BLM will generally prioritize the processing of leases awarded under subpart 2809 before applications submitted under subpart 2804. For applications submitted under subpart 2804, the BLM will categorize an application as High Priority based on the following screening criteria: (a) High-priority applications are given processing priority over medium- and low-priority applications and may include lands that meet the following criteria:

If the RMP were amended, the project could potentially fall into the Low Priority category

Low-priority applications may not be feasible to authorize. These applications may include lands that meet the following criteria:

(1) Lands near or adjacent to lands designated by Congress, the President, or the Secretary for the protection of sensitive viewsheds, resources, and values (*e.g.*, units of the National Park System, Fish and Wildlife Service Refuge System, some National Forest System units, and the BLM National Landscape Conservation System), which may be adversely affected by development;

(2) Lands near or adjacent to Wild, Scenic, and Recreational Rivers and river segments determined suitable for Wild or Scenic River status, if project development may have significant adverse effects on sensitive viewsheds, resources, and values;

(3) Designated critical habitat for federally threatened or endangered species, if project development may result in the destruction or adverse modification of that critical habitat;

(4) Lands currently designated as Visual Resource Management Class I or Class II;

(5) Right-of-way exclusion areas; *or*

(6) Lands currently designated as no surface occupancy for oil and gas development in BLM land use plans.

Area of Critical Environmental Concern

An RMP revision could designate the Golden Currant proposed project site as an Area of Critical Environmental Concern. Ideally, this could be an expansion of the Stump Spring ACEC.

The resources on the site that could potentially qualify for an ACEC would be:

1. Close proximity to the Old Spanish National Historic Trail
2. Desert tortoise habitat
3. Habitat for mesquite and associated species (like the phainopepla)
4. Fossils of Plio-Pleistocene megafauna and other paleontological resources located in badlands topography.

As the BLM states: *"Areas of Critical Environmental Concern or "ACEC" designations highlight areas where special management attention is needed to protect important historical, cultural, and scenic values, or fish and wildlife or other natural resources. ACECs can also be designated to protect human life and safety from natural hazards. ACECs can only be designated during the land-use planning process."*[5]

An ACEC can be nominated by anyone. It would be evaluated through land use planning using the best available information and public outreach.

BLM states:

If a nominated area meets the criteria, an interdisciplinary planning team develops potential management options and incorporates the proposed ACEC into a draft land use plan. Members of the public have the opportunity to review and comment on proposed ACEC and the associated management options during a 90-day public comment period.[6]

The point is, using a resource management plan that is outdated by 25 years eliminates much of the opportunity for the public and stakeholders to be involved. Resource Management Planning should not be viewed as an obstacle by the BLM but rather a tool to make the most informed decisions managing our public lands.

Other Impacts

Significant cumulative impacts are not avoidable if the BLM maintains plans to permit 18,000 acres of solar projects in the area. At this point BLM has approved the 3,000-acre Yellow Pine Solar Project and is considering Rough Hat Clark at 2,400 acres, Rough Hat Nye at 3,500 acres, Copper Rays at 5,100 acres and Mosey Solar at 3,500 acres. BLM has approved the Trout Canyon substation with the intention of developing the area and sacrificing the resources in the area.

A grassroots effort is underway to nominate an Amargosa National Monument in California, which would encompass the Shoshone, Death Valley Junction, and Tecopa region, the Wild and Scenic Amargosa River and other reaches, as well as the unique wildlands and open desert spaces from Amargosa Valley, the California portion of Pahrump Valley, to the Kingston Range and Shadow Valley. The diverse history and ecology of the region has attracted many visitors seeking soft recreational opportunities. Developing industrial energy-sprawl projects adjacent to

[5] ACEC | Bureau of Land Management (blm.gov)
[6] ACEC | Bureau of Land Management (blm.gov)

the proposed monument would ruin the views and historic character of the region. The Golden Currant Solar Project is proposed to be built right along Tecopa Road, which would be a main entrance road and scenic route to enter the proposed National Monument.

Desert Tortoise

We have not seen any results from the April desert tortoise surveys for the Golden Currant Solar Project, but data from surveys from the 4 other sites (Rough Hat Clark, Rough Hat Nye, Copper Rays and Yellow Pine) predicted that all 4 of the sites had a low density of desert tortoises at 3.04 per square mile. As BLM is aware, the tortoise numbers were undercounted and nearly 3 times the predicted number of desert tortoises were located and moved on the Yellow Pine Solar site during the Spring 2021 desert tortoise clearance. It is also quite possible that the biologists did not locate all the adult tortoises because the clearance was conducted on a record-breaking drought year.

The numbers of desert tortoises found on the Yellow Pine site exceeded the predicted total by both the Bureau of Land Management and the U.S. Fish and Wildlife Service. The Final Environmental Impact Statement for the Yellow Pine Solar Project predicted that based on population estimates, approximately 53 adult desert tortoises, 276 subadults or juveniles, and 69 hatchlings are anticipated to be displaced by project-related construction activities via translocation. [7]

The Biological Opinion predicted that the Phase I Tortoise Clearance Area would enclose an area of 3,233.5 acres from which an estimated 39 adults (95% CI = 27 to 59) would need to be translocated from the Yellow Pine Solar Project, and 1 adult (95% CI = 0 to 2) would be translocated by GLW. In addition to adult tortoises, it was estimated that many more juvenile tortoises would also require translocation.

Starting in April of 2021, Boulevard Associates LLC hired tortoise biologists to clear the Yellow Pine site of every tortoise they could find. In spite of record-breaking dry conditions, biologists found and moved 139 desert tortoises from the site. In a personal communication with the BLM, the final numbers were reported as:

Adults = 85 (33 Females, 52 Males)
Juveniles 110-179 mm = 30
Juveniles 110 mm = 24

This is over double the predicted number of adults that were found. In fact, biologists for Candela Renewables, applicants for the two Rough Hat projects, recently stated in a public meeting that the desert tortoise density for the Yellow Pine Solar Project site in now believed to be 11 per square mile.

We also found out though personal communication with federal agencies that 26 to 30 of the relocated adults were killed by predators – mostly badgers. That is about a 30 percent mortality for the adults found. On Page 88, the Biological Opinion for Yellow Pine Solar states *"we*

[7] Yellow Pine Solar Project Final Environmental Impact Statement, Volume I: Chapters 1-4 (blm.gov)

anticipate that survival rates of adult desert tortoises moved from the project sites will not significantly differ from that of animals that have not been moved. We expect that desert tortoises would be at greatest risk during the time they are spending more time aboveground than resident animals. We cannot precisely predict the level of risk that will occur after moving desert tortoises ***because regional factors that we cannot control or predict (e.g., drought, predation related to a decreased prey base during drought, etc.) would likely exert the strongest influence on the mortality rates".***

This record-breaking drought year may have been the cause of the high mortality and there is no evidence that the resident tortoises experienced the same mortality as the relocated ones killed by predators.

The Mojave Population of the Agassiz's desert tortoise was listed as Threatened by the US Fish and Wildlife Service (USFWS) in 1990 followed by the designation of critical habitat in 1994. In 2000, the USFWS began systematically surveying tortoise populations in critical habitat and recovery unit areas to determine population trends. Based on their findings (USFWS 2015), which are briefly summarized in the chart, we convinced that the Mojave Population of the Agassiz's desert tortoise should be federally listed as Endangered rather than Threatened.

Recovery Unit: Designated Critical Habitat Unit/Tortoise Conservation Area	Surveyed area (km^2)	% of total habitat area in Recovery Unit & CHU/TCA	2014 density/km^2 (SE)	% 10-year change (2004–2014)
Western Mojave, CA	**6,294**	**24.51**	**2.8 (1.0)**	**–50.7 decline**
Fremont-Kramer	2,347	9.14	2.6 (1.0)	–50.6 decline
Ord-Rodman	852	3.32	3.6 (1.4)	–56.5 decline
Superior-Cronese	3,094	12.05	2.4 (0.9)	–61.5 decline
Colorado Desert, CA	**11,663**	**45.42**	**4.0 (1.4)**	**–36.25 decline**
Chocolate Mtn AGR, CA	713	2.78	7.2 (2.8)	–29.77 decline
Chuckwalla, CA	2,818	10.97	3.3 (1.3)	–37.43 decline
Chemehuevi, CA	3,763	14.65	2.8 (1.1)	–64.70 decline
Fenner, CA	1,782	6.94	4.8 (1.9)	–52.86 decline
Joshua Tree, CA	1,152	4.49	3.7 (1.5)	+178.62 increase
Pinto Mtn, CA	508	1.98	2.4 (1.0)	–60.30 decline
Piute Valley, NV	927	3.61	5.3 (2.1)	+162.36 increase
Northeastern Mojave	**4,160**	**16.2**	**4.5 (1.9)**	**+325.62 increase**
Beaver Dam Slope, NV, UT, AZ	750	2.92	6.2 (2.4)	+370.33 increase
Coyote Spring, NV	960	3.74	4.0 (1.6)	+ 265.06 increase
Gold Butte, NV & AZ	1,607	6.26	2.7 (1.0)	+ 384.37 increase
Mormon Mesa, NV	844	3.29	6.4 (2.5)	+ 217.80 increase
Eastern Mojave, NV & CA	**3,446**	**13.42**	**1.9 (0.7)**	**–67.26 decline**
El Dorado Valley, NV	999	3.89	1.5 (0.6)	–61.14 decline
Ivanpah, CA	2,447	9.53	2.3 (0.9)	–56.05 decline
Upper Virgin River	***115***	***0.45***	***15.3 (6.0)***	***–26.57 decline***
Red Cliffs Desert	*115*	*0.45*	*15.3 (6.0)*	*–26.57 decline*
Range-wide Area of CHUs - TCAs/Range-wide Change in Population Status	**25,678**	**100.00**		**–32.18 decline**

The table includes the area of each Recovery Unit and Tortoise Conservation Area (TCA), percent of total habitat, density (number of breeding adults/km2 and standard errors = SE), and the percent change in population density between 2004 and 2014. Populations below the viable level of 3.9 breeding individuals/km2 (10 breeding individuals per mi2) (assumes a 1:1 sex ratio) and showing a decline from 2004 to 2014 are in red.


^One of the translocated desert tortoises killed by badgers in 2021 for the Yellow Pine Solar Project. (photo from BLM Freedom of Information Act Request)

An Analysis of Storm Water should be made

The applicant should develop a detailed erosion and sedimentation control plan, and a flood risk control plan now for public review. Proposed project sites are often located on an alluvial fan that acts as an "active stormwater conveyance" between mountains and valleys. Widespread bajada flooding events and sheetwash deposition occurs. The consequences of allowing flooding through the project would be too great. How does the project propose to maintain the solar fields if floodwaters jump the banks of the washes? In addition, alluvial fans often have shifting flow channels and pathways, so there is no guarantee that washes will not shift over 30 years.

Fugitive Dust

Nevada's large-scale solar projects have recently had a poor record in violating air quality controls, as we have recorded in photographs such as at the 800-acre Sunshine Valley Solar Project in Amargosa Valley. This mowed-vegetation project repeatedly had fine particulate whirlwinds, and dust clouds emerging from disturbed desert surfaces in construction zones. Despite water trucks attempting to water-down loose dirt, the solar project was too large to control all dust. Construction continued on windy days, yet even on mild breezy days we saw wind-blown dust and clouds of fine particulates from disturbed ground in the construction site. Construction, especially on windy days, would create huge dust black-outs and greatly impact visibility. Removal of stabilized soils and biological soil crust creates a destructive cycle of airborne particulates and erosion. As more stabilized soils are removed, blowing particulates from recently eroded areas act as abrasive catalysts that erode the remaining crusts, thus resulting in more airborne particulates.

The Golden Currant site is nearly 40 percent clay-based badlands topography and will create a very big dust issue if it is crushed for this kind of development.

We are concerned that industrial construction in the region will compromise the air quality to the point where not only visual resources, but public health will be impacted. Epidemiologists investigated an outbreak of valley fever that had sickened 28 workers at two large solar power construction sites in San Luis Obispo County[8]

^Photo of the fugitive dust caused by the Sunshine Valley Solar Project, Amargosa Valley, Nevada in summer of 2019.

Avian impacts

Placing up to 30 square miles of solar panels in this area from 5 projects will have avian impacts. The avian impacts are documented in several solar projects. It is thought that the projects mimic water and cause birds to hit the solar panels. Data from 7 solar projects in California has revealed 3,545 bird kills from 183 species from 2012 to 2016. This can be referenced from the 2016 Multi-Agency Avian Solar Working Group conference from 2016.[9]

The area is close to the Stump Spring wetland and only about 30 miles from the Tecopa/ Shoshone Amargosa River area. It is quite possible this project could cause avian mortality.

Other Wildlife and Plants

The project will impact:

Burrowing owls

American badgers

Kit foxes

Pahrump buckwheat -- Pahrump Valley buckwheat *(Eriogonum bifurcatum*), a BLM Sensitive Species. Alkaline sand flats and slopes, within saltbush communities at elevations of 1,969–2,700 feet. Associated with Corncreek-Badland-Pahrump soils due to its salinity and association

8 https://www.latimes.com/archives/la-xpm-2013-may-01-lame-ln-valley-fever-solar-sites-20130501- story.html
9 http://blmsolar.anl.gov/program/avian-solar/docs/Avian Solar_CWG_May_2016_Workshop_Slides.pdf

with relict lakebeds and lake terraces. **Pahrump Valley buckwheat has been observed on this project site.** We request that the project be completely moved off this soil type to avoid potential for destroying populations of this species that did not flower during 2018 and 2019. Pahrump Valley buckwheat is a BLM Sensitive species, meaning population or distribution of the wildlife is in a significant decline, the population is threatened as a result of disease or predation or ecological or human causes, and/or the primary habitat of the wildlife is deteriorating.

Other rare plants possibly impacted:

Aven Nelson Phacelia (*Phacelia anelsonii*)

Rosy Twotone Beardtongue (*Penstemon bicolor ssp. roseus*)

Yellow Twotone Beardtongue (*Penstemon bicolor* ssp.*bicolor*) (deserving of ESA protection)

White-Margined Beardtongue (*Penstemon albomarginatus*) (deserving of ESA protection)

Death Valley Ephedra (*Ephedra funerea)*

New York Mountains *Catseye (Cryptantha tumulosa*)

Spring Mountains Milk-Vetch (*Astragalus remotus*)

Nye Milk-Vetch (*Astragalus nyensis*)

Mojave Milk-Vetch (*Astragalus mohavensis* var. *mohavensis)*

White Bear Poppy (*Arctomecon merriamii*)

Cacti and Yucca are considered Forest Products under 43 CFR 5420.0-6. Even with a site plan that avoids washes, the majority of these plants would be destroyed.

Possible mule deer and bighorn sheep.

And a host of other species. Construction will kill millions of living organisms.

Sensitive Birds Will Be Impacted Bendire's thrasher (*Toxostoma bendirei)* may occur. Joshua trees are present in areas near the project, and Mojave yuccas are abundant. Therefore, the project may impact suitable breeding or foraging habitat for this species. Targeted surveys should be undertaken for this species. Le Conte's thrasher (*Toxostoma lecontei)* is also present.

The project may impact suitable breeding or foraging habitat for this species Phainopepla (*Phainopepla nitens*) which inhabits Stump Spring. There are stands of mesquite located within the project area; therefore, the project will impact suitable breeding or foraging habitat for this species. Scott's oriole *(Icterus parisorum)* was recorded by Nevada Division of Wildlife (NDOW) within 10 miles of the project area. The project may impact suitable breeding or foraging habitat for this species.

Large Mammal Habitat Will Be Fragmented

A Mountain lion was recorded within the analysis area from NDOW records. We have seen mule deer in Mojave yucca and creosote scrub on alluvial fans within a few miles of the project site in Pahrump Valley.

Bats May Be Impacted A diversity of bats may feed in the project area, migrate through, and roost in yuccas: Allen's big-eared bat (*Idionycteris phyletism),* Big brown bat (*Eptesicus fuscus),* Big free-tailed bat (*Nyctinomops macrotis*), Brazilian free-tailed bat (*Tadarida 30 brasiliensis*), Brazilian free-tailed bat (*Tadarida brasiliensis*), Canyon bat (formerly western pipistrelle) (*Parastrellus hesperus*), Fringed myotis (*Myotis thysanodes*), Hoary bat (*Lasiurus cinereus*), Long-eared myotis (*Myotis evotis*), Long-legged myotis (*Myotis volans*), Pallid bat (*Antrozous pallidus*), Silver-haired bat (*Lasionycteris noctivagans*), Spotted bat (*Euderma maculatum*), Townsend's big-eared bat (*Corynorhinus townsendii*), Western red bat (*Lasiurus blossevillii),* Western small-footed myotis (*Myotis ciliolabrum*), and Yuma myotis (*Myotis yumanensis*). Night-lighting installed for safety purposes may create light pollution in bat foraging areas, which may disorient foraging bats.

Soils and Biological Soil Crusts Will Be Significantly Impacted

Biotic soils and desert pavement commonly occur as a mosaic on the project site. Desert pavements are a matrix of rock fragments that form smooth, pavement-like surfaces. Biotic soils are living surface features comprised of soil particles enmeshed in a complex web of cyanobacteria, mosses, lichens, bacteria, algae, and fungi that send roots and filaments deep into the soil, helping to sequester Carbon. Both desert pavements and biotic soils provide a protective soil covering that reduces wind and water erosion potential and further impact soil moisture dynamics. Disruption of fragile biotic soils or removal of desert pavements generally increase wind and water erosion potential.

Cultural Resources

BLM needs to undertake full consultation with the Pahrump Paiute, Timbisha Shoshone, and other tribal entities with interest in the area.

The area was conceived as a Cultural Landscape during the California Energy Commission Evidentiary Hearing in Shoshone CA for the proposed Hidden Hills Solar Electric Generating System in March 2013[10]. Southern Paiute and Chemehuevi elders described the Salt Song Trail area passing through this region. This needs further analysis.

Paleontological Resources

The clay-based badlands on the site could potentially contain fossils. The badlands are Quaternary basin fill formed as groundwater discharge deposits at the base of the alluvial fan. The site could contain fossils of Plio-Pleistocene megafauna. How many paleontological resources would be damaged by the project? Is there an inventory of any large mammal fossils on the site?

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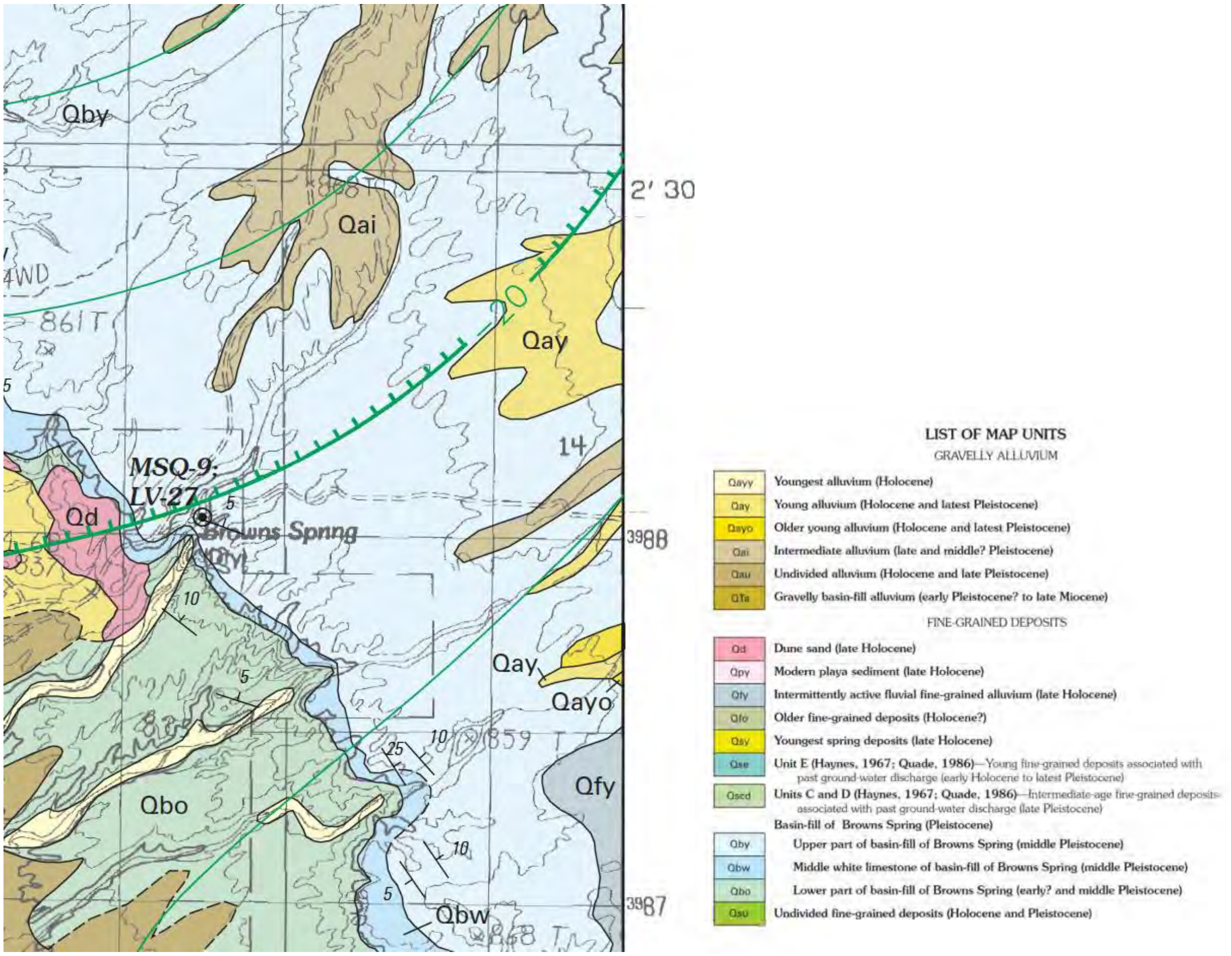
[10] http://basinandrangewatch.org/HiddenHills-hearing.html

The following geologic map of the Mound Spring Quadrangle, Nye and Clark Counties, Nevada, shows a portion of the proposed solar project site on top of mid and early Pleistocene Brown's Spring basin fill which could hold fossils. Brown's Spring is at the end of the Front Site Road.



From: https://pubs.usgs.gov/mf/2002/mf-2339/mf-2339.pdf

These sites are protected by the Paleontological Resources Preservation Act of 2009 (PRPA) (16 U.S.C. § 470aaa 1-11). This law was established 12 years after the last revision of the RMP.

The primary legislation pertaining to fossils from NPS and other federal lands is the Paleontological Resources Preservation Act of 2009 (PRPA) (16 U.S.C. § 470aaa 1- 11) which was enacted on March 30, 2009 within the Omnibus Public Land Management Act of 2009. PRPA directs the Department of Agriculture (U.S. Forest Service) and the Department of the Interior (National Park Service, Bureau of Land Management, Bureau of Reclamation, and Fish and Wildlife Service) to manage and protect paleontological resources on Federal land using scientific principles and expertise. The Secretary shall develop appropriate plans for inventory, monitoring, and the scientific and educational use of paleontological resources, in accordance with applicable agency laws, regulations, and policies. These plans shall emphasize interagency *coordination and collaborative efforts where possible with non-Federal partners, the scientific community, and the general public.* (see [Paleontological Resources Preservation Act.pdf (blm.gov)]())

A diverse assemblage of fossil megafauna was recovered from the Las Vegas Valley in southern Nevada, providing opportunities for paleontologists to study the paleoecology of these deposits. Vetter (2007) undertook isotopic reconstruction of diet in extinct large herbivores: *Mammuthus, Equus, Bison,* and *Camelops* from the Late Pleistocene assemblage of megaherbivore teeth recovered from the Gilcrease spring mound.

The Tule Springs fauna was recovered from the northwestern Las Vegas Valley and provides the most complete Pleistocene faunal record for the area. The Tule Springs excavation in the 1960s yielded fossil material of invertebrates (primarily molluscs), amphibians, reptiles, birds, small mammals, and large carnivores and herbivores.

The formations are similar to those located in the Tule Springs Fossil Beds National Monument. The Bureau of Land Management needs to coordinate with the National Park Service to ensure that Best Management Practices are used to protect any fossil on the Golden Currant Site.

Indeed, *Mammuthus columbi* fossils have been found in Pahrump Valley, NV. Conin et al (1998) found two mammoth tooth fragments in Pahrump Valley, held in the author's collection.

Paleontological surveys need to be undertaken in these deposits before any solar project is approved here.

Western Honey Mesquite

There are Western Honey Mesquite (*Prosopis glandulosa)* located on the project site. These trees have been impacted by water drawdown but still are a unique ecological part of this desert that should be avoided. They provide habitat to several BLM Sensitive and Special Status Species[11]

Mesquite trees furnish shade and wildlife habitat where other trees will not grow. They will often be found in alkaline soils near water holes.

Although a single flower of the blossom is only a few millimeters long, they are clustered into a yellow creamy blossom attracting many different types of pollinators.

At the Golden Currant virtual meeting, the BLM stated that not all mesquite habitat would be avoided.

Topography

About 40 percent of the site is composed of badlands cut by canyons with vertical walls. The area would have to be leveled to build a solar project. Much of the site is steeper than the 5 percent or under slope required for solar on public lands in the Western Solar Plan:

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[11] 2017 Final BLM NV Sensitive and Special Species Status List .pdf

*"The geographic boundaries for exclusion categories 13, 14, 28, 29, 31, and 32 are explicitly defined through the Solar PEIS ROD and its associated maps, and these boundaries will not be updated in the future**. The geographic boundaries for exclusion category 1 (lands with slope greater than 5%)** and exclusion category 2 (lands with solar insolation levels less than 6.5 kWh/m2) will not be updated in the future; they may, however, be refined at the individual project level as necessary based on site-specific information."* [12]

^Eroded badlands topography on the site, early to mid Pleistocene in age.

Public Access/Multiple Use

The project would surround the Front Site Road and be built close to scenic Cathedral Canyon. The project would potentially close off over 7 square miles of public lands with barbed wire fences. This directly conflicts with BLM's mission of Multiple Use. No other uses could be compatible in this area.

"Congress tasked the BLM with a mandate of managing public lands for a variety of uses such as energy development, livestock grazing, recreation, and timber harvesting while ensuring natural, cultural, and historic resources are maintained for present and future use. [13]

---

[12] Exclusion Areas under the BLM Solar Energy Program (anl.gov)
[13] Our Mission | Bureau of Land Management (blm.gov)

Clark County Multi-Species Conservation Plan

BLM should give the history of the Wheeler Wash Allotment that overlaps the solar project proposal, and give the reason that the allotment is no longer active. Was the allotment designated as non-active in order to protect desert tortoise, phainopepla, and other species covered in the Clark County Multi-Species Habitat Conservation Plan[14]?

Reasonable Alternatives to this Project: Distributed Energy

In 2020, the nation of Vietnam installed 9 GW of solar energy on rooftops[15] . They simply don't have volumes of land to sacrifice for large-scale solar projects, so they utilized their built environment, proving that significant amounts of solar energy can be generated from rooftops and other built structures.

Researchers from Vibrant Clean Energy found the cheapest way to reduce emissions actually involves building 247 gigawatts of rooftop and local solar power (equal to about one-fifth of the country's entire generating capacity today). In this scenario, consumers would save $473 billion, relative to what electricity would otherwise cost.[16]

In September 2016, Dr. Rebecca Hernandez of University of California, Davis published a study, Solar Energy Potential on the Largest Rooftops in the United States. This study was conducted on the rooftops of 5,418 elementary schools in Korea to determine the feasibility of achieving net-zero energy solar buildings through rooftop PV systems (Hernandez et al. 2013)

Conclusion

If the Golden Currant Solar Project is approved, it will result in the destruction of many irreplaceable resources located on public lands managed by the BLM including wildlife, plants, cultural sites and public access. The project is being reviewed through a BLM Resource Management Plan that has not been updated for 25 years. Many changes have occurred including the designation of the Old Spanish National Historic Trail. We believe this is a very inappropriate location for a solar energy project and request that the BLM not only reject the application but pause the entire review until the Southern Nevada Resource Management Plan can be revised. A revision would allow both the public and the BLM provide better management that would protect this valuable site for future generations.

Sincerely.

(Groups/Organizations)

---

[14] https://files.clarkcountynv.gov/clarknv/Environmental%20Sustainability/Desert%20Conservation/MSHCP/ccfeis.pdf

[15] Scaling up Rooftop Solar in Vietnam – More than 9GW installed in 2020 – pv magazine International (pv-magazine.com)

[16] https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_ES_Final.pdf

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References:

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cc: Jon Raby, State Director, Bureau of Land Management, Nevada

Tracy Stone-Manning, Director, Bureau of Land Management

Deb Haaland, Interior Secretary

Clark County Commissioner Justin Jones

Senator Jacky Rosen

Senator Catherine Cortez-Masto

Nevada State Senator Pete Goicoechea

Nevada State Assemblyman Gregory Hafen

[EXTERNAL] Golden Currant Solar Project Variance

[redacted]
Fri 8/5/2022 8:43 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

I'm writing you today in opposition of the proposed solar project. This is vital habitat for a number of endangered species, and projects like these are much better suited to land that has already been altered by man kind. I urge you to do the right thing, and reject this proposal.

Thank you,
[redacted]

[EXTERNAL] Re: Follow-up Information: Golden Currant Solar

[redacted]

Mon 8/8/2022 8:51 AM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

Good morning Beth,

Attached are my comments for the BLM Golden Currant Solar Variance Process. Thank you for allowing me extra time to send them to you this morning. As I said in my previous email, a storm knocked out the internet in Independence and I wasn't able to see your email until Saturday. I then used the information in your email and other sources available with the internet to complete the comments over the weekend. I wanted to send them to you as early as possible on Monday morning, and here they are.

Thank you for the extra time over the weekend, which was very much appreciated.

Thank you,

[redacted]

On Fri, Aug 5, 2022 at 8:58 AM BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov> wrote:

> Good Morning [redacted],
>
> Thanks for contacting me with your questions. As a follow-up, I am attaching:
>
> - The complete Solar PEIS Record of Decision (ROD)
> - An excerpt of the Solar PEIS ROD that pertains to the Variance Process and Factors to be Considered
>
> Here is a link to the Solar PEIS page that discusses the Variance Process - https://blmsolar.anl.gov/variance/process/
>
> As an example that you can look at, here is a link to the Webpage for the Rough Hat Clark County Solar Project (also proposed in Pahrump Valley), on the right hand side near the bottom there are documents included that reflect the Variance Factor Analysis Report and Determinations

- https://www.blm.gov/press-release/bureau-land-management-hold-virtual-public-information-forums-rough-hat-clark-county

Bureau of Land Management to hold virtual public information forums for Rough Hat Clark County Solar Project | Bureau of Land Management - blm.gov

LAS VEGAS - The Bureau of Land Management, Las Vegas Field Office, will host two virtual information forums -- December 8 and 9 -- to gather public input on the Rough Hat Clark County Solar Project proposed on approximately 2,400 acres of BLM-managed public land located in the Pahrump Valley in Clark County immediately adjacent to the county line, southeast of the Town of Pahrump and ...

www.blm.gov

You also requested a list of Tribes that BLM has consulted with on this project, we still have to follow-up on that request.

Please let me know if you need additional time to get your comments in to us.

Regards,
Beth Ransel

Southern Nevada District Energy & Infrastructure Team
Bureau of Land Management, Interior Regions 8 & 10

Follow BLM Southern Nevada on Social Media: Twitter | Facebook | YouTube | Flickr

August 6, 2022

[redacted]

Bureau of Land Management
Southern Nevada District Office
4701 N. Torrey Pines Drive,
Las Vegas, NV 89130

RE: Comments on the Golden Currant Solar Project Variance Process
Email sent to: BLM_NV_SND_EnergyProjects@blm.gov

Bureau of Land Management:

Thank you for the opportunity to comment on the Golden Current Solar Project (Project) Variance Process. The Project should be denied a Right-of-Way because it would cause many adverse impacts which are cited below. The area for this Project should have been included within the Right-of-Way Exclusion Area for BLM's Solar Programmatic Environmental Impact Report (PEIS) of 2012. Instead, it was designated within a "variance" area which was a catch-all designation for anything which was not relegated to a Solar Energy Zone (SEZ) or placed in a Right-of-Way Exclusion Area. This left thousands of acres of land with a High Potentialfor Conflict as de facto Solar Energy Zones, and the point of environmentalscreening in a Programmatic EIS became pointless. The result of this poor planning effort of ten years ago thus became a needless burden for everyone involved in dealing with a Project which is environmentally and culturally unsuitable project for this location in the Pahrump Valley.

1. The Nevada-Wide Resource Management Plan now being developed must be completed first.

The BLM's Las Vegas Resource Management Plan of 1998 for the area is out of date by 24 years. There is now a BLM Nevada-Wide Resource Management Plan revision being developed which would employ a holistic, landscape level analysis for the creation of land-use plans for BLM public lands in Nevada. Since there are multiple utility-scale solar projects now proposed for the Pahrump Valley and other areas of Nevada, it makes sense to first develop the congressionally-mandated Resource Management Plan before approving potentially destructive projects which will cause irreparable harm to the eco-culturallandscapes of the Mojave and Great Basin Deserts. The potential negative cumulative impacts of building an approximately 225 square mile zone of utility-scale solar installations from within southern Pahrump neighborhoods in the north to within a half mile of the mesquite bosque lands of the Stump Spring drainage to the south will be enormous (see the Golden Currant Solar Project Map Package, p. 4, BLM 6-14-22). In addition, the Front Sight private shooting range adjacent to the Project Area must be included in the cumulative impact analysis.

Many years of BLM staff time and public meetings were spent developing The *Draft Resource Management Plan/Environmental Impact Statement* (Las Vegas and Pahrump Field Offices, Fall 2014), and then was suddenly dropped with no explanation by the incoming Trump Administration after 2016. The plan was supposed to be in place to help plan solar developments in Nevada. Now there is no current plan, just piecemealproject-by-project utility-scale solar developments, often approved within the sketchiest category of the 2012 Solar PEIS, Variance Areas. There should be no solar developments in the Variance areas or the Solar Energy Zones (SEZs) in Nevadauntil the Nevada-Wide Resource Management Plan is completed.

2. The Golden Currant Solar Project Area is located in a proposed Area of Critical Environmental Concern (ACEC) and utility-scale solarprojects are incompatible with ACECs.

The Stump Spring ACEC was proposed to be expanded into the Project area as an Alternative in the *Draft Resource Management Plan/Environmental Impact Statement*, Fall 2014). Because of the withdrawal of the Draft RMP/EIS, all protective land use actions of the rare and ecologically important mesquite acacia woodland in the Project area have been suspended. The Stump Spring ACEC was proposed to be expanded into the Project areabecause the similar type of mesquite acacia woodland is found there.

I know the area well having first camped at Stump Spring over 39 years ago in 1983. In that year, I hiked 350 miles of the Old Spanish Trail from Camp Cady (east of Barstow) to Pinto, Utah. Like many before me, I used Stump Spring on the Old Spanish Trail for water and was lucky to find a beautifulstream undera willow and many mesquite trees. Because of groundwaterdepletion in the Pahrump Valley, Stump Spring is even more precarious as a watersource than it used to be. The Spring is now mostly dry, and the cottonwoods and willows described by previous travelers are now all dead, except forone willow (personal observation, 11-21-22). Any unnecessary waterextraction in the area, such that which could occur in the Project area, could have devastating consequences for the riparian habitat at Stump Spring as will as the Project site. With the Pahrump Valley in a state of groundwater overdraft for decades, even a relatively small amount of water use in the Project area could have very negative consequences for the riparian habitat.

3. The Golden Currant Solar Project is located within 5 miles of the Old Spanish Historic Trail corridor which is designated as an Area of High Potential for Resource Conflict(AHPRC) forutility-scale solarprojects in the Solar PEIS, and thus should be rejected.

The Project will adversely affect the Old Spanish National Historic Trail if built because it will be located within the Old Spanish Trail corridor, a five mile area on either side of the center line of the congressionally designated Old Spanish Historic Trail.[1] Obviously, this will impact the linear cultural landscape of the Trail for present and future generations.

Many travelers of the Old Spanish Trail did not find enough water at Stump Spring, and had to seek water at other springs to the north, probably crossing the Project area on theirway to Mound Springs or othernearby places for water. These side routes of the Old Spanish Trail on or near the Project area are depicted on the map below, excerpted from *The Old Spanish National Historic Trail: A Report on Cultural and Visual Resources in the Near Vicinity of the Proposed Hidden Hills Solar Energy System Plant, Inyo County, California*, by Jack Prichett, Old Spanish Trail Association (p. 44, April 2012). The Golden Currant Solar Project is in the area northwest of Stump Spring.

The Hidden Hills Solar Energy Generation System (HHSEGS) plant lies amidst a network of Old Spanish Trail routes linking a series of springs to the north and west of Stump Spring. Stump Spring appears on many maps and in many accounts, such as Fremont's 1845 report, of the Old Spanish Trail. When Stump Spring was dry, parties using the Old Spanish Trail would go to the neighboring springs to the northwest. These include Hidden Spring (which was the water source for Hidden Springs Ranch and orchards in the 1950s and 60s; Le Rocher qui pleu, which is an active seep, with ferns and year-round moisture; and Mound Spring (Prichett, 2012).

4. The Golden Current Solar Project meets many of the criteria as listed in TABLE A-2 : Exclusions under BLM's Solar Energy Program in the *Approved Resource Management Plan Amendments/Recordof Decision (ROD) for Solar Energy Development in Six Southwestern States,* Bureau of Land Management, October, 2012, and therefore should be redesignated froma Variance area to a Right-of-Way exclusion Areaforplanning utility-scale projects in BLM's Southern District of Nevada.

Selected Exclusions (not comprehensive) from **TABLE A-2 Exclusions under *BLM's Solar Energy Program, Approved RMP Amendments/ROD* (Oct. 2012, pp. 38-32) in which the Golden Current Solar Project is eligible:**

21. **[The Old Spanish National Historic Trail corridor meets this criterion]** All units of the BLM National Landscape Conservation System, congressionally designated National Scenicand Historic Trails (National Trails System Act [NTSA], P.L. 90-543, as amended), and trails recommended as suitable for designation through a congressionally authorized National Trail Feasibility Study, or such qualifying trails identified as additional routes in law (e.g., West Fork of the Old Spanish National Historic Trail), including any trail management corridors identified for protection through an applicable land use plan. Trails undergoing a congressionally authorized National Trail Feasibility Study will also be excluded pending the outcome of the study.

24. **[The Ma-hav Ethnographic Landscape as delineated in the *Hidden Hills Solar Energy Generating Systems Ethnographic Report*, by Thomas Gates, Ph.D. Ethnographer, August 2012, for the proposed *Hidden Hills Solar Energy Generation System (HHSEGS) plant*, California Energy Commission, which was ultimately rejected. The Ma-hav Ethnographic Landscape and Salt Song Landscape are within the boundaries of the proposed Golden Currant Solar Project]** Traditional cultural properties and Native American sacred sites as identified through consultation with tribes and recognized by the BLM.

5. Native American Tribes that were consulted during the development of the Solar PEIS and/or have cultural relationships to the lands of the proposed Golden Current Solar Project must have government-to-government consultation with the BLM for this Project. Non-federally recognized Tribes, such as the Pahrump Paiute, and individual religious practitioners familiar with the Project area and the Ma-have Ethnographic Landscape must also be consulted.

The Big Pine Paiute Tribe of the Owens Valley (Tribe) was not consulted forthis Project (personalcommunication with Big Pine Tribal Historic Preservation Officer, 8-5-22), although the Tribe and other Owens Valley Tribes were consulted by the California Energy Commission for the proposed *Hidden Hills Solar Energy Generation System* adjacent to the Project area in the Pahrump Valley. The Big Pine Paiute Tribe and other Owens Valley Tribes also have or had consultation relationships with the Department of Energy regarding the Nevada Test Site and Yucca Mountain, and with the U.S. Air Force at Nellis Air Force Base. All these federalfacilities are in southern Nevada.

6. Distributed Generation must also be considered an Alternative to utility-scale solar projects such as the Golden Currant Solar Project.

Distributed Generation must be considered as a viable alternative to utility-scale solar projects which have already impacted, and are planned to impact thousands of acres of rare and fragile ecosystems, culturalresources, and sacred sites. The Yellow Pine Solar Project is a tragic case in point. The Nevada-Wide Resource Management Plan must include the Distributed Generation alternative. It is simply impossible to site utility-scale solar projects in the Mojave and Great

Basin deserts without destroying valuable landscapes for present and future generations. A comprehensive, emergency-leveleffort at all levels of government—federal, state, county, local—can be implemented to avoid the *needless* destruction of these lands. Articles such as *Transmission-Independent Renewable Energy*, by solar engineer Bill Powers, show how non-destructive distributed generation, renewable energy is a viable alternative (*Desert Report*, August 2022, pp. 16-18).

Thank you for your consideration, and I hope we all can work together to protect the desert and develop renewable energy as quickly as possible.

Thank you,

[redacted]

[redacted]

[1]*Old Spanish National Historic Trail Comprehensive Administrative Strategy*, Bureau of Land Management National Park Service, Department of the Interior, Denver, CO and Salt Lake City, UT, December 2017.

[EXTERNAL] Golden Currant Solar Project Variance

[redacted]@gmail.com>

Fri 8/5/2022 10:16 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

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Stop selling off and destroying nevadas wilderness. Yellow Pine is disgusting to look at. The BLM is a disgrace. Along the front sight road my family has been gather an edible plant in good years for decades, golden currant would wipe that away forever.

[EXTERNAL] Golden Currant Solar Project Variance

[redacted]gmail.com>

Thu 7/28/2022 9:21 PM

To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

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I’m totally not for this. It’s not a good idea to mess with the deserts ecosystem, as it’s very sensitive and takes centuries to rebuild habitats. However, I think solar farms are brilliant ideas on areas such as buildings that are already in creation or shaded parking structures and other areas where we can improve vertically and take advantage of the sun.

Sent from my iPhone

[EXTERNAL] Golden Currant Solar Project Variance

[redacted] [redacted]gmail.com>
Fri 8/5/2022 4:48 PM
To: BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov>

5 attachments (17 MB)
IMG_2146.jpeg; IMG_2120.jpeg; IMG_2127.jpeg; IMG_2143.jpeg; IMG_2148.jpeg;

Dear BLM staff,

I have four big concerns about the Golden Currant Solar project and have included some photo documentation:

1. The project application area is adjacent to both Stump Springs and Brown's Spring. Both of these areas include large mesquite groves and deep gorges that are an important part of the Southern Paiute cultural landscape. These springs and mesquite areas are referenced in the traditional Salt Songs and Silver Songs. They are important for the Journey to the afterlife, and the songs specify medicine and food that is found in this area. The Brown's Spring and Stump Springs mesquite gorges are still used for food and medicine gathering to this day. The impacts would to cultural resources would harm the local Native American community and would not be easily mitigated. A solar project in this area would prevent the southern Paiute from accessing an important cultural landscape.

2. A large part of the Golden Currant Solar project is likely part of the same geologic formation as Tule Springs on the north side of Mount Charleston. The area likely contains ice age fossils and this must be evaluated according to the paleontology ordinances associated with NEPA.

3. The Golden Currant Solar project would come within about 50 feet of Queho's gravesite. Queho was an indigenous man at the end of the 19th century. His gravesite is visited by thousands of people every year, as is Cathedral Canyon.

4. The Golden Currant site is heavily used by hikers, campers, and OHV riders, especially the areas around Front Sight and Cathedral Canyon roads. There is a trail that runs adjacent to Tecopa road that is a popular hiking trail, and this intersects with another hiking/ohv trail south of Front Sight road that runs from east to west across the site.

Please see photos below of Queho's gravesite, the ohv/hiking trail south of Front Sight road, one of the mesquite gorges on the Golden Currant site that is also likely part of the Tule Springs formation, [redacted]

[redacted] and the Cathedral Canyon gorge directly adjacent to the site that is also typical of the gorges found throughout the Golden Currant site.

Sincerely,

[redacted]


1919
NEVADA'S
RENEGADE
INDIAN
ALONE

[redacted]