Copper Rays Solar Project

Public Scoping Report

Bureau of Land Management
Southern Nevada District Office
Pahrump Field Office
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Bureau of Land Management

Public Scoping Report

Copper Rays Solar Project (NVN-089655)

Prepared for:

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Acronyms

AC	Alternating Current
ACHP	Advisory Council on Historic Preservation
BLM	Bureau of Land Management
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FLPMA	Federal Land Policy and Management Act
MW	Megawatt
NDOW	Nevada Department of Wildlife
NEPA	National Environmental Policy Act
NOI	Notice of Intent
OHV	Off-Highway Vehicle
PEIS	Programmatic Environmental Impact Statement
PM_{10}	Fine Particulate Matter, 10 Micrometers or Smaller
POD	Plan of Development
Project	Copper Rays Solar Project
PV	Photovoltaic
Q&A	Question and Answer
1998 Las Vegas RMP	1998 Las Vegas Resource Management Plan
RMPA	Resource Management Plan Amendment
ROD	Record of Decision
ROW	Right-of-Way
SHPO	Nevada State Historic Preservation Office
VRM	Visual Resource Management

1 Introduction

1.1 Summary of Proposed Action

Copper Rays Solar LLC (Applicant) applied to the U.S. Department of the Interior, Bureau of Land Management (BLM) Pahrump Field Office for a right-of-way (ROW) grant to provide the necessary land and access for the construction, operation, and decommissioning of a proposed solar facility and interconnection to the regional transmission system. The Applicant is proposing the Copper Rays Solar Project (Project), consisting of an up to 700-megawatt (MW) alternating current (AC) solar photovoltaic (PV) power generating facility, including battery energy storage, on approximately 5,050 acres[1] of BLM-managed public land in the Pahrump Valley in Nye County, Nevada. The Project site is immediately adjacent to the Clark County line, southeast of the Town of Pahrump, and approximately 40 miles west of Las Vegas.

The Project is located on federal lands administered by the BLM under the 1998 Las Vegas Resource Management Plan (RMP). The Project site is located within a variance area for solar power generation under the 2012 Approved Resource Management Plan Amendments/Record of Decision (ROD) for Solar Energy Development in Six Southwestern States; however, the application for the Project was considered a "pending" application under the accompanying Solar Programmatic Environmental Impact Statement (PEIS) as it was submitted prior to the publication of the Supplement to the Draft Solar PEIS. Because of this, the Project is not subject to any decisions adopted by the Solar PEIS ROD, including the variance process. Though the Project was not subject to the variance process, application evaluation was completed as required by the regulations. The solar project prioritization and the application evaluation are separate processes and come before the National Environmental Policy Act (NEPA) process.

The NEPA review for the Project includes an amendment to the 1998 Las Vegas RMP to address a potential Visual Resource Management (VRM) Class modification from Class III to Class IV and to potentially modify two existing utility corridors that traverse the ROW application area.

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

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[1] Note the ROW acreage presented is at the time of the scoping period and that the overall size of the ROW will continue to be refined throughout the NEPA process.

1.2 Purpose of Public Scoping Report

The NEPA process is initiated with scoping. Scoping is an early and open process for determining the extent of issues to be addressed in the Resource Management Plan Amendment (RMPA) and Environmental Impact Statement (EIS) and for identifying the significant issues related to the Proposed Action. The scoping process seeks comments from interested and potentially affected parties including affected members of the public, agencies, Tribes, and organizations.

This Public Scoping Report summarizes the scoping effort and documents the issues and concerns raised by agencies, Tribes, organizations, and individuals during the scoping comment period. The intent of scoping is to obtain feedback to focus the analysis in the RMPA/EIS on significant issues and reasonable alternatives, and eliminate extraneous discussion.

2 Scoping and Solicitation of Comments under NEPA

2.1 Overview

During the scoping period, the BLM informed the public, landowners, federal, state, and local government agencies, Tribes, and interested stakeholders about the Project and solicited their input. The BLM announced the Project and the initiation of the scoping process, held two public scoping meetings, and invited the public to comment and ask questions. The public scoping meetings were announced in the Notice of Intent (NOI), publicized on the Project website and BLM social media accounts, in postcards mailed to interested stakeholders, and through public notices/news releases. These outreach and notification activities are described in more detail in the following sections.

2.2 Notice of Intent

The formal scoping process begins with publishing a NOI in the Federal Register. The Federal Register is the official federal daily publication for rules, proposed rules, and notices of federal agencies and organizations. The publication of the NOI serves as the official notice that the BLM is commencing preparation of an RMPA/EIS. The BLM published the NOI to prepare an RMPA/EIS for the Project in the Federal Register (Volume 87, Number 218) on November 14, 2022.

The NOI initiated the 45-day public scoping period for the RMPA/EIS and described the Project and the environmental review process.[2] It also identified contact information, the BLM website for the Project, and how comments could be submitted. The comment period began on November 14, 2022, with a request that all comments be received by December 29, 2022. In response to formal requests for extension of the scoping period, citing concerns regarding the commenting period overlapping two major holidays, the BLM extended the scoping period to until January 13, 2023 (60 days total). The NOI for the Project is included as Appendix A.

2.3 Public and Agency Notification

The BLM sent 5,404 postcards and emails notifying the public, state and local representatives, agencies, and non-governmental organizations of the initiation of the scoping period and the BLM's intent to prepare an RMPA/EIS. These notifications identified the dates and times of the

[2] The Notice of Segregation for the Project was published in the Federal Registry on October 21, 2021 during the application evaluation process.

public scoping meetings, the BLM's Project website for specific information on how to register for the meetings and Project information, and how to submit comments. A copy of the postcard is included in Appendix B. For members of the public who had previously provided email contact information, the BLM sent emails with the information from the postcard. For the scoping period extension, the BLM sent emails, published a news release, and updated the Project website with information on the extension date.

2.4 News Release

The BLM issued a news release and posted it on the BLM website on November 10, 2022, announcing the Project, dates for public scoping meetings, and requesting comments. A link to the project website with information on the project, including the news release, was provided via email to interested parties who provided email contact information. The BLM also issued a second news release, which was emailed to interested parties and posted on the BLM website on December 2, 2022, announcing the extension of the scoping period. Copies of the news releases are included in Appendix B.

2.5 BLM Website and Comment Methods

The BLM posted information on the Project website at https://eplanning.blm.gov/eplanning-ui/project/2019523/510. The information posted included an announcement of the public scoping meetings, materials presented at the public scoping meetings, methods to submit comments, Project information, point of contact information, and the official NOI. The BLM invited comments through a variety of methods, specifically:

- By email;
- During the public scoping meetings, including questions and verbal comments;
- By mail; and
- By submittal on the BLM National NEPA Register Project website.

Comments were accepted through January 13, 2023.

2.6 Public Scoping Meetings

The BLM hosted two public scoping meetings using the Zoom platform. At the meetings, the BLM provided a description of the NEPA process, information on the Project, and the opportunity to ask questions and provide public comments. The number of attendees and the time the scoping meetings were held are listed in Table 1.

Table 1 Dates of Scoping Meetings

Meeting Date/Time	Pre-Registered	Attended
December 6, 2022 6:00 p.m. to 8:00 p.m. PST	46	26
December 7, 2022 6:00 p.m. to 8:00 p.m. PST	36	25
Total	**82**	**51**

Registration for the scoping meetings opened on November 14, 2022 and was announced via the press release, emails, NOI, Project website, and postcards. Registration was required to attend the scoping meeting(s) and participants were able to register at any time, including during the scoping meeting(s). The two virtual public scoping meetings 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 able to register and participate via phone. Those who were not able to join the scoping meeting(s) live, could access a recording of the meeting(s) in addition to the list of questions and answers from the meeting(s) on the Project website.

2.6.1 Presentation

The presentation opened with a welcome and overview by Caitlin Gilleran of Panorama Environmental, a consultant for the BLM. The Pahrump Field Office Field Manager, Nicholas Pay, provided an introduction for the meeting. BLM Project Manager, Whitney Wirthlin, then provided information about the Project, the completed application evaluation process, and the NEPA process. The presentation included maps and information about the Project location, descriptions of the major Project components, information about the NEPA process, and resources for additional information.

After the formal presentation, Caitlin Gilleran facilitated a live question and answer (Q&A) session with Whitney Wirthlin, which was followed by a verbal input portion and meeting closeout by Nicholas Pay. Throughout the meeting, participants were reminded that the public input period would close on January 13, 2023, and that additional comments could be sent in via email, mail, or submitted through the Project's BLM National NEPA Register website. Additional information about the Q&A and verbal input portions of the virtual public scoping meetings is provided below.

The PowerPoint presentation provided a visual aid for the virtual public scoping meetings and is provided in Appendix C. As previously mentioned, the entirety of each virtual public meeting was recorded and posted to the Project website: https://eplanning.blm.gov/eplanning-ui/project/2019523/570.

2.6.2 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 by BLM staff in the Q&A feature or verbally answered live by the BLM Project Manager, Whitney Wirthlin.

Twenty-seven questions were asked and answered during Scoping Meeting 1. Twenty-one questions were asked and answered during coping Meeting 2. A copy of all questions and answers for both scoping meetings is provided in Appendix D.

2.6.3 Verbal Comment

Verbal comments could be provided during the verbal comment portion of the virtual public meetings. The meetings remained open for verbal comment until 8 p.m. There were 22 individuals who selected 'Yes' or 'Maybe' during the registration process when asked if they would like to provide a verbal comment for Scoping Meeting 1. There were 13 individuals who selected 'Yes' or 'Maybe' during the registration process when asked if they would like to provide a verbal comment for the Scoping Meeting 2. A transcription of the verbal comments received is provided in Appendix D.

A link to the recording(s) for the virtual public scoping meetings, which include the verbal public comment portion, is available at: https://eplanning.blm.gov/eplanning-ui/project/2019523/510.

2.7 Agency Coordination

The BLM invited a total of 10 federal, 13 state, and three local agencies to serve as cooperating agencies on the Project:

Federal

1. Advisory Council on Historic Preservation (ACHP)
2. Bureau of Indian Affairs – Western Regional Office
3. U.S. Department of Defense – National Test and Training Range
4. U.S. Environmental Protection Agency (EPA) – Region 9
5. Military Aviation and Installation Assurance Siting Clearinghouse
6. National Parks Service – Interior Regions 8, 9, 10, and 12
7. U.S. Army Corps of Engineers – Nevada/Utah Regulatory Section
8. U. S. Fish and Wildlife Service – Southern Nevada District Office Ecological Services Program; Reno Fish and Wildlife Office; and Migratory Bird Program
9. U.S. Forest Service – Spring Mountain National Recreation Area
10. U.S. Bureau of Reclamation – Interior Region 8-Lower Colorado Regional Office

State of Nevada

1. Nevada Department of Public Safety
2. Nevada Department of Transportation
3. Nevada Department of Wildlife (NDOW) – Southern Region
4. Nevada Department of Conservation and Natural Resources – Off-Highway Vehicles (OHV) Program
5. Nevada Division of Forestry
6. Nevada Division of Environmental Protection

7. Nevada Division of Water Resources
8. Nevada Division of State Parks
9. Nevada Division of State Lands
10. Nevada Division of Emergency Management
11. Nevada Governor's Office of Energy
12. Nevada State Historic Preservation Office (SHPO)
13. Public Utilities Commission of Nevada

Local

1. Clark County Department of Environment and Sustainability
2. Clark County Department of Aviation
3. Nye County

Tribes

BLM invited 15 Tribes to serve as cooperating agencies on the Project:

1. Bishop Paiute Tribe
2. Chemehuevi Indian Tribe
3. Colorado River Indian Tribes
4. Fort Independence Indian Community of Paiute Tribes
5. Fort Mojave Indian Tribe
6. Kaibab Band of Paiute Indians
7. Las Vegas Paiute Tribe
8. Moapa Band of Paiutes
9. Paiute Indian Tribe of Utah
10. San Juan Southern Paiute Tribe
11. Timbisha Shoshone Tribe
12. Twenty-nine Palms Band of Mission Indians
13. Utu Gwaitu Paiute Tribe
14. Big Pine Paiute Tribe of the Owens Valley
15. Lone Pine Paiute-Shoshone Tribe

As of February 2023, 12 eligible agencies have accepted cooperating agency status on the

1. U.S. Fish and Wildlife Service Ecological Services Program
2. U.S. Fish and Wildlife Service Migratory Bird Program
3. EPA – Region 9
4. Nevada Department of Conservation and Natural Resources, OHV Program
5. Nevada Division of Forestry
6. Nevada Division of Emergency Management
7. Clark County Department of Aviation
8. Clark County Department of Environment and Sustainability
9. NDOW

10. Nevada Department of Public Safety
11. Nye County
12. Moapa Band of Paiutes

2.8 Tribal Consultation

BLM invited Native American Tribes to participate in the scoping process for the Project, including the Moapa Band of Paiutes, Las Vegas Paiute Tribe, Timbisha Shoshone Tribe, Chemehuevi Indian Tribe, Twenty-Nine Palms Band of Mission Indians, Kaibab Band of Paiute Indians, Fort Mojave Indian Tribe, Colorado River Indian Tribes, Fort Independence Indian Community, San Juan Southern Paiute Tribe, Utu Utu Gwaitu Tribe, Bishop Paiute Tribe, Big Pine Paiute Tribe of Owens Valley, Paiute Indian Tribe of Utah, and Lone Pine Paiute-Shoshone Tribe. Through outreach, the BLM requested assistance in identifying any issues or concerns about the Project, including the identification of sacred sites and places of traditional religious and cultural significance that might be affected.

The BLM is conducting on-going government-to-government consultation with the Moapa Band of Paiutes and Timbisha Shoshone Tribe, as well as coordination with tribal staff from the Chemehuevi Indian Tribe and Twenty-Nine Palms Band of Mission Indians. The Moapa Band of Paiutes' concerns have been focused on the protection of cultural and natural resources, long-term impacts of the Proposed Action, cultural sensitivity training for personnel, and the involvement of the Tribe in different aspects of the Project. The Timbisha Shoshone and the Twenty-Nine Palms Band of Mission Indians are interested in the protection of desert tortoises. The Timbisha Shoshone Tribe and Chemehuevi Indian Tribe expressed concerns about potential impacts to areas of tribal interest. Additionally, the Twenty-Nine Palms Band of Mission Indians shared concerns about the long-term impact of the Proposed Action to the environment and their interest in the protection of cultural resources. During the NEPA process, the BLM will identify any potential impacts to natural, cultural, and visual resources in the EIS and continue consultation with Tribes to ensure that concerns are considered in proposed mitigation.

3 List of Commenters

3.1 Introduction

This section summarizes and characterizes the list of commenters that submitted comments during the scoping period and the number of comments received. Comments were received from federal and state agencies, non-governmental organizations, and individuals from the public. Comments were received by email, through the BLM's National NEPA Register website, and as verbal comments and questions during the public scoping meetings. The questions and transcribed comments from the public scoping meetings are provided in Appendix D. Full recordings of the comments from the scoping meetings are available at: https://eplanning.blm.gov/eplanning-ui/project/2019523/510.

In addition to verbal comments received during the virtual scoping meetings, the BLM received 39 comment letters/emails. Each comment letter was read and evaluated to identify key concerns/topics to be addressed in the EIS and RMPA. Written comments are presented in Appendix E.

Section 4 of this report summarizes key concerns/topic areas identified from the comments received throughout the public scoping period. 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 RMPA/NEPA analysis for the Project.

3.2 Identification of Commenters and Number of Comments Received

3.2.1 Overview of Commenters

A total of seven individuals provided nine oral comments during Scoping Meeting 1 and a total of seven individuals provided 10 oral comments during Scoping Meeting 2 as listed in Table .

3 LIST OF COMMENTERS

Table 2 Individuals Who Provided Comments during Public Meetings

Scoping Meeting 1	Scoping Meeting 2
Joyce Barishman	Laura Cunningham
Kevin Emmerich	Heather Gang
Carl Van Warmerdam	Michael Fender
Teresa Skye	Edward LeBlanc
Mike Barishman	Kevin Emmerich
Ammie Nelson	Susie Hertz
John Hiatt	Fred Sauberman

A total of five individuals asked 27 questions during Scoping Meeting 1 and a total of eight individuals asked 23 questions during Scoping Meeting 2 as listed in Table .

Table 3 Individuals Who Asked Questions during Public Meetings

Scoping Meeting 1	Scoping Meeting 2
Kevin Emmerich	Don and Susie Hertz
Carl van Warmerdam	Laura Cunningham
Ammie Nelson	Heather Gang
John Hiatt	Michael Fender
Joyce Barishman	Edward LeBlanc
	Marcus Pearson
	Fred Sauberman
	Karen Beyers

BLM received a total of 37 comment emails and letters during scoping. Two additional comment letters requested that the BLM extend the comment period due to the holiday season. Table 4 identifies all comments received from each agency, organization, or individual and the date received. Table 5 summarizes the number of comments by affiliation.

3 LIST OF COMMENTERS

Table 4 Comments Received During Public Scoping Period

Commenter		Letter Date
Government Agencies		
Clark County Department of Environment and Sustainability	Araceli Pruett	November 14, 2022
Death Valley National Park	Mike Reynolds	December 21, 2022
Nevada State Assembly	Gregory Hafen	December 29, 2022
Clark County Department of Aviation	John Wagner	January 11, 2023
Nye County Natural Resources	Megan Labadie	January 11, 2023
Clark County Department of Aviation	John Wagner	January 13, 2023
EPA	Ann McPherson	January 13, 2023
NDOW, Southern Region	Bradford Hardenbrook	January 13, 2023
Nevada State Clearinghouse Department of Conservation and Natural Resources	Scott Carey	January 13, 2023
Non-Governmental Organizations		
Blue Ribbon Coalition	Simone Griffin	January 12, 2023
Amargosa Conservancy	Mason Voehl	January 12, 2023
Desert Tortoise Council	Edward LaRue	January 13, 2023
Basin and Range Watch/Western Watersheds Project/Mojave Green	Kevin Emmerich	January 14, 2023
Defenders of Wildlife/The Nature Conservancy/The Wilderness Society	Perter Gower / Dalia Madi	January 17, 2023
Individuals [a]		
23 Individuals		Multiple Dates

Note:

Personal identifying information was redacted for individuals from the public providing comment. Duplicate letters and letters requesting a scoping period extension were not included with the individual letter counts.

Table 5 Written Comment Letters by Commenter Affiliation

Affiliation	# Received	Percent
Government		
Federal	2	5%
State	3	8%
County	4	11%
Non-Government Organizations	5	14%
Individuals	23	62%
Total	**37**	**100%**

Note:
Duplicate letters and letters requesting a scoping period extension were not included with the letter counts.

3.2.2 Federal, State, and Local Agencies

Comments from federal, state, and local agencies included the:

- EPA
- National Park Service, Death Valley National Park
- Clark County Department of Aviation
- NDOW, Southern Region
- Nye County Natural Resources
- Clark County Department of Environment & Sustainability
- State of Nevada Assembly
- Nevada State Clearinghouse: Nevada Division of Water Resources

The agencies raised issues concerning Project and cumulative impacts to groundwater resources, surface water, visual quality, glare, dark skies, migratory and nesting birds, cultural resources, vegetation, OHV use, and Mojave desert tortoise. Agencies requested that all facilities associated with construction, panel reflection, and dust from proposed construction be analyzed and pointed out the importance of avoiding impacts to airspace. Agencies also expressed concern about air quality impacts of fine particulate matter (PM_{10}) in the form of windblown and vehicle-generated dust. A request by one agency was made to provide specific information regarding the decommissioning of panels and batteries as there is not sufficient capacity at local landfills. Additional information on issues raised during the scoping period are provided in Section 4.

3.2.3 Non-Governmental Organizations

Non-governmental organizations that provided comments included:

- Desert Tortoise Council
- Amargosa Conservancy
- Blue Ribbon Coalition
- Basin and Range Watch/Western Watersheds Project/Mojave Green
- Defenders of Wildlife/The Nature Conservancy Nevada Field Office/The Wilderness Society

The non-governmental organizations raised issues concerning the protection of biological resources, specifically regarding Mojave desert tortoise, connectivity, and habitat as well as special status plants and birds. They also raised issues concerning the cumulative impacts in the Pahrump Valley from the solar facilities and associated gen-tie lines. The non-governmental organizations requested a range of alternatives be analyzed in the EIS including an urban/rooftop solar alternative, an alternative that avoids the existing utility corridors, a conservation alternative, and an alternative that develops highly degraded land. Several commenters requested analysis of an action alternative that would allow the land to be used for multiple uses (e.g., recreationalists, Mojave desert tortoise) in accordance with Federal Land Policy and Management Act (FLPMA). One commenter noted that the Las Vegas RMP as well as the Solar PEIS are older and out-of-date necessitating that the Project be paused until these documents can be updated. Other comments requested protection of water resources, notably due to concerns caused by groundwater use for the Project and adjacent cumulative projects. One commenter noted that motorized and non-motorized recreation occurs in the Project area and the impacts of the Project on this use. A few commenters expressed concerns related to visual, air quality, and climate change impacts. One comment requested that a facility closure and restoration plan be prepared to address restoration and disposal of facility components. Additional information on issues raised during the scoping period is provided in Section 4.

3.2.4 Individuals

Comments from individuals were submitted by residents in the Pahrump Valley, recreationalists, and other interested individuals. Many of the commenters indicated opposition to the Project or thought it was already denied approval. The individual comments focused on the loss of Mojave desert tortoise species and their habitat, including other endangered or native plants and animals. Commenters mentioned that as mitigation, the allocation of grazing permits could be limited or not renewed to address impacts on desert tortoise. Commenters raised concerns regarding the proximity of solar projects to residents and questioned what influence the Nye County’s solar project moratorium would have on the Project. Commenters also raised concerns over the Project’s visibility, cumulative impacts from the numerous solar projects in the area, and fugitive dust that could be created by the Project. Commenters stressed the importance of considering alternatives, specifically solar projects on disturbed lands, rooftop solar, and distributed generation. Additional information on issues raised during the scoping period are provided in Section 4.

4 Issues Raised During Scoping

4.1 Overview of Issues Raised

This section of the Public Scoping Report summarizes the various issues raised in the comments submitted by governmental agencies, non-governmental organizations, and individuals during the scoping process. The comments focused on the Project's potential effects to environmental resource topics covered in EISs. The comments could be categorized into the following topics:

1. Project description
2. Human environment issues
3. Natural environment issues
4. Indirect and cumulative impacts
5. Project alternatives
6. EIS administrative and permitting issues

Table 6 identifies the number of comment letters that mentioned each of the key environmental topics. Non-substantive comments are those that expressed an opinion with no supporting information. Two commenters noted that they were in favor of solar development, however also stated that the Project should not destroy pristine desert areas. One verbal commenter during the scoping meetings requested listeners to think of the potential benefit solar could bring to the Pahrump Valley. Multiple comments shared opposition to the Project. Four written commenters stated that the No Project Alternative should be selected, and they are not in favor of the Project being built. In addition, verbal commenters noted the BLM should not approve the Project during the scoping meetings. The largest number of comments received raised concerns regarding natural resources, mostly focusing on desert tortoise, desert vegetation, water resources, air quality, and fugitive dust. Visual resources and alternatives were also raised by numerous comments.

Table 6 Number of Comment Letters/Forms/Verbal Comments/Questions Addressing Key Topics

Topic	# of Letters/Forms/Verbal Comments/Questions Including the Topic
Project Description and Design	7
Purpose and Need	7
Human Environment	
Visual Resources, Glare, and Lighting	12
Land Use	3
Public Safety, Hazards, and Fire	3
Cultural and Tribal Cultural Resources	2
National Historic Trail	2
Recreation	5
Socioeconomics and Environmental Justice	4
Noise	2
Natural Environment	
Biological Resources	41
Water Resources and Hydrology	21
Air Quality and Dust	11
Climate Change	3
Cumulative Impacts	12
Alternatives	12
Mitigation	6
EIS Administrative and Permitting Issues	13
Scoping Period Extension Requests	2
Issues Outside the Scope of the EIS	21

Note:

Most commenters addressed multiple topics in one letter/email or verbal comment, resulting in a count well over the 43 total comment documents received (or the 19 recorded verbal comments and 50 questions). Duplicate letters were not included twice in this resource topic count.

4.2 Project Description, Design, and Purpose and Need

The EPA stated that the EIS needs a clearly stated purpose and need. The EPA and other commenters noted that the Project should be clear about how vegetation management would be addressed during the construction of the Project.

Basin and Range Watch/Mojave Green/Western Watersheds Project stated that the purpose and need for the Project should incorporate the goals of the Endangered Species Act in order to consider a conservation alternative. The Desert Tortoise Council believes that the BLM's management of the Mojave desert tortoise and habitat is not in compliance with the FLPMA. Defenders of Wildlife/The Nature Conservancy/The Wilderness Society commented that they recognized the contribution that this Project could have on a carbon-free energy sector and the BLM's mandate to manage public lands for multiple uses according to FLPMA.

4.3 Human Environment Issues

4.3.1 Visual Resources, Glare, and Lighting

Several individuals were concerned about visual impacts of solar projects, including from State Route 160 and from surrounding recreation areas and nearby wilderness or other sensitive areas. The EPA was concerned about impacts to night skies due to lighting and provided recommendations to address light pollution.

The Clark County Department of Aviation noted that the Project could result in glare and may interfere with aviation infrastructure and shared potential impact information. The Clark County Department of Aviation recommended a glare study be completed for the Project, based on the particular solar panel type that would be utilized, and including the Project as well as other proposed projects in the area.

Nye County commented that cumulative impacts on the visual quality of the area must be analyzed and mitigated. Nye County indicated that a solar facility is not a moderate change to the characteristic of the landscape in accordance with VRM Class III, which is designated for part of the site. Basin and Range Watch/Mojave Green/Western Watersheds Project also commented on the RMPA to change the VRM Class III, indicating that the designation was planned for and well thought out in the 1998 Las Vegas RMP.

4.3.2 Land Use

The Blue-Ribbon Coalition expressed understanding and support for shared use of public lands. They stated that they believe responsible recreational use of public lands can exist in harmony with ecosystem needs. One individual commented on the loss of public land for recreation activities, specifically off highway vehicle use.

The Clark County Department of Aviation recommended that the 7460-1 Notice of Proposed Construction of Alteration form be filed with the Federal Aviation Administration prior to construction of the gen-tie transmission structures as the proposed structures would be in the vicinity of the Caas Private Airport and may have impacts from solar panel glare. The Clark County Department of Aviation also shared locations and additional information on National Airspace System infrastructure within 25 miles of the proposed Project area.

Nye County commented that the analysis must include a review to ensure compliance with the goals and policies of the Pahrump Regional Planning District Master Plan Update (2014) and 1998 Las Vegas RMP.

The NDOW suggested that the applicant consider the land use activities that would be displaced by the large complex of renewable energy developments and consider that these uses would ultimately shift to new areas, changing the complexion of land use types and intensity of use on local landscapes.

Basin and Range Watch/Mojave Green/Western Watersheds Project recommended establishing an Area of Critical Environmental Concern (ACEC) for desert tortoise habitat during the RMPA/EIS process for the project. The BLM is reviewing the recommendation in accordance with the BLM ACEC Manual (BLM Manual 1613). The Wilderness Society, The Nature Conservancy, Defenders of Wildlife, and the Natural Resources Defense Council recommended the BLM conduct a land use plan amendment for the proposed solar development and conservation to provide an avenue for ACEC designation.

4.3.3 Public Safety, Hazards, and Fire

Nye County noted that the Applicant should ensure the PV panels can be recycled or decommissioned. Nye County noted that there is not sufficient landfill capacity or ability to accept solar waste (including lithium-ion batteries). Nye County requested the Applicant develop a disposal plan for the solar panels and battery infrastructure. Nye County also commented that solar panels and battery storage systems have the potential to start fires and could affect public health and safety. Nye County recommended a fire mitigation and prevention plan be part of the proposed Project.

Two commenters asked about the disposal of solar panels during the decommissioning of the Project. One also questioned where a panel would be disposed of if it were to break during operation. The EPA noted that the EIS should address hazardous wastes, including from the battery storage facility. The EPA noted that the EIS should address whether pesticides, herbicides, or rodenticides would be used.

The Desert Tortoise Council commented that spread of invasive species could increase the frequency, intensity, and human-caused and naturally occurring fires. Basin and Range Watch/Mojave Green/Western Watersheds Project also commented on this potential impact.

4.3.4 National Historic Trail

The Nevada State Assemblyman commented about the Project limiting access to the Old Spanish National Historic Trail. A commenter brought up that the proximity of the proposed

Project site is close to the federally protected Old Spanish National Historic Trail and further noted that both the primary route through Stump Springs and the alternate route through Pahrump Springs are in the Project area. The commenter asked that the impacts to this designated historic resource area be addressed. Basin and Range Watch/Mojave Green/Western Watersheds Project commented that the Project would be visible from the Old Spanish National Historic Trail. Note that the Project would be beyond the 5-mile corridor boundary of the Old Spanish National Historic Trail.

4.3.5 Cultural and Tribal Cultural Resources

The EPA commented that it was important for formal government-to-government consultation and recommended that the EIS summarize the consultation, main tribal concerns, how the concerns were addressed, and whether continuing consultation was warranted. The EPA further requested that the EIS include an analysis of impacts on cultural resources and how effects would be avoided or minimized.

The Nevada State Assemblyman expressed concerns of potential impacts of the Project on the cultural landscape for tribal lands in the area.

4.3.6 Recreation

Nye County commented that the Project site is an area used by OHV recreationalists. Additional comments were shared from the Nevada Offroad Association regarding the impacts commercial solar has on OHV use, noting that indirect impacts from dust can also inhibit OHV use in the area as well as the loss of uninterrupted open lands and views. Another individual commented on the loss of public land for recreation activities, specifically OHV. A comment also stated that a Travel Management Plan is not in place for the Pahrump Valley area and a map of existing routes needs to be prepared.

The Blue-Ribbon Coalition noted that the Project area is commonly used by recreationalists and requested a thorough inventory of current trails to get an accurate baseline of use. This commenter expressed understanding and support for shared use on public lands but noted that large-scale closures unfairly and inequitably deprive people with disabilities the ability to recreate using OHVs.

Some individuals commented on the trails and public access to the surrounding areas. Two commenters brought up concerns with OHV recreation and its availability, along with its potential harm to desert tortoise. Commenters also noted impacts to nearby recreational areas due to the visibility of the Project.

4.3.7 Socioeconomics and Environmental Justice

Some commenters raised concerns during the public scoping meetings' verbal comment period regarding the potential for decreased property values and stated that the economic stimulation from the Project would be short lived. Nye County also raised concerns over property values.

The EPA noted that the EIS should discuss the potential for disproportionate adverse impacts to minority and low-income populations and the approaches used to foster public participation by these populations.

4.3.8 Noise

Two commenters expressed concerns about noise pollution from construction equipment and vehicles.

4.4 Natural Environment Issues

4.4.1 Biological Resources

Numerous individuals noted that the Project would be built in high-quality desert tortoise habitat and would impact desert tortoises. Comments noted that drought conditions in the area may affect desert tortoises, especially translocated tortoises, which should be considered in the analysis. Comments expressed concern with potential predation of desert tortoises that are translocated from the Project area.

The Desert Tortoise Council requested the analysis include sufficient surveys and data for special status plants, migratory birds, burrowing owl, and Mojave desert tortoise and recommended that the survey area be much larger than the Project site. The Desert Tortoise Council provided specific recommendations for the desert tortoise analysis (e.g., addressing roads, gen-tie lines) and mitigation. This comment also stated that the analysis should not rely exclusively on previous environmental documents for solar development as current conditions affecting desert tortoises have changed over the previous 10 years. The Desert Tortoise Council also provided information and recommendations on desert tortoise mitigation plans that should be included with the Draft EIS, including translocation plans, desert tortoise predator management plan, and fire prevention/management plan for infrastructure components.

Basin and Range Watch/Mojave Green/Western Watersheds Project stated that 33 of the adult tortoises relocated for the Yellow Pine Solar Project were killed by predators and expressed concerns about ensuring this does not happen as part of this Project. They also mentioned that construction methods such as vegetation mowing could crush animal burrows, destroy biological soil crust, pulverize desert pavement soils, and promote the spread of invasive weeds.

Multiple comments stated the EIS analysis should analyze effects of the Project as it related to the attraction of wildlife, such as migratory birds, waterfowl and marsh birds, night flying species, and other avian species, due to the reflective nature of solar panels (lake effect). Potential effects may include increased avian injury or mortality and should be considered in the avian impacts for the proposed Project. Commenters also expressed concerns about loss of desert vegetation and habitat. Requests were made to analyze impacts on sensitive vegetation including the mesquite bosque. The NDOW recommended these potential effects should be considered in the Bird and Bat Conservation Strategy prepared for the proposed Project.

The NDOW expressed concern with potential wildlife species habitat loss, fragmentation, and degradation from the direct, indirect, and cumulative effects of the Project. The NDOW noted the EIS should also address impacts to ground-nesting birds and foraging bird species (such as Golden eagles), including potential project design features such as breeding bird surveys and monitoring prior to and during construction, with appropriate buffer distances for avoidance if nests are observed. The NDOW also requested Gila monster encounter protocols should be followed during construction and operation of the proposed Project. The NDOW noted that a worker education program should also be incorporated.

The EPA commented on potential impacts on biological resources including Mojave desert tortoise, migratory birds, desert pavement, and invasive species and provided recommendations to avoid or minimize impacts, like maintaining vegetation on site and creating wildlife movement structures in fencing. The EPA also raised concerns for mesquite and acacia bosques adjacent to the Project area, and potential impacts to these species from changes in hydrologic flow and groundwater based on proposed Project components. Several other comments raised concerns about invasive species proliferation and requested the analysis address this concern.

4.4.2 Water Resources and Hydrology

In their comment letter, the EPA indicated that the following water resource issues should be discussed in the EIS: information on Clean Water Act Section 303(d)-impaired waters, impacts of changing precipitation patterns as it relates to stormwater management, phased approach to grading and removal of vegetation, placement of solar panels to minimize erosion, quantity and source of water for construction and operation, and impacts to waters of the U.S. and desert washes. The EPA and NDOW also stressed the importance of maintaining drainages and washes across the Project area and avoiding construction of facilities in these features by utilizing avoidance buffers.

Nye County and other commenters requested information on where the water used for construction and operations would be sourced and noted that cumulative impacts need to be considered. Nye County requested additional information and analysis from the proponent on the impacts to water needs if soil stabilizers are used, versus utilizing just water, for dust control.

Comments discussed the impacts to water resources and the use of water during construction and operation, noting that it should be quantified including off-site consumption. An individual noted that the BLM is ignoring the long-term effects a drought would have on the water resources. A separate commenter requested studies be conducted on water use before construction of solar projects is approved.

The Amargosa Conservancy noted that the combined water consumption of solar projects in the area, including this Project, could well exceed the 4 percent of perennial yield of the local groundwater basins. The BLM should consider the cumulative effect of all the solar projects on limited groundwater resources, including individual groundwater wells in Pahrump, the Amargosa Wild and Scenic River, Old Spanish National Historic Trail, Pahrump Valley Wilderness Areas, and the Amargosa Rive Basin. The Amargosa Conservancy also expressed concerns about changes in groundwater flows from the proposed Project and other proposed projects within the area, which may affect the Amargosa Basin.

The Death Valley National Park expressed concern for groundwater availability, noting that water use for solar energy development and operations may strain already over-allocated groundwater basins and could impact the park. The Death Valley National Park also shared information on the recent groundwater model developed for the US Geological Survey, which suggests the groundwater basin in the Pahrump Valley is interconnected with other basins, which could result in discharge level changes at Furnace Creek and the Amargosa Wild and Scenic River. The Nevada State Clearinghouse Department of Conservation and Natural Resources provided comments regarding water rights and how transfers could be authorized. Information was also provided on requirements associated with well drilling and geotechnical soil borings.

4.4.3 Air Quality and Dust

Numerous individuals expressed concerns about air quality and the dust that would be generated during construction, as well as the effects on local communities and public health. Commenters also noted that construction of the Yellow Pine Solar Project resulted in substantial dust, which is in a similar area as the Project.

The EPA indicated that the EIS should provide a discussion of ambient air conditions and impacts to air quality and should provide mitigation measures to minimize effects related to greenhouse gas, fugitive dust, and other emissions, such as air quality monitoring. The EPA indicated the EIS should address potential impacts related to exposure to Valley Fever. Basin and Range Watch/Mojave Green/Western Watersheds Project also commented about Valley Fever and the potential to affect nearby residents and workers.

The Clark County Department of Environment and Sustainability and Nye County expressed concern regarding the impacts of PM_{10} in the form of windblown and vehicle-generated dust if appropriate dust control measures are not applied to the Project. These concerns were raised due to the existing high wind, desert area, wind erosion, and PM_{10} entrainment from disturbed areas and unpaved roads. The Clark County Department of Environment and Sustainability also suggested that any impacts to air quality as a result of surface disturbance and other project activities be analyzed and mitigated through the implementation of appropriate water erosion and dust control measures and that best management practices should be implemented in any area where the desert's natural crust is broken.

The Clark County Department of Aviation noted that dust could interfere with aviation infrastructure.

4.4.4 Climate Change

Comments were submitted expressing concern about potential cumulative impacts to climate change from the proposed solar facility. Multiple comments were submitted with concerns about increases in temperature within the Project area, which would have impacts on global climate change. The Desert Tortoise Council noted that destruction of native desert vegetation will result in less carbon sequestration. This commenter also requested that the analysis address climate change, global warming, and the effects the Proposed Action may have on climate change.

4.5 Cumulative Impacts

Numerous commenters, including agencies, organizations, and individuals, noted that cumulative impacts from the Project, and other projects proposed in the Pahrump Valley, to resources, especially biological resources, groundwater use, and dust could be substantial and should be thoroughly analyzed. In their comment letter, EPA recommended including the following information in the DEIS;

- The current condition of the resource as a measure of past impacts.
- The trend in the condition of the resource as a measure of present impacts. For example, the health of the resource is improving, declining, or in stasis.
- All on-going, planned, and reasonably foreseeable projects in the study areas, which may contribute to cumulative impacts.
- The future condition of the resource based on an analysis of impacts from reasonably foreseeable projects or actions added to existing conditions and current trends.
- Mitigation measures or conservation management actions that can be consistently and transparently applied to future projects.

The Desert Tortoise Council recommended use of the eight principals from Council of Environmental Quality's guidance on cumulative effects analysis for desert tortoise.

The Clark County Department of Aviation noted the EIS should consider the cumulative impacts of gen-tie lines on aviation and ensure they are not an obstacle as well as glare impacts. The Clark County Department of Aviation also requested that a cumulative analysis of transmission capability be conducted to determine whether new power line installation would be needed, which would then necessitate an airspace analysis.

The Amargosa Conservancy requested that the BLM consider the cumulative effect of all the solar projects on limited groundwater resources, including individual groundwater wells, in Pahrump.

Defenders of Wildlife/The Nature Conservancy/The Wilderness Society requested that the cumulative impact analysis address all likely connected actions in addition to projects planned for, or currently operating in, the Project area.

4.6 Project Alternatives

Many individuals and organizations and several agencies submitted comments regarding Project alternatives. The comments generally requested that the EIS include a range of alternatives to ensure that the full spectrum of alternatives to the proposed Project are fully considered and evaluated.

Various commenters specified rooftops (residential and hotels), other developed areas, previously disturbed/damaged land, locations away from developed areas, and various smaller sites as alternative locations for building the Project. One specific individual commenter stated that a distributed energy alternative should be considered on top of all factories, business buildings, and even on hazardous sites. Nye County recommended an alternative be developed to move the Project to a more remote area, due to Project proximity to the community of Pahrump and the Pahrump Regional Planning District Master Plan Update, which identified the lands within the Project area for County disposal nomination.

The EPA indicated that the EIS should include a reasonable range of alternatives that meet the stated purpose and need, including options for avoiding environmental impacts. The EPA provided some recommendations for potential alternatives including alternatives that incorporate buffers around desert washes and an alternative that involves use of overland travel site preparation techniques.

Nye County requested a site alternative to address socio-economic, water, recreational, and property value impacts.

Basin and Range Watch/Mojave Green/Western Watersheds Project submitted comments that the BLM should consider a conservation alternative to the Project to prioritize desert tortoise recovery and protect on-site resources. The Basin and Range Watch/Mojave Green/Western Watersheds Project also requested consideration of a conservation alternative to protect on-site resources and discussed distributed rooftop solar alternatives.

The Desert Tortoise Council suggested a Project alternative that avoids existing utility corridors and avoids creating new and realigned utility corridor segments, due to potential impacts.

The Amargosa Conservancy recommended existing Solar Energy Zones or Designated Leasing areas should be identified as alternatives to the proposed Project area.

4.7 Mitigation

The Clark County Department of Environment and Sustainability commented that the BLM should mitigate through water erosion, dust control measures, and best management practices.

Desert Tortoise Council commented that the BLM should determine the effectiveness of implemented mitigation for the tortoise/tortoise habitat. They also indicated the DEIS should include effective mitigation for all direct, indirect, and cumulative effects to the tortoise and its habitats. Mitigation should use the best available science with a commitment to implement the mitigation commensurate to impacts to the tortoise and its habitats. The Desert Tortoise Council also stated the Draft EIS should also include a plan for desert tortoise monitoring, including desert tortoise connectivity corridor functionality.

A commenter suggested mitigation measures for desert tortoise, including closing and reclaiming OHV vehicle routes in sensitive desert tortoise habitat.

Several comments noted that the BLM could require retirement of existing grazing allotments as mitigation for impacts to desert tortoise.

Nye County noted that mitigation and prevention of any potential increase in fire risk from the proposed Project should be prioritized for public health and safety, which may include site worker monitoring during operations and maintenance of the Project.

The EPA provided several recommendations to reduce impacts including specific design features, preparation of plans, and specifics that should be included in the plans.

Defenders of Wildlife/The Nature Conservancy/The Wilderness Society commented that without compensatory mitigation there is no mechanism to remedy adverse impacts on desert tortoises, desert vegetation, and the ecosystem. This commenter requested an evaluation to determine the need for compensatory mitigation.

4.8 EIS Administrative and Permitting Issues

The EPA requested that technical reports that lead to conclusions regarding environmental consequences be included as appendices in the EIS. Nye County commented that a Special Use Permit from the Nye County Planning Department must be requested. Defenders of Wildlife/The Nature Conservancy/The Wilderness Society suggested that the BLM analyze environmental impacts of the solar projects in development or proposed in the Pahrump Valley as part of a programmatic EIS, ideally the Western Solar Plan PEIS, rather than separate EISs for a holistic and consistent approach.

4.9 Scoping Period Extension Requests

Two commenters formally requested that the scoping period be extended due to the overlap with holidays.

4.10 Issues Outside the Scope of the EIS

No written comment fully supported the proposed Project, however one verbal commenter asked those attending the virtual public scoping meeting to consider the benefits the proposed Project would bring to the local area. One commenter noted that they thought the Project was turned down in Pahrump.

Commenters requested the Project's NEPA review be paused until the 1998 Las Vegas RMP and Solar PEIS are revised. Multiple comments stated the proposed Project should be postponed until BLM completes a comprehensive planning effort to account for the number of solar projects proposed within the area. Multiple comments recommended the BLM approach projects similar to BLM's comprehensive Mojave Desert renewable energy plan in California. Comments were submitted suggesting the Pahrump Valley area undergo comprehensive plan to be designated as a Designated Leasing Area/Solar Energy Zone.

5 Summary of ACHP and Section 106 Consultation Comments

The BLM received one comment letter from the Advisory Council on Historic Preservation and three comment letters from the Nevada SHPO. The Advisory Council on Historic Preservation stated that the BLM must meet the standards in 36 CFR §§ 800.8(c)(1)(i) through (v). In one letter, the SHPO declined the formal role of a cooperating agency. The SHPO provided several comments in each of the two other letters with requests for additional information or maps to be provided in the cultural resources report. In the SHPO's most recent letter they ask that the BLM follow the procedures outlined in 36 CFR §§ 800.8(c) to coordinate and align the Section 106 process with the NEPA process. Letters received from both agencies are included in Appendix E.

Currently consultation is ongoing and is not yet complete. Additional information will be provided and made available in the Draft RMPA/EIS. Table 7 shows the comment letters the BLM has received from these two agencies and the dates received.

Table 7 Cultural Resource Comment Letters

Commenter	Date
Advisory Council on Historic Preservation	
Advisory Council on Historic Preservation	March 18, 2022
Nevada SHPO Preservation Office	
Nevada SHPO	May 11, 2021
Nevada SHPO	June 3, 2022
Nevada SHPO	November 3, 2022

6 Next Steps in the NEPA Process

Substantive comments received during the scoping period will be considered during the preparation of the Draft RMPA/EIS; however, not all comments will be considered.

An important part of the environmental planning process is engaging the public and relevant agencies from the earliest stages of and throughout the planning process to address issues, comments, and concerns. Figure 1 provides a summary of the RMPA/EIS NEPA process[3]. Although the BLM welcomes public input at any time during the environmental analysis process, the next official public comment period will begin when the Draft RMPA/EIS is published. The Draft RMPA/EIS will be made available to all members of the public, agencies, and Tribes. The availability of the Draft RMPA/EIS will be announced via a Notice of Availability in the Federal Register and a 90-day public comment period will follow. Public meetings will be held during the public comment period.

At the conclusion of the public comment period, the Draft RMPA/EIS will be revised, followed by publication of the Final RMPA/EIS. The availability of the Final RMPA/EIS will be announced via a Notice of Availability in the Federal Register. The date the notice appears in the Federal Register initiates a required 30-day availability period and 60-day Governor's Consistency Review. Although the 30-day availability period is not a formal public comment period, the BLM may receive comments. If there are comments on the Final RMPA/EIS, the BLM will determine if they have merit (for example, if the comments identify significant new circumstances or information relevant to environmental concerns and bear upon the Proposed Action and action alternatives or if the comments note a correction to be addressed). Any comments received may be addressed in the ROD.

The BLM will prepare the ROD to document the selected alternative and any accompanying mitigation measures. The ROD will be signed by the BLM's authorizing officer. No action concerning the proposal may be taken until the ROD has been issued, except under conditions specified in Council of Environmental Quality regulations (40 CFR § 1506.1).

[3] Note that the BLM has posted documents related to the application evaluation process that occurred prior to the NEPA process on the Project website: https://eplanning.blm.gov/eplanning-ui/project/2019523/570.

6 NEXT STEPS IN THE NEPA PROCESS

Figure 1 NEPA Process Flowchart

Appendix A

Notice of Intent

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[LLNVS00000.L51010000.ER0000. LVRWF2208330.22X; N–89655; MO# 4500164258]

Notice of Intent To Amend the Las Vegas Resource Management Plan and Prepare an Environmental Impact Statement for the Proposed Copper Rays Solar Project in Nye County, Nevada

AGENCY: Bureau of Land Management, Interior.

ACTION: Notice of intent.

SUMMARY: In compliance with the National Environmental Policy Act of 1969, as amended (NEPA), and the Federal Land Policy and Management Act of 1976, as amended (FLPMA), the Bureau of Land Management (BLM) Nevada State Director intends to prepare a Resource Management Plan (RMP) amendment with an associated Environmental Impact Statement (EIS) for the Copper Rays Solar Project and by this notice is announcing the beginning of the scoping period to solicit public comments and identify issues, and is providing the planning criteria for public review.

DATES: The BLM requests the public submit comments concerning the scope of the analysis, potential alternatives, and identification of relevant information and studies by December 29, 2022. To afford the BLM the opportunity to consider issues raised by commenters in the Draft RMP amendment/EIS, please ensure your comments are received prior to the close of the 45-day scoping period or 15 days after the last public meeting, whichever is later.

The BLM will conduct two public scoping meetings (virtually):

- December 6, 2022, 6–8 p.m. Pacific Time., Virtual via Zoom. Registration is required. To register in advance for this webinar, visit: *https://eplanning.blm.gov/eplanning-ui/project/2019523/510*
- December 7, 2022, 6–8 p.m. Pacific Time., Virtual via Zoom. Registration is required. To register in advance for this webinar, visit: *https://eplanning.blm.gov/eplanning-ui/project/2019523/510*

ADDRESSES: You may submit comments on issues and planning criteria related to the Copper Rays Solar Project by any of the following methods:

- *Website: https://eplanning.blm.gov/eplanning-ui/project/2019523/510*
- *Email: BLM_NV_SND_EnergyProjects@blm.gov*
- *Mail:* BLM, Pahrump Field Office, Attn: Copper Rays Solar Project, 4701 North Torrey Pines Drive, Las Vegas, NV 89130–2301

Documents pertinent to this proposal may be examined online at the project ePlanning page: *https://eplanning.blm.gov/eplanning-ui/project/2019523/510* and at the Southern Nevada District Office.

FOR FURTHER INFORMATION CONTACT: Whitney Wirthlin, Project Manager, telephone (725) 249–3318; address 4701 North Torrey Pines Drive, Las Vegas, NV 89130–2301; email *BLM_NV_SND_EnergyProjects@blm.gov.* Contact Whitney Wirthlin to have your name added to our mailing list. 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 for contacting Whitney Wirthlin. 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: This document provides notice that the BLM Nevada State Director intends to prepare an RMP amendment with an associated EIS for the Copper Rays Solar Project, announces the beginning of the scoping process, and seeks public input on issues and planning criteria. The RMP amendment is being considered to allow the BLM to evaluate the Copper Rays Solar Project, which would require amending the existing 1998 Las Vegas RMP.

The proposed project and planning area is in Nye County, southeast of the Town of Pahrump and approximately 40 miles west of Las Vegas, and encompasses approximately 5,127 acres of public lands.

On October 27, 2020, Copper Rays Solar, LLC filed an updated right-of-way application to the BLM Pahrump Field Office for the Copper Rays Solar Project (Project) requesting authorization to construct, operate, maintain, and eventually decommission a 700-megawatt photovoltaic solar electric generating facility, battery storage facilities, associated generation tie-line, and access road facilities. Copper Rays Solar, LLC submitted the initial right-of-way application for the proposed project in September 2010, thus the project is not subject to the decisions adopted by the Record of Decision for Solar Energy Development in Six Southwestern States (BLM 2012). The electricity generated would be collected at the onsite substation and conveyed to the Gamebird Substation located north of the project site via transmission line. Construction for the facilities is estimated to take approximately 72 months across multiple phases. The lands within the proposed project area were segregated, subject to valid existing rights, for a term of two years beginning October 21, 2021, with publication of the Notice of Segregation in the **Federal Register**.

The scope of this land use planning process does not include addressing the evaluation or designation of areas of critical environmental concern (ACEC) and the BLM is not considering ACEC nominations as part of this process.

Purpose and Need

The BLM's preliminary purpose and need for this Federal action is to respond to FLPMA right-of-way applications submitted by Copper Rays Solar, LLC under Title V of FLPMA (43 U.S.C. 1761) to construct, operate, maintain, and decommission a solar generation power plant and ancillary facilities on approximately 5,127 acres of BLM land in Nye County, Nevada, in compliance with FLPMA, BLM right-of-way regulations, the BLM NEPA Handbook (BLM 2008), U.S. Department of the Interior NEPA regulations, and other applicable federal and state laws and policies. In accordance with FLPMA, public lands are to be managed for multiple uses that consider the long-term needs of future generations for renewable and non-renewable resources. The BLM is authorized to grant rights-of-way on public lands for systems of generation, transmission, and distribution of electrical energy (Section 501(a)(4)). The preliminary purpose and need also includes an amendment to the 1998 Las Vegas RMP to address utility corridor modifications based on the project boundary location and to adjust the Visual Resource Management Class III unit that contains the proposed project to respond to the proponent's application.

Preliminary Alternatives

The Proposed Action is to approve a right-of-way to Copper Rays Solar, LLC to construct, operate, and eventually decommission the proposed solar project and associated facilities with the potential to generate 700-megawatts of alternating current energy on 5,127 acres of BLM administered lands. The Proposed Action also includes an amendment to the 1998 Las Vegas RMP in order to modify multiple utility corridors and to adjust the Visual Resource Management Class III unit that contains the proposed project.

An Energy Policy Act of 2005 Section 368 Energy Corridor, Segment # 224–225, intersects the western portion of the project area. A Southern Nevada District Utility Corridor, established by the RMP, intersects the southwest corner of the project area. Per the BLM's Land Use Planning Handbook (H–1601–1 Section VII.B), in order for the project to be consistent with the RMP, a plan amendment to modify both utility corridors outside of the Copper Rays Solar Project area will be required.

The Visual Resource Management Class for the project area includes Class III, which requires a RMP amendment to change the Class III area to Class IV in order for the project to be consistent with the RMP, per the BLM Land Use Planning Handbook (H–1601–1 Section VII.B).

Additional action alternatives have not been identified to date but would be developed by taking into consideration comments and input submitted during the application evaluation determination process and scoping.

Under the No Action Alternative, BLM would not issue a right-of-way grant for the solar project and associated facilities. The proposed Project would not be constructed, and existing land uses in the project area would continue. Additionally, the BLM would not undertake a RMP amendment to adjust utility corridors and modify the Visual Resource Management Class.

The BLM welcomes comments on all preliminary alternatives as well as suggestions for additional alternatives.

Planning Criteria

The planning criteria guide the planning effort and lay the groundwork for effects analysis by identifying the preliminary issues and their analytical frameworks. Preliminary issues for the planning area have been identified by BLM personnel and from early engagement conducted for this planning effort with Federal, State, and local agencies; Tribes; and other stakeholders. The BLM has identified preliminary issues for this planning effort's analysis. The planning criteria are available for public review and comment at the ePlanning website (see **ADDRESSES**).

Summary of Expected Impacts

The analysis in the EIS will be focused on the proposed solar project and associated facilities, including battery storage and transmission line construction. The BLM evaluated the proposed Project application per the 43 CFR 2800 application evaluation determination process. Through this process, the BLM completed public outreach and Agency and Indian Tribal Nations coordination specific to the proposed Project. From the input received, the expected impacts from construction, operation, and eventual decommissioning of the solar project, associated facilities, and the RMP amendment could include:

- Potential desert tortoise habitat disturbance and changes in genetic connectivity habitat from construction of the proposed facilities;
- Potential effects to cultural resources in the project area from construction activities;
- Potential modifications to the visual character of the area;
- Potential effects to basin groundwater resources from the proposed construction water needs for the project;
- Potential socioeconomic impacts from the proposed project to local communities;
- Potential air quality impacts from proposed construction activities;
- Potential impacts to vegetation species as a result of construction, operations, and decommissioning of the project and associated facilities;
- Potential effects to the recreational opportunities and public use of the proposed project area due to construction and operations of the solar facility; and
- Potential cumulative effects with other reasonably foreseeable actions in the area.

Preliminary issues for the project have been identified by the BLM, other Federal agencies, the State, local agencies, Tribes, and the public during the application evaluation process. The following may be impacted by the proposed project and will be considered for detailed analysis in the EIS: threatened and endangered species, biological resources, vegetation resources, visual resources, cultural resources, air quality, climate change, recreation, socioeconomics, water resources, and cumulative effects from reasonably foreseeable actions in the area. Habitat for the federally listed desert tortoise is in this project area.

Anticipated Permits and Authorizations

Along with the right-of-way grant issued by the BLM, Copper Rays Solar, LLC anticipates needing the following authorizations and permits for the proposed project: Biological Opinion and Incidental Take Permit from the U.S. Fish and Wildlife Service; Consultation under Section 106 of the National Historic Preservation Act with the Advisory Council on Historic Preservation and Nevada State Historic Preservation Office; Section 404 Permit from the U.S. Army Corps of Engineers; Wildlife Special Purpose permit from the Nevada Department of Wildlife; Nevada Division of Environmental Protection Stormwater and Groundwater Discharge permits and Temporary in Waterways Work permit; Nevada Public Utilities Commission Permit to Construct; Nevada Division of Water Resources water rights modification permits; Nevada State Fire Marshall Hazardous Materials Storage permit; Nye County Special Use Permit; and other Nye County permits, as necessary. Further details on these permitting requirements may be found in the Plan of Development for the Copper Rays Solar Project.

Schedule for the Decision-Making Process

The BLM will provide additional opportunities for public participation consistent with the NEPA and land use planning processes, including a 90-day comment period on the Draft RMP Amendment/EIS and concurrent 30-day public protest period and 60-day Governor's consistency review on the Proposed RMP Amendment. The Draft RMP Amendment/EIS is anticipated to be available for public review Spring 2023 and the Proposed RMP Amendment is anticipated to be available for public protest in Fall 2023 with an Approved RMP Amendment and Record of Decision in Spring 2024.

Public Scoping Process

This notice of intent initiates the scoping period and public review of the planning criteria, which guide the development and analysis of the Draft RMP Amendment/EIS.

The BLM will be holding two virtual scoping meetings (see **DATES** and **ADDRESSES** sections earlier). The specific date(s) and location(s) of any additional scoping meetings will be announced at least 15 days in advance through the project ePlanning web page: *https://eplanning.blm.gov/eplanning-ui/project/2019523/510.*

The purpose of the public scoping process is to determine relevant issues that will influence the scope of the environmental analysis, including alternatives and mitigation measures, and to guide the process for developing the EIS. Federal, State, and local agencies and Tribes, along with other stakeholders that may be interested or affected by the BLM's decision on this project, are invited to participate in the scoping process and, if eligible, may request or be requested by the BLM to participate as a cooperating agency. The BLM encourages comments concerning the proposed Cooper Rays Solar Project and RMP amendment, possible measures to minimize and/or avoid adverse environmental impacts, and any other information relevant to the Proposed Action.

The BLM also requests assistance with identifying potential alternatives to the Proposed Action. As alternatives should resolve an issue with the Proposed Action, please indicate the purpose of the suggested alternative. In addition, the BLM requests the identification of potential issues that should be analyzed. Issues should be a result of the Proposed Action or Alternatives; therefore, please identify the activity along with the potential issues.

Lead and Cooperating Agencies

The BLM Pahrump Field Office is the lead agency for this EIS and RMP amendment. The BLM has initially invited 27 Agencies and 15 Indian Tribal Nations to be cooperating agencies to participate in the environmental analysis of the Project.

Of those invited, 11 agencies have accepted cooperating agency status: U.S. Fish and Wildlife Service Ecological Services Program, U.S. Fish and Wildlife Migratory Bird Program; U.S. Environmental Protection Agency Region 9; Clark County Department of Aviation; Clark County Department of Environment and Sustainability; Nye County; Nevada Department of Wildlife; Nevada Division of Forestry; Nevada Department of Conservation and Natural Resources, Off-Highway Vehicles Program; Nevada Division of Emergency Management; and Nevada Department of Public Safety. Additional agencies and organizations may be identified as potential cooperating agencies to participate in the environmental analysis of the Project.

Responsible Official

The Nevada State Director is the deciding official for this planning effort and proposed Copper Rays Solar Project.

Nature of Decision To Be Made

The nature of the decision to be made will be the State Director's selection of land use planning decisions for managing BLM-administered lands under the principles of multiple use and sustained yield in a manner that best addresses the purpose and need.

The BLM will decide whether to grant, grant with conditions, or deny the right of way application. Pursuant to 43 CFR 2805.10, if the BLM issues right-of-way grant(s), the BLM decision maker may include terms, conditions, and stipulations determined to be in the public interest.

Interdisciplinary Team

The BLM will use an interdisciplinary approach to develop the EIS/RMP amendment in order to consider the variety of resource issues and concerns identified. Specialists with expertise in the following disciplines will be involved in this process: air quality, archaeology, botany, climate change (greenhouse gases), environmental justice, fire and fuels, geology/mineral resources, hazardous materials, hydrology, invasive/non-native species, lands and realty, National Conservation Lands, National Trails, public health and safety, recreation/transportation, socioeconomics, soils, visual resources, and wildlife.

Additional Information

The BLM will identify, analyze, and consider mitigation to address the reasonably foreseeable impacts to resources from the proposed plan amendment and all analyzed reasonable alternatives and, in accordance with 40 CFR 1502.14(e), include appropriate mitigation measures not already included in the proposed plan amendment or alternatives. Mitigation may include avoidance, minimization, rectification, reduction or elimination over time, and compensation; and may be considered at multiple scales, including the landscape scale.

The BLM will utilize and coordinate the NEPA and land use planning processes for this planning effort to help support compliance with applicable procedural requirements under the Endangered Species Act (16 U.S.C. 1536) and Section 106 of the National Historic Preservation Act (54 U.S.C. 306108) as provided in 36 CFR 800.2(d)(3), including public involvement requirements of Section 106. The information about historic and cultural resources and threatened and endangered species within the area potentially affected by the proposed plan amendment will assist the BLM in identifying and evaluating impacts to such resources.

The BLM will consult with Tribal Nations on a government-to-government basis in accordance with Executive Order 13175, BLM MS 1780, and other policies. Tribal concerns, including impacts on Indian trust assets and potential impacts to cultural resources, will be given due consideration. Federal, State, and local agencies, along with Tribal Nations, and other stakeholders that may be interested in or affected by the proposed action that the BLM is evaluating, are invited to participate in the scoping process and, if eligible, may request or be requested by the BLM to participate in the development of the environmental analysis as a cooperating agency. The BLM intends to hold a series of government-to-government consultation meetings. The BLM will send invites to potentially affected Tribal Nations prior to the meetings. The BLM will provide additional opportunities for government-to-government consultation during the NEPA process.

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 made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Authority: 40 CFR 1501.7, 43 CFR 1610.2, and 2800)

Jon Raby,

State Director.

[FR Doc. 2022–24623 Filed 11–10–22; 8:45 am]

BILLING CODE 4310–HC–P

DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[L14400000 PN0000 HQ350000 212; OMB Control No. 1004–0119]

Agency Information Collection Activities; Submission to the Office of Management and Budget for Review and Approval; Permits for Recreation on Public Land

AGENCY: Bureau of Land Management, Interior.

ACTION: Notice of information collection; request for comment.

SUMMARY: In accordance with the Paperwork Reduction Act of 1995 (PRA), the Bureau of Land Management (BLM) proposes to renew an information collection.

DATES: Interested persons are invited to submit comments on or before December 14, 2022.

ADDRESSES: Written comments and recommendations for this information collection request (ICR) should be sent within 30 days of publication of this notice to *www.reginfo.gov/public/do/PRAMain.* Find this particular information collection by selecting ''Currently under 30-day Review—Open for Public Comments'' or by using the search function.

FOR FURTHER INFORMATION CONTACT: To request additional information about

Appendix B

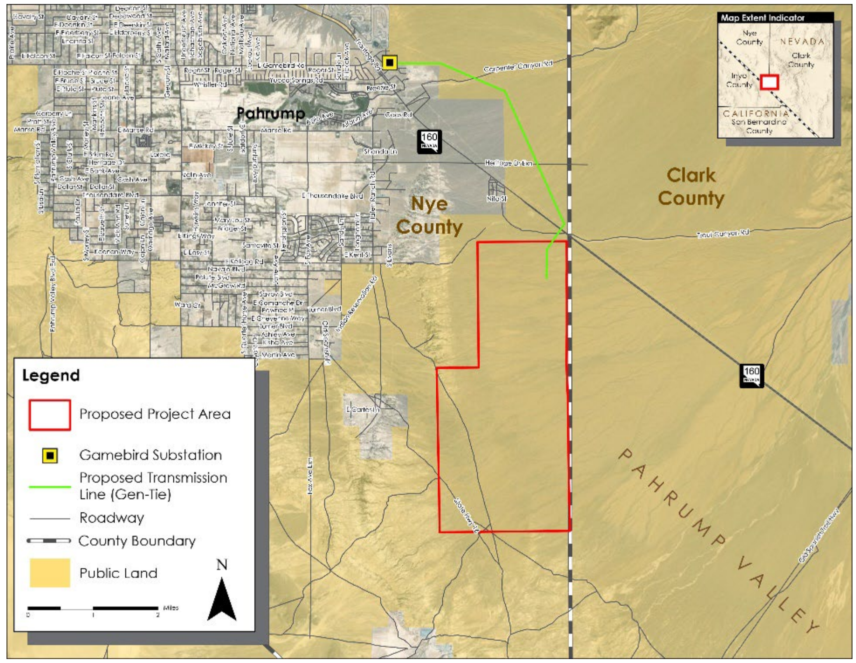
Public Mailer/News Release

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

NOTICE OF VIRTUAL PUBLIC SCOPING MEETINGS

Copper Rays Solar, LLC, is proposing the construction, operation and maintenance, and eventual decommissioning of the Copper Rays Solar Project, a photovoltaic solar power project located on public lands in Nye County, Nevada. The BLM issued a determination to initiate the National Environmental Policy Act process for the Copper Rays Solar Project in March 2022. The Copper Rays Solar Project would consist of a 700-megawatt solar facility with a battery energy storage system within a 5,050-acre right-of-way on public lands managed by the BLM Pahrump Field Office. A Notice of Intent to Prepare an Environmental Impact Statement and Resource Management Plan Amendment for the Proposed Copper Rays Solar Project in Nye County, Nevada was published in the Federal Register on November 14, 2022, opening a 45-day public comment period which closes on December 29, 2022.

The BLM is seeking public comments on the Copper Rays Solar Project and will hold virtual public meetings on December 6 and December 7, 2022 from 6 p.m. to 8 p.m. Pacific Time.



Stamp

BLM Southern Nevada District Office
Attn: Copper Rays Solar Project
4701 N Torrey Pines Drive
Las Vegas, NV 89130

To register for the public meetings, please use the following link https://eplanning.blm.gov/eplanning-ui/project/2019523/510. If you have any questions or technical issues trying to register for the public meetings, please call 650-340-4821 for assistance. The public meetings will include a brief presentation followed by a question-and-answer section, and then a public comment section.

The Notice of Intent initiated a public 45-day public comment period, which will end December 29, 2022. Written comments may be mailed to the BLM Pahrump Field Office, Attn: Copper Rays Solar Project, 4701 N. Torrey Pines Drive, Las Vegas, NV, 89130 or emailed to BLM_NV_SND_EnergyProjects@blm.gov. Comments may also be submitted utilizing the “Participate Now” function at the Project ePlanning page.

Please note: 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 made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

For more information, please visit https://eplanning.blm.gov/eplanning-ui/project/2019523/510

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

BLM SEEKS COMMENTS ON PROPOSED COPPER RAYS SOLAR PROJECT

Project would generate up to 700 megawatts of clean energy

LAS VEGAS – The Bureau of Land Management Pahrump Field Office is seeking public comments on the proposed Copper Rays Solar Project in Nye County, Nevada. The Copper Rays Solar Project would consist of the construction, operation, and eventual decommissioning of photovoltaic solar modules and associated facilities necessary to generate up to 700 megawatts of electricity on 5,127 acres of public land southeast of Pahrump, Nevada.

The 45-day scoping comment period will open November 14, 2022 with publication in the Federal Register of the Notice of Intent to amend the Las Vegas Resource Management Plan and prepare an Environmental Impact Statement. The scoping period will close December 29, 2022.

The BLM will hold two virtual scoping meetings for the Copper Rays Solar Project on December 6 and December 7, 2022, from 6 p.m. to 8 p.m. Pacific Time. More information on the meetings is available on the project ePlanning website at https://eplanning.blm.gov/eplanning-ui/project/2019523/510.

“Public comments are critical as we continue to evaluate the proposed project,” said Nicholas Pay, BLM’s Pahrump Field Office Manager. “The type of comments that would be most helpful during the scoping period include potential local concerns and issues related to the Proposed Action, identification of potential alternatives and issues to be analyzed, possible measures to minimize or avoid adverse environmental impacts, information about historic and cultural resources within the area that may potentially be affected, and any other information relevant to the Proposed Action.”

The expected life of the project is 30 years. The public land for the proposed project area is southeast of Pahrump, Nevada, approximately 40 miles west of Las Vegas, Nevada, and located adjacent and to the south of State Route 160. Project construction would take six years over multiple phases. More information about the proposed project can be found on BLM’s ePlanning website at https://eplanning.blm.gov/eplanning-ui/project/2019523/510.

The BLM manages vast stretches of public lands with the potential to make significant contributions to the nation’s renewable energy portfolio and provides sites for environmentally sound renewable energy projects. Efficient deployment of renewable energy from our nation’s public lands is crucial in achieving President Biden’s goal of a carbon pollution-free power sector by 2035, as well as Congressional direction in the Energy Act of 2020 to permit 25 gigawatts of solar, wind, and geothermal production on public lands no later than 2025.

Written comments may be mailed to the BLM, Pahrump Field Office, Attn: Copper Rays Solar Project, 4701 N. Torrey Pines Drive, Las Vegas, NV, 89130, or emailed to BLM_NV_SND_EnergyProjects@blm.gov. Comments may also be submitted utilizing the “Participate Now” function at the Project ePlanning page at: https://eplanning.blm.gov/eplanning-ui/project/2019523/510. For more information, please contact Whitney Wirthlin at 725-249-3318 or via email at BLM_NV_SND_EnergyProjects@blm.gov.

Before including addresses, phone numbers, email addresses, or other personal identifying information in comments, be aware that entire comments-including personal identifying information-may be made publicly available at any time. While commenters can request that personal identifying information be withheld from public review, the BLM cannot guarantee that we will be able to do so.

-BLM-

The BLM manages more than 245 million acres of public land located primarily in 12 western states, including Alaska, on behalf of the American people. The BLM also administers 700 million acres of sub-surface mineral estate throughout the nation. Our mission is to sustain the health, diversity, and productivity of America’s public lands for the use and enjoyment of present and future generations.

MORE PRESS RELEASES

RELEASE DATE

Thursday, November 10, 2022

ORGANIZATION

Bureau of Land Management

OFFICE

Southern Nevada District Office

CONTACTS

Name: Project Information
Phone: 725-249-3318

Name: Media contact
Phone: 702-515-5057

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

BLM EXTENDS PUBLIC SCOPING PERIOD FOR THE COPPER RAYS SOLAR PROJECT ENVIRONMENTAL IMPACT STATEMENT AND RESOURCE MANAGEMENT PLAN AMENDMENT

Las Vegas –Bureau of Land Management has extended the public scoping period for the Copper Rays Solar Project Environmental Impact Statement and Resource Management Plan Amendment after receiving several requests due to concerns about the scoping period overlapping several major holiday periods. The public scoping period now closes on January 13, 2023.

"Public input during the scoping period is critically important to informing the development of the environmental review for the Copper Rays Solar Project," said Nicholas Pay, Pahrump Field Office Manager.

The Copper Rays Solar Project is located on 5,050 acres of BLM-managed public land in Nye County, Nevada, southeast of the town of Pahrump and 40 miles west of Las Vegas. The project includes a photovoltaic solar power generating facility with battery storage and interconnection to the regional transmission system. The electricity generated from the project would be collected at the onsite substation and conveyed to the existing Gamebird substation located northwest of the project site via a generation gen-tie transmission line. Additional information can be found at the project webpage: https://eplanning.blm.gov/eplanning-ui/project/2019523/510

The BLM manages vast stretches of public lands with the potential to make significant contributions to the nation's renewable energy portfolio and provides sites for environmentally sound renewable energy projects. Efficient deployment of renewable energy from our nation's public lands is crucial in achieving President Biden's goal of a carbon pollution-free power sector by 2035, as well as Congressional direction in the Energy Act of 2020 to permit 25 gigawatts of solar, wind, and geothermal production on public lands no later than 2025.

Written comments may be submitted by any of the following methods:

- Email: BLM_NV_SND_EnergyProjects@blm.gov
- ePlanning: Utilize the "Participate Now" function at the Project webpage: https://eplanning.blm.gov/eplanning-ui/project/2019523/510
- Mail: BLM, Pahrump Field Office, Attn: Copper Rays Solar Project, 4701 North Torrey Pines Drive, Las Vegas, NV 89130-2301

Additionally, the BLM is hosting two virtual public scoping meetings, scheduled for December 6 and December 7, 2022 from 6 p.m. to 8 p.m. Pacific Time. To register for the meeting, please utilize the following links.

December 6, 2022 Virtual Scoping Meeting Registration: https://us02web.zoom.us/webinar/register/WN_SgKc-YJfT_eZemQbyycFVg

December 7, 2022 Virtual Scoping Meeting Registration: https://us02web.zoom.us/webinar/register/WN_r2OKY8P3SX-BCnOvUYIZ9g

If you have questions about this project, please contact Whitney Wirthlin, Project Manager, at 725-249-3318.

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment – including your personal identifying information – may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

The BLM manages more than 245 million acres of public land located primarily in 12 western states, including Alaska, on behalf of the American people. The BLM also administers 700 million acres of sub-surface mineral estate throughout the nation. Our mission is to sustain the health, diversity, and productivity of America's public lands for the use and enjoyment of present and future generations.

MORE PRESS RELEASES

RELEASE DATE

Friday, December 2, 2022

ORGANIZATION

Bureau of Land Management

OFFICE

Southern Nevada District Office

CONTACTS

Name: Project Information
Phone: 725-249-3318

Name: Media Contact
Phone: 702-515-5057

Appendix C

Scoping Meeting Presentation

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

Copper Rays Solar Project

Scoping Meeting December 2022

Agenda

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

Introductions

Presenters

- Nicholas Pay, BLM Pahrump Field Office Manager
- Whitney Wirthlin, BLM Project Manager
- Caitlin Gilleran, Project Manager, Panorama Environmental

Additional BLM Participants

- Steve Leslie
- Beth Ransel
- Lara Kobelt
- Mary Ann Vinson
- Jennifer Durk
- Matt Klein
- Kirsten Cannon
- Curtis Walker
- Mark Slaughter

Questions and Input

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

- Question & Answer portion: written questions can be submitted throughout meeting but will only be verbally answered during this portion of the meeting
- Verbal Public comment: after the presentations and Q&A portion

Want to provide comments after the meeting?

Comments can also be submitted during the scoping period until January 13, 2023, via:

EMAIL: BLM_NV_SND_EnergyProjects@blm.gov

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

Comments

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.

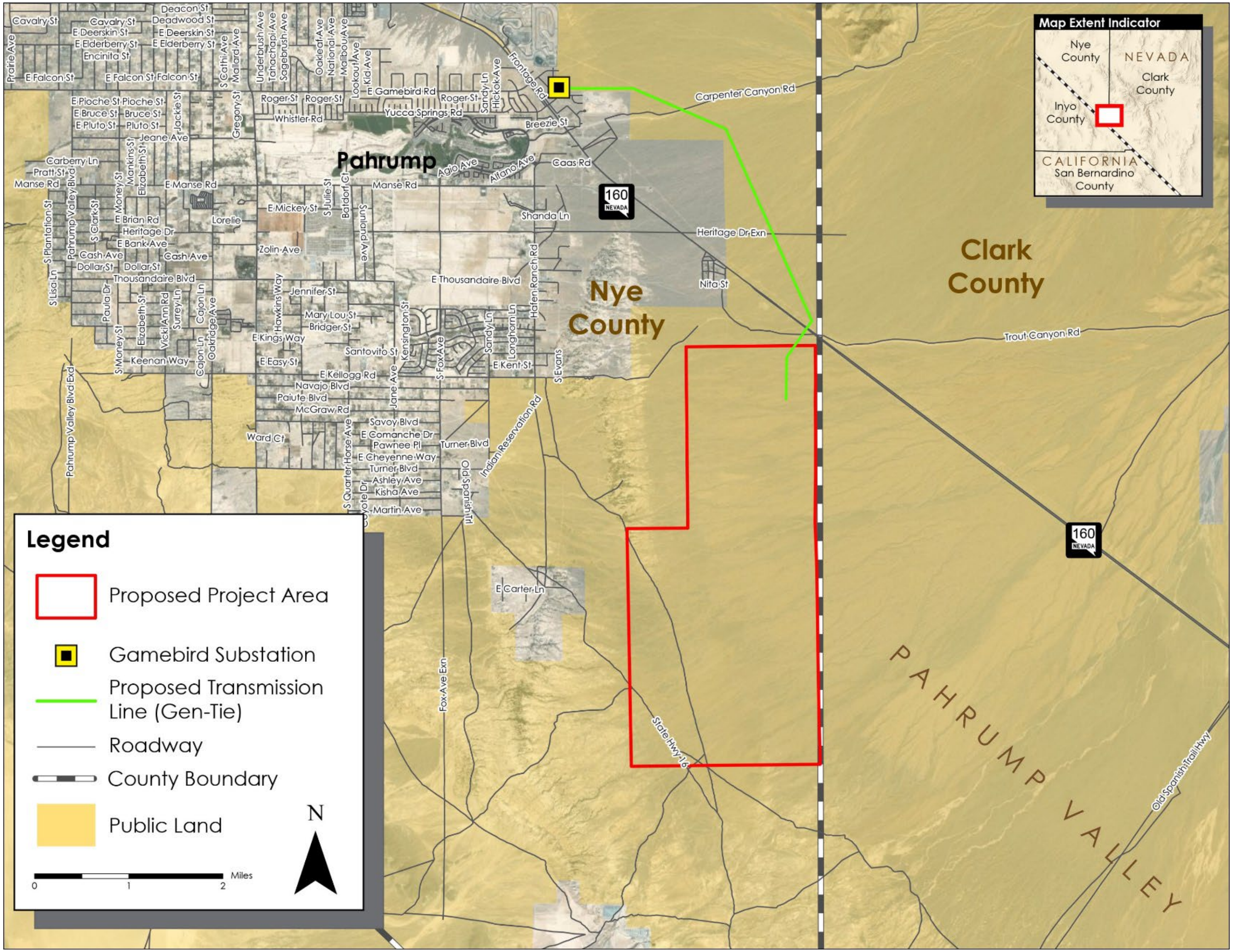
While you can ask that your personal identifying information be withheld from public review, the BLM cannot guarantee that they will be able to do so. Anonymity is not allowed for submissions from organizations or businesses and from individuals identifying themselves as representatives or officials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

Copper Rays Solar Project

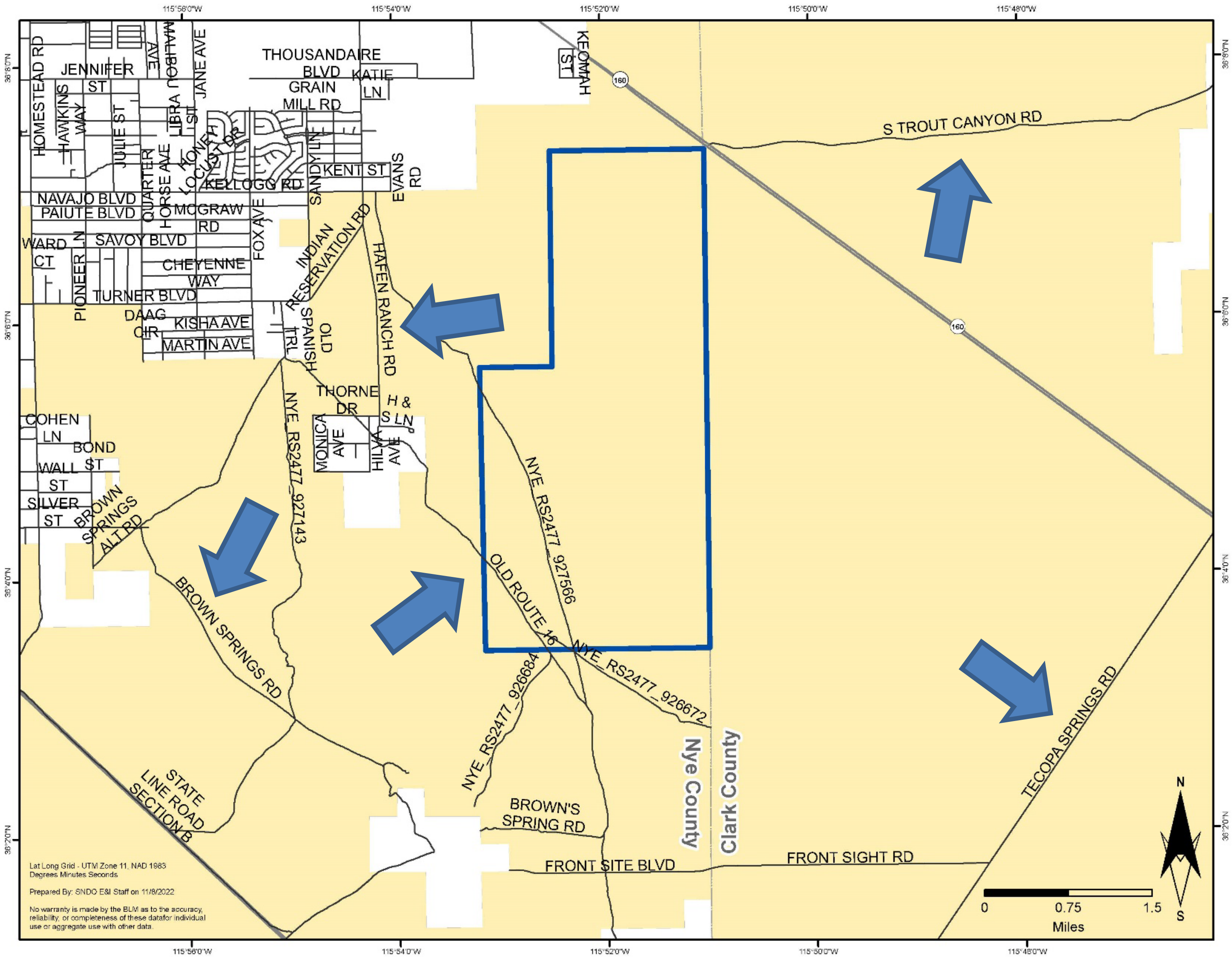
- Copper Rays Solar, LLC submitted a right-of-way application for the construction, operation, maintenance, and eventual decommissioning of a solar facility with interconnection to the regional transmission system.
- The project would consist of a 700-megawatt alternating current solar photovoltaic power generating facility with a battery energy storage system and a 5-mile generation-tie (gen-tie) line to the Gamebird Substation.
- The request is to use approximately 5,050 acres of public land managed by the BLM Southern Nevada District, located in the Pahrump Valley in Nye County, approximately 40 miles west of Las Vegas and southeast of the Town of Pahrump, Nevada.
- The BLM conducted an initial evaluation of the project right-of-way application with public meetings conducted in December 2021. The application evaluation was determined complete on March 4, 2022.

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

Copper Rays Solar Project



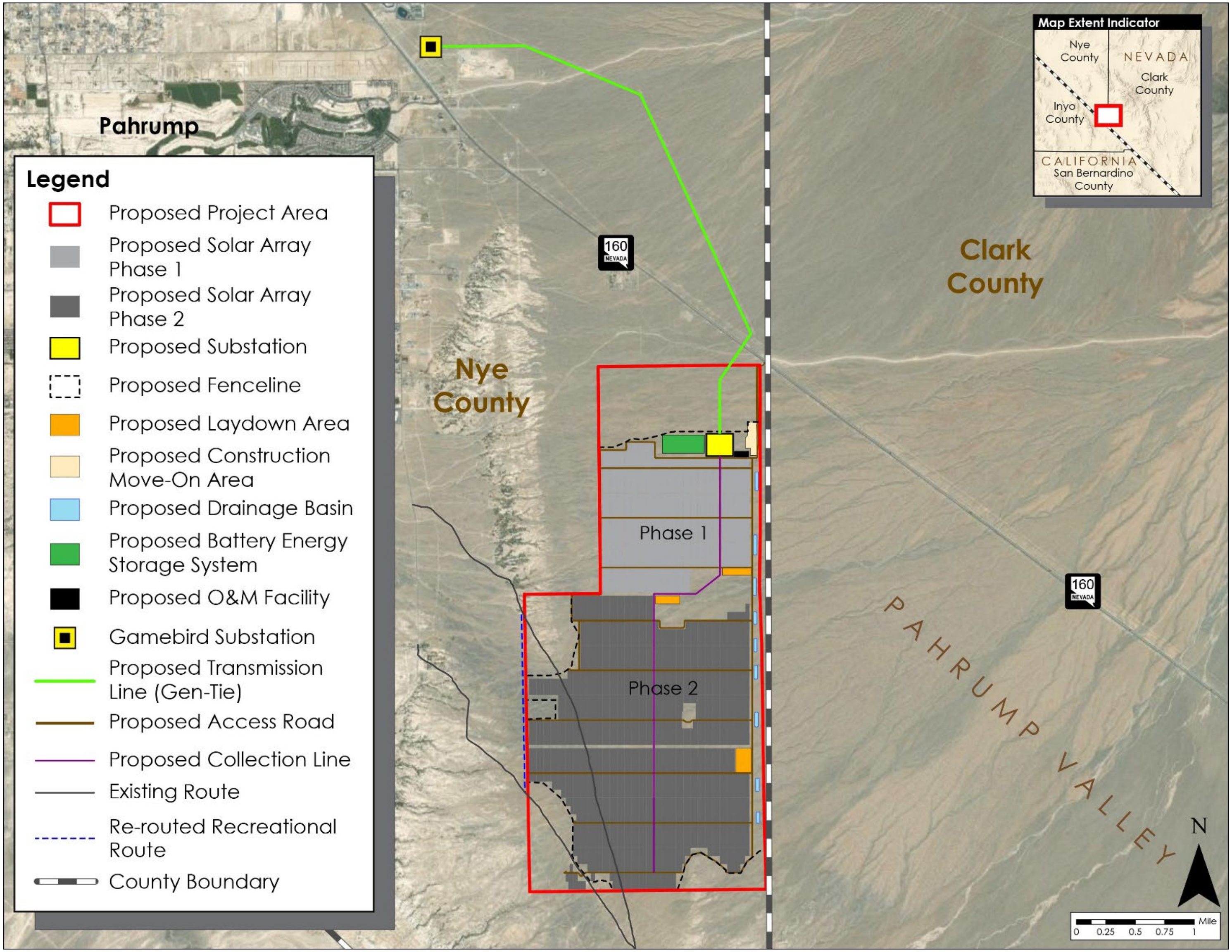
Copper Rays Solar Project



Copper Rays Solar Project Components

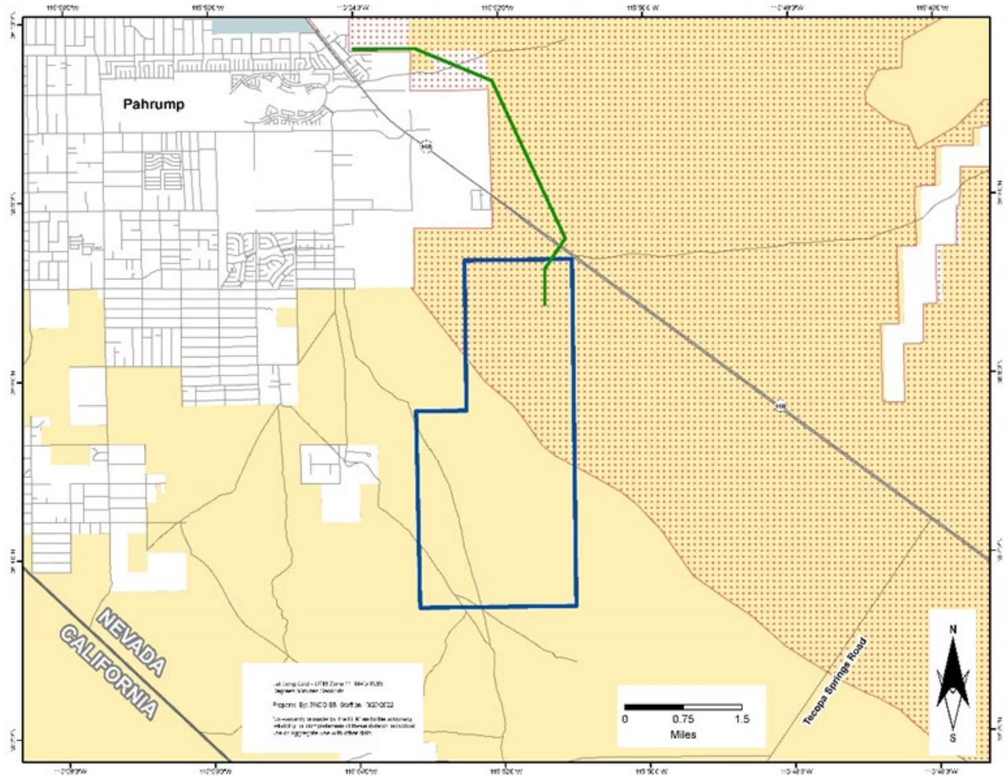
Component	Description
Right-of-way	5,050 acres of solar facility, gen-tie line corridor, and access road right-of-way
Solar Facility	700 MW of solar array blocks with monofacial or bifacial solar photovoltaic modules on single-axis trackers
	Underground DC collection system
	Aboveground and/or underground 34.5 kV collection systems to on-site substation
	Power conversion stations (PCSs) with backup power
	35 acres of battery energy storage system
Infrastructure	Single primary access road and drive off SR-160
	Perimeter firebreak
	Perimeter and internal roadway system
	4.7-acre O&M area with O&M office and storage buildings, water tank, septic system, trash storage, and parking
	Permanent Supervisory Control and Data Acquisition (SCADA) system for remote monitoring and control
	Four 10-foot-tall solar meteorological stations
	Desert tortoise exclusion and security fencing
	Drainage basins and other drainage controls
Transmission and Communications	One 27.6-acre on-site substation
	5 miles of 230kV gen-tie line from on-site 230kV substation to GridLiance West's Gamebird Substation
	Overhead and/or underground fiber optic communication line along gen-tie route

Project Components



Resource Management Plan Amendment

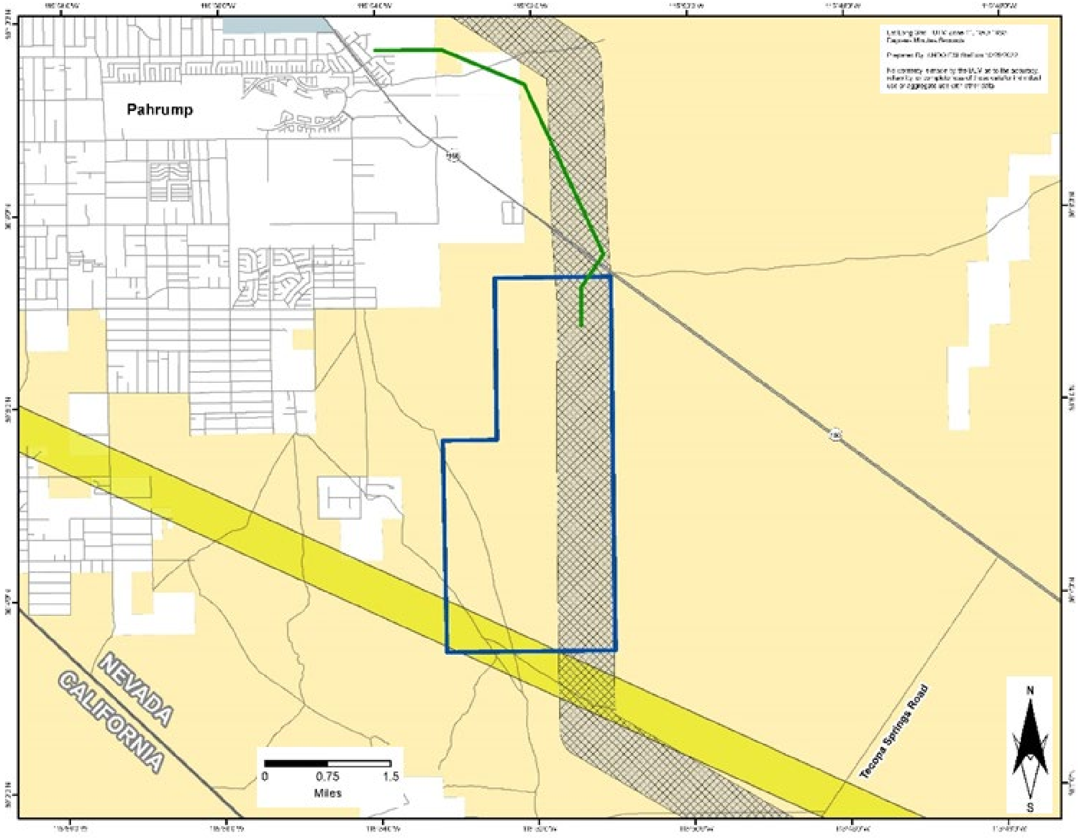
- The Copper Rays Solar Project will include an analysis of a Resource Management Plan Amendment to the 1998 Las Vegas Resource Management Plan
- If approved, the amendment would modify the Visual Resource Management Class based on project objectives
  - Would modify the VRM classification from VRM Class III to Class IV to achieve conformance with the RMP
- Analysis of the RMP Amendment would be included in the Environmental Impact Statement analysis for the project
- During the scoping process, the BLM provides RMP Amendment preliminary Planning Criteria for review, which is available at the project website



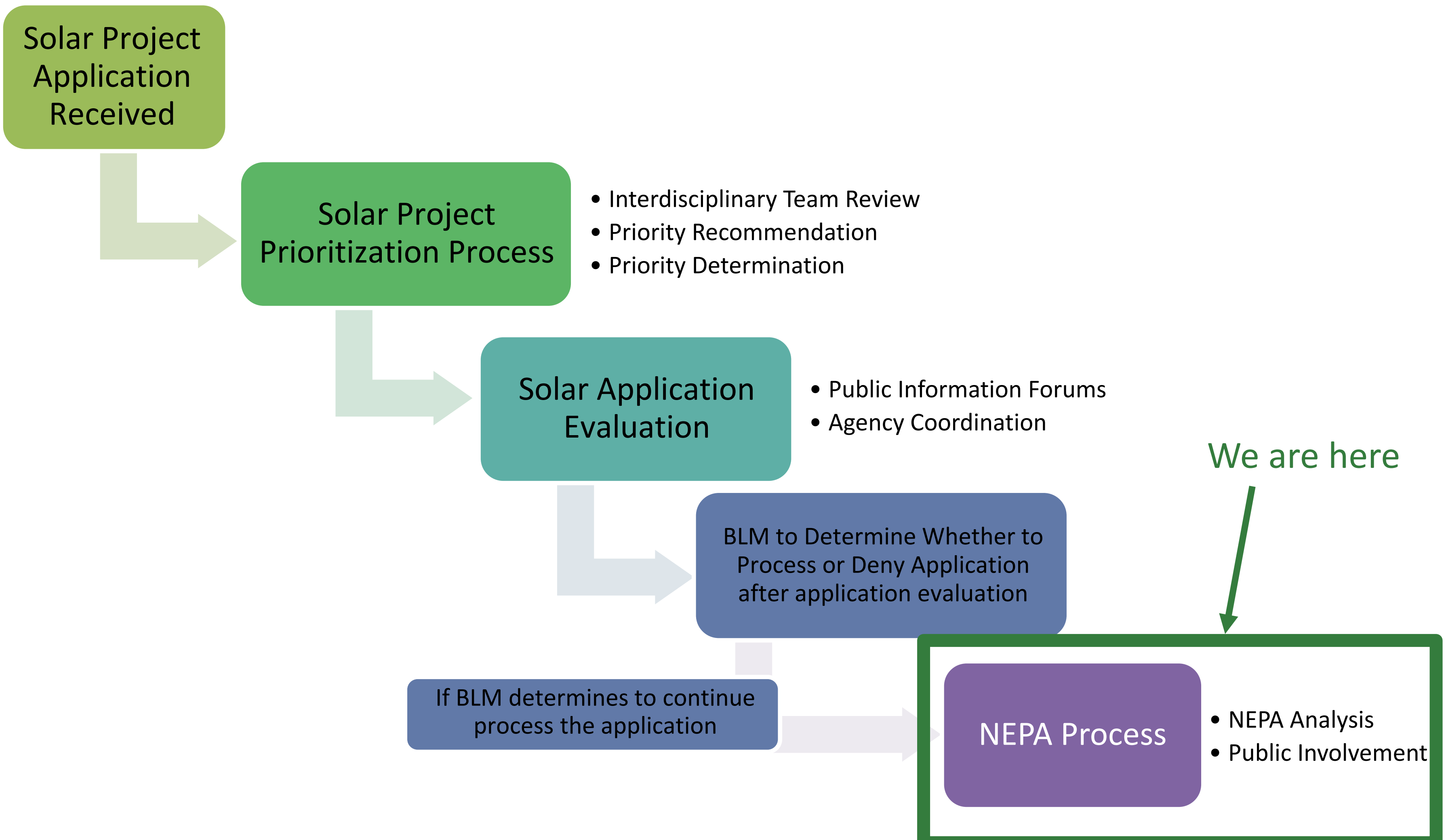
Resource Management Plan Amendment

- A plan amendment is also being considered to modify two utility corridor alignments (West Wide Energy Corridor and a Southern Nevada District Utility Corridor) that intersect the proposed project area

- May instead be considered under a larger planning process, like the BLM Nevada Statewide RMP Modernization process



Copper Rays
Application Review Process



Application Evaluation Review

- The application evaluation review for the project was conducted in coordination with appropriate federal, state, and local agencies and Tribes, and public outreach.
- In December 2021, the BLM hosted two virtual public information forums and an agency meeting with federal, state, local, and Tribal governments to gather public input.
- Submissions during the input period were reviewed and summarized for the project. Issues identified from the input period will be carried forward into the NEPA process for the project.
- The BLM sent letters to and conducted field trips for Native American tribes to assess initial interest on the project and invite the Tribes to initiate formal government-to-government consultation. Tribal consultation is ongoing.
- Additional information on the application evaluation review for the Copper Rays Solar Project can be found at the project webpage.

NEPA Process

We are here

1. Notice of Intent
   November 2022
2. Public Scoping (We are here)
   November 14 to January 13, 2023
3. Notice of Availability
   Draft EIS
   Summer 2023
4. 90-day Public Review & Comment Period
   Summer-Fall 2023
5. Notice of Availability
   Final EIS
   Winter 2023-2024
6. 30-day Protest Period
   Winter 2023-2024
7. 60-day Governor's Consistency Review
   Winter 2023-2024
   (starts concurrent with protest period)
8. Record of Decision
   Spring 2024

Preliminary Issues Identified by the BLM and Public During Application Evaluation

- Wildlife and Vegetation
- Visual Resources
- Recreation including Off-Highway Vehicle Use and Access to Public Lands
- Socioeconomics/Economics
- Air Quality and Climate
- Cultural and Tribal Resources
- Traffic and Safety
- Water Resources

Technical Studies

Technical Reports	Timeframe	Status
Air Quality Modeling Report	Fall-Winter 2022	In Progress
Avian Surveys/Acoustic Analysis Reports	Completed	BLM Approved
Botanical Surveys and Reports	Fall 2022	Under BLM Review
Cultural Resource Surveys and Report*	Spring 2023	Under BLM Review
Desert Tortoise Surveys and Reports	Completed	BLM Approved
Economic Report	Fall-Winter 2022	In Progress
Final Drainage Study	Fall-Winter 2022	In Progress
Jurisdictional Waters Delineation	Fall-Winter 2022	Under BLM Review
Thrasher Survey and Report	Completed	BLM Approved
Traffic Impact Assessment	Fall-Winter 2022	In Progress
Visual Resources Technical Report	Fall-Winter 2022	In Progress
Water Supply Assessment	October 2022	Completed by Applicant

Note: Status is as of early November 2022.
* Gen-tie corridor surveys and reporting is underway.

Biological and Vegetation Resources

- Identified Issues
  - Special status wildlife
  - Sensitive vegetation and soils
- Consultations
  - US Fish & Wildlife Service, Section 7 Endangered Species Act Consultation
    - Biological Opinion
    - Tortoise Translocation Plan
  - Nevada Department of Wildlife Consultation
    - Consultation, Take Permit
- Technical Reports Required
  - Desert Tortoise, Avian, and Botanical Surveys and Reports (for project area and generation tie line)

Visual Resources and Recreation

- Identified Issues
  - Solar application area is within Visual Resource Management Class III area – 1998 RMP needs to be amended to Class IV for compatibility with solar development
  - Views of the project area from motorists along State Route 160 and surrounding communities
  - Off-Highway Vehicle trails and use in the area
  - Nonmotorized recreation and camping
  - Access to public lands

- Technical Studies Required
  - Visual Resources Technical Report with simulations
  - Off-Highway Vehicle trail use data collection

Cultural and Tribal Resources

- Identified Issues
  - Old Spanish National Historic Trail – more than seven miles from the Project
  - Cultural Resources and Tribal Concerns
- Consultations
  - State Historic Preservation Office, Consultation under Section 106 of the National Historic Preservation Act
    - Will be integrated with the NEPA process for the project
  - Tribal Consultations
- Technical Reports Required
  - Cultural Resources Report

Air Quality and Climate Change

- Identified Issues
  - Valley Fever from dust
  - Greenhouse gas emissions and carbon sequestration
  - Temperature increase from solar panel installation
  - Fugitive dust and pollution
- Technical Reports Required
  - Air Quality Modeling Report

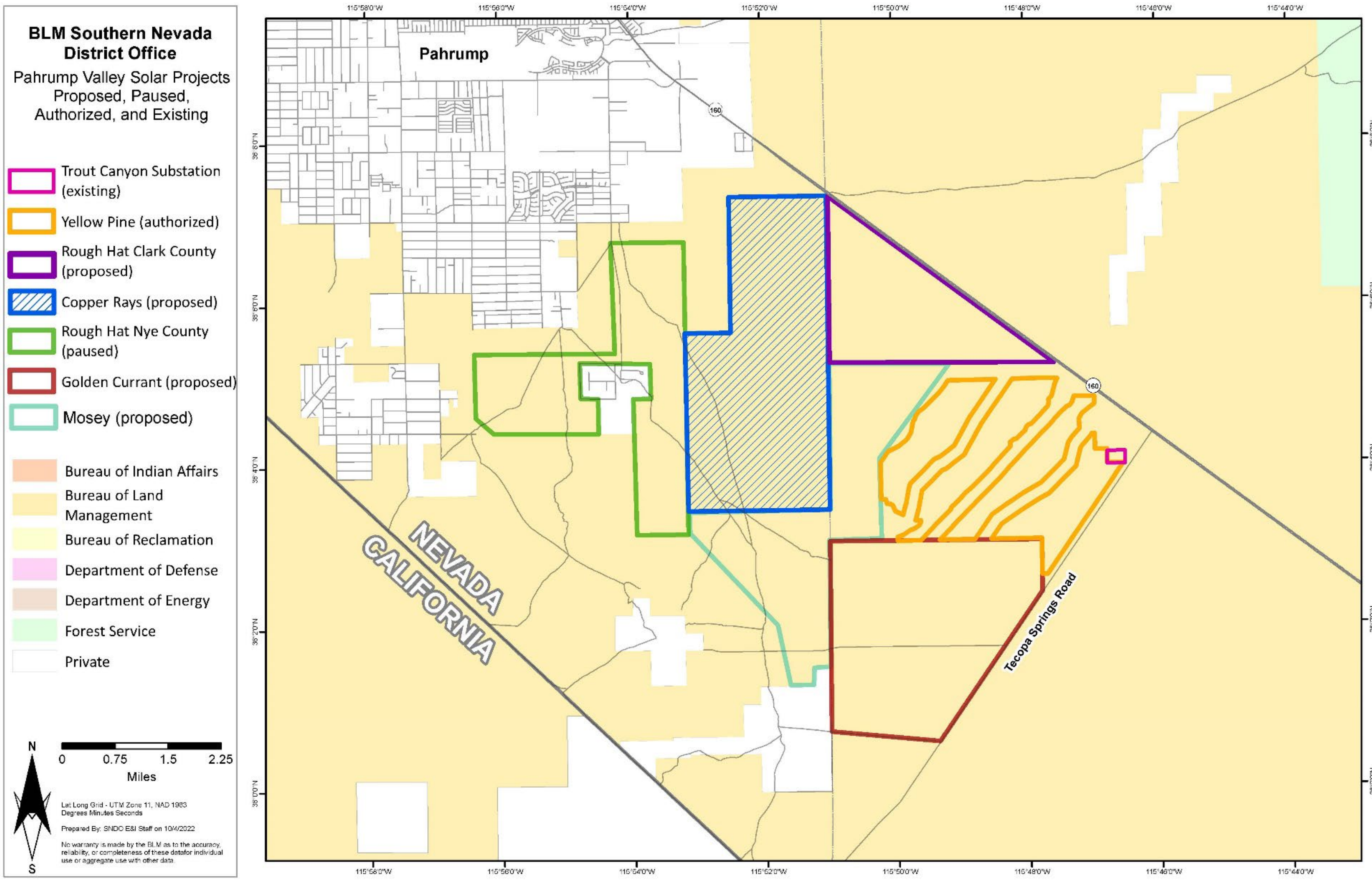
Socioeconomics, Public Safety, and Traffic

- Identified Issues
  - Local communities and job creation
  - Construction traffic and public safety
  - Pahrump Bypass route
  - Concern about proximity to residences
- Technical Reports Required
  - Traffic Technical Study
  - Economic Report

Water Resources

- Identified Issues
  - Quantity and source of water for construction
  - Affect on existing water resources and supply
  - Stormwater and erosion
- Consultations
  - Nye County permits
  - U.S. Army Corps of Engineers, Section 404 of Clean Water Act Permit
    - Jurisdictional waters
- Technical Reports Required
  - Water Supply Assessment
  - Drainage Study

Cumulative Effects - Solar Projects within the Pahrump Valley



Next Steps

- Public scoping period
  - Scoping is the process by which the BLM solicits input on the issues, impacts, and potential alternatives that will be addressed in the upcoming environmental analysis of the proposed project.
  - Public input on the Copper Rays Solar Project will be accepted until January 13, 2023.

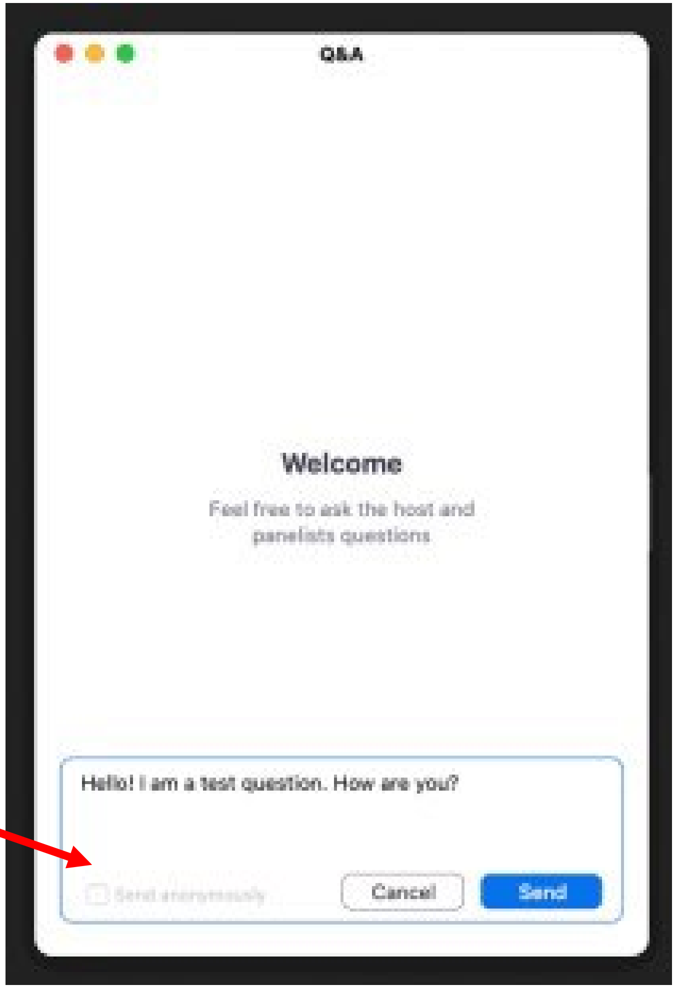
- The information gathered will be considered in the Draft EIS expected Summer 2023.
- For more information on the project see: https://eplanning.blm.gov/eplanning-ui/project/2019523/510

What Types of Input Would be Most Helpful Now

- Comments suggesting how to refine the solar project to avoid or reduce impacts to natural resources (plants, wildlife, soils), landscape views, and recreation (OHV trails, horseback riding, target shooting)
- Comments suggesting reasonable alternatives to the solar project as currently proposed
- Comments suggesting specific issues/concerns for the BLM to evaluate in detail
- Comments identifying other past, present, or foreseeable future human activities in the area that are also causing (or will cause) impacts to natural resources, landscape views, or recreation

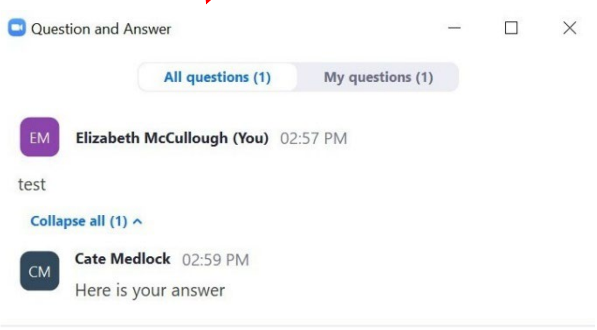
Question and Answer Section

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



2. Type your question here

3. BLM will answer your question in Zoom or live



More information is available at the website: https://eplanning.blm.gov/eplanning-ui/project/2019523/510

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. Don and Susie Hertz
2. Kevin Emmerich
3. Michael Fender
4. Laura Cunningham
5. Teresa Skye
6. Linda Marianito
7. Simone
8. Lawrence Calkins
9. David MacLeod
10. Shannon Salter

02:00

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. David Attaway
2. Marcus Pearson
3. Heather Gang
4.
5.
6.
7.
8.
9.
10.

02:00

How to Submit Further Comments

More information is available at the website:

https://eplanning.blm.gov/eplanning-ui/project/2019523/510

Want to provide a comment?

EMAIL: BLM_NV_SND_EnergyProjects@blm.gov
Please put Attn: Copper Rays Solar Project in the Subject line

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

EPLANNING:
Use the “Participate Now” function at the project ePlanning page:
https://eplanning.blm.gov/eplanning-ui/project/2019523/510

Public Scoping period closes
January 13, 2023

ePlanning Copper Rays Webpage

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

BLM National NEPA Register

DOI-BLM-NV-S030-2022-0009-EIS

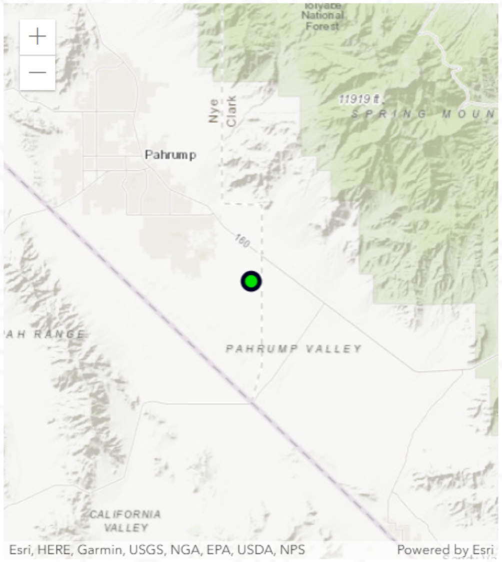
- Home
- Documents
- Maps
- How to Get Involved
- Timeline
- Participate Now

Last Updated: 11/16/2022, 14:52:36 MST

Copper Rays Solar Project

Project Information

NEPA Number:	DOI-BLM-NV-S030-2022-0009-EIS
Project Name:	Copper Rays Solar Project
Project Type:	Environmental Impact Statement
Project Status:	In Progress - Public Scoping Period
Lead Office:	Pahrump FO
Last Updated:	11/16/2022 15:52:36 MDT



Project Description

The Copper Rays Solar Project is located on 5,050 acres of BLM-managed public land in Nye County, Nevada, southeast of the town of Pahrump and 40 miles west of Las Vegas and includes a photovoltaic solar power generating facility with battery storage and interconnection to the regional transmission system. The electricity generated from the project would be collected at the onsite substation and conveyed to the existing Gamebird substation located northwest of the project site via a generation gen-tie transmission line. Construction for the facilities is estimated to take approximately 54-months over two phases. Additional information can be found in the "Documents" section to the left of this webpage. Please note, the scoping materials and project webpage information reflects the most recently submitted Plan of Development acreage, which is slightly less that what was presented in the Notice of Intent, published on November 14, 2022. The most recent Plan of Development can be found in the "Documents" section on the left side of this webpage.

Project Location

City:	Pahrump
State/Territory:	Nevada
Zip Code:	89061

Contact 1

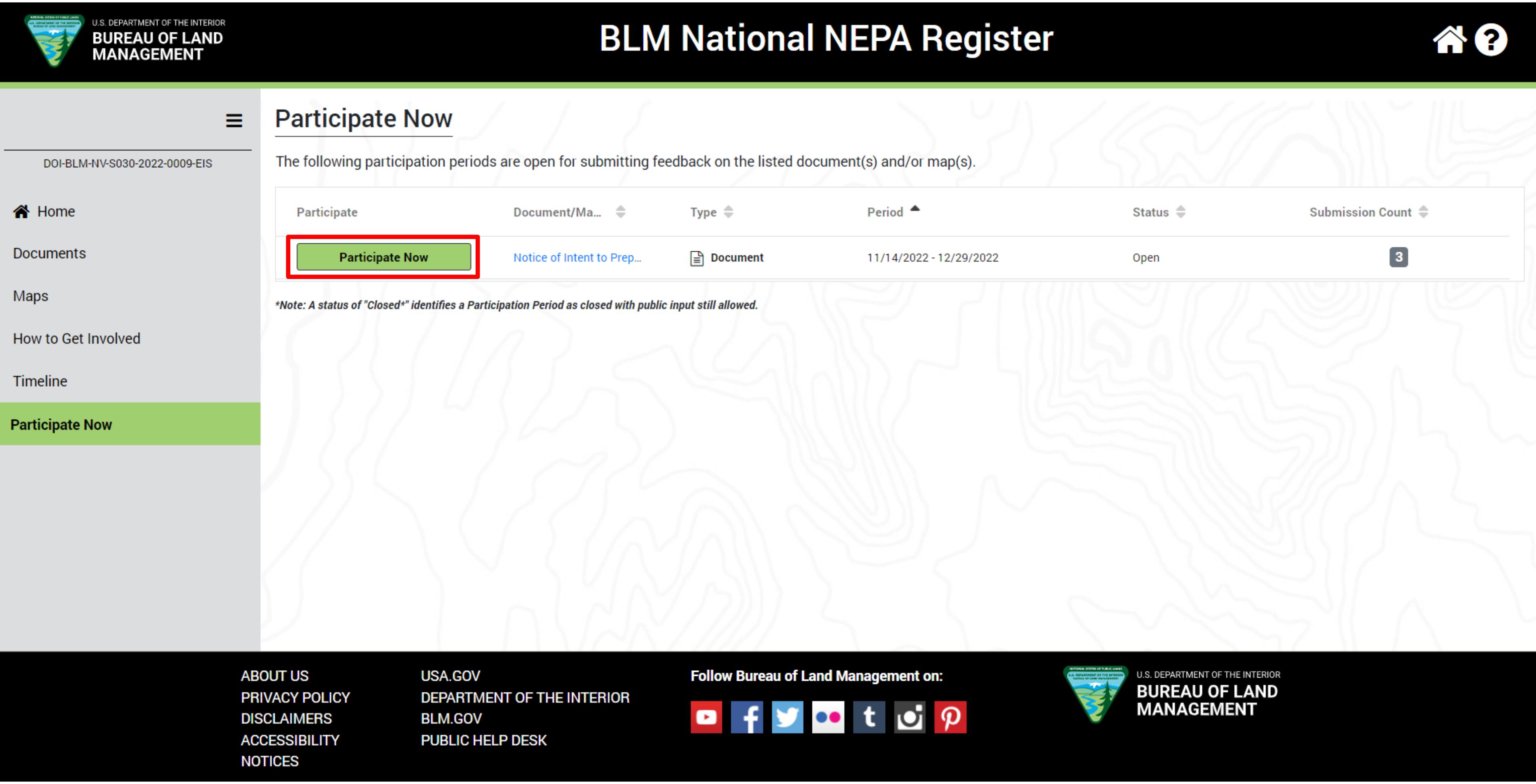
Name: Matthew Klein

What's New

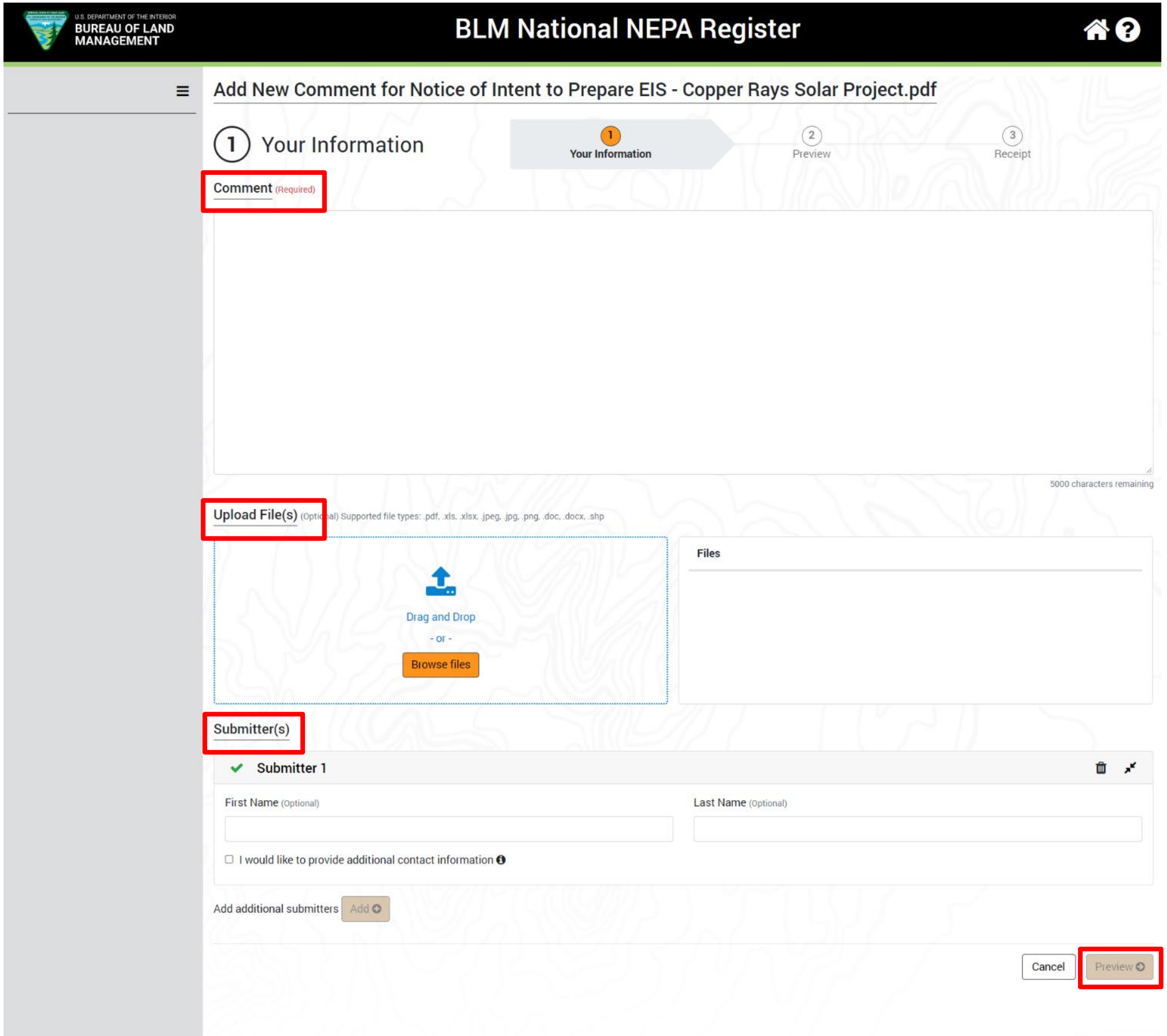
PROJECT PUBLIC SCOPING PERIOD OPEN AS OF NOVEMBER 14, 2022

The Bureau of Land Management Pahrump Field Office is seeking public comments on the proposed Copper Rays Solar Project in Nye County, Nevada. The 45-day scoping comment period opened November 14, 2022 and will close December 29, 2022. The BLM will hold two scoping meetings (virtually) for the Copper Rays Solar Project on December 6 and December 7, 2022 from 6 p.m. to 8 p.m. Pacific

ePlanning Copper Rays Participate Now



ePlanning Copper Rays Comment Page



Appendix D

Q&A and Comment Transcriptions from Virtual Scoping Meetings

Copper Rays Solar Project Scoping Meeting 1 – 12/6/2022

Question Report

Questions are from the Q&A chat feature. Answers are either in accordance with the scoping meeting transcription or provided from the Q&A chat feature.

	Question	Answer
1	"Nye County has a workshop for the Master Plan in progress. They have a moratorium on Solar Projects until it's completed. Citizens of Pahrump do not want Solar projects within 30-40 miles from our County Towns and Townships. And we don't want our water used. There isn't enough grey water to use for project 2000 acre or more!" "What have you done to make sure this project won't have adverse effects on other Counties??"	The scoping process is an early step in the NEPA Environmental Analysis and review, we are currently seeking comments and input from the public to assist in developing the issues and impacts that we would carry forward in the environmental review for the Project. This can also include impacts to known resources, information on identifying mitigations to minimize potential impacts, analyzing reasonable alternatives, and disclosing environmental impacts that could result from the proposed Project. The public will have an opportunity to review and comment on the draft and final Environmental Impact statement and resource management plan amendment. Additionally, both Clark and Nye counties are participating as cooperating agencies for the development of the Environmental Impact Statement and the Resource Management Plan Amendment and will provide their expertise that will aid in development of the analysis that's presented in those documents.
2	"How close will the nearest private residence be from this project border? Less than one mile?"	Yes, the Project boundary would be approximately 0.7 of a mile to the nearest private residence.
3	"Will desert tortoises be released back on the project site?"	The BLM and U.S. Fish and Wildlife Service have designated both the Trout Canyon and the Stump Springs translocation areas that could potentially be used as recipient sites for the tortoises, from the Copper Rays Solar Project Area. If the project is approved, those translocated tortoises would not be released back into the project area following the construction.
4	"How many acre feet of water for construction and how many acre feet for operation?"	The Project anticipates needing up to 500-acre feet of water per year for construction of the Project and less than 10-acre feet of water for operations and maintenance. The applicant has indicated that water would be purchased from nearby and existing water rights owners and no new water rights would be secured.

	Question	Answer
5	"Does the applicant have water rights secured? Will the water come from onsite wells?"	The Project applicant has indicated that water for the Project would be purchased from nearby existing water rights owners and that no new water rights would be secured. The applicant would engage in best practices for the Project and is committed to complying with the regulations and coordinating with the Nevada State Engineer, as well, as implementing other measures to help ensure groundwater basin integrity. Copper Rays Solar LLC is currently updating their Project water supply assessment to provide additional information on the identified water source and which would be utilized for construction and operations and maintenance during the development. We do set any comments submitted during the application evaluation period, that we received did indicate concerns for water use, and identified water source. Those concerns are being carried forward into the NEPA analysis and will be analyzed during the environmental assessment or environmental analysis for the Project. We'll also consider the cumulative effects of the Project, as well, as the other Projects in the Pahrump Valley with that analysis.
6	"When will the Nevada-wide RMP revision happen?"	The Nevada Wide Resource Management Plan Modernization Project is currently being managed by the BLM in the Nevada State Office and a timeline has not yet been established. Information will be available on ePlanning when that is made available.
7	"How many Joshua trees? How many Mojave yuccas? How many Parish's club cholla? Will Joshua trees be salvaged or mulched?"	Belt transects were distributed in different soil types across the project area in order to best estimate cacti and yucca density. From these belt transects it was estimated that there are approximately 50 Joshua Trees within the project area. There are approximately 37,000 Mojave yucca's are estimated within the Project area. There are no Parish Club Cholla that were identified in the belt transects that were used to estimate cacti and yucca density within the Project Area.

	Question	Answer
8	"How does the Nye County moratorium on solar projects impact this review?"	The BLM is aware of the Nye County Board of Commissioners, approval of a 6-month temporary moratorium on the county's processing of future applications for renewable energy facilities. While they're conducting public hearings to consider changes to the County Code for Projects that are proposed on BLM managed lands within Nye County the BLM is coordinating closely with the County for review of those applications. For the Copper Rays Solar Project specifically Nye County is a cooperating agency for the preparation of the Environmental Impact Statement and BLM values the critical coordination between Nye County and the input for the review of the Projects.
9	"The Inflation Reduction Act directs the BLM to approve 2 million acres of onshore oil and gas leases somewhere on public lands for every solar project that has been approved. How is this being handled by BLM? Also requires 40 or 60 millio9n acres of offshore leases. Pretty strange, but that is in the bill and is law now."	The Inflation Reduction Act conditions the issuance of Right-of-Ways for Wind, and solar energy development on public lands on 2 things. The BLM having held an onshore lease sale during the 120-day period before the issuance of the wind or solar energy development right of way and the BLM having offered in the one year period proceeding the date of the issuance of that right of way, lesser of 2 million acres or 50% of the acreage for which expressions of interest had been submitted in that year. Following the NEPA review process, if BLM does issue a record of decision or if BLM issues a record of decision approving the Project, the BLM will ensure that compliance with the Inflation Reduction Act provisions prior to issuing the solar development right of way.
10	"Will the large the amount of people in Pahrump who oppose these projects influence your decision? Saying these projects are unpopular is an understatement."	The BLM is currently in the scoping period and we are inviting input from the public. This is the early stages of the environmental review process and the information provided tonight and during comments will assist in the Environmental Impact Statement development for the project. We appreciate everybody's input and public input is a very critical part of this process and it is considered by BLM decision makers.
11	"Will the mesquite on the site be avoided? How high is the water table?"	There were approximately 5 acres of Mesquite habitat identified within the Copper Rays Solar Project boundary. Currently the applicant's Plan of Development proposes to avoid direct impacts to the mesquite bosque within the Project boundary. We do not currently have information about the depth of the water table within the project area.
12	"Is Cathedral Solar being reviewed?"	The BLM recently received a new application in the Pahrump Valley for a solar energy development project. This is the Cathedral Solar Project. BLM is currently doing a preliminary review of the application.

	Question	Answer
13	"How many tortoises are there in the project area?"	Surveys were conducted April 1 through April 8 in 2021, these surveys yielded 55 adult tortoises, and 5 juvenile tortoises, which were observed within the project area. Based upon the survey informed model it is estimated that 137 desert tortoises reside within the Project area.
14	"What other endangered species are in the project area?"	The desert tortoise is the only species on the threatened and endangered species list that resides within the Project area.
15	"how long is the construction period? who will dispose of the panels?"	The Copper Rays Solar Project is proposed to be constructed in 2 phases. Phase one is estimated to take approximately 21 months to construct and has the potential to generate 200 megawatts of energy. Phase 2 is estimated to take approximately 33 months to construct with the potential to generate 500 megawatts of Energy. Additional information on the Project including a more detailed scheduled layout from the applicant, can be found in the Preliminary Plan of Development which we've included on the project website and there's a link for in the chat.
16	"Will all the vegetation on the site be removed or will it be preserved in some form?"	Copper Rays Solar, LLC is proposing for this project mowing, with vegetation cut to less than 12 inches or just disk and roll construction techniques for the site preparation with the proposed solar field areas. There would be minimal grading only where necessary.[a] The Southern Nevada BLM District Office is working on standardizing best management practices for vegetation management during construction as well as operations and maintenance of the solar facilities. We're doing this in order to have consistency between project analysis. Through the NEPA process, product design features, mitigation measures, and other action alternatives that address vegetation management, may be developed and analyzed.
17	"Has anyone looked at the water used in Boulder City project? 20,000,000 million gallons water was used in 2 months"	We're currently in the scoping period for the Project and we are listening and welcoming a submittal of information that would assist us in the environmental review, including scientific studies, and other data projects so if you could please submit that information or comments to the project email which we can go ahead and put in the chat.
18	"The town of Pahrump is not for this project so why would you even consider moving forward with this project? Does the BLM not consider humans?"	The BLM is required to respond to applications that are submitted. We're currently in the scoping period and we're requesting information that would assist with the development of the environmental analysis for this Project. We welcome comments and input from the public that will assist in review of the Project through the NEPA for process.

	Question	Answer
19	"I would also like to see the BLM answer all of these questions in writing that have been asked by your viewers. Can you please supply that?"	Recordings of the meetings will be posted to the Project ePlanning page. Additionally, we will be developing a scoping summary report that will capture all comments, questions, and answers from the meeting as well, as additional comments that are submitted by writing and that report will be included and published on the ePlanning website as well for review.
20	"People in Pahrump that own water rights do have limits on the use water. How can this project buy water from those that hold rights? This would put people over the limit of rights that they hold, and they would be in violation. How could this be allowed to take place."	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 and the BLM would consider impacts from the water use on connected sources and cumulatively across the area.
21	"How will associated oil and gas leases impact climate change? Will the solar project offset C02 emissions from the oil leases?"	Based on input that was received during the application evaluation process for the Copper Rays Solar Project, the BLM will be considering the effects of the Project on climate change and greenhouse gas and emissions through the Environmental Impact Statement analysis. We are currently in the scoping period and we are gathering information and peer review literature related to this topic. So if you do have any of that information and would like to share it please feel free to email it to the email that is at the Project website or you can also participate now on the ePlanning page and submit comments and attachments that way as well.
22	"Will the Joshua trees be salvaged or mulched?"	Joshua trees within the proposed temporary disturbance areas will be transplanted and then replanted into those temporary disturbance areas after construction in the areas are recontoured. The applicants plan of development currently proposes to mow or disk and roll the site with limited grading. Through the NEPA process though project design features, mitigation measures, and other action alternatives, that would address vegetation management which would also include the management of Joshua trees or other yucca species within the solar project may be developed and analyzed.
23	"How is it that there can be a taking for an endangered species?"	Incidental take permits allow for the permittee to take a threatened and endangered listed species if such taking is incidental to and not the purpose of carrying out an otherwise lawful activity. Take limits are set by coordination by the U.S. Fish and Wildlife Service, and the BLM and are based upon site specifics surveys. Take is only allowable if an action is not deemed to be to place a population in jeopardy.

	Question	Answer
24	"The link about Boulder City project https://thenevadaglobe.com/environment/solar-farm-uses-twenty-million-gallons-of-water-in-two-months/"	Thank you for submitting this information.
25	"I used Boulder city as a model and it will take 277 acre feet of water for the first part of this project, and 3555 acre feet of water for the 2nd half. Water rights were over allocated for Pahrump by the State Engineer. There is 20,000 acre feet of water from only one source every year. who is BLM working with to know what is available?"	Similar to the question previously asked 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 and the BLM would consider those impacts for water use from the projects within the basin.
26	"Water Rights BLM must consider that again people who own rights are capped on who we can use. So you really did not answer the question. We cannot supply this project legitimately."	Thank you for your comment. We also welcome submittal of any additional information that you think would be helpful for the BLM to use for analysis of this issue to BLM_NV_SND_Energyprojects@blm.gov.
27	"Will tomorrow's meeting be the same?"	The presentation will be the same. The Q&A and comments will be based on the attendee participation.

Note:

Minor editorial changes were made to the questions and answers, including correction of spelling, spacing, and typing errors.

[a] Please refer to the latest Plan of Development (POD) for proposed site preparation methods. "Within the solar field areas, existing vegetation would be worked into the underlying surface soils using the technique of "disk and roll" and where necessary, conventional grading, will be used to prepare the site for post and PV panel installation, in accordance with January 2023 POD."

Verbal Comment Transcript

The comments provided are in accordance with the scoping meeting transcription.

	Commenter	Comment
1	Joyce Barishman	Hi, good evening, Caitlin I see the beautiful background on your picture of the desert. Yeah, it's just gorgeous, by you allowing this project, we will lose all of this beauty and I don't know how the BLM could allow this to take place. There's so many problems here with desert tortoises, water, and dust pollution. From my house I live 3 miles from this project. I will be able to see it, and that will not be a pretty site to me. I don't want to have that and this project should not be allowed to take place. The people of Pahrump do not want it, and I do not want it. Thank you.

APPENDIX D

	Commenter	Comment
2	Kevin Emmerich	Hello, thank you. My name's Kevin Emmerich. My organization is Basin and Range Watch, I wanna first start out by saying, Rough Hat Clark County, that's the one right next to this, you revealed that that area along with Copper Rays is a high tortoise density of 5.6 per square kilometer, that's probably about 7 or 8 per square, mile. Interestingly that is higher, than most of the established official recovery unit for the desert tortoise and that's because desert tortoise were, seeing a range wide decline of 37% according to the Fish and Wildlife Service, but here you have close to 30 square miles of existing or solar application that it looks like you're planning to approve the BLM think about this. If you keep approving these projects, take that habitat away. You're not gonna relieve them back under the Project. You will be contributing to the extinction of this species. It's going downhill or we can make the decision to say no to this project. You can go down in history as saving this species that's what it's coming down to. First solar by the way, is notorious for fugitive dust and we were used to the first Solar, Desert Sunlight, Antelope Valley Solar Rack SO Pat Roller sent workers home with Valley Fever, look it up, They're gonna hurt the people in Pahrump. And you mentioned in Nevada-wide Resource Plan revision I'd like you to wait. You would prove that project will you make that revision because if you wait, we can give you an alternative. That preserve this last really good that the report is there
3	Carl Van Warmerdam	So, my name's Carl Van Warmerdam. Just want to I'm advocating for the Desert Tortoise and want to remind the BLM that the Endangered Species Act ensures that the actions of implementing, this Copper Rays Solar Farm is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification, of critical habitat, or determined for any listed species, including the Desert Tortoise. The ESA section, 7.A.2 additionally section 7.A.1. ESA requires BLM as with all Federal agencies to utilize their authorities and furtherance of the purpose of this act by carrying out programs where the conservation of endangered species is. So, you will be taking out 5,000 acres of endangered Desert Tortoise habitat and killing/taking 150 endangered species. I don't see this as being incidental at all. That habitat will be gone, those tortoises will be gone you're pushing them off but they aren't going to survive other work. So, I just don't understand it

	Commenter	Comment
4	Ammie Nelson	Hello, can you hear me, okay, I want to remind the BLM Pahrump has over 10,000 transplants from California and a lot of these people were at the board of commissioners meeting and the planning board's meeting speaking out against any kind of solar project. They not only ruin the ecosystem for hundreds of years. They generate a sound, low pitch sound. They put in lights that disturb people that are close by, and we don't benefit. We don't get any benefit from these Solar Projects. So, I don't know why Clark County is going to the BLM or the Southern Nevada Water Association is going to the BLM and saying let's put these over here by Pahrump. We don’t want them out here we're trying to put into our master plan, that they not be put in within 50 miles of us. We don't want them in our towns, we don't want them near our towns, or near our County. So, if Clark County wants to continually destroy the ecosystem let them do it on their side of the mountain. Don't keep bringing it out here using our water and our resources and I don't care how many of these people that own water rights say they have it's just going to deplete our water system totally with projects like this and they just keep coming. This isn't the first one we've got another one already in progress out here it closer than this one's going to be, but it's going to do as much damage when this one gets started. So, I hope you turn this down and listen to the people. I was on the last webinar, and it didn't go well then either and I think the solar people backed out because of our comments. Thank you.
5	John Hiatt	Okay. Thank you. I would like to address the cumulative impacts problem here. When the programmatic solar EIS was done a number of solar energy zones were designated and then the rest of the area was considered variance area. You are now in the process of creating a de facto solar energy zone here, one of the largest actually in the State. There were at least 20,000 acres with the summation of all these projects. I think that it would be very wise to complete the cumulative impact analysis for all of the projects before proceeding with the rest of the EIS for any project, and certainly this one. The Mojave Desert is probably the most intact ecosystem left in the continental United States and the BLM has identified I’m told something like 9.1 million acres in Nevada, which are suitable for solar and various agencies and organizations have said that we might need as much as 20 million acres of solar panels to decarbonize the economy. The western United States, basically that would if that happened we could lose essentially all the Mojave Desert in Nevada that's less than 5% slope and with all the tortoise is gone, everything gone. It is incredibly important that we preserve intact and functioning ecosystems and I don't really see much of any attempt here on the part of the BLM to maintain functionality of the ecosystem once these things are put in place. Also the idea that somehow this will be decommissioned and go away and be reclaimed in 20 years, is nonsensical. This is a permanent industrialization of the desert and that needs to be admitted to by the BLM and the planning needs to take that into account thank you

	Commenter	Comment
6	Teresa Skye	Hi! I did a hike today in the Mohave Desert with a group of friends and thought about the solar farms that are being put in. I was surrounded by desert pavement, by beautiful plants of the desert, clean air it wasn't dusty, and this would all change with all these solar farms that are being planned for our beautiful valley. 20,000 acres I think is the number. The gentleman previously mentioned how all these things are being done piecemeal and it really needs to be looked at as a whole. The entire connectivity of these places has to be looked at and how it affects the desert wildlife and the desert plants. We live in a beautiful location. I'm sad now as I drive from Vegas to Pahrump and see if It's a slightly windy day, I see the Yellow Pine Site, the wind blowing and I really wonder if the people in the southern part of the Valley, Mountain Falls, and Artesia Area really understand what's going on very few miles outside of their properties. Outside of their locations and I think that as a community we need to let those people know what's going on, because frankly, I talked to once in a while I run across the friend and they have no knowledge of this, of what's happening and with these solar farms being put in. So, I think we need to spread the word more. I think we need to get it out there as a group and we're not against solar, as a family, we have solar on our roofs. But it's not the way to go to dig up our desert. Thank you
7	Mike Barishman	Okay, my husband would like to speak. His name is Mike Barishman. So can you please set the timer for him? Good evening, ladies and gentlemen are Pahrump valley. Good evening, ladies and Gentlemen of Pahrump Valley, you know we've heard a lot of Technical Jargon, but you know we haven't heard anything about what these solar farms are going to do or what they're not gonna do for our Pahrump Valley. First of all, I'm looking at a map here, a proposed pause authorized and construction solar projects in the Pahrump Valley. Ladies and Gentlemen, this looks like the lob from outer space that is going to swallow our entire Pahrump valley from the bottom all the way up, to the 160, and beyond. What the solar farms will not do for our valley, they will not create any significant local job market, not at all there are not going to contribute in any tangible way to our economy. I'm not talking about buying a few lunches for a couple of employees. They will bring no tangible results. They're not gonna lower our energy costs. If anything, our energy costs are going to go up. What they will do for our valley they'll increase surrounding air temperatures, outside air temperatures, they're going to go up by about 5% as was told by us back in March from the people who want to do a Rough Hat. What else they will do, they will destroy public lands, and Flora and Fauna. I don't know what makes people think that they care about the Flora and Fauna, will lower our water tables that are going to create more airborne dust and dirt. They're gonna lower our property values. The solar farms want to use our roads, our infrastructure, our water, and we're not going to get anything back in return we got to get informed and get the word out to everybody in Pahrump, everybody in Mountain Falls, Cottonwoods, Artesia, all the way up to Simkis because we're gonna get swallowed by the solar farms and burned to a crisp in the bottom up that's it I'm done.

	Commenter	Comment
8	Ammie Nelson	They need to attend the planning and zoning meetings on Wednesday nights at 6 pm. at the Florida County Commissioners building over on Calvada Eye and they could also attend these follow ups with the Board of County Commissioners, every first and third Tuesday of the month and those are held at 10 am. People can call into them. They can watch them on granicus or they can go in person. I highly recommend that they go there and have their voices heard so that none of these projects get an ok and if something can be done to eliminate the Southern Nevada Water Authority from having any say so about the water that we use out of our town. Clark County has use of water, but they don't want to put in their own wells. From basin 162 they want to use our water and so there's some greedy people out here they're overextending their water rights and people need to speak up and get informed and bring their friends to these meetings, so that they can be heard, and they can stop these projects. I thank you very much.
9	John Hiatt	Thank you. The 1976 federal land management and policy act essentially designated the BLM as a multiple use agency, meaning that lands could be used for more than one thing. This movement towards renewable energy, specifically solar panels is really a single use which will last permanently into the far indefinite future. But yet there's no real planning for how we're gonna deal with this. I think the BLM is completely remiss in not undertaking a major planning effort with lots of public input. As we embark on the largest single use permanent use of BLM land, BLM lands that's ever happened I think most of the people who think of public land have no idea that potentially and probably certainly millions of acres of public land will be devoted to renewable energy to the exclusion of any other use. So I'm very disappointed that the leaders in the BLM are not raising the alarm and saying before we move down this road. We need to actually have some discussions and some plans to how we maintain intact ecosystems and how we as keep from based from having the entire desert that's not mountainous turned into an industrial zone. Thank you

Copper Rays Solar Project Scoping Meeting 2 – 12/7/2022

Question Report

Questions are from the Q&A chat feature. Answers are either in accordance with the scoping meeting transcription or provided from the Q&A chat feature.

	Question	Answer
1	"How is the town of Pahrump supposed to have capacity to expand when BLM has effectively blocked all land to the south with solar projects, effectively cutting off our economic growth capacity?"	The BLM is required to respond to applications that are submitted. Currently we are conducting an environmental review to consider this application and we're in the public scoping period. Comments made during the scoping including the concern you're identifying at this time for expense of the town would be considered as part of this process. If there's any additional information, we would love to have that submitted related to your concern. You can send that information to the email address that is in the chat or you can also submit comments through ePlanning using the participate now function.
2	"If this project is approved, will associated oil and gas drilling also be authorized, per the Inflation Reduction Act? Where is the oil and gas drilling to be authorized?"[a]	The Inflation Reduction Act conditions the issuance of a right of way for wind and solar energy development on public lands based on 2 things; the BLM having held an onshore lease sale during the 120 day period before the issuance of the wind and solar energy development for those right of ways on public land; and then the second thing is BLM having offered in one year period preceding the date of the issuance of the right of way, the lesser of 2 million acres or 50% of the acreage for which the expressions of interest had been submitted. Following the NEPA review process, if the BLM does issue a Record of Decision approving the Project, the BLM will ensure compliance with the Inflation Reduction Act provisions prior to issuing the solar development Right of Way.
3	"If this project is approved, will associated oil and gas drilling also be authorized, per the Inflation Reduction Act? Where is the oil and gas drilling to be authorized?" [a]	Same as above.
4	"Please explain the "disk and roll" land clearing method. Does it disturb desert pavement?"	The disking is a type of tilling that will break up the soil and vegetation and creates a more uniform soil surface. This type of construction practice would disturb desert pavement.

	Question	Answer
5	"What type of containment will be around the battery storage complex?"	Engineering renderings for the battery storage complex are in the development stage have not yet been submitted to date.
6	"What is the desert tortoise density here, from surveys?"	Desert Tortoise surveys were completed April 1 through April 8, 2021, one of those Surveys, 55lLive adult tortoise, and 5 juvenile tortoises were observed within the Project area. Based upon these surveys as well and a survey informed model we can estimate that 137 total Desert Tortoises within the Project area and there's a calculated tortoise density from those surveys, as well that would be 6.7 tortoises per square kilometer
7	"What is the desert tortoise density here, from surveys?" [a]	Same as above
8	"Why are you so hell bend to build in Pahrump?"	As we stated the applicant, Copper Rays Solar LLC has identified and applied for the proposed Copper Rays Solar site. BLM did complete the application prioritization process, as well as the application evaluation review of the proposed Project. The application evaluation process involved public and agency meetings as well as additional agency and tribal coordination. From the information that was gathered during that process the BLM did determine to continue to process the Copper Rays Solar Project and initiate the NEPA process. Input gathered during the application evaluation process will then be incorporated into the NEPA process for the Project which includes issues and alternatives identification and additional information on the application evaluation determination can be found at the Project website.
9	"Why can't there be an updated visual corridor criteria developed, as the one you are using is nearly 25 years old?"	We would appreciate any additional information on the visual corridor criteria and about your concern so that could be considered during the process. You can submit that information to the email that we put in the chat or you can also use the ePlanning participate now.

	Question	Answer
10	"Is the area being considered for a new solar energy zone under the new Solar PEIS revision or RMP revision"	The Secretary of the Interior did recently announce that the BLM will be updating the 2012 Solar PEIS, based on information of improved technology, new transmission infrastructure, and also the administrations clean energy goals. As part of that update, the BLM is considering adding more States, adjusting exclusion areas, exclusion criteria, and seeking to also identify new or expanded areas to prioritize solar development. That update process will be published in the Federal Register, which will open a sixty-day public comment period. If you'd like to provide comments on the potential update to the Solar PEIS they're also having public scoping meetings both in person and virtually. We can post in the chat the ePlanning web page for the solar project update and we'll put that in there so you could check out information on that and also register or plan to attend those meetings. Specific to the Copper Rays Solar project that is a separate planning process from the planning process for the solar PEIS update. Both proposals are currently in the early stages of the NEPA process. So, it's unknown at this time how they would interact. As both NEPA documents progress the BLM Southern Nevada District will coordinate with our BLM and Headquarters office to determine what is needed for the Copper Rays Solar analysis. I think the last part of that question was also about the Statewide RMP revision. So the Nevada-wide Resource Management Plan Modernization Project is being managed by the BLM Nevada State Office and a timeline has not yet been established.
11	"How can the 5000-acre Copper Rays project use 500 acre ft of water during construction, While the smaller Rough Hat Clark is going to use 800?"	The water needs for those 2 projects have been identified based on water needs assessments that were prepared by the project sponsors. The BLM is currently in the scoping process for that Project and for this Project and would appreciate any scientific literature data or any other information that may assist in the preparation of the environmental analysis including any literature related to water usage or water hydrology within the basin. Please submit that information to the email that we put in the chat. You can also use ePlanning to submit a comment and attach documents to that comment.

	Question	Answer
12	"To what extent does BLM plan to evaluate the cumulative impacts of the various proposed and reasonably certain future projects in the area, given the concentration of existing and pending projects in the Pahrump Valley?"	As we kind of explained in the presentation we'll be identifying and evaluating those potential impacts from the Copper Rays Solar Project as well as cumulatively those other related, past, present, and reasonably foreseeable feature actions during the environmental analysis for the EIS. In order, to ensure these effects, are fully considered the BLM is requesting any information during the scoping period related to other past, present, and reasonably foreseeable actions that are proposed on federal, state, local, or even private lands, in the vicinity of the proposed project. So, if you do have any information on additional projects outside of those ones that we've identified within the Pahrump Valley that are proposed and under review we would appreciate that during the scoping period. You can describe that during verbal comments later in the meeting you can also provide that written through the option we had in the chat. Additionally public involvement and agency coordination as well as Native American Tribal Consultation will also help inform our cumulative effects analysis and further define those issues and recently foreseeable actions.
13	"That was great beat around the bush, the question is why are you determine to build solar farms in Pahrump instead of building in non-populated areas."	The BLM is responding to applications that have been submitted. Like we stated, we're currently in the environmental review for the consideration of the application and that's why we're conducting public scoping to form the analysis. Once drafted the draft Environmental Impact Statement and the Resource Management Plan Amendment would be made available for public review and comment and then the final EIS and the Resource Management Plan Amendment will inform BLM's Decision on the application. We welcome your comments during this process for consideration and then development of the environmental review.
14	"Will the project offer me money for my land if it falls with the project's area?"	The BLM cannot respond to this question. The Project sponsor Copper Rays Solar LLC, determines their own outreach to the local community for the Project.
15	"What chemicals are approved for use as dust palliatives?"	Right now, the BLM does not have that information on hand. However, that would be part of our restoration plan that would be developed for the Project and as that is developed as part of the NEPA process that would be available for public review.

	Question	Answer
16	"What are the land reclamation requirements?"	As part of the environmental review process and during the NEPA process, a restoration plan which would be focused on minimizing and repairing construction impacts and a decommissioning plan which would be focused on the end-to-end of life reclamation. Both of those plans would be developed using the Southern Nevada District BLM standard templates. If the Project is approved, the BLM would also require the applicant to provide an adequate reclamation bond to cover the full decommissioning and restoration of the site. All projects are required to submit a bond prior to ground disturbing activities, which includes construction and having a reclamation bond in place for an approved project means that the company was able to complete decommissioning. If a company was unable to complete decommissioning for any reason the BLM could attach that bond and utilize those funds up to the full amount identified to complete decommissioning and restoration.
17	"How can we make it known that we want the projects you have shown in this presentation, to be re-evaluated based on updated PEIS stipulations that are to be upcoming? Why do these projects have to be pushed through when updates are coming - we are going to be victimized by old regulations, all for the benefit of the applicants, when the land belongs to the citizens - not the applicants."	As mentioned and referenced in the comment, the BLM did recently publish the notice of intent for the update to the Solar PEIS and we will put the website information for that update process. They will be opening a 60 day comment period for that update for folks to submit comments and information for that process. The update to the Solar PEIS is a separate planning process. However, we do also welcome comments that assist in the preparation of the environmental review for the solar project.
18	"Will this project increase business for the city of Pahrump?"	Socioeconomic or economic impacts from the Project are not known at this time. However, that was information that was submitted during the application evaluation process and so we will be carrying forward that information into the NEPA analysis and to help with that analysis of economic impacts of the project to local communities. We will be completing, the applicant is currently completing an economic modeling report, which the BLM will review and that will be provided for review during the draft Environmental Impact Statement process.

	Question	Answer
19	“Volunteers helping in NDOW/NDOT seasonal surveys for DT and wildlife roadkill on highways, (through DT range that's within BLM boundaries), have been told, that over ~3 yrs, ArcGIS mapped "clusters" of observations are just now indicating highway crossing spots naturally preferred by DTs and wildlife. Seven days in April seems a short time to be able to determine DT density #s and importance of decades old DT routes and paths for 5050 acres.”	Thank you for your comment. A team of approved Desert Tortoise Biologists conducted a full areal coverage survey utilizing the U.S. Fish and Wildlife standardized belt transect survey method within that time.
20	“Presently Nye County has implemented a six month moratorium on solar projects in the county because of the many applications to build in the throughout the county. How is BLM receiving this?”	The BLM is aware of Nye County Board of County Board of Commissioners approval of a 6-month temporary moratorium on the County's processing of any future applications for renewable energy facilities while it conducts public hearings to consider changes to its code. For projects that are proposed on BLM-managed lands within Nye County, the BLM is coordinating closely with Nye County for the review of the applications. For the Copper Rays Solar Project, Nye County is a Cooperating Agency for the preparation of the Environmental Impact Statement. The BLM values this critical coordination with Nye County and their input for review of the projects.
21	“How will downgrading the visual class impact property values in Pahrump?”	The BLM is currently in the scoping process and is collecting public input to assist in preparation of the Environmental Impact Statement and Resource Management Plan Amendment. The BLM will prepare a socio-economic analysis to assist in development of the environmental review. The BLM welcomes comments, scientific studies, data, or other information that may assist in the consideration of this topic. Please submit any additional information you have that could assist in the review to BLM_NV_SND_energyprojects@blm.gov

	Question	Answer
22	"Last evening a question was asked, are there other endangered species found within the project footprint and buffer boundaries? Answer was, No. I am told that is a logical and expected, answer where the keystone DT is still undisturbed, and successful in its singular and essential work, above and below ground -- which is the reason for any other desert-adapted creatures even being able to exist and reproduce there. Remove the DT and its work, and we - actually will - have a big list of plants and animals that are gone from there. Only by the design of human - business. Thank you for your consideration of the potential irreversible damage possible."	Thank you for your comment. If you have any additional information relating to your comment, including any scientific studies, data, or other information, please submit that information so it can be considered along with your comment. The email address for submitting additional comment and information is - BLM_NV_SND_energyprojects@blm.gov
23	"I have used information I heard at Desert Tortoise Council's Introductory training course, and their USFWS- USGS- attended symposia."	Thank you for sending the additional information.

Note:

Minor editorial changes were made to the questions and answers.

[a] These two comments were submitted twice through the Q&A feature. Both comments were answered live and the answer is provided in the table.

Verbal Comment Transcript

The comments provided are in accordance with the scoping meeting transcription.

	Commenter	Comment
1	Don and Susie Hertz	Good evening. My main concern and my comment of this evening is with regard to location. When you look at the map that you put up this evening, which we've seen many times already. Of the 5 to 6 plus installations that you plan to put in Nye Clark Counties along Route 160 and you look at the visual impact and the natural impact of such a vast amount of mileage of land that is going to impact us in so very many ways in such a populated area. It's really frightening. On the other hand if a person got in a car and drove to the west into California, into some very unpopulated areas and very logically drive toward Baker, California, there's access to power lines, there's access to water, and there are very unpopulated areas and this is just one minor example of a place where the BLM land could be utilized with much less impact to so many people, so much and so much nature, and I am making a plea on behalf of myself and my fellow citizens that you evaluate some place like that rather than this populated area which is prone to growth, between here and Las Vegas and an existing town. Of a couple 100 years of history that you are now damaging and destroying, both socially and economically, and environmentally, by your choice of putting this power, which is going to be used in California and not benefited from here in Nevada. By putting the power in the State who's going to use the power in the first place. That is a very serious plea and I will make it continuously until you move it. Thank you.
2	Kevin Emmerich	Hi, my name is Kevin Emmerich. My organization is Basin and Range Watch and you're talking about a very high desert tortoise, density and this day and age about 20 years ago or so if you said, there were 6.7 per square, kilometer, that would probably be a low density compared to a lot of the recovery, units like over in the west Mojave Desert. They had in the 1990's 200 per square mile up to that on some of the recovery units. So it tells you what's happening. The desert tortoise is crashing and population. This population however, you're saying a 137 may be on the site that could be an undercount and at 6.7 per square mile in 22 is higher than now most of the recovery units. I would like to request that you delay this Project and a lot of the other projects in the South Pahrump Valley until you can revise that Nevada Resource Management Plan and revise them all simply because that would give us an opportunity to say, Hey, slow down on these solar projects, and let's protect the tortoise, let's slow down and let's not enable the extinction of the species really that's the keystone there are several other there are no doubt millions of living organizations on that 5,000, acre, what 8 point square mile site that will be crushed and killed by those bulldozer this is a net biodiversity loss for solar panels that do the same job on rooftops and over parking lot. Would really be immoral to approve this project. Thank you

	Commenter	Comment
3	Michael Fender	Okay, you can hear me good. I did it right. First of all I'd like to say thanks to Don and Susie Hertz for the comment and what Kevin said as well. I concur with what both of them said. I presently live about a mile and a quarter from this particular project, so I really don't want to be looking at a large junkyard every day, several times a day, or maybe once or twice a week. When I'm going in that direction, I fear this is where it's coming to. We have too much here in Pahrump Valley that needs to be consumed by such material objects. I can understand they have a meaning, but this meaning is we are giving up our where we live for other people elsewhere that are millions compared to only what 50,000 here in the Pahrump Valley to have something like this consume the valley. This is only one of the six solar projects that are proposed, besides the current, you know, the Yellow Pine, but they also you also have another one. I understand it's about 9,000 acres, that's going to be up there by Mount Potosi on the Sandy Valley Road which is up before the Nevada Utility Commissions so when I look at this overall picture you're literally going to turn this valley into a junkyard. What will happen is the heat will rise, land values are going to drop, people are going to move away, and if that's what you really want to see, our government wants to see. You're basically kicking people off their own land, forcing them off because of these particular projects. There is another, there's by variances, there's 9.1 million other acres throughout Nevada in places that do not have such populations and it's written right in that PEIS anyway. That's all I have to say thank you very much.
4	Laura Cunningham	My comment is I've looked at the Yellow Pine Solar Project under construction and it really does destroy the desert. It has 8ft tall chain link fences with barbed wire that keep the public out. This is an important recreation land, it has biodiversity, and I just think that making south Pahrump valley into an industrial energy zone is not the right thing to do for Nevada. For people that recreate there and live there and for the biodiversity, I mean the tortoises. That's as Kevin said, that's incredibly high density higher than most critical habitat units. So we've got a thriving Mojave Desert Tortoise ecosystem, their habitat, but we're going to destroy it, for so-called green energy, that's not green. Thanks that's all I have.

	Commenter	Comment
5	Heather Gang	Hi! I have kind of a bad internet. So I apologize if I cut out. I see there are many resource conflicts with this Project just from looking at your own Project priority determination worksheet. So I'm not gonna tell you anything you don't already know. Natural riparian wetlands are nearby, it's a sensitive hydrogeographic basin over allocated basin. So you know we shouldn't be passing projects that will pump more water in our basin. Sensitive soil resources and you know some really beautiful desert pavements out there that take hundreds of thousands of years to form. I seriously doubt they'll be able to restore those, and they definitely won't be able to put this in without damaging those. It's sensitive habitat for Desert Tortoise and maybe Pahrump Valley Buckwheat and nearby Mesquite Bosque are important for birds, those are all from your own analysis. There you say in your analysis that groundwater issues are not influencing the priority level until additional information is gathered. Well, how far do you let the process go before you start getting this information and making these decisions? You know the same thing with the decommissioning and reclamation plan. It says in the report that it doesn't even have to be developed until the 6 months prior to closure. Well, it's too late. Then the vegetation and the soils are destroyed and you have no plans for how to reclaim them. You know in the last meeting the Rough Hat Clark you said that you would be happy with 60% reclamation of plants. I don't know whether you mean 60% of the biodiversity, 60% of the covered area by plants, or you know you don't explain what you mean by that so thank you. (Second time speaking) – In the beginning of your presentation, you basically said that if the project doesn't fit the Resource Management Plan or the Visual Resource Management class you're going to change the Resource Management Plan so the Project can proceed. Do you realize how bad that sounds, I agree with Kevin Emmerich that these things are being pushed through so fast that the issues can't be properly addressed. There's so many projects right now pending, threatening our valley here and valleys throughout Nevada and I just like to say the same thing I said at the last meeting; that we can't afford to lose more wildlife habitat on this planet. We're in an extinction crisis and habitat loss is one of the driving factors. I know you think this is gonna fix climate change but the habitat loss is just as big of an issue as climate change. Yeah, that's it. Thank you.

	Commenter	Comment
6	Michael Fender	Thanks for letting me speak again. I would just like to add that if people were to actually, if they were to do this same thing in another part of the United States where it's highly forested where people go camping, where people go fishing, where people hunt, and where we get our lumber to build things, and you start tearing down the forest to build solar farms. You really believe there's a bill and believe and all the other agencies provided in this project, you really think they're gonna do that by destroying the habitat in a forest area. I mean it's really, I know that's a loaded question but I think everybody needs to see it from the other side of the fence and this is no different. All we have is created. So we got tortoises, we got badgers, and we got Yucca. That's our forest and like I said before there's another 9 million acres someplace else within this State, it can be utilized. It's already been and sort of scorched. So you what you might say so Nevada got a lot to offer. But there's other areas other than here. Let's say, Yeah, there's other areas other than here, that's all I have to say. Thank you very much.
7	Edward LeBlanc	Hello, great I just wanted to add I like some of the things that some of the people commented on and that I agree. There’s other areas around here that they can build this stuff. Why do they have to encroach right up to our backyard with these solar panels? There is a study out that this increases the heat range in our area, this is like I said before there’s other areas that can be built as a lot of desert space, and right over the border in California that they could build these things. They don't need to be building this stuff right in our backyard, and I am gonna be going to commissioner’s meetings. I'm gonna join my fellow people from Pahrump and we're going to try to stop this corporation that is trying to kill our area. I planned to move here to enjoy this this area for my retirement and now I got this big corporation trying to destroy my property, destroy my way of life here, and I just don't like it. It makes me very, very mad, and I want to try my best to join everybody in this town. We are going to try to stop this place or stop these guys from doing this to us. That's all I got to add. Thank you.

	Commenter	Comment
8	Kevin Emmerich	Okay. Thank you. Kevin Emmerich again, Basin and Range Watch. Thank you, the solar projects here are being permitted by the BLM or are being reviewed simply because there's a political mandate to do so. I wanna point out that I feel that the folks in the Southern Nevada Office have really been doing a good job, as far as being transparent, providing us with information, and explaining how this process works. That being said those politics seem to be nullifying the very purpose for building these projects. The solar energy in order to achieve what other conventional forms of energy have to needs to use a lot of land. That's a low density energy and so multiple acres square mile it is required in order to achieve the goals we get that. So we have this political mandate called the Inflation Reduction Act and I can't even remember what page it's on. But it says for every solar project permitted, 2 million acres of oil and gas leases will permit on shore and something, like 60 million offshore. So to ask ourselves, what is the purpose of having this project? On a political scale on a presidential scale. We hear it's for climate change. So what happens here, we permit 5,000 acres, or how many megawatts and solar panels and then we permit a bunch of oil drilling. So can somebody explain that to me, nobody can because it's politics. But when in your environmental review let's think about this because we are talking bulk biodiversity loss, we're talking loss of many cultural resources and yes, the town of Pahrump and south Pahrump. Those people are gonna get hit pretty hard with fugitive dust probably water table lowering and just depression. They're just gonna have to live next to this monstrosity. So yes, and your purpose, and need and consider will it even offset Co 2 emissions, with so many required oil and gas leases associated, thank you.
9	Don and Susie Hertz	Hi, thank you, I just wanted to make a comment or a plea to you the BLM. I was just looking and analyzing how many people are participating in this evening's comments as a gauge to how many people might be listening to this meeting this evening. Considering that we live in a town of 50,000 people and that there were 15 people set up to make comments this evening, that's a pretty catastrophic small response of participants. It tells me that there are very few people who are aware of this process of meetings and opportunity to hear what's going on and have input to the process. My plea to you BLM is to find a way, an effective way to notify the public beyond you know getting on a mailing list, an email list that you get from peer to peer, like maybe putting a publication notice in the Pahrump Valley Times, and the Valley Electric Publication that goes out to every electric power user in the Pahrump Valley. You know, take some responsibility for what you're doing and notifying the public so we have an opportunity to get some information from you to give you some information. So this doesn't feel as if the snow is being and the wall is being pulled over our eyes as a population. I would feel a little bit more comfortable if we felt as if you were being a little bit more proactive than just you know a random I got on a mailing list in an email list, because I knew somebody that's my request as a citizen and you are legislating for we the citizens.
10	Fred Sauberman	Okay. Thank you. What I've heard tonight is negativity. I'm wondering why nobody has mentioned about the clean energy that may be provided to the City of Pahrump and also about the increase for business, and the increase for land value if such a company comes over here to establish their work. So I ask everybody who's listening to think about that question, well maybe respond to it. Thank you.

Appendix E (Part I)

Comment Letter and Forms

Government Agencies

From:	Araceli Pruett
To:	BLM_NV_SND_EnergyProjects
Subject:	[EXTERNAL] Copper Rays Solar Project, EIS
Date:	Monday, November 14, 2022 9:56:29 AM
Attachments:	20211222 Clark County DES Copper Rays Solar Project Comment Letter.pdf

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

Good Morning,

We received the Notice of Intent to Prepare an Environmental Impact Statement and Resource Management Plan Amendment associated with the proposed Copper Rays Solar Project. You might recall that we provided comments on the proposed project on December 21, 2021. A copy of that comment letter is attached and our comments remain the same.

If you have any questions or need anything further, please let me know.

Thanks,

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

DES
DEPARTMENT OF ENVIRONMENT AND SUSTAINABILITY
air quality · desert conservation PROGRAM · sustainability

4701 W. Russell Road 2nd Floor
Las Vegas, NV 89118-2231
Phone: (702) 455-5942 • Fax: (702) 383-9994
Marci Henson, Director

December 22, 2021

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

Email: BLM_NV_SND_EnergyProjects@blm.gov

Re: Copper Rays Solar Project, Nye County, NV

To Whom It May Concern:

The Department of Environment and Sustainability (DES) has reviewed the documentation associated with the proposed construction, operation, and eventual decommissioning of the Copper Rays Solar Project, a photovoltaic solar power project in Nye County, Nevada. The proposed project would include 700 MW solar and battery storage facilities on approximately 5,127 acres of BLM-administered land in the Pahrump Valley in Nye County, immediately adjacent to the Clark County line and approximately 40 miles west of Las Vegas. In addition, Copper Rays Solar, LCC has applied for a right-of-way grant to provide the necessary land and access for the construction and operation of the proposed solar facility and interconnection to the regional transmission system.

The Las Vegas Valley (Hydrographic Area 212) in Clark County is currently designated as a marginal nonattainment area for the 2015 ozone National Ambient Air Quality Standards (NAAQS) and an attainment area subject to a maintenance plan for the Carbon Monoxide and PM_{10} NAAQS. Hydrographic Areas 164A, 164B, 165, 166, 167, 212, 213, 214, 216, 217, and 218 (excluding the Moapa River Indian Reservation and the Fort Mohave Indian Reservation) are attainment areas subject to a maintenance plan for the 1997 ozone NAAQS. Clark County is in attainment/unclassifiable for the $PM_{2.5}$, Sulfur Dioxide, Lead, Nitrogen Dioxide, and 2008 ozone NAAQS.

Although the project area is located in Nye County and outside of our jurisdiction, DES is concerned about the impacts of fine particulate matter (PM_{10}) in the form of windblown and vehicle-generated dust if appropriate dust control measures are not applied to the project. Because the project is located in a high-wind, desert area, wind erosion and PM_{10} entrainment from disturbed areas and unpaved roads occur at a higher rate than normal, allowing impacts to the Las Vegas Valley in extreme cases. DES requests that any impacts to air quality as a result of surface-disturbing and other project activities be analyzed and mitigated through the implementation of appropriate water erosion and dust control measures and other project-specific measures and best management practices for any area where the deserts natural crust is broken.

Thank you for the opportunity to review and comment on this project. If you have further questions, please contact me at 702-455-3206.

Sincerely,

Araceli Pruett

Araceli Pruett, Senior Planner
Division of Air Quality

From:	Araceli Pruett
To:	BLM_NV_SND_EnergyProjects@blm.gov
Subject:	Copper Rays Solar Project
Date:	Wednesday, December 22, 2021 11:30:00 AM
Attachments:	20211222 Clark County DES Coppe[redacted]s Solar Project Comment Letter.pdf

Good Morning,

Please see the attached letter concerning the above-described project. If you have any questions, please let me know.

Thanks,

Araceli Pruett, Senior Planner
Clark County Department of Environment & Sustainability
Division of Air Quality
4701 West Russell Road, Suite 200
Las Vegas, NV 89118-2231
(702) 455-3206 – desk
(702) 455-5942 – front desk
(702) 383-9994 – fax

From:	BLM_NV_SND_EnergyProjects
To:	Araceli Pruett
Subject:	Automatic reply: [EXTERNAL] Copper Rays Solar Project
Date:	Wednesday, December 22, 2021 11:31:56 AM

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.

This email is monitored, if you are seeking additional information we will get back to you as quickly as possible. Thank you for your interest in public lands.

Energy & Infrastructure Team
Southern Nevada District
Bureau of Land Management

From:	Reynolds (DEVA), Mike L
To:	BLM_NV_SND_EnergyProjects
Cc:	Rozzell, Lara R; Lee, Lena FS; Wines, Abigail (Abby); Sappington, Johnny (Mark); Ransel, Beth E; NPS PWR NEPA Compliance
Subject:	Death Valley NP - Comments on upcoming BLM Energy Project (Copper Rays)
Date:	Wednesday, December 21, 2022 11:11:22 AM
Attachments:	NPS_Comments_NOI_C[redacted]er Rays_2022.12.01.pdf

Howdy - Please see Death Valley NP comments on upcoming proposed Solar Energy Project.

Thanks,
-Mike

Mike Reynolds
Superintendent
Death Valley National Park

IN REPLY REFER TO:
1.D (DEVA)

Memorandum

To: Project Manager, Bureau of Land Management Southern Nevada District Energy & Infrastructure Team (bransel@blm.gov)

From: Superintendent, Death Valley National Park

Subject: Notice of Intent for the Copper Rays Solar Project

The National Park Service (NPS) appreciates the opportunity to provide scoping comments to the Bureau of Land Management (BLM) on a Notice of Intent to prepare an Environmental Impact Statement under the National Environmental Policy Act (NEPA) for the Copper Rays Solar Project (the project). As an active conservation partner with federal and non-federal agencies and organizations, we offer these comments towards the continued environmental health of our public lands and economic sustainability of our deserts.

The project is one of a series of new and proposed solar projects located east of Death Valley National Park (DVNP) in the Pahrump Valley. The National Park Service (NPS) recognizes the important role that renewable energy development plays in the global response to climate change, and to the economic and environmental health of the Mojave Desert areas in Nevada and California.

Concern: The NPS is concerned about cumulative effects to the shared landscape and NPS resources. Rising interest in solar energy development could further impact the following resources at DVNP:

- Water availability, particularly groundwater availability – Water use for solar energy development and operations may strain already overallocated groundwater basins. The most recent groundwater model developed by the United States Geological Survey, Death Valley version 3, suggests the groundwater basin in the Pahrump Valley is interconnected and water withdrawals in the area may affect water levels to discharge areas supporting sensitive desert riparian ecosystems at Furnace Creek in Death Valley NP and the Amargosa Wild and Scenic River.

Recommendation: The NPS recommends that the BLM consider the cumulative impacts already analyzed in addition to all the proposed utility-scale transmission in the vicinity of the proposed project. Furthermore, due to the intense development interest in the Pahrump Valley, the NPS recommends the analysis include all proposed and pending projects, including those in the bidding and research phase or put on hold. Please evaluate the cumulative effects to water availability with respect to the resources and values of DVNP.

The NPS administers DVNP under authority of the 1916 Organic Act and the 1994 California Desert Protection Act, for the long-term preservation of the park's natural and cultural resources, and to provide for the public enjoyment of these lands. In 2019, over 1.7 million visitors came to the park, generating over $147 million of local economic activity and supporting over 1,700 jobs in the area. Visitors come from around the world to participate in activities at the park that range from hiking to stargazing to camping.

The NPS appreciates the ongoing coordination with BLM and looks forward to additional opportunities of mutually beneficial participation. By addressing impact topics on NPS lands and NPS-administered sites, we can provide the utmost protection of resources and the visitor experience. If you have any questions or need additional information, please contact DVNP Superintendent, Mike Reynolds (mike_reynolds@nps.gov), or External Energy & Minerals Specialist, Lena Lee (lena_lee@nps.gov).

From:	Hafen II, Gregory T. Assemblyman
To:	BLM_NV_SND_EnergyProjects
Subject:	[EXTERNAL] Copper Rays Solar Project - Public Comment Period
Date:	Thursday, December 29, 2022 12:44:26 PM
Attachments:	~~Opposition to Copper Rays Solar Project.pdf~~

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

BLM Pahrump Field Office,

Attached is my opposition letter to the Copper Rays Solar Project.

Respectfully,

Gregory T. Hafen II
Nevada State Assembly
Office: 775.727.1629
Email: Gregory.Hafen@asm.state.nv.us
5250 Hafen Ranch Road
Pahrump, NV 89061

GREGORY T. HAFEN II
ASSEMBLYMAN
District No. 36

COMMITTEES:
Member
Ways and Means
Health and Human Services
Revenue

State of Nevada Assembly

Eighty-First Session

DISTRICT OFFICE:
5250 Hafen Ranch Road
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Twitter: @GHafenII

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401 South Carson Street
Carson City, Nevada 89701-4747
Office: (775) 684-8805
Fax No.: (775) 684-8533
Email: Gregory.Hafen@asm.state.nv.us
www.leg.state.nv.us

December 29, 2022

Bureau of Land Management, Southern Nevada District Office
Attn: Copper Rays Solar Project
4701 North Torrey Pines Drive
Las Vegas, Nevada 89130

To Whom It May Concern:

As the Nevada State Assemblyman for District 36, I represent and speak out on behalf of over 73,000 Nevadans regarding issues that affect our community. I want to take this time to express my opposition to the Copper Rays Solar Project. The concerns of my constituents and myself include, but are not limited to: potential long-term impacts of the project to the quality of life and cultural landscape for tribal lands and others who live in the vicinity of the project; environmental impacts that could have deleterious effects to the native flora and fauna, some of which are protected species; potential air and noise pollution from construction equipment and vehicles; and potentially destructive consequences and limited access to the Old Spanish National Historic Trail and other public lands. I am concerned that the voices advocating for development are increasingly drowning out those of us in rural Nevada.

At the same time if the project continues to move forward, I would like to respectfully request that the BLM collaborate with the Nye County Board of Commissioners to develop an agreement to mitigate the closure of public lands, any impacts to air and water resources, and potential loss of property taxes. This collaborative effort will foster an exchange of information and ideas among policy stakeholders, maximize resources, and develop a more expedient, systematic framework for an implementation plan.

Thank you for your time and consideration of this matter. Please email me at Gregory.Hafen@asm.state.nv.us if you would like to further discuss my opposition to the Copper Rays Solar Project. I would be happy to expand upon my comments above and be of any other assistance that may be helpful to you in your consideration of the Copper Rays Solar Project.

Sincerely,

Gregory T. Hafen II
Nevada State Assemblyman

GTH/tlc:CW230398

From:	John Wagner
To:	BLM_NV_SND_EnergyProjects
Cc:	James Chrisley; Terry Ferrell; Christa Schueler; brandall@kaplankirsch.com; lpotter@kaplankirsch.com; Wirthlin, Whitney J
Subject:	[EXTERNAL] Copper Rays Solar Project Environmental Impact Statement Scoping Comments
Date:	Wednesday, January 11, 2023 7:20:43 AM
Attachments:	CCDOA Commen[redacted]ping – [redacted]per Rays EIS.pdf

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Please see the attached CCDOA EIS scoping comments on the Copper Rays Solar Project.

Feel free to contact me directly on my office line or cell if you have any questions or concerns.

Kindly,

John M. Wagner, Ph.D.

Airport Program Administrator - SNSA
Strategic Planning I Director's Office
Clark County Department of Aviation
Office: (702) 261-5732 I Cell: (725) 285-7374
johnw@lasairport.com

Department of Aviation

ROSEMARY A. VASSILIADIS
DIRECTOR

POSTAL BOX 11005
LAS VEGAS, NEVADA 89111-1005
(702) 261-5211
FAX (702) 597-9553

January 11, 2022

Whitney Wirthlin
Attn: Copper Rays Solar Project
Bureau of Land Management (BLM)
Las Vegas Field Office
4701 North Torrey Pines Drive
Las Vegas, NV 89130-2301

Transmitted via email to:
BLM_NV_SND_EnergyProjects@blm.gov

RE: Copper Rays Solar Project Environmental Impact Statement Scoping Comments

Dear Ms. Wirthlin:

The Clark County Department of Aviation (CCDOA) wishes to thank you for the opportunity to provide comments as a cooperating agency on the Environmental Impact Statement (EIS) and a Resource Management Plan Amendment for the Proposed Copper Rays Solar Project. We understand that the project is located on 5,050 acres of BLM-managed public land in Nye County, Nevada, southeast of the town of Pahrump and 40 miles west of Las Vegas and includes a photovoltaic (PV) solar power generating facility with battery storage and interconnection to the regional transmission system.

Based on our review of the project information, we have identified the following potential impacts and recommendations:

- Potential Obstacles Associated with Construction

  The project description identifies the need for a five-mile 230 kV transmission line from the site to the Gamebird substation. The transmission line includes towers estimated to be approximately 125 feet above the ground, which will run in the vicinity of the Caas Private Airport (NV98). The design and location of the line should be in harmony with the airport and not create a hazard to aircraft operations. We recommend that the 7460-1 - *Notice of Proposed Construction or Alteration* form be filed with the Federal Aviation Administration (FAA) prior to construction.

  Although the information provided indicated that the facility would connect to an existing substation for this phase of the project, it is not clear if the cumulative effects of the entire project, or this project combined with other solar projects in the area, will drive the need for additional transmission line infrastructure. An analysis of transmission line requirements considering the cumulative power distribution needs of the project combined with the needs of other proposed energy projects in the area is recommended. The analysis should indicate whether new powerline infrastructure is needed. If new infrastructure is necessary, further analysis of the airspace impacts of the transmission towers is required in accordance with the Title 14 Code of Federal Regulations Part 77 – *Safe, Efficient Use, and Preservation of the Navigable Airspace*.

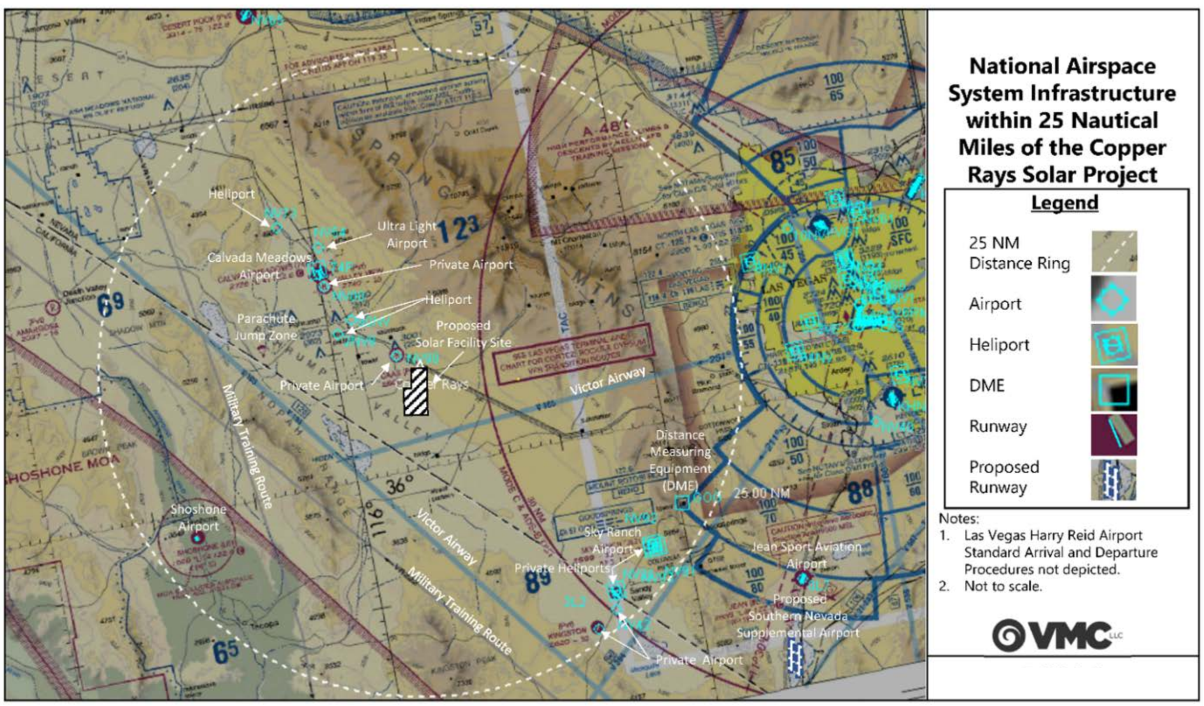
- <u>Panel Reflection</u>

  Another potential impact is the panel reflection of sunlight resulting in glare. The full extent of glare-related problems cannot be determined with the current information provided. The concern is that the reflection from the panels may interfere with the aviation operations around the proposed development in VFR corridors used by pilots to navigate to and from airports, jump zones in the area, and with operations associated with the future flight procedures associated with the Southern Nevada Supplemental Airport (SNSA).

  The reflections of this project and the other proposed projects (e.g., the Rough Hat Clark Project) may cumulatively create significant reflections in areas where aircraft operate as shown in **Exhibit 1**. Therefore, these sites should be reviewed together when evaluating National Airspace System impacts.

  In addition to filing a 7460-1 form to the FAA, it is recommended that a glare study be conducted based on the specific PV panels to be used at the plant, evaluating the reflection of the sunlight throughout the day and the potential reflective impacts on the aviation infrastructure and operations to include SNSA.

Exhibit 1



- <u>Dust from Proposed Construction</u>

  As standard with PV projects, the 72-month construction period may generate significant increases in dust and traffic starting winter of 2024 through the winter of 2025/2026. This is assuming a construction start date of spring 2024. Dust related to construction may interfere with the aviation infrastructure around the proposed development, including VFR routes used to transition from airport to airport in the vicinity of the facility.

  Further study on the impact of dust related to the project's construction is recommended.

Again, we thank you for the opportunity to provide comments on this project as a cooperating agency and look forward to our continued participation throughout this process. If you have any additional questions or concerns, please contact John Wagner at johnw@lasairport.com or (702) 261-5732.

Sincerely,

John M. Wagner

John M. Wagner, Ph.D.
Airport Program Administrator - SNSA
Clark County Department of Aviation

cc: J. Chrisley, CCDOA
T. Ferrell, CCDOA
C. Schueler, CCDOA
L. Potter, KKR
B. Randall, KKR

From:	Megan R. Labadie
To:	BLM_NV_SND_EnergyProjects
Cc:	Wirthlin, Whitney J; Klein, Matthew D
Subject:	[EXTERNAL] Nye County Comments, Copper Rays Solar Project - DOI-BLM-NV-S030-2022-0009-EIS
Date:	Wednesday, January 11, 2023 11:59:48 AM
Attachments:	~~Nye Comments [redacted] Rays Solar.pdf~~

Please see our attached comments for the subject solar development project. Nye County appreciates the opportunity to participate in the NEPA process with BLM. Kindly contact us with any questions or if further information is necessary.

Regards

Megan Labadie
Administrative Technical Coordinator
Nye County Natural Resources
2101 E. Calvada Blvd., Ste. 100
Pahrump, NV 89048
(775) 751-4355

Nye County Scoping Comments
for the
Copper Rays Solar Project
NEPA Number DOI-BLM-NV-S030-2022-0009-EIS
January 11, 2023

1) The proponent must request a Special Use Permit from the Nye County Planning Department subject to approval as established in Nye County Code Title 17 Chapter 10.

2) The proposed area for development will remove public lands indefinitely from multiple use. The Pahrump Regional Planning District (PRPD) Master Plan Update (2014) identifies the area for County disposal nomination; a nomination provided to BLM predating the proponent's application. The proponent should consider an alternative, more remote area for development and mitigate the visual impacts to the desert and mountain landscape to the maximum extent possible, as the project location is very unfavorable to the nearby community of Pahrump.

3) The County strongly suggests the proponent seek PV panels for the project that are manufactured by a company which also recycles broken, damaged, or otherwise decommissioned panels. There is neither sufficient landfill capacity, nor the ability to accept solar waste in Nye County. This comment applies to the disposal of lithium-ion batteries, which the EPA considers hazardous waste, as well as waste associated with construction and decommissioning. A well-established operation disposal plan in addition to the decommissioning plan should clearly describe what the proponent plans to do with any waste coming from the project in a manner that does not burden the County's waste facilities.

4) The proponent should be extremely specific as to where the water is coming from, how it establishes the estimated 800 AF water for full construction and 16 AFA estimate for operations and maintenance, and what should happen if the proponent requires more water than anticipated. Nye County is aware that the proponent will seek water from existing water rights holders but strongly recommends a review of the project's water use, estimate, and source with the Nye County Water District regarding the water required for this project. The cumulative impacts of all proposed solar development using water within Basin 162 are significant.

5) In the PRPD Master Plan Update (2014), the project area is designated BLM managed Multiple Use. The Land use designations, descriptions and objectives are as follows (*bold added*):

LAND USE DESIGNATIONS, DESCRIPTIONS AND OBJECTIVES

1. BLM Multiple Use Area
   BLM-MUA Purpose: To identify potential mining areas, and lands to be reserved for State, Nye County, Nye County Water District, the Town of Pahrump for future development of public facilities, public educational facilities, renewable energy projects, and public infrastructure, industrial, commercial or residential development **and to protect these areas from encroachment by incompatible uses.**

   Nye County and BLM must review permit requirements to lease or otherwise use such land for compliance with the goals and policies of this Master Plan and the BLM Resource Management Plan of the Las Vegas District to ensure any use, temporary or permanent, will not jeopardize or negatively impact the historic, scenic, archaeological, habitat, cultural, water resources and air quality of the Pahrump Valley.

BLM must consider local land use plans when considering proposed projects.

6) In addition to removing public lands from multiple use, this project will also remove desert habitat and wildlife, with no responsibility of restoration of the land.

7) The BLM has basic stewardship responsibilities to identify and protect visual values on all public lands. The Visual Resource Inventory is a process BLM created to determine scenic values within the SNDO. The proposed project is located within a Class III VRM; "The objective of this class is to partially retain the existing character of the landscape. 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." Cumulative impacts from surrounding current and proposed solar development projects significantly impact the visual quality of the area and should be evaluated and mitigated in the EIS, as an industrial solar field is not a moderate change to the characteristic of the landscape and are predominate features as viewed by the casual observer and surrounding residences.

8) Dust control is an ongoing health hazard resulting from solar development during construction, specifically Yellow Pine Solar, which has caused poor air quality in the community of Pahrump despite having a Dust Control Plan in compliance with the Clark County Dust Control Permit. Dust abatement and enforcement should be clearly established and laid out for the proposed project, including mitigation and consequences of any dust control issues within the community resulting from the project. Grading, mowing, and cutting of vegetation will exasperate fugitive dust, which affects the health and safety of the community and the integrity of the topsoil.

9) The proponent's POD states, "where water is insufficient to control dust, soil stabilizers approved by BLM and USFWS will be used within the fenced solar field to control dust to County standards." Please provide data of how much water would be saved should the proponent use soil stabilizers and how stabilizers may affect native habitat and wildlife.

10) Solar panels and battery storage systems have the potential to start fires. This project abuts the town of Pahrump. As the project will likely only have 1 or 2 long term workers for site operation who will not always be on site, fire mitigation and prevention should be a prioritized plan as part of the proposed project for public health and safety purposes.

11) The project is located within an area where the community and tourists enjoy OHV recreational access. The County shares in the Nevada Offroad Associations comments and concerns in their letter to BLM (BLM_NV_SND_EnergyProjects@blm.gov) dated January 7, 2022.

Specifically, *"It has been reported to NVORA by the Nevada motorized community that previous special use permits for motorized recreation use have been rejected on the basis that there are biological and cultural concerns in the area of the proposed commercial activity development of the Copper Rays Solar Project. NVORA questions the scoping process that has determined that the ground disturbing activities of the commercial installation of the Copper Rays Solar Project will not adversely affect the biological and cultural values identified in previous scoping processes of lesser ground disturbing activities of proposed OHV recreational use. The inequality that the BLM continues to display with regard to the protection and management of motorized recreation values in the State of Nevada is unacceptable.*

"NVORA also recognizes that the proposed area is the footprint of the physical structures only and does not include previously identified mitigating concerns that have increased the footprint of other Nevada solar projects to date. Other Nevada commercial solar project footprints became much larger when nearby authorized dust creating activity inhibited the projected solar energy production thereby permanently removing additional motorized recreation values from inventory that was not part of the original project scoping process and proposal presented to the public and surrounding community leadership. The rural nature of the surrounding communities of the Copper Rays Solar Project, and others like it, is such that the State of Nevada and national economic development agencies have unequivocally determined that outdoor recreation is a major and vital component of established and growing rural tourism-based economies. Maintaining the existing recreation inventory of motorized public land access, motorized trails, and Nevada's large open and uninterrupted spaces and views is a priority to maintain and stimulate the rural tourism economies of the State of Nevada.

"Due to the proposed permanent loss of the State identified economic value of motorized recreation trails and public access, NVORA and the Nevada motorized recreation community insist that a more proactive and comprehensive proposal include a plan to preserve the miles of motorized trail and acres of uninterrupted views that the Copper Rays Solar Project and future solar projects will permanently remove from BLM recreation value inventory. Replacing motorized recreation areas and trail systems with recreation areas that restrict motorized use is not an acceptable land exchange. NVORA, Nevada rural community citizens and the motorized recreation community is willing and prepared to be fully engaged in actively providing a proposal for alternative motorized trails and open uninterrupted spaces in cooperation with BLM land managers to be developed at the expense of the Copper Rays Solar, LLC."

12) The proponent estimates construction will take 54 months. This is a significant nuisance to the neighboring residents in southern Pahrump who will be most impacted by this project on environmental and public health and safety levels. In addition, it will also lower the property value of nearby homes, affecting the local and regional economy. Again, the County suggests relocation of this project to a more suitable area away from the community of Pahrump.

13) The proponent must adequately demonstrate an alternative, practicable site for project development and sufficient socio-economic justification for the adverse water, recreational, and property value impacts it would cause.

From:	John Wagner
To:	BLM_NV_SND_EnergyProjects
Cc:	James Chrisley; Terry Ferrell; Christa Schueler; lpotter@kaplankirsch.com; Bob Randall
Subject:	[EXTERNAL] Copper Rays Solar Project Environmental Impact Statement, Supplemental Scoping Comments
Date:	Friday, January 13, 2023 2:01:24 PM
Attachments:	CCDOA Supplementa[illegible] Copper Rays EIS.pdf VMC Copper Ra[illegible] 12312022.pdf

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Please see the attached CCDOA EIS supplemental scoping comments and report on the Copper Rays Solar Project.

Feel free to contact me directly on my office line or cell if you have any questions or concerns.

Kindly,

John M. Wagner, Ph.D.

Airport Program Administrator - SNSA
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LAS

Department of Aviation

ROSEMARY A. VASSILIADIS
DIRECTOR

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January 13, 2023

Whitney Wirthlin
Attn: Copper Rays Solar Project
Bureau of Land Management (BLM)
Las Vegas Field Office
4701 North Torrey Pines Drive
Las Vegas, NV 89130-2301

Transmitted via email to:
BLM_NV_SND_EnergyProjects@blm.gov

RE: Copper Rays Solar Project Environmental Impact Statement, Supplemental Scoping Comments

Dear Ms. Wirthlin,

On Wednesday, January 11, 2023, Clark County Department of Aviation (CCDOA) submitted scoping comments as a cooperating agency on the Environmental Impact Statement (EIS) and Resource Management Plan Amendment for the Proposed Copper Rays Solar Project.

I am writing to supplement those comments with the attached report prepared by CCDOA's expert consultant, Mr. Robert Varani of VMC LLC, regarding the potential impacts of the Copper Rays Solar Project on aeronautical operations in the area, including the Southern Nevada Supplemental Airport (SNSA). This expert report contains information and recommendations that CCDOA requests that BLM consider in preparing the EIS for the Proposed Copper Rays Solar Project. Specifically, VMC LLC recommends that the EIS include:

- A glare study based on the specific PV panels to be used at Copper Rays, evaluating the reflection of sunlight throughout the day and the potential reflective impacts on aviation operations in the area. In particular, VMC LLC recommends that the glare study consider the cumulative effects of all proposed solar panels in the area and include proposed instrument flight procedure designs associated with the SNSA;

- An analysis of transmission line requirements considering the cumulative power distribution needs of the Sopper Rays Solar Project, combined with the needs of other energy projects contemplated in the area. The analysis should indicate whether new powerline infrastructure is needed for the cumulative needs of all the proposed energy projects, and, if so, further an analyze the airspace impacts of the transmission towers;

- A requirement that the project sponsor adhere to the Notice of Proposed Construction process and file the proper 7460-1 forms with the FAA, given the potential glare issues; and

- Consideration of Copper Rays Solar Project and Rough Hat Solar Project together to evaluate the cumulative impacts of the two projects on the national airspace system, given the nature of FAA reviews and the close proximity of the sites to one another.

Thank you for the opportunity to submit these supplemental scoping comments and for your consideration. We look forward to our continued participation as a cooperating agency for the Copper Rays Solar Project. If you have any questions or concerns, please do not hesitate to contact me at johnw@lasairport.com or (702) 261-5732.

Sincerely,

John M. Wagner, Ph.D.
Airport Program Administrator – SNSA
Clark County Department of Aviation

ENCLOSURE

cc: J. Chrisley, CCDOA
T. Ferrell, CCDOA
C. Schueler, CCDOA
L. Potter, KKR
B. Randall, KKR

To: Lori Potter, Kaplan Kirsch Rockwell
From: Robert Varani, VMC LLC; Stuart Hansen, VMC LLC; Angela Merrifield, VMC LLC
CC:
Date: December 31, 2022

Re: Scoping Comments for Copper Rays Solar Project Environmental Impact Statement

Introduction

This memo aims to advise the Clark County Department of Aviation on the scoping elements of the Copper Rays Solar Facility Environmental Impact Study (EIS). Kaplan Kirsch Rockwell (KKR) has hired VMC LLC (VMC) to advise on the plant's potential impacts on aeronautical operations in the area.

Methodologies used to prepare this memo included an initial review of the National Airspace System (NAS) infrastructure within 25 nautical miles of the project, a review of Federal Aviation Administration (FAA) regulations, Orders, and Advisory Circulars, the project description as detailed by the Bureau of Land Management (BLM), the revised Plan of Development dated October 7, 2022, and attendance of project scoping public hearings on December 6 and December 7, 2022. The following paragraphs describe VMC's review of the project and recommendations for scoping items to be included in the EIS.

Project Description

The Copper Rays Nye County solar project is one of six projects proposed for development in an area located southeast of Pahrump, Nevada (NV). The project includes two phases spanning over 5,100 acres of land and consists of a 700-megawatt photovoltaic solar electric generating facility with numerous solar panels, a battery storage facility, an associated generation tie-line to the Gamebird substation located north of the project site, and access road facilities. Construction of the facility is estimated to occur over 72 months across two phases. It will begin upon approval of the Governor's Consistency Review and a Record of Decision, anticipated in the spring of 2024. **Exhibit 1** shows the project site plan for the solar facility, and **Exhibit 2** details the development by project phase.

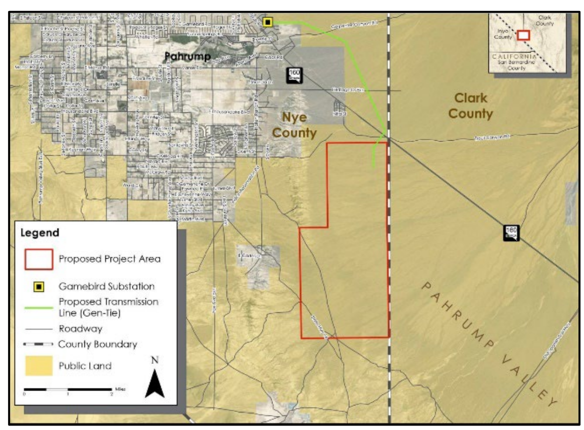

Exhibit 1 – Copper Rays Solar Facility Site Plan

Management • Engineering • Research • Technical Services
1650 West End Blvd. | Suite 100 | St. Louis Park, MN 55416
Phone: 763.259.5767 | email: info@vmcllc.com

NAS Infrastructure in the Vicinity of the Project

Based on data from the FAA National Flight Data Center (NFDC), the following NAS infrastructure exists within 25 miles of the proposed site:

- Three public-use airports,
- Four private-use airports,
- One ultralight airport,
- One public-use heliport,
- Seven private-use heliports,
- Three Victor (V) airways,
- One parachute jump zone,
- Two military training routes, and
- Five Standard Terminal Arrival Route procedures for the Las Vegas Harry Reid International Airport

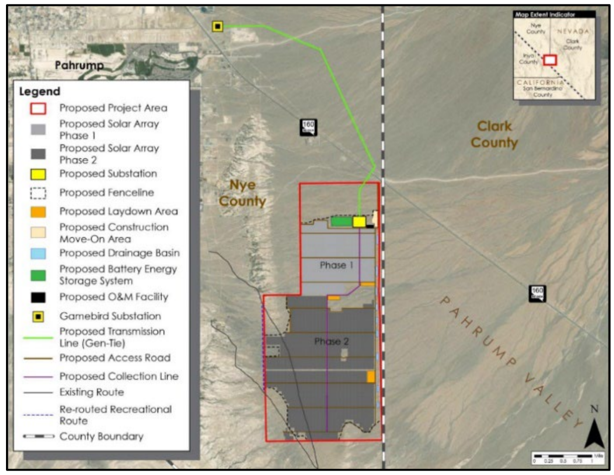

Exhibit 2 – Copper Rays Solar Facility Development by Phase

Other facilities to consider are the Jean Sport Aviation Airport and the proposed Southern Nevada Supplemental Airport located within approximately 30 NM of the project. **Exhibit 3** shows this infrastructure graphically.

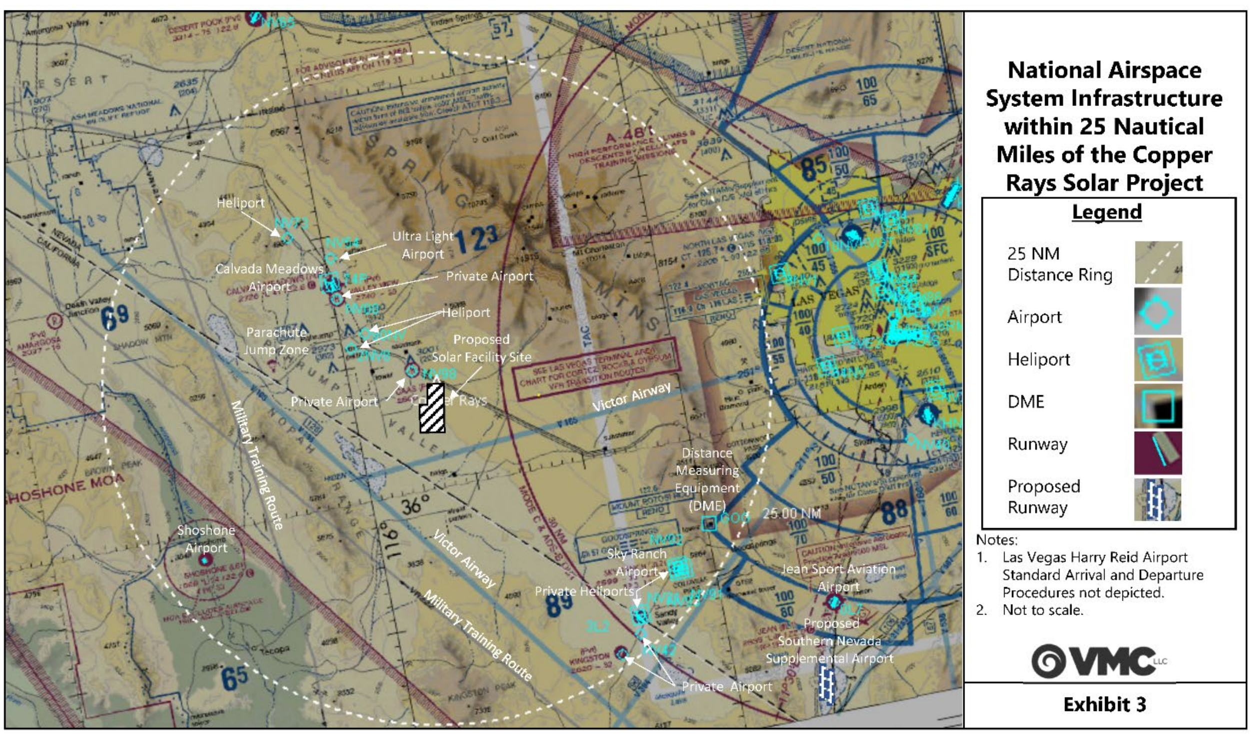

Exhibit 3

Federal Aviation Administration Regulations
The FAA is the leading United States (US) agency in charge of the protection and safety of navigable airspace. FAA defines navigable airspace as "the airspace at or above the minimum altitudes of flight that includes the airspace needed to ensure safety in the takeoff and landing of aircraft." Congress has charged the FAA with administering this airspace in the public interest as necessary to ensure the safety of aircraft and its efficient use. As owners and operators of multiple airports and recipients of Federal Airport Improvement Grants, the Clark County Department of Aviation is also responsible for protecting navigable airspace and ensuring safety.

The primary document for airspace protection is Title 14 Code of Federal Regulations Part 77 – *Safe, Efficient Use, and Preservation of the Navigable Airspace* (CFR Part 77). CFR Part 77 provides guidance detailing the protection of airspace considering obstacles, electromagnetic interference to aviation navigational, communications, and surveillance systems, and ocular interference resulting from smoke, dust, glare, or light. VMC applied these standards as a basis for our recommendations for EIS scoping elements.

Possible Impacts
Construction of the solar facility may create impacts based on tall structures, panel reflections, and dust.

- **Tall Obstacles Associated with Construction** – The project description identifies the need for a five-mile 230 kV transmission line from the site to the Gamebird substation. The transmission line includes towers estimated to be approximately 125 feet above the ground, which will run in the vicinity of the Caas Private Airport (NV98). The design and location of the line should be in harmony with the airport and not create a hazard to aircraft operations. Further, it is recommended that FAA 7460-1 Notice of Proposed Construction forms be filed prior to construction.

  Although the information provided on the BLM website and presented in the Public Hearings has indicated that the facility will connect to an existing substation for this phase of the project, it is not clear if the cumulative effects of the entire project (or the project with others in the area), will drive the need for additional transmission line infrastructure. Further analysis should be prepared and presented.

- **Panel Reflection -** A more permanent concern is the panel reflection of sunlight resulting in glare. The full extent of glare-related problems cannot be determined with current information. Further study will need to define specific panel/coating types and other specific design features. However, the south-oriented panels may reflect uncollected light into the southern sky and, following the sun, sweep across an even

1650 West End Blvd. | Suite 100 | St. Louis Park, MN 55416
Phone: 763.259.5767 | email: info@vmcllc.com

wider area. The glare can be more intense the less perpendicular it is to the sun's rays, and a fixed axis project may reflect into the sky for an extended period with higher intensity glare. Reflections of the solar panels from this site may interfere with the aviation operations around the proposed development in VFR corridors used by pilots to navigate to and from airports and jump zones in the area and with operations associated with the future flight procedures associated with the Southern Nevada Supplemental Airport. The reflections of this project and the other proposed projects (e.g., the Rough Hat Project) may cumulatively create significant reflections in areas where aircraft operate. Therefore, these sites should be reviewed together when evaluating NAS impacts.

- **Dust and from Proposed Construction -** As standard with PV projects, the 72-month construction period may mean significant increases in dust and traffic starting winter of 2024 through the winter of 2025/2026. This is assuming a construction start date of fall 2024. Dust related to construction may interfere with the aviation infrastructure around the proposed development, including VFR routes used to transition from airport to airport in the vicinity of the facility.

Scoping Recommendations
VMC recommends further study on the impact of panel reflection, potential obstacles, and dust related to the project's construction on the aviation infrastructure. Specifically, the EIS should include the following:

- A glare study based on the specific PV panels to be used at the plant, evaluating the reflection of the sunlight throughout the day and the potential reflective impacts on aviation operations in the area. The glare study should consider the cumulative effects of all proposed solar panels in the area and include proposed instrument flight procedure designs associated with the Southern Nevada Supplemental Airport
- An analysis of transmission line requirements considering the cumulative power distribution needs of the project combined with the needs of other proposed energy projects in the area. The analysis should indicate whether new powerline infrastructure is needed for the cumulative needs of all the proposed energy projects. If new infrastructure is necessary, further analysis of the airspace impacts of the transmission towers is required.
- Because of the potential glare issues, we recommend that it be a requirement in the EIS and Record of Decision that the project sponsor adheres to the Notice of Proposed Construction process and files the proper 7460-1 forms to the FAA.
- Because of the nature of FAA reviews and the close proximity of the sites, we recommend the Copper Rays Solar Project and Rough Hat Solar Project be evaluated together to consider the cumulative impacts on the NAS.

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From: McPherson, Ann
To: Wirthlin, Whitney J; BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] EPA"s scoping comments on the proposed Copper Rays Solar Project
Date: Friday, January 13, 2023 3:23:29 PM
Attachments: 2023-01-13_EPA[redacted]Rays.signed.pdf

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

Good afternoon, Whitney –

Attached please find a copy of EPA's scoping comments on the proposed Copper Rays Solar Project. Thank you for providing us with the opportunity to provide feedback. Please contact me if you have any questions about our comments.

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

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

January 13, 2023

Whitney Wirthlin
Bureau of Land Management
Pahrump Field Office
Attn: Copper Rays Solar Project
4701 North Torrey Pines Drive
Las Vegas, Nevada 89130-2301

Subject: Scoping Comments for the Copper Rays Solar Project, Nye County, Nevada

Dear Whitney Wirthlin:

The U.S. Environmental Protection Agency has reviewed the Federal Register Notice published on November 14, 2022, requesting comments on the Bureau of Land Management's decision to prepare an Environmental Impact Statement and Amend the Las Vegas Resource Management Plan for the proposed Copper Rays Solar Project in Nye County, Nevada. Our comments are provided pursuant to the National Environmental Policy Act, Council on Environmental Quality regulations (40 CFR Parts 1500-1508), and our NEPA review authority under Section 309 of the Clean Air Act.

The EPA is a cooperating agency under NEPA for this project. We appreciate the opportunity to highlight our concerns and recommendations to the BLM. The proposed Copper Rays Solar Project would consist of a 700-megawatt solar photovoltaic project, battery storage facilities, gen-tie line, and access roads located on approximately 5,127 acres of BLM-administered lands southeast of the Town of Pahrump and about 40 miles west of Las Vegas. The proposed project would be constructed in two phases – Copper Rays 1 (200 MWs) and Copper Rays 2 (500 MWs) – and would include an approximately 5-mile gen-tie to the Gamebird Substation.

The EPA supports renewable energy resource development consistent with Executive Orders 13990 and 14008 and the Energy Act of 2020. Using renewable energy resources, such as solar power, can help the nation meet its energy requirements while reducing greenhouse gas emissions. The EPA also supports the vision that the next generation of utility-scale solar projects will utilize alternative (non-traditional) construction methods that can significantly reduce intensive project impacts. Replacing harmful site preparation techniques like 'grading' and 'disk and roll' with less intrusive measures such as 'overland travel' within solar panel array areas, can reduce adverse ecosystem effects without significantly impeding project development or impacting worker safety.

In the Federal Register Notice the BLM requests assistance with identifying potential alternatives to the Proposed Action. The proposed Copper Rays Solar Project would be situated within the Pahrump Valley in direct proximity to several other proposed utility-scale solar projects (Rough Hat Clark County, Rough Hat Nye County, Golden Currant, Mosey) and the Yellow Pine Solar Project which is under construction. Given this situation, the EPA supports an alternative that not only minimizes environmental impacts on site, but also preserves function and habitat at a landscape level across the combined solar project development area within the Pahrump Valley. For example, desert washes and buffers should be maintained across all project sites, including Copper Rays, thus preserving their value as wildlife passageways and as conduits supporting downgradient microphyll woodlands and mesquite/acacia bosques.

Current best management practices are being developed in the BLM Southern Nevada District that should be considered at all proposed projects in the Pahrump Valley. These BMPs, if utilized, will reduce significant project impacts by preserving soil structure, seed banks, and a set percentage of vegetation (including cacti and yucca), maintaining hydrologic flow patterns on site, and conserving small wildlife habitat. Using construction techniques that have less impact will also result in the retention of biological soil crusts, reduce air quality impacts from dust, and reduce water use during construction. Enhancing permeability across the combined solar project development area within the Pahrump Valley will reduce the overall impacts to wildlife.

We appreciate the opportunity to provide scoping comments on this project. Attached please find our detailed comments. When the Draft EIS is released for public review, please send one copy to the address above (mail code: TIP-2) and notify me. If you have any questions, please contact me at (415) 972-3545 or mcpherson.ann@epa.gov.

Sincerely,

Ann McPherson
Environmental Review Branch

Enclosure: EPA's Detailed Scoping Comments

U.S. EPA DETAILED COMMENTS ON THE SCOPING NOTICE FOR THE COPPER RAYS SOLAR PROJECT, NYE COUNTY, NEVADA, JANUARY 13, 2023

Purpose and Need

In the Draft Environmental Impact Statement, clearly identify the underlying *purpose* and *need* for the proposed project (40 CFR 1502.13). When formulating the *need*, identify and describe the underlying problem, deficiency, or opportunity that the action is meant to address. Describe the criteria used to determine the minimum project size that would be considered feasible to achieve the underlying need. Discuss the proposed project in the context of the larger energy market that this project would serve and discuss how the project would assist Nevada in meeting renewable energy portfolio standards and goals, address anticipated electric demand, and improve reliability and resilience of the Western electric grid.

Alternatives Analysis

A reasonable range of alternatives will include options for avoiding significant environmental impacts. Reasonable alternatives could include, but are not necessarily limited to, alternative configurations and mountings, alternative capacities, alternative site preparation techniques, alternative energy storage options, and gen-tie interconnection options. In the alternatives analysis, describe the approach used to identify environmentally sensitive areas and the process used to designate them in terms of sensitivity. Consider written and verbal comments provided during the scoping process and other public engagement opportunities.

Present the environmental impacts of the proposed action and alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decision maker and the public (40 CFR 1502.14). Quantify the potential environmental impacts of each alternative to the greatest extent possible (e.g., acres of habitat impacted). Consider both short- and longer-term effects, beneficial and adverse effects, as well as effects on public health and safety. Discuss the reasons for eliminating alternatives which are not evaluated in detail.

Potential Alternatives to the Proposed Action

The EPA supports an alternative that minimizes environmental impacts on site and also preserves function and habitat at a landscape level across the combined solar project development area within the Pahrump Valley. Desert washes and buffers should be maintained across all sites, including Copper Rays, thus preserving their value as wildlife passageways and as conduits supporting microphyll woodlands and mesquite/acacia bosques. The EPA also supports the use of 'less impact construction techniques' where topsoil and vegetation are preserved as much as possible. Site preparation techniques like 'grading' and 'disk and roll' should be minimized and replaced with less intrusive measures such as 'overland travel.' Keeping vegetation in place provides a more hospitable habitat for native species and pollinators, stabilizes soil, preserves soil structure, reduces erosion and dust, and reduces the need for restoration.

Cumulative Impacts Analysis

Cumulative impacts are identified in 40 CFR 1508.1(g)(3) as "effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions over a period of time." Cumulative impact analyses describe the threat to resources as a whole, presented from the perspective of the resource instead of from the individual project. Discussions of cumulative impacts are usually more effective when included in the larger discussions of environmental impacts from the action (the environmental consequences chapter), as opposed to discussing cumulative impact analyses in a separate chapter.

In the cumulative impacts analysis, identify how resources, ecosystems, and communities in the vicinity of the project have already been, or will be, affected by past, present, or future activities in the project area. Characterize these resources in terms of their response to change and capacity to withstand stresses. We recommend focusing on resources of concern or resources that are "at risk" and/or are significantly impacted by the project before mitigation. This analysis provides an opportunity to identify potential large, landscape-level regional impacts, as well as potential large-scale mitigation measures.

The CEQ Regulations also require analysis of "reasonably foreseeable environmental trends and planned actions in the area(s)" (40 CFR 1502.15). In the Draft EIS, discuss the influx of proposed solar projects near the town of Pahrump and within Southern Nevada, in general. Consider setting thresholds for development based on maintaining local air quality, groundwater availability, sensitive resources, and critical habitat. Such thresholds can help ensure that areas where significant solar energy production is being considered, as in the Pahrump Valley, do not become so developed as to compromise critical habitat, migration corridors, or intact ecosystem functioning. Ensure that function and habitat are maintained at a landscape level across the combined solar project development area within the Pahrump Valley.

Since the construction and development of multiple solar projects near the town of Pahrump may result in the need for additional housing and services to support the new employment demand, discuss the indirect growth inducing impacts that may occur in conjunction with the proposed Project.

The U.S. Environmental Protection Agency recommends that the Draft EIS identify which resources will be analyzed, which ones are not, and why. For each resource analyzed, we recommend including the following information:

- Identify the current condition of the resource as a measure of past impacts.
- Identify the trend in the condition of the resource as a measure of present impacts. For example, the health of the resource is improving, declining, or in stasis.
- Identify all on-going, planned, and reasonably foreseeable projects in the study areas which may contribute to cumulative impacts.
- Identify the future condition of the resource based on an analysis of impacts from reasonably foreseeable projects or actions added to existing conditions and current trends.
- Identify mitigation measures or conservation management actions that can be consistently and transparently applied to future projects.

Water Resources

Water Supply and Water Quality

The Draft EIS should estimate the quantity of water the project will require during the construction phase and during operations (e.g., cleaning the PV panels during routine maintenance). Describe the source of this water and potential effects on other water users. If groundwater will be used, identify the potentially affected groundwater basin(s), and discuss whether the basin is over-appropriated or has been classified as a 'designated groundwater basin.' Discuss water availability given the rapid influx of renewable energy projects and mining projects in the general area. Evaluate impacts to groundwater recharge, springs or other surface water bodies, groundwater dependent natural resources, biological resources, and the potential for subsidence. If water will be supplied from an off-site source, analyze environmental impacts associated with the transport and storage of such an alternative water supply. Identify available technologies to minimize or recycle water.

Clean Water Act Section 404 Applicability

In the Draft EIS, describe all waters of the U.S. that could be affected by the project alternatives and include maps that clearly identify all waters within the project area. Avoidance of any wetlands/waters of the U.S is strongly recommended. If avoidance is not possible, we recommend early consultation with the U.S. Army Corps of Engineers (Corps) to determine if the proposed project would require a Section 404 permit under the Clean Water Act. If so, it is advisable to ensure that the NEPA alternatives are consistent with the alternatives analysis required under the CWA Section 404 (b)(1) Guidelines. In comparing alternatives, specify the acreages and channel lengths, habitat types, values, and functions of the waters that would be affected. We recommend including a verified jurisdictional determination from the Corps in the Draft EIS if waters cannot be avoided.

Avoidance of Desert Washes and Protection of Mesquite/Acacia Bosques

In addition to avoiding wetlands and waters of the U.S., we recommend careful micro-siting of project components to avoid and protect ephemeral drainages, desert washes, and dry wash woodlands. Desert washes perform a diversity of hydrologic, biochemical, and geochemical functions that directly affect the integrity and functional condition of higher-order waters downstream. Healthy ephemeral washes with characteristic plant communities control rates of sediment deposition and dissipate the energy associated with flood flows. Ephemeral washes also provide habitat for breeding, shelter, foraging, and movement of wildlife. Many plant populations are dependent on these ecosystems and have adapted to their unique conditions. These values are present regardless of whether the washes are deemed jurisdictional under Section 404 of the CWA.

Mesquite and acacia bosques are located in the western section of the Copper Rays site. Desert washes/ ephemeral washes act as conduits carrying water/groundwater to the mesquite/acacia bosques. Preserving desert washes across the site – and their function as conduits – will be essential in protecting the microphyll woodlands. A stormwater drainage plan that blocks flow across the site or that redirects stormwater to detention areas elsewhere will impact the function of the washes and, ultimately, may destroy the mesquite/acacia bosques.

Placement of Panels to Minimize Erosion and Impacts to Site Hydrology

Placement of PV panels within washes could result in erosion, migration of channels, and local scour. To minimize potential impacts associated with erosion, we recommend: 1) avoiding placement of support structures in washes; 2) committing to the use of natural washes in their present location and natural form; 3) utilizing existing natural drainage channels on site in lieu of concrete-lined channels; 4) avoiding microphyll woodlands and mesquite/acacia bosques; 5) including adequate natural buffers for flood control; 6) minimizing the number of road crossings over washes; 7) designing necessary crossings to provide adequate flow-through during storm events; 8) limiting grading; 9) maintaining micro-level topography to the greatest extent possible; and 10) mounting PV panels at sufficient height above ground to maintain natural vegetation.

Incorporating Buffers

We recommend that larger desert washes be given wide buffers so that channels may adjust to new hydraulic conditions without the need for major human-made structures. Within the Yellow Pine Solar Project site, 500-feet buffers were included on both sides of the three main washes to allow for an approximated 1,000-feet corridor over existing washes between subareas. In addition, project facilities at Yellow Pine were offset along Tecopa Road and SR 160 to provide a minimum buffer of 400 feet from both roads. The 400-foot offset was incorporated to provide a safe distance for vehicular traffic, prevent damage of the site from beyond the security fence, and reduce visibility of the site from public use areas. We recommend that the Bureau of Land Management consider similar buffers at the Copper Rays Solar Project and that these stipulations be applied consistently and transparently to all projects under development in the Pahrump Valley.

Flood Control and Sizing Stormwater Infrastructure
Consider in the Draft EIS the impacts of changing precipitation patterns on the proposed project. For example, discuss the anticipated extent and depth of overland flows throughout the development areas given a 100-year flood event as compared to a 500-year event, including where critical infrastructure would be located, so that early consideration may be given to improving the resiliency of the project.

Clean Water Act Section 303(d)
The CWA requires States to develop a list of impaired waters that do not meet water quality standards, establish priority rankings, and develop action plans called Total Maximum Daily Loads (TMDLs) to improve water quality. The Draft EIS should provide information on any CWA Section 303(d) impaired waters in the project area, describe whether the project could contribute to this impairment, and include any mitigation measures that will be implemented to avoid further degradation of impaired waters.

<u>Site Preparation – Minimizing Impacts to Soils and Vegetation</u>
The EPA encourages BLM and the applicant to work cooperatively together to ensure that the amount of surface disturbance is minimized to the greatest extent practicable. The EPA strongly supports implementation of design features that would minimize grading, soil disturbance, and vegetation removal during construction. When soil is disturbed and vegetation is removed – especially in desert environments – soil erosion increases, as well as dust. Removing vegetation also negatively impacts animal species who rely on it for food and habitat. Grading, the most invasive construction technique, can also change the site topography and disrupt natural hydrology and drainage.

Replacing harmful site preparation techniques with less intrusive measures – as has been done at the Gemini Solar Project Site – can reduce adverse ecosystem effects without significantly impeding project development or impacting worker safety. Techniques that have been shown to be effective at reducing impacts to soil and vegetation during construction on site include:

- Utilize 'Overland Travel' as much as possible instead of high-impact methods like disk and roll or grading.
- Assemble as much of the racking material as possible in laydown areas, which minimizes travel along panel rows. Designate primary travel routes between panel arrays – every 3rd row – to minimize disturbance in other rows. Keep disturbance to one primary travel path to avoid zigzagging, which in the long run reduces other impacts.
- Ensure that there are well-trained construction monitors on site focused on ensuring that construction/vehicle trips impacts are minimized.
- Limit grading to specific areas – roads, substation, O&M facilities, laydown areas, some equipment pads, and in discrete areas within the arrays due to structural design limitations.
- Utilize smaller rubber-wheeled vehicles, lightweight skid steers, small cranes, tractors, and rubber-tired forklifts to minimize soil disturbance.
- Keep soils out of drainages, preserve protective buffers alongside washes, and maintain hydrologic flow patterns within the site.

- Mount batteries, transformers, and inverters on elevated platforms to allow soils underneath to remain pervious.
- Bend and pin tortoise fencing instead of trenching it in, to minimize disturbance along the fence line.
- Incorporate propagule islands, patches of intact vegetation and soils that provide seeds and soil microbial propagules, to facilitate revegetation or recolonization of adjacent disturbed areas.
- Construct the project in phases, which reduces dust and allows areas to begin recovery sooner.
- Monitor vegetation recovery on site after construction by developing a Restoration Plan. Use benchmarks and required restoration measures (if much disturbance has taken place) to ensure adherence to Biological Opinion and to ensure sufficient plant growth after construction.

Air Quality

In the Draft EIS, provide a detailed discussion of ambient air conditions (baseline or existing conditions), National Ambient Air Quality Standards, criteria pollutant nonattainment areas, and potential air quality impacts of the project, including cumulative and indirect impacts, for each fully evaluated alternative. Emissions of all air pollutants, including greenhouse gases, should be estimated for construction and operations. Specify emission sources by pollutant from mobile sources, stationary sources, and ground disturbance. Analyze reasonable, practicable mitigation measures to reduce project-related emissions. Typical mitigation measures include design changes to reduce construction and operations emissions, fugitive dust control measures, mobile and stationary source controls, and administrative controls.

Installation of Dust Monitoring Equipment

Given the number of solar projects proposed in the Pahrump Valley, consider installation of real-time PM_{10} dust monitoring equipment (e.g., Desert Sunlight) to monitor dust during both the construction and operational phases of the project. It is also critical to monitor dust during off-hours and non-workdays, as wind events can result in undocumented emission events and potentially hazardous exposures. With a network of monitors across multiple project sites, data can be used to provide a feedback mechanism to develop more effective strategies to further reduce direct and cumulative fugitive dust emissions in the Pahrump Valley. Further recommendations include:

- Ensure that real-time PM_{10} data is accessible.
- Present data within a helpful context (e.g., compared to public health standards).
- Standardize ways to summarize data and identify who will be responsible for that task.
- Identify funding mechanism during project development or consider this as an operational cost.
- Monitors should remain in operation for the lifetime of the project

Valley Fever

Portions of the proposed Copper Rays Solar Project may include areas[1] that contain *Coccidioides immitis*, a fungus causing Valley Fever in humans. Ground disturbing activities associated with the proposed project may result in dispersal of *Coccidioides* spores. Include, in the Draft EIS, a discussion of this potential health and safety impact, as well as measures that can prevent or reduce the risk of exposure to workers and residents.

[1] https://www.cdc.gov/fungal/diseases/coccidioidomycosis/images/valley-fever-map-2017.jpg

Night Skies

In the Draft EIS, consider the value of night skies particularly in rural areas of Nevada, which offer some of the darkest skies and best opportunities for stargazing. We recommend that BLM promote natural dark skies and minimize artificial lighting to preserve these night skies. Light pollution should be reduced as much as possible to minimize disruptions to nocturnal wildlife, impacts to cultural resources, and viewsheds. Use sustainable outdoor lighting principles to the greatest extent possible: Light only *if* you need it; Light only *when* you need it; Light only *where* you need it; Use appropriate color spectra; Use the minimum of light necessary.

Effective techniques for reducing light pollution on the site include:

- Prepare a 'Lighting' or 'Lighting Mitigation Plan' that addresses construction and operational phases of development.
- Commit to full darkness and the use of motion-controlled sensors.
- Use LED warm-colored bulbs (i.e., yellow or amber versus blue or white).
- Make sure bulbs are recessed, fully shielded, full cutoff, and direct all light downward.
- Utilize motion sensors, timers, and dimmers, which can reduce brightness when not in use.
- Identify if reflective tape or other reflective surfaces could serve the same purpose as another light source.

Biological Resources and Habitat Protection

The EPA recommends coordination with the U.S. Fish and Wildlife Service and Nevada Department of Wildlife on matters pertaining to species and habitat protection. We offer the following general recommendations based on our experience with multiple solar projects:

Protected Species and Habitat

In the Draft EIS, identify all petitioned and listed threatened and endangered species and critical habitat that might occur within the project area. The EPA recommends that BLM coordinate with the USFWS to determine whether consultation under Section 7 of the Endangered Species Act would be required. We recommend that the Draft EIS include a biological assessment in an appendix, as well as a description of the progress or outcome of ESA consultation with the USFWS. We recommend that BLM coordinate with the USFWS and NDOW to ensure that current and consistent surveying, monitoring, and reporting protocols are applied in all species protection and mitigation efforts. The Draft EIS should indicate what measures will be taken to protect important wildlife habitat areas from potential adverse effects of proposed activities.

Analysis of impacts and mitigation for listed species should include: 1) baseline conditions of habitats and populations of the covered species: 2) a clear description of how avoidance, mitigation, and conservation measures will protect and encourage the recovery of the covered species and their habitats within the project area; 3) monitoring, reporting and adaptive management efforts to ensure species and habitat conservation effectiveness; and 4) identification of nearby migration corridors and potential for habitat fragmentation.

Desert Tortoise Habitat

The project location contains habitat for the threatened Mojave desert tortoise, a species that is experiencing negative impacts from multiple sources, including renewable energy projects. The proposed project area is located in, or in proximity to, two tortoise translocation areas in the Pahrump Valley – the Trout Canyon Translocation Area, and the Stump Springs Translocation Area. The Draft EIS should illustrate the location of these two translocation areas; describe the process and timeline of how these areas were designated as translocation areas; and discuss any potential impacts to tortoise within these translocation areas that might occur, as well as ways to avoid, minimize, or mitigate for such impacts. Discuss the direct, indirect, and cumulative impacts that the Copper Rays Solar Project, as well as other reasonably foreseeable solar projects proposed nearby, are expected to have on this species. Discuss landscape-level impacts that multiple projects proposed in the Pahrump Valley may have on this species, including fragmenting or isolating desert tortoise populations and restricting gene flow.

In 2021, the U.S. Geological Survey published a report[2] that discusses the importance of connectivity for Mojave Desert Tortoise populations including management recommendations for maintaining a viable recovery network. According to the report, managing the entire remaining matrix of desert tortoise habitat for permeability may be better than delineating fixed corridors, particularly given the uncertainty about long-term condition of habitat under a changing climate. Discuss whether these recommendations have been considered for desert tortoise habitat within the Pahrump Valley.

Impacts to Birds
In the Draft EIS, discuss whether there is increased fatality risk to birds, particularly waterfowl, associated with solar PV arrays. Birds may mistake the PV panels for water – the so-called lake effect – resulting in unexpected deaths of birds from collisions with the solar panels. Discuss the issue of avian mortality and describe measures to minimize potential impacts. We recommend that the Bird and Bat Conservation Strategies include avian mortality monitoring and adaptive management measures. BLM should ensure that fatality data is uniformly collected at each utility-scale solar project in order to better quantify the scale of impacts and which taxonomic groups are most impacted.

In the Draft EIS, verify that the design of the transmission line would comply with current standards and practices that reduce the potential for raptor fatalities and injuries. The commonly referenced source of such design practices is found within the Avian Power Line Interaction Committee documents: *Suggested Practices for Avian Protection on Power Lines: State of the Art in 2006* manual and *Reducing Avian Collisions with Power Lines: The State of the Art in 2012*.

Nevada's Executive Order 2021-18 – Creating the Nevada Habitat Conservation Framework
On August 23, 2021, Nevada Governor Steve Sisolak signed Executive Order 2021-18 which instructs the Nevada Departments of Wildlife, Transportation and Natural Resources to develop a plan called the Nevada Habitat Conservation Framework (Framework). Through coordination with land management agencies and other interested parties, the State will use the Framework to evaluate threats, prioritize landscapes, and develop strategies to restore and conserve at risk wildlife habitats, including migration corridors. A key component of the Framework will be the development of the statewide Nevada Wildlife Connectivity Plan that seeks to identify and conserve migratory corridors for ungulates and other key species. The EPA encourages the BLM to work closely with NDOW, NDOT, and NDCNR to ensure that the proposed project does not impact sensitive species, critical habitat, migration corridors, and scenic landscapes within the state of Nevada, in accordance with Executive Order 2021-18.

Increasing Site Permeability
Increasing site permeability and maintaining vegetation on site can provide short-term and long-term benefits for wildlife. Prohibiting fencing over major washes, minimizing fencing between project boundaries, utilizing shared roads between projects, incorporating wildlife access holes within fences,

[2] Averill-Murray, R.C., Esque, T.C., Allison, L.J., Bassett, S., Carter, S.K., Dutcher, K.E., Hromada, S.J., Nussear, K.E., and Shoemaker, K., 2021, Connectivity of Mojave Desert tortoise populations—Management implications for maintaining a viable recovery network: U.S. Geological Survey Open-File Report 2021–1033, 23 p., https://doi.org/ 10.3133/ ofr20211033.

raising fences after construction are all options that should be considered to allow for greater permeability across project boundaries and reduce the overall impacts to wildlife across the combined solar project development area within the Pahrump Valley. Preserving desert washes and microphyll woodlands serves a double benefit by protecting valuable resources and preserving built-in wildlife passageways. Discuss how permeability could be further enhanced at these sites.

Avoiding Cryptobiotic Soil Crusts

The EPA recommends avoiding disturbance of any desert pavement/cryptobiotic soil crusts present in the project application area and adopting alternative construction methods and installation techniques that will minimize impacts to soil crusts to the maximum extent possible.

Invasive Species

Executive Order (E.O.) 13112, *Invasive Species* (February 3, 1999), mandates that federal agencies, whose actions may affect the status of invasive species, use their relevant authorities to prevent their introduction, provide for their control, and minimize the economic, ecological, and human health impacts that invasive species cause. The Draft EIS should describe how the Copper Rays Solar Project will meet the requirements of E.O. 13112. We recommend including an invasive plant management plan for the monitoring and control of noxious weeds.

Climate Change

Executive Order 13990 on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis (January 20, 2021) asserts that the Administration should bolster resilience to climate change. In the Draft EIS, discuss how the effects of climate change could impact the project and project area and how the project would be designed to address potential climate change-related impacts. For example, describe how the proposed Project would be affected by foreseeable trends – a scenario of continued decreasing precipitation, changing frequency of intense storms and related flood events, increased occurrence of wildfires, and persistent drought. We also recommend discussing how climate change may affect the covered species and the habitats on which they depend.

Consultation with Tribal Governments

It is important that formal government-to-government consultation take place early in the scoping phase of the project to ensure that all issues are adequately addressed in the Draft EIS. The principles for interactions with tribal governments are outlined in the presidential "Memorandum on Government-to Government Relations with Native American Tribal Governments" (April 29, 1994) and Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments" (November 6, 2000). On November 2009, the Presidential Memorandum on Tribal Consultation was issued and required each agency to prepare and periodically update a detailed plan of action to implement the directive of EO 13175. On January 26, 2021, the Biden Administration committed to strengthening the relationship between the Federal Government and Tribal Nations and to advancing equity for Native Americans.[3] As a resource, we also recommend the document *Tribal Consultation: Best Practices in Historic Preservation,*[4] published by the National Association of Tribal Historic Preservation Officers.

In the Draft EIS, summarize the results of tribal consultation and identify the main concerns expressed by tribes, how those concerns were addressed, and what additional or continuing consultations may be warranted. We also recommend identifying any protection, mitigation, and enhancement measures

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[3] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/26/memorandum-on-tribal-consultation-and-strengthening-nation-to-nation-relationships/

[4] National Association of Tribal Historic Preservation Officers. May 2005. Tribal Consultation: Best Practices in Historic Preservation. Available at http://www.nathpo.org/PDF/Tribal_Consultation.pdf.

identified by tribes. Identify resources with cultural and religious significance to each Tribal community and ensure that treaty rights and privileges are addressed appropriately.

On November 15, 2021, a Presidential Memorandum[5] on Indigenous Traditional Ecological Knowledge and Federal Decision Making, directed federal agencies to develop robust plans for ensuring meaningful Tribal consultation on agency work that may affect Tribal Nations and the people they represent. To the extent appropriate, solicit and elevate Indigenous Traditional Ecological Knowledge into the Tribal consultation process to better inform decision-making.

National Historic Preservation Act
Consultation for tribal cultural resources is required under Section 106 of the National Historic Preservation Act. Historic properties under NHPA are properties that are included in the National Register of Historic Places or that meet the criteria for NRHP. Section 106 of NHPA requires a federal agency, upon determining that activities under its control could affect historic properties, to consult with the appropriate State Historic Preservation Office/Tribal Historic Preservation Office. Under NEPA, any impacts to tribal, cultural, or other treaty resources must be disclosed in the Draft EIS. Section 106 of NHPA requires that federal agencies consider the effects of their actions on cultural resources, following the regulation at 36 CFR 800.

In the Draft EIS, discuss how BLM would avoid or minimize adverse effects on the physical integrity, accessibility, or use of cultural resources or archaeological sites, including traditional cultural properties, throughout the project area. Clearly discuss mitigation measures for archaeological sites and TCPs. We encourage BLM to append any Memoranda of Agreements to the Draft EIS, after redacting specific information about these sites that is sensitive and protected under Section 304 of NHPA. We also recommend providing a summary of all coordination with tribes and with the SHPO/THPOs, including identification of NRHP eligible sites and development of a Cultural Resource Management Plan.

Environmental Justice and Public Participation
In the Draft EIS, assess impacts to local communities consistent with Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (February 11, 1994). Discuss in the Draft EIS the potential for disproportionate adverse impacts to minority and low-income populations and the approaches used to foster public participation by these populations. We recommend using the EPA's Environmental Justice Screening and Mapping Tool, EJSCREEN[6] to help identify potential communities with environmental justice concerns that may be impacted by the project. Assessment of project impacts on minority and low-income populations should reflect coordination with those affected populations. For more information on effective public participation in the NEPA process, please also consult the following resources:

- *Promising Practices for EJ Methodologies in NEPA Reviews;*[7]
- *The Citizen's Guide to the National Environmental Policy Act;*[8] and
- *Community Guide to Environmental Justice and NEPA Methods.*[9]

[5] https://www.whitehouse.gov/wp-content/uploads/2021/11/111521-OSTP-CEQ-ITEK-Memo.pdf
[6] https://www.epa.gov/ejscreen
[7] https://www.epa.gov/sites/production/files/2016-08/documents/nepa_promising_practices_document_2016.pdf
[8] https://ceq.doe.gov/docs/get-involved/citizens-guide-to-nepa-2021.pdf
[9] https://www.energy.gov/sites/prod/files/2019/05/f63/NEPA%20Community%20Guide%202019.pdf

Monitoring and Adaptive Management

The proposed project will impact a variety of resources for an extended period of time. As a result, we recommend that the project be designed to include an environmental inspection and monitoring program to ensure compliance with all mitigation measures and assess their effectiveness. In the Draft EIS, describe the monitoring program and how it will be used as an effective feedback mechanism (i.e., adaptive management) so that any needed adjustments can be made to the project to meet environmental objectives throughout the life of the project. We also recommend that the Draft EIS describe a mechanism to consider and implement additional mitigation measures.

Hazardous Waste and Pesticides

The Draft EIS should discuss the potential impacts of waste generation, including hazardous waste, from construction and operation activities, as well as the proposed battery storage facilities. The document should identify projected waste types and volumes and describe their expected storage, disposal, and management. The Draft EIS should explain how the generation of hazardous waste would be minimized and identify applicable federal hazardous waste requirements. If PV panel trackers will utilize hazardous materials such as refrigerants, discuss and evaluate potential impacts from accidental or unexpected releases. The Draft EIS should discuss whether any pesticides, including herbicides or rodenticides, would be used at the project site.

Battery Storage

Include an analysis of the potential energy needs of the proposed battery energy storage systems (e.g., for HVAC), discuss to what extent such needs can be met by energy generated on site by the solar facility, and include air emission estimates, as needed. Consider mounting batteries, transformers, and inverters on elevated platforms to allow soils underneath to remain pervious.

Other Considerations for NEPA Review – Access to Technical Reports

The EPA recommends that all technical reports that lead to conclusions regarding environmental consequences be included as appendices to the Draft EIS available through at the BLM National NEPA Register website. Providing technical documents in the appendices as well as requisite summary information helps to ensure a comprehensive report with data easily accessible to reviewers, the public and the decision maker.

From: Brad Hardenbrook
To: BLM_NV_SND_EnergyProjects
Cc: Jasmine Kleiber; NevadaClearinghouse
Subject: [EXTERNAL] Scoping: Copper Rays Solar Project
Date: Friday, January 13, 2023 4:25:06 PM
Attachments: E2023-173SR23-071BL[redacted]Clark_13Jan2023.pdf

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

Good afternoon,

Please find the attached pdf presenting the Nevada Department of Wildlife's scoping input for the proposed project.

Have a great weekend!

Brad

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January 13, 2022

NDOW-SR#: 23-071
SAI#: E2023-173

BLM Pahrump Field Office
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BLM_NV_SND_EnergyProjects@blm.gov

Re: NOI and Public Scoping for DOI-BLM-NV-S030-2022-0009-EIS: Proposed Copper Rays Solar Project, Pahrump Valley, Nye County (Project)

To Whom This Concerns:

The Nevada Department of Wildlife (NDOW) appreciates the opportunity to provide scoping comments on the proposed Project. We understand the right-of-way lease area would be located on ~5,127 acres of predominately undeveloped public land managed by the BLM near the town of Pahrump. The facility would include a photovoltaic solar power generation capacity of up to 700 MW with 35 acres of battery storage. The electricity generated from the project would be collected at an onsite substation and conveyed on ~5 miles of gen-tie line to the Gamebird Substation. The Project is adjacent and west of the proposed Rough Hat Clark Solar Project and west of the Yellow Pine Solar Project currently under construction.

As with other renewable energy projects, NDOW recognizes the value in construction and operation of the Project for contributing to national renewable energy portfolios and lessening reliance on fossil-fuels. In view of the magnitude of solar energy development and other changing land use demands in Nye County's eastern Mojave Desert biome, NDOW reviews the regional setting for maintaining sustainable, healthy wildlife populations and habitats. From a larger landscape perspective, the Project would potentially be one of several contiguous solar energy facilities situated over ~21,000 acres within Nye and Clark counties south of State Route 160, west of Tecopa Road and south-southeast of the town of Pahrump. Considerations for habitat availability and connectivity for terrestrial and volant species on both the Project site and larger vicinity are of interest.

As in our recent scoping comments to the Rough Hat Clark Solar project, we anticipate indirect effects and cumulative effects will be analyzed in a more holistic manner, inclusive of developing impact avoidance, minimization, and if needed, off-site mitigation. Where this is readily apparent are project management approaches concerning the Mojave desert tortoise and the Priority 1 habitat connectivity area in the Pahrump Valley. Interagency visits in 2022 to several solar energy developments underscored varying perspectives for appropriate onsite impact minimization and off-site mitigation. For onsite best management practices, the Gemini Solar project presently offers the standard for optimizing potential of sustainable habitats on facility grounds, inclusive of restoring habitat availability in a relatively short time frame for displaced resident wildlife like the desert tortoise. While the level of impact minimization practices at Gemini Solar are promising, achievement is uncertain.

We further recognize pre-construction character, physical and biotic, among proposed solar energy sites may differ from those at Gemini Solar, lending inherently individual challenges in habitat conservation opportunities and outcomes. Based on our observations in Pahrump Valley, a goal would be preservation of existing hydrographical character of the Project site and vicinity to remain undisturbed and intact, and PV array installation should avoid site preparation of grading, discing, or a twice-over combination of mowing followed by drive and crush.

Adaptiveness in developing and testing best management practices while acquiring knowledge to short and long-term responsiveness by vegetation, consequences for wildlife, and facility O&M are germane; particularly mindful of the direct and indirect influences of factors like the extended drought regime, unsettled patterns of emerging climate change, and changing complexion of land use types and intensity on local landscapes. Additional to short-term and long-term inferences related to expected changes from direct habitat loss, fragmentation, and degradation of existing landscape conditions in the Project site and nearby renewable energy developments, are the indirect effects and cumulative effects to nearby areas. Land use activities displaced by the large complex of renewable energy developments will ultimately shift to new areas subject to increased use. Consideration for the potential effects to species requiring large foraging areas and associated physiological costs for self-maintenance and reproductive potential within breeding territories such as that for the Golden Eagle (*Aquila chrysaetos*) is an example.

Alternately, the Project may contribute to unintentional attractants of wildlife during and post-construction. For example, migratory birds like loons and grebes, which are night flyers, are known to mistake roadways and other reflective surfaces as bodies of water. Should birds survive landing aground they are unable to take flight as they require long stretches of water from which to become airborne. A marsh bird, the ESA-listed Yuma Ridgeway's Rail (*Rallus obsoletus*), is not a stranger to desert oases like Ash Meadows National Wildlife Refuge and the Overton Wildlife Management Area. Although Yuma Ridgeway's rail is a sporadic migrant[1], avian mortality of water and marsh birds at solar energy facilities situated in the desert environs is documented.[2] An increased potential for avian injury or mortality coincident with spatial increases of solar energy development is plausible and worthy of consideration as a bird and bat conservation strategy for construction and post-construction phases of the Project is prepared.

Other birds worthy of mention for consideration are the Lesser Nighthawk (*Chordeiles acutipennis*) and Burrowing Owl (*Athene cunicularia*), species protected under the Migratory Bird Treaty Act and

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[1] Harrity, E.J. and C.J. Conway. 2020. Satellite transmitters reveal previously unknown migratory behavior and wintering locations of Yuma Ridgway's Rails. *J. Field Ornithol.* 91(3):300–312. DOI: 10.1111/jofo.12344

[2] Kagan, R. A., T. C. Viner, P. W. Trail, and E. O. Espinoza. 2014. Avian mortality at solar energy facilities in southern California: a preliminary analysis. National Fish and Wildlife Forensics Laboratory, Ashland, OR

State of Nevada (NAC 503.050). Both are ground-nesting birds. The Lesser Nighthawk is extremely well-camouflaged making it difficult to detect if not flushed. Eggs and nestlings are also extremely well-camouflaged and may not be seen unless the parent bird's flush origin is noted; even then, eggs and nestlings are very difficult to detect. During construction, we would recommend any breeding site detections be marked and monitored in such a way avoiding attention by predators and a buffer distance appropriate for avoiding disturbance to the nest site(s) be observed by workers until such time nestlings have fledged.

As NEPA analyses continue addressing species like the Mojave desert tortoise inclusive of developing a worker education awareness program, and should the Project move forward, NDOW requests observance of our Gila monster encounter protocols during construction and operations. These are online at https://www.ndow.org/publications/?phrase=Gila+monster+encounter+protocolI. A special purpose permit for moving desert tortoises out of harm's way is also required. These materials are online at https://www.ndow.org/publications/?phrase=special+purpose+permit. Local assistance on these items can be provided by Wildlife Diversity Regional Supervisor, Matt Flores located at NDOW's Southern Region office in Las Vegas. He can be reached at 702.668.3936 or by email at mhflores@ndow.org.

NDOW values the opportunity in having become a cooperating agency to this Project and look forward to thoughtful discussions of lessons learned such as those from the Gemini and Yellow Pine projects and overall onsite conservation efforts coming to light in the solar energy complex. For additional assistance on this scoping input, please contact me or Matt Flores.

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

From:	Clearinghouse
To:	BLM_NV_SND_EnergyProjects; Klein, Matthew D; Wirthlin, Whitney J
Subject:	[EXTERNAL] Nevada State Clearinghouse Comments for SCOPING BLM Copper Rays Solar Project EIS and RMP Amendment - Nye County
Date:	Friday, January 13, 2023 8:59:26 AM
Attachments:	E2023-173 Not[redacted]Comments.pdf

Whitney,

Attached please find a copy of the comments received through the Nevada State Clearinghouse for DOI-BLM-NV-S030-2022-0009-EIS the scoping notice for the Copper Rays Solar Project EIS and RMP Amendment in Nye County (Clearinghouse ID: E2023-173). If you have any questions or need any additional information about these comments, please feel free to contact me.

One additional scoping comment on behalf of the Nevada State Clearinghouse program regarding this project is that if this RMP amendment is going to trigger a 60-day Governor's Consistency review, the Clearinghouse program coordinates and works closely with the Governor's Office on these types of reviews for the State of Nevada. Please contact me scarey@lands,nv.gov or 775-684-2723 for any future 60-day Governor's Consistency review associated with the RMP amendment for the Copper Rays Solar Project EIS.

Thank You,

Scott Carey
Nevada State Clearinghouse
Department of Conservation and Natural Resources
901 S. Stewart Street, Suite 5003
Carson City, NV, 89701
NevadaClearinghouse@lands.nv.gov
(775)684-2723

Comment # 1

From: Thomas C. Pyeatte Jr.
Agency: Nevada Division of Water Resources
Title: Professional Engineer
Phone: 775-684-2862
Email: tpyeatte@water.nv.gov
Date Received: 11/22/2022

See Attached

Nevada State Clearinghouse
Department of Conservation and Natural Resources
901 South Stewart Street, Suite 5003
Carson City, NV 89701
775-684-2723
http://clearinghouse.nv.gov
www.lands.nv.gov

DATE: November 22, 2022
Division of Water Resources
Nevada SAI # E2023-173

Project: SCOPING BLM Copper Rays Solar Project EIS and RMP Amendment - Nye County

____________No comment on this project ______X_____Proposal supported as written

AGENCY COMMENTS:

NRS – Nevada Revised Statutes
NAC – Nevada Administrative Code

General:

Compliance with Nevada water law is required.

All waters of the State belong to the public and may be appropriated for beneficial use pursuant to the provisions of NRS Chapters 533 and 534 and not otherwise.

Water shall not be used from any source unless the use of that water is authorized through a permit issued by the State Engineer. For underground sources, certain uses of water may be authorized through the issuance of a waiver pursuant to NRS Chapter 534 and NAC Chapter 534.

Any ownership transfer of water rights shall be sufficiently documented through a chain of title and a report of conveyance submitted to the State Engineer's Office as provided by NRS 533.384. The State Engineer is authorized and is responsible for maintaining water right files and accompanying documents as per NRS Chapters 111, 240, 375, 532, 533 and 534.

Any water from a water purveyor may require a change application if the place of use is outside of their service area.

Water leased from an existing water right holder requires a change application be filed and permitted prior to use for the proposed project. Existing users are bound by the terms of their permit for point of diversion, place of use and manner of use. A temporary or permanent is needed to convert water to this proposed project. Contact the Nevada Division of Water Resource's Basin Specialist for the Pahrump Valley Hydrographic Basin with questions you may have regarding water for this proposed project. You may also reach out to a licensed Nevada

Water Right Survey. A list of water right surveyors can be found on our website at: http://water.nv.gov/WaterRightsSurveyors.aspx

Water for Construction Projects

Ensure that any water used on a project for any manner of use shall be provided by an established utility or under permit or temporary change application or waiver issued by the State Engineer's Office with a manner of use acceptable for suggested project's water needs. Any water from a water purveyor may require a change application if the place of use is outside of their service area. Water leased from an existing water right holder requires a change application be filed and permitted prior to use for the proposed project. Existing users are bound by the terms of their permit for point of diversion, place of use and manner of use. A temporary or permanent is needed to convert water to this proposed project. Contact the Nevada Division of Water Resource's Basin Specialist for the Pahrump Valley Hydrographic Basin with questions you may have regarding water for this proposed project. You may also reach out to a licensed Nevada Water Right Survey. A list of water right surveyors can be found on our website at: http://water.nv.gov/WaterRightsSurveyors.aspx

Wells and Geotechnical Soil Borings

All wells must be noticed, drilled, constructed, and plugged in accordance with NRS Chapter 534 and NAC Chapter 534, and the work must be completed by a licensed well driller as provided by NRS Chapter 534.

Any unauthorized or unpermitted drill holes/wells (water or monitor wells or geotechnical soil boring) that may be located on existing, acquired or transferred lands, are ultimately the responsibility of the owner of the property and must be plugged and abandoned as required in NAC Chapter 534.

Abandoned wells need to be reported to the State Engineer's Office and must be plugged in accordance with NAC Chapter 534.

A waiver to drill a well must comply with the provisions of NRS Chapter 534 and NAC Chapter 534 and the terms of the waiver approval.

Individuals

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] Copper Rays Solar Project
Date: Monday, November 14, 2022 11:15:33 PM

The Crescent Dunes solar facility was an epic failure. How can you justify building the Copper Rays solar facility? What due diligence has been done so history doesn't repeat itself? Does the budgeted number include the cost to integrate ALL of the solar energy produced into existing energy grids? Once the solar panel(s) have reached the end of their lifecycle, how will they be disposed of? How much will it cost to locate the "dead" panel, remove said panel, dispose of panel and install a new panel?

Lastly, I ask a question and please do not dismiss my conjecture without critical thinking. A principle of the 1st law of thermodynamics is that work produces heat. Nothing is free. Has anyone looked to see if there is a correlation between an increase in solar energy and/or batteries and an increase in climate change? Again, nothing is free. There has to be some affect on the environment no matter the energy source. If we're going to enact policy and change let's be absolutely sure we are making the right decisions for the sake of our future.

From: [redacted]
To: BLM_NV_SND_EnergyProjects; letters@nytimes.com; yourviews@app.com; scoops@huffpost.com
Subject: [EXTERNAL] Fwd: Scoping Period Open for Copper Rays Solar Project EIS and RMP Amendment
Date: Monday, November 14, 2022 5:02:33 PM

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public comment on federal register

i do not support this solar installation. put solar on tops of all factory and business buildings, put it on hazardous sites. do not pollute virgin land with this stuff. thatis not the place for it. the damn solar plants dont last more than 20 years and are horribly destrucive otmaeriels to build them. they dont last. no longevity to them.
this commetn is for the public recod. pleas receipt. [redacted]

---------- Forwarded message ---------
From: **BLM_NV_SND_EnergyProjects** <BLM_NV_SND_EnergyProjects@blm.gov
Subject: Scoping Period Open for Copper Rays Solar Project EIS and RMP Amendment
To:

Good morning,

The BLM has published a Notice of Intent to Prepare an Environmental Impact Statement and a Resource Management Plan Amendment for the Proposed Copper Rays Solar Project in the Federal Register. This notice begins the 45-day scoping period for the project and announces two virtual public scoping meetings, scheduled for December 6 and December 7, 2022 from 6 p.m. to 8 p.m. Pacific Time.

December 6, 2022 Virtual Scoping Meeting
Registration: https://us02web.zoom.us/webinar/register/WN_SgKc-YJfT_eZemQbyycFVg

December 7, 2022 Virtual Scoping Meeting
Registration: https://us02web.zoom.us/webinar/register/WN_r2OKY8P3SX-BCnOvUYIZ9g

Copper Rays Solar, LLC has applied for a right-of-way grant for the construction, operation, and eventual decommissioning of a proposed 700-megawatt photovoltaic solar facility, including a battery storage facility and interconnection to the regional transmission system, on BLM-managed public land in Nye County, Nevada. The Copper Rays Solar Project is proposed on approximately 5,127 acres located in the Pahrump Valley, adjacent to the Nye-Clark County line, southeast of the Town of Pahrump and approximately 40 miles west of Las Vegas. More information can be found at the project ePlanning website:

https://eplanning.blm.gov/eplanning-ui/project/2019523/510.

The public scoping period is being held as part of the NEPA process for the Environmental Impact Statement. The scoping period for the project will conclude on December 29, 2022. Comments must be received prior to the close of the scoping period or 15 days after the last public scoping meeting, whichever is later, to be included in the Draft EIS. Written scoping comments can be submitted by any of the following methods:

- Email: BLM_NV_SND_EnergyProjects@blm.gov
- ePlanning: Utilize the "Participate Now" function at the Project webpage: https://eplanning.blm.gov/eplanning-ui/project/2019523/510
- Mail: BLM, Pahrump Field Office, Attn: Copper Rays Solar Project, 4701 North Torrey Pines Drive, Las Vegas, NV 89130-2301

If you have any questions, please contact Whitney Wirthlin, Project Manager, Energy and Infrastructure Team, by telephone at (725)-249-3318 or via email at wwirthli@blm.gov.

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

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] Fwd: DENY DESTRUCTION OF VIRGIN LAND
Date: Monday, November 14, 2022 5:06:54 PM

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

publccommetn on federal register

i do not support the use of public lands for this. i want wild horses and burros to live on this land. it should be kept virgin land and not used for solar plants which disintegrate after 20 years. they are not a good long term investment for the taxpayer of this country. deny this project. deny this use of public land.
[redacted]

[Federal Register Volume 87, Number 218 (Monday, November 14, 2022)]
[Notices]
[Pages 68187-68189]
From the Federal Register Online via the Government Publishing Office
[www.gpo.gov]
[FR Doc No: 2022-24623]

[[Page 68187]]

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DEPARTMENT OF THE INTERIOR

Bureau of Land Management

[LLNVS00000.L51010000.ER0000.LVRWF2208330.22X; N-89655; MO# 4500164258]

Notice of Intent To Amend the Las Vegas Resource Management Plan and Prepare an Environmental Impact Statement for the Proposed Copper Rays Solar Project in Nye County, Nevada

AGENCY: Bureau of Land Management, Interior.

ACTION: Notice of intent.

SUMMARY: In compliance with the National Environmental Policy Act of 1969, as amended (NEPA), and the Federal Land Policy and Management Act of 1976, as amended (FLPMA), the Bureau of Land Management (BLM) Nevada State Director intends to prepare a Resource Management Plan (RMP) amendment with an associated Environmental Impact Statement (EIS) for the Copper Rays Solar Project and by this notice is announcing the beginning of the scoping period to solicit public comments and identify issues, and is providing the planning criteria for public review.

DATES: The BLM requests the public submit comments concerning the scope of the analysis, potential alternatives, and identification of relevant information and studies by December 29, 2022. To afford the BLM the opportunity to consider issues raised by commenters in the Draft RMP amendment/EIS, please ensure your comments are received prior to the close of the 45-day scoping period or 15 days after the last public meeting, whichever is later.

The BLM will conduct two public scoping meetings (virtually):

December 6, 2022, 6-8 p.m. Pacific Time., Virtual via Zoom. Registration is required. To register in advance for this webinar, visit: https://eplanning.blm.gov/eplanning-ui/project/2019523/510

December 7, 2022, 6-8 p.m. Pacific Time., Virtual via Zoom. Registration is required. To register in advance for this webinar, visit: https://eplanning.blm.gov/eplanning-ui/project/2019523/510

ADDRESSES: You may submit comments on issues and planning criteria related to the Copper Rays Solar Project by any of the following methods:

Website: https://eplanning.blm.gov/eplanning-ui/project/2019523/510
Email: BLM_NV_SND_EnergyProjects@blm.gov
Mail: BLM, Pahrump Field Office, Attn: Copper Rays Solar Project, 4701 North Torrey Pines Drive, Las Vegas, NV 89130-2301

Documents pertinent to this proposal may be examined online at the project ePlanning page: https://eplanning.blm.gov/eplanning-ui/project/2019523/510 and at the Southern Nevada District Office.

FOR FURTHER INFORMATION CONTACT: Whitney Wirthlin, Project Manager, telephone (725) 249-3318; address 4701 North Torrey Pines Drive, Las Vegas, NV 89130-2301; email BLM_NV_SND_EnergyProjects@blm.gov. Contact Whitney Wirthlin to have your name added to our mailing list. 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 for contacting Whitney Wirthlin. 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: This document provides notice that the BLM Nevada State Director intends to prepare an RMP amendment with an associated EIS for the Copper Rays Solar Project, announces the beginning of the scoping process, and seeks public input on issues and planning criteria. The RMP amendment is being considered to allow the BLM to evaluate the Copper Rays Solar Project, which would require amending the existing 1998 Las Vegas RMP.

The proposed project and planning area is in Nye County, southeast of the Town of Pahrump and approximately 40 miles west of Las Vegas, and encompasses approximately 5,127 acres of public lands.

On October 27, 2020, Copper Rays Solar, LLC filed an updated right-of-way application to the BLM Pahrump Field Office for the Copper Rays Solar Project (Project) requesting authorization to construct, operate, maintain, and eventually decommission a 700-megawatt photovoltaic solar electric generating facility, battery storage facilities, associated generation tie-line, and access road facilities. Copper Rays Solar, LLC submitted the initial right-of-way application for the proposed project in September 2010, thus the project is not subject to the decisions adopted by the Record of Decision for Solar Energy Development in Six Southwestern States (BLM 2012). The electricity generated would be collected at the onsite substation and conveyed to the Gamebird Substation located north of the project site via transmission line. Construction for the facilities is estimated to take approximately 72 months across multiple phases. The lands within the proposed project area were segregated, subject to valid existing rights, for a term of two years beginning October 21, 2021, with publication of the Notice of Segregation in the Federal Register.

The scope of this land use planning process does not include addressing the evaluation or designation of areas of critical environmental concern (ACEC) and the BLM is not considering ACEC nominations as part of this process.

Purpose and Need

The BLM's preliminary purpose and need for this Federal action is to respond to FLPMA right-of-way applications submitted by Copper Rays Solar, LLC under Title V of FLPMA (43 U.S.C. 1761) to construct, operate, maintain, and decommission a solar generation power plant and ancillary facilities on approximately 5,127 acres of BLM land in Nye County, Nevada, in compliance with FLPMA, BLM right-of-way regulations, the BLM NEPA Handbook (BLM 2008), U.S. Department of the Interior NEPA regulations, and other applicable federal and state laws and policies. In accordance with FLPMA, public lands are to be managed for multiple uses that consider the long-term needs of future generations for renewable and non-renewable resources. The BLM is authorized to grant rights-of-way on public lands for systems of generation, transmission, and distribution of electrical energy (Section 501(a)(4)). The preliminary purpose and need also includes an amendment to the 1998 Las Vegas RMP to address utility corridor modifications based on the project boundary location and to adjust the Visual Resource Management Class III unit that contains the proposed project to respond to the proponent's application.

Preliminary Alternatives

The Proposed Action is to approve a right-of-way to Copper Rays Solar, LLC to construct, operate, and eventually decommission the proposed solar project and associated facilities with the potential to generate 700-megawatts of alternating current energy on 5,127 acres of BLM administered lands. The Proposed Action also includes an amendment to the 1998 Las Vegas RMP in order to modify multiple utility corridors and to adjust the Visual Resource Management Class III unit that contains the proposed project.

An Energy Policy Act of 2005 Section 368 Energy Corridor, Segment # 224-225, intersects the western portion of the project area. A Southern Nevada District Utility Corridor, established by the RMP, intersects the southwest corner of the project area. Per the BLM's Land Use Planning Handbook (H-1601-1 Section VII.B), in order for the project to be consistent with the RMP, a plan amendment to modify both utility corridors outside of the Copper Rays Solar Project area will be required.

The Visual Resource Management Class for the project area includes Class III, which requires a RMP amendment to change the Class III area to Class IV in order for the project to be consistent with the RMP, per the BLM Land Use Planning Handbook (H-1601-1 Section VII.B).

Additional action alternatives have not been identified to date but would be developed by taking into consideration comments and input submitted during the application evaluation determination process and scoping.

Under the No Action Alternative, BLM would not issue a right-of-way grant for the solar project and associated facilities. The proposed Project would not be constructed, and existing land uses in the project area would continue. Additionally, the BLM would not undertake a RMP amendment to adjust utility corridors and modify the Visual Resource Management Class.

The BLM welcomes comments on all preliminary alternatives as well as suggestions for additional alternatives.

Planning Criteria

The planning criteria guide the planning effort and lay the groundwork for effects analysis by identifying the preliminary issues and their analytical frameworks. Preliminary issues for the planning area have been identified by BLM personnel and from early engagement conducted for this planning effort with Federal, State, and local agencies; Tribes; and other stakeholders. The BLM has identified preliminary issues for this planning effort's analysis. The planning criteria are available for public review and comment at the ePlanning website (see ADDRESSES).

Summary of Expected Impacts

The analysis in the EIS will be focused on the proposed solar project and associated facilities, including battery storage and transmission line construction. The BLM evaluated the proposed Project application per the 43 CFR 2800 application evaluation determination process. Through this process, the BLM completed public outreach and

Agency and Indian Tribal Nations coordination specific to the proposed Project. From the input received, the expected impacts from construction, operation, and eventual decommissioning of the solar project, associated facilities, and the RMP amendment could include:

Potential desert tortoise habitat disturbance and changes in genetic connectivity habitat from construction of the proposed facilities;

Potential effects to cultural resources in the project area from construction activities;

Potential modifications to the visual character of the area;

Potential effects to basin groundwater resources from the proposed construction water needs for the project;

Potential socioeconomic impacts from the proposed project to local communities;

Potential air quality impacts from proposed construction activities;

Potential impacts to vegetation species as a result of construction, operations, and decommissioning of the project and associated facilities;

Potential effects to the recreational opportunities and public use of the proposed project area due to construction and operations of the solar facility; and

Potential cumulative effects with other reasonably foreseeable actions in the area.

Preliminary issues for the project have been identified by the BLM, other Federal agencies, the State, local agencies, Tribes, and the public during the application evaluation process. The following may be impacted by the proposed project and will be considered for detailed analysis in the EIS: threatened and endangered species, biological resources, vegetation resources, visual resources, cultural resources, air quality, climate change, recreation, socioeconomics, water resources, and cumulative effects from reasonably foreseeable actions in the area. Habitat for the federally listed desert tortoise is in this project area.

Anticipated Permits and Authorizations

Along with the right-of-way grant issued by the BLM, Copper Rays Solar, LLC anticipates needing the following authorizations and permits for the proposed project: Biological Opinion and Incidental Take Permit from the U.S. Fish and Wildlife Service; Consultation under Section 106 of the National Historic Preservation Act with the Advisory Council on Historic Preservation and Nevada State Historic Preservation Office; Section 404 Permit from the U.S. Army Corps of Engineers; Wildlife Special Purpose permit from the Nevada Department of Wildlife; Nevada Division of Environmental Protection Stormwater and Groundwater Discharge permits and Temporary in Waterways Work permit; Nevada Public Utilities Commission Permit to Construct; Nevada Division of Water Resources water rights modification permits; Nevada State Fire Marshall Hazardous Materials Storage permit; Nye County Special Use Permit; and other Nye County permits, as necessary. Further details on these permitting requirements may be found in the Plan of Development for the Copper Rays Solar Project.

Schedule for the Decision-Making Process

The BLM will provide additional opportunities for public participation consistent with the NEPA and land use planning processes, including a 90-day comment period on the Draft RMP Amendment/EIS and concurrent 30-day public protest period and 60-day Governor's consistency review on the Proposed RMP Amendment. The Draft RMP Amendment/EIS is anticipated to be available for public review Spring 2023 and the Proposed RMP Amendment is anticipated to be available for public protest in Fall 2023 with an Approved RMP Amendment and Record of Decision in Spring 2024.

Public Scoping Process

This notice of intent initiates the scoping period and public review of the planning criteria, which guide the development and analysis of the Draft RMP Amendment/EIS.

The BLM will be holding two virtual scoping meetings (see DATES and ADDRESSES sections earlier). The specific date(s) and location(s) of any additional scoping meetings will be announced at least 15 days in advance through the project ePlanning web page: https://eplanning.blm.gov/eplanning-ui/project/2019523/510.

The purpose of the public scoping process is to determine relevant issues that will influence the scope of the environmental analysis, including alternatives and mitigation measures, and to guide the process for developing the EIS. Federal, State, and local agencies and Tribes, along with other stakeholders that may be interested or affected by the BLM's decision on this project, are invited to participate in the scoping process and, if eligible, may request or be requested by the BLM to participate as a cooperating agency. The BLM encourages comments concerning the proposed Cooper Rays Solar Project and RMP amendment, possible

measures to minimize and/or avoid adverse environmental impacts, and any other information relevant to the Proposed Action.

The BLM also requests assistance with identifying potential alternatives to the Proposed Action. As alternatives should resolve an issue with the Proposed Action, please indicate the purpose of the suggested alternative. In addition, the BLM requests the identification of potential issues that should be analyzed. Issues should be a result of the Proposed Action or Alternatives; therefore, please identify the activity along with the potential issues.

Lead and Cooperating Agencies

The BLM Pahrump Field Office is the lead agency for this EIS and RMP amendment. The BLM has initially invited 27 Agencies and 15 Indian Tribal Nations to be cooperating agencies to participate in the environmental analysis of the Project.

Of those invited, 11 agencies have accepted cooperating agency status: U.S. Fish and Wildlife Service Ecological Services Program, U.S. Fish and Wildlife Migratory Bird Program; U.S. Environmental Protection Agency Region 9; Clark County Department of Aviation; Clark County Department of Environment and Sustainability; Nye County; Nevada Department of Wildlife; Nevada Division of Forestry; Nevada Department of Conservation and Natural Resources, Off-Highway Vehicles Program; Nevada Division of Emergency Management; and Nevada Department of Public Safety. Additional agencies and organizations may be identified as potential cooperating agencies to participate in the environmental analysis of the Project.

Responsible Official

The Nevada State Director is the deciding official for this planning effort and proposed Copper Rays Solar Project.

Nature of Decision To Be Made

The nature of the decision to be made will be the State Director's selection of land use planning decisions for managing BLM-administered lands under the principles of multiple use and sustained yield in a manner that best addresses the purpose and need.

The BLM will decide whether to grant, grant with conditions, or deny the right of way application. Pursuant to 43 CFR 2805.10, if the BLM issues right-of-way grant(s), the BLM decision maker may include terms, conditions, and stipulations determined to be in the public interest.

Interdisciplinary Team

The BLM will use an interdisciplinary approach to develop the EIS/RMP amendment in order to consider the variety of resource issues and concerns identified. Specialists with expertise in the following disciplines will be involved in this process: air quality, archaeology, botany, climate change (greenhouse gases), environmental justice, fire and fuels, geology/mineral resources, hazardous materials, hydrology, invasive/non-native species, lands and realty, National Conservation Lands, National Trails, public health and safety, recreation/transportation, socioeconomics, soils, visual resources, and wildlife.

Additional Information

The BLM will identify, analyze, and consider mitigation to address the reasonably foreseeable impacts to resources from the proposed plan amendment and all analyzed reasonable alternatives and, in accordance with 40 CFR 1502.14(e), include appropriate mitigation measures not already included in the proposed plan amendment or alternatives. Mitigation may include avoidance, minimization, rectification, reduction or elimination over time, and compensation; and may be considered at multiple scales, including the landscape scale.

The BLM will utilize and coordinate the NEPA and land use planning processes for this planning effort to help support compliance with applicable procedural requirements under the Endangered Species Act (16 U.S.C. 1536) and Section 106 of the National Historic Preservation Act (54 U.S.C. 306108) as provided in 36 CFR 800.2(d)(3), including public involvement requirements of Section 106. The information about historic and cultural resources and threatened and endangered species within the area potentially affected by the proposed plan amendment will assist the BLM in identifying and evaluating impacts to such resources.

The BLM will consult with Tribal Nations on a government-to-government basis in accordance with Executive Order 13175, BLM MS 1780, and other policies. Tribal concerns, including impacts on Indian trust assets and potential impacts to cultural resources, will be given due consideration. Federal, State, and local agencies, along with Tribal Nations, and other stakeholders that may be interested in or affected by the proposed action that the BLM is evaluating, are invited to participate in the scoping process and, if eligible, may request or be requested by the BLM to participate in the development of the environmental analysis as a cooperating agency. The BLM intends to hold a series of government-to-government consultation meetings. The BLM will send invites to potentially affected Tribal Nations prior to the meetings. The BLM will provide additional opportunities for government-to-government consultation during the NEPA process.

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 made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Authority: 40 CFR 1501.7, 43 CFR 1610.2, and 2800)

Jon Raby,
State Director.
[FR Doc. 2022-24623 Filed 11-10-22; 8:45 am]
BILLING CODE 4310-HC-P

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] Copper Ray solar project
Date: Monday, November 14, 2022 12:28:28 PM

This letter is to express opposition to this project. Driving toward Las Vegas on HWY 160 yesterday, with some wind, thick dust was evident everywhere. This was especially true by the Yellow Pine solar site. There’s no way the owners of these sites are going to control the dust in our valley as building starts and these sites become operational. Who do they think they’re kidding?
And the destruction to desert habitat and landscape is heartbreaking to contemplate.
No to any more solar installations in the Pahrump Valley!

Sent from my iPad

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] Copper Ray solar project
Date: Monday, November 14, 2022 12:30:36 PM

This letter is to express opposition to this project. Driving toward Las Vegas on HWY 160 yesterday, with some wind, thick dust was evident everywhere. This was especially true by the Yellow Pine solar site. There’s no way the owners of these sites are going to control the dust in our valley as building starts and these sites become operational. Who do they think they’re kidding?
And the destruction to desert habitat and landscape is heartbreaking to contemplate.
No to any more solar installations in the Pahrump Valley!

[redacted]
Sent from my iPad

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL]
Date: Tuesday, November 15, 2022 8:48:54 AM

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

I thought it was turned down in Pahrump.

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] Copper Rays Solar Project
Date: Friday, November 18, 2022 10:39:47 AM

The published planning documents for Copper Rays Solar Project do not appear to address the proximity of the project site to the federally protected Old Spanish National Historic Trail. Both the primary route through Stump Springs and the alternate route through Pahrump Springs are in this area. Impacts to this designated historic resource must be addressed. The BLM allowed Gemini Solar to destroy several miles of intact pack mule trail from the original Old Spanish Trail route through California Wash despite its being clearly within the designated Historic Trails corridor. The BLM also disregarded photographs and mapping coordinates collected on site that clearly documented the actual trail location. These historic treasures will be of interest long after these solar projects have come and gone, please protect them for future generations.

[redacted]

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Cc: [redacted]
Subject: [EXTERNAL] Copper Ray Solar, LLC - Pahrump, NV
Date: Saturday, November 19, 2022 12:25:12 PM

1. **No!**
2. I do not want the desert or BLM land area around Pahrump surrounded or covered by solar panels.
3. I do not want the fragile desert turf torn up for 6 years or forever by doing the maintenance and repairs required to keep the panels functioning.
4. I reject the idea that solar is a sustainable source of efficient power.
5. There has not been a proven recycle/disposable plan for the equipment one the life span is reached.
6. Until a **MADE IN AMERICA (all parts)** is required on this project……**NO, NO, NO** is my answer to tearing up this desert land.

Sent from Mail for Windows

ePLANNING

Comment Submission

Project: DOI-BLM-NV-S030-2022-0009-EIS - Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS - Copper Rays Solar Project.pdf

Submission ID: SC-1-500304541

Comment

This proposed action is another example in BLM's pathetic pattern of unnecessarily putting solar energy and tortoise conservation in conflict.

The climate and extinction crises are rapidly getting worse and BLM should strive for compatible solutions for both of them. But BLM refuses to do the proactive and regional planning that could accomplish that outcome.

Instead, BLM reactively accepts piecemeal applications that pit solar against tortoises.

BLM is allowing political expedience to supersede proper NEPA and ESA compliance. Tortoises continue to decline in population as a result. This is a needless tragedy.

Submitter(s)

Submitter 1

Name:BLM won’t help tortoises
Address: Not Provided
Group or Organization Name: Not Provided

Disclaimer

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment - including your personal identifying information - may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Withhold my personally identifying information from future publications on this project) - ***NO***

CONSERVATION BIOLOGY OF FRESHWATER TURTLES AND TORTOISES

A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group

Edited by

Anders G.J. Rhodin, John B. Iverson, Peter Paul van Dijk, Craig B. Stanford, Eric V. Goode, Kurt A. Buhlmann, Peter C.H. Pritchard, and Russell A. Mittermeier

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

Kristin H. Berry and Robert W. Murphy

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Number 5 (Installment 13) 2019: Account 109

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Conservation Biology of Freshwater Turtles and Tortoises:
A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group
Rhodin, Iverson, van Dijk, Stanford, Goode, Buhlmann, Pritchard, and Mittermeier (Eds.)
Chelonian Research Monographs (ISSN 1088-7105) No. 5 (Installment 13), doi:10.3854/crm.5.109.agassizii.v1.2019

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

Kristin H. Berry[1] **and Robert W. Murphy**[2]

[1]*U.S. Geological Survey, 21803 Cactus Avenue, Suite F, Riverside, California 92518 USA [kristin_berry@usgs.gov];*
[2]*Royal Ontario Museum, Toronto, Canada [bob.murphy@utoronto.ca]*

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 and age. Females lay from 1 to 10 eggs per clutch and from 0 to 3 clutches annually, with eggs hatching after 67 to 104 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. Disturbed habitats were vulnerable to invading non-native grasses and forbs, creating an 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 catastrophic effects of habitat loss and degradation. Tortoise populations have declined rapidly in density, and most populations are below 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 designated 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.

Distribution. – USA. Distributed in parts of the southern Great Basin, Mojave, and western Sonoran deserts in southeastern California, southern Nevada, northwestern Arizona, and southwestern Utah, north and west of the Grand Canyon/Colorado River complex, with the exception of a small population east of the Colorado River.

Synonymy. – *Xerobates agassizii* Cooper 1861, *Testudo agassizii*, *Gopherus agassizii*, *Gopherus polyphemus agassizii*, *Scaptochelys agassizii*, *Xerobates lepidocephalus* Ottley and Velázques Solis 1989.

Subspecies. – None currently recognized.

Status. – IUCN 2019 Red List: Vulnerable (VU A1acde+2cde; assessed 1996); TFTSG Provisional Red List: Critically Endangered (CR; assessed 2011, 2018); CITES: Appendix II (Testudinidae spp.); 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 Stejneger (1893). It was listed as a subspecies of *Gopherus polyphemus* by Mertens and Wermuth (1955) and referred to the genus *Scaptochelys* by Bramble (1982). *Gopherus lepidocephalus,* described by Ottley and Velázques Solis (1989) based on introduced specimens from the Cape Region of Baja California Sur, Mexico, is a junior synonym of *G. agassizii*. Bramble erected *Scaptochelys* for the clade containing the western species of *Gopherus*, but this name was preoccupied (Bour and Dubois 1984). Recently, Bramble and Hutchison (2014) advocated for the splitting of *Gopherus* into two genera, including *Xerobates* (for the desert species and *G. berlandieri*), but the splitting seems unnecessary, and their proposed taxonomy has not been followed. Recent genetic and morphological work on the previously wide-spread species *G. agassizii* sensu lato has led to the recognition and description of the Sonoran or Morafka's Desert Tortoise, *G. morafkai* (Murphy et al. 2011) in Arizona and Sonora, Mexico, and the Sinaloan Thornscrub Tortoise, *G. evgoodei* (Edwards et al. 2016a) in southern Sonora and Sinaloa, Mexico, markedly limiting the range of *G. agassizii* sensu stricto.

Phylogenetic Relationships. — The genus *Gopherus* contains six species that consist of two major sister-groups:

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

1) *G. polyphemus* and *G. flavomarginatus*, and 2) *G. berlandieri*, *G. evgoodei*, *G. morafkai*, 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. morafkai* may have originated via environmental-dependent parapatric speciation where exogenous selection limited genetic introgression (Edwards et al. 2016c). Later, the divergence of the sister species *G. agassizii* and *G. morafkai* 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. — This and other sections focus primarily on peer-reviewed literature in journals and on recent articles summarizing topics. The published literature on *G. agassizii* contains papers on wild, free-ranging tortoises, tortoises maintained in small and large pens, head-started tortoises, and captives. For most topics, we emphasize studies on 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 1), but the

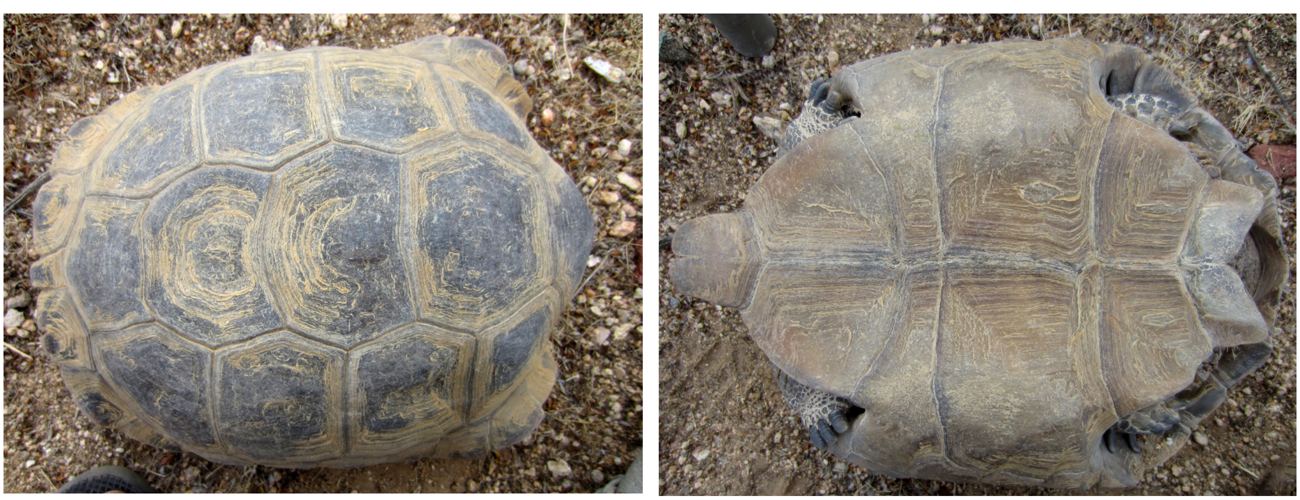

Figure 2. Adult male *Gopherus agassizii* from the Desert Tortoise Research Natural Area, Mojave Desert, California. First captured in 1979 at a CL of 292 mm, he was recaptured repeatedly and in 2012 had a CL of 300 mm (these photos) and estimated to be at least 70 years old. Photos by U.S. Geological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

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

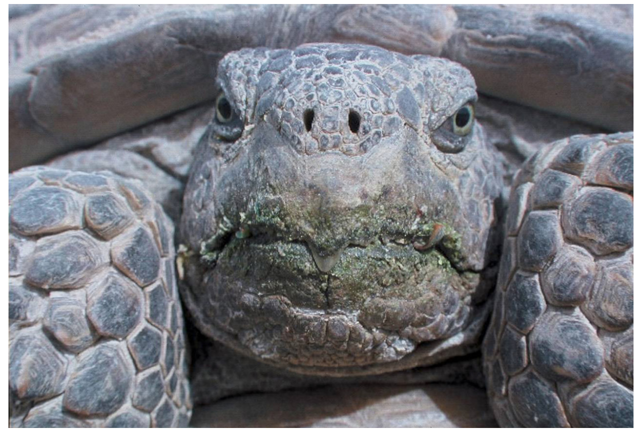

Figure 4. Adult *Gopherus agassizii* with a green beak (from foraging) in spring. Photo by Mark Massar.

largest recorded wild individual was a female from Lucerne Valley, California, first marked in 1980 at 364 mm CL and recaptured in 1986 at 374 mm CL (U.S. Geological Survey files; Berry, unpubl. data). The largest recorded wild male was 330 mm CL, marked in 1982 at the Desert Tortoise Research Natural Area in the western Mojave Desert (Table 1). At that location, 8.9% of adult males were ≥300 mm CL. Larger tortoises may have been more common several decades ago. Ragsdale (1939) wrote that he frequently met healthy old tortoises 15 inches (ca. 380 mm) CL across the back 25–30 years prior (1909–1914), before paved highways came to the Colorado Desert area.

The carapace shape ranges from relatively high-domed and rounded in the west to low-domed and oval in the southern and eastern part of 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 have a larger gular horn, generally becoming more pronounced and upturned with size and age. In contrast, females have a smaller, shorter, and generally flatter gular horn. The gular horn tends to be notched early in adulthood but notching may disappear in old adults. The tails in males are longer than in females, projecting beyond the shell and often leaving a linear line or lines in sand when walking, whereas the tail of females does not extend beyond the carapace or plastron. Colors of the integument 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 range from shades of light to dark brown, gray, or black with yellowish, reddish, greenish, and olive tones. Limb colors also vary with axillary 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. flavomarginatus* by having relatively smaller 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. polyphemus* and *G. flavomarginatus*, but the distance from the bases of the first to fourth claws is the same on all feet in *G. agassizii* (Auffenberg and Franz 1978). *Gopherus agassizii* and closely related *G. berlandieri*,

Table 1. Mean sizes and weights of adult female and male Mojave Desert Tortoises (*Gopherus agassizii*) in three desert regions of the geographic 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 Desert sites had tank tracks and litter from World War II military exercises.

Sizes and Weights	West Mojave: Desert Tortoise Research Natural Area Interior	East Mojave: Fenner Valley	Colorado Desert: Chuckwalla Bench
Year sampled	1982	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)	214.5 (183–247)	222.3 (188–254)
males	249.1 (180–330)	242.5 (182–307)	243.3 (190–291)
Mean weight, g (range):			
females	2522 (1200–3750)	2148 (1111–2915)	2215 (1350–3300)
males	3302 (1350–6950)	3044 (1115–6000)	2897 (1350–4750)

Figure 5. Young adult female *Gopherus agassizii* from Ward Valley in the Colorado 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 having a wedge-shaped versus a rounded snout (Auffenberg and Franz 1978). *Gopherus agassizii* differs from *G. morafkai* 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 (Weinstein and Berry 1989). Finally, *G. agassizii* and *G. morafkai* both differ from the newly described *G. evgoodei* in having a higher shell in profile. *Gopherus evgoodei* also differs in having rounded foot pads, multiple enlarged spurs on the radial-humeral joint, 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 originally described, the geographic range of *Gopherus agassizii* (sensu lato) extended from southeastern California, southern Nevada, and southwestern Utah south through Arizona and Sonora and into the northern part of Sinaloa, Mexico (Stebbins 1966; Auffenberg and 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 years later, *G. morafkai* 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, Mexico (Edwards et al. 2016a).

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

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

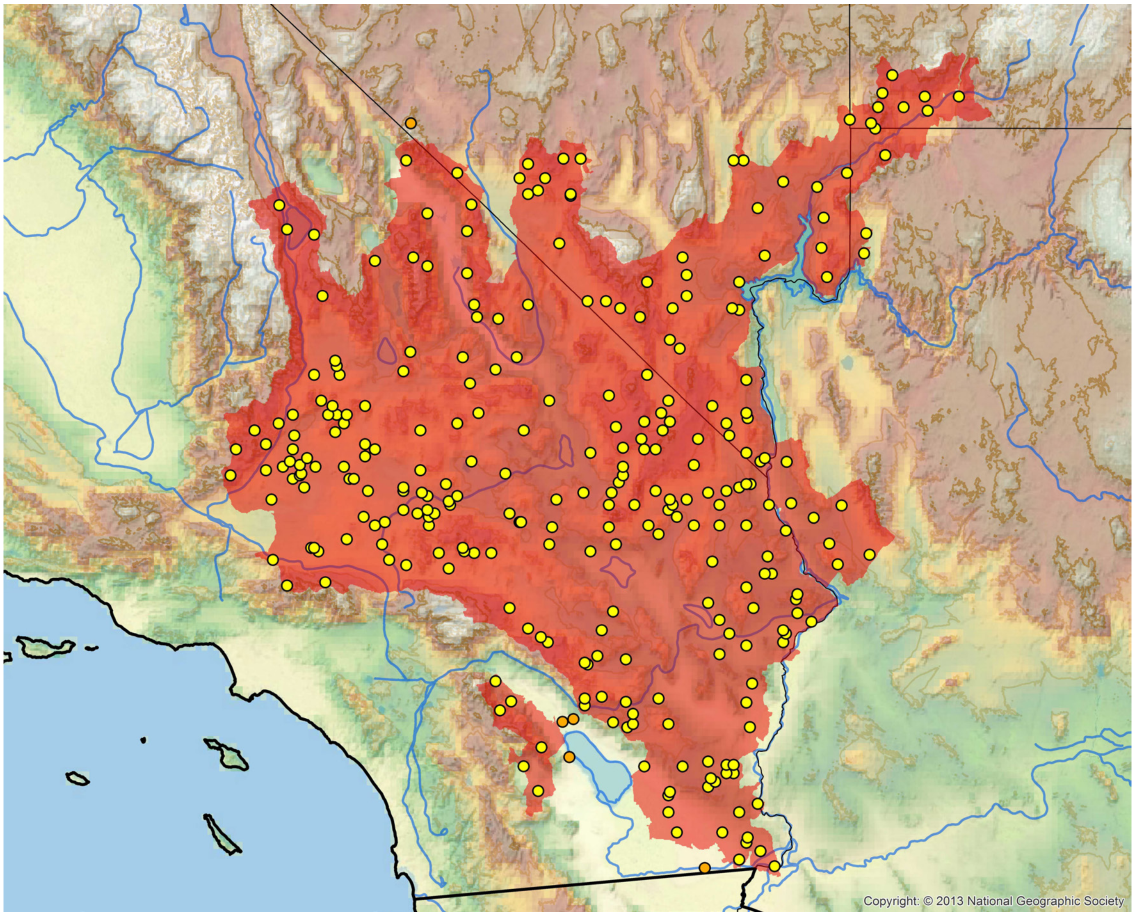

Figure 7. Distribution of *Gopherus agassizii* in California, Nevada, Utah, and Arizona in the USA. Yellow dots = museum and literature occurrence records of native populations based on Iverson (1992) plus more recent and authors' data; orange dots = uncertain native or introduced specimens; red shading = projected historic distribution. Distribution based on GIS-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 al. 2009; TTWG 2017), and adjusted based on authors' subsequent data.

Desert Reserve and adjacent lands in 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 their taxonomic identities. Nineteen hybrids were identified by Edwards et al. (2015), most as F_2 mixtures and were primarily in the ecotone; one additional hybrid individual, a backcross, was found in the Arrastra Mountains. Inman (2019) concurred, demonstrating separation of niches between the two species.

Most of the geographic range of *G. agassizii* occurs within the Mojave 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 range occur 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 Peninsular Range in the western Sonoran Desert. Using Recovery Units and critical habitat units or Tortoise Conservation Areas as a guide, approximately 55% of Tortoise 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* have contracted along the margins and fragmented in the interior, with losses from agricultural, urban, energy, and military developments, as well as transportation corridors and roads. Hundreds of square kilometers of tortoise habitat have been lost in the southwestern Mojave Desert, but do not yet show on maps of 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 include Indian Wells, Antelope, Victor, Apple, Chuckwalla, and Las Vegas valleys in California and Nevada, and St.

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

Gopherus agassizii can be found in unusual places and ecosystems outside its geographic range. Captives frequently escape, are released or translocated (unauthorized) without regard to sites of origin. Animals found in the Cape Region of Baja California Sur, Mexico, were mistakenly described as the purported new species, *G. lepidocephalus* (Ottley and Velázques Solis 1989). In addition, mass authorized translocations have occurred (see summaries in Murphy et al. 2007). In a study of the genetics of 180 captive tortoises in three cities in Arizona within the range of *G. morafkai*, more than 40% were *G. agassizii* from the Mojave Desert or were hybrids (Edwards et al. 2010). In a similar study of 106 captive tortoises from three desert communities in the Mojave Desert, the genotypes of only 44% were *G. agassizii* of local origin, 55% were assigned to one of seven *G. agassizii* genetic units from outside the local area, and one tortoise was genotyped as *G. morafkai* (Edwards and Berry 2013).

Population Genetics. — Murphy et al. (2007) provided the first analysis of population differentiation across the landscape to assess the correspondence between Recovery Units in the 1994 Recovery Plan and genetic patterning. Their analysis used mtDNA sequences from 125 Desert Tortoises and 16 microsatellite loci of 628 animals collected from 31 sample sites. Analyses recovered substantial differentiation within the Western Mojave Recovery Unit. However, the authors had very limited sampling in Nevada and Utah.

Hagerty and Tracy (2010) performed a similar assessment using 20 different microsatellite loci with larger sampling in Utah, Nevada, and the northern deserts of California, but relatively poor sampling in the western and southern part of the species' range; they recovered an alternative pattern. Later, Hagerty et al. (2011) applied landscape genetic analyses to those data and recovered patterns that were largely compatible with those of Murphy et al. (2007) when considering sample sizes; larger sample sizes in northern areas for Hagerty and Tracy (2010) and southern areas for Murphy et al. (2007) yielded more details. The U.S. Fish and Wildlife Service's (USFWS) Recovery Office assumed that a strategy of random sampling would outperform strategic sampling of populations, and therefore relied on the Hagerty and Tracy (2010) study. Rico et al. (2015) modeled the two sampling strategies and discovered that strategic population sampling vastly outperformed random sampling, thereby giving credence to the study of Murphy et al. (2007).

Recently, Sánchez-Ramírez 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 western Mojave Desert. Their analyses also identified 12 highly differentiated outlier genes likely involved in adaptations.

On a microgeographic scale, Desert Tortoises at a study area in the central Mojave Desert exhibited weak genetic structure (Latch et al. 2011). Analyses identified two subpopulations with low genetic differences and evidence of gene flow. Topography, specifically slope (the predominant factor) and roads, influenced local gene flow, with the changes 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 vegetation associations (Weinstein 1989; Rautenstrauch and O'Farrell 1998; Longshore et al. 2003; Keith et al. 2008; Berry et al. 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 banks or walls of ephemeral washes (Woodbury and Hardy 1948; Burge 1978; Rautenstrauch and O'Farrell 1998; Andersen et al. 2000; Berry et al. 2006; Mack et al. 2015).

Habitat Use. — Cover of shrubs or trees is essential for protection from extremes of temperature, precipitation, and predators. Over 70% of cover sites (burrows, pallets) occur beneath shrubs, with the larger shrubs or trees preferred (Burge 1978; Berry and Turner 1986). The vegetation of shrubs, trees, cacti, and perennial grasses differs regionally within the 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 et al. 1982; USFWS 1994, 2011). For example, throughout the geographic range, most rainfall occurs in fall and winter. However, in the eastern and northeastern Mojave and western Sonoran deserts, summer rainfall is important, resulting in shifts in vegetation types. Similarly, numbers of annual freezing days are high in the north (e.g., Desert Game Range, Nevada: 126 days) dropping to just a few days in the southern part of the range in the western Sonoran Desert (1 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 habitat. The most common associations contain creosote bush (*Larrea tridentata*), usually with white bur-sage (*Ambrosia dumosa*) or cheesebush (*A. salsola*) and several other species of shrubs, cacti, and perennial grasses. With increasing elevation, multiple species of woody shrubs and tree yuccas (Joshua tree, *Yucca brevifolia,* and Mojave yucca, *Y. schidigera*) become more common, with blackbrush (*Coleogyne ramosissima*) associations

Figure 8. Habitats of *Gopherus agassizii*. **a.** Ecotone between Mojave and Great Basin deserts, Utah, Upper Virgin River Recovery Unit. Photo by Ann McLuckie. **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 Unit. Photo by Kristin H. Berry.

present in higher elevations. In the northeast corner of the geographic range, in the Red Cliffs Desert Reserve in Utah, vegetation is transitional between Mojave Desert and Great Basin, combined with sand dune systems. Sand sage (*Artemisia filifolia*), creosote bush, blackbrush, Nevada ephedra *(Ephedra nevadensis*), and big galleta (*Hilaria rigida*) are common (McLuckie et al. 2002).

The western Sonoran Desert is a warmer, hotter desert with a higher proportion of precipitation occurring in summer. This desert is also characterized by creosote bushes, but a major difference is the presence of microphyll woodlands of blue palo verde (*Parkinsonia florida*), smoke tree (*Psorothamnus spinosus*), and ironwood (*Olneya tesota*) in ephemeral stream channels separated by desert pavements or open desert with ocotillo (*Fouqueria splendens*) mixed with creosote bush, other shrubs, and cacti (Berry 1984).

More detailed descriptions of vegetation are in the first Recovery Plan and appendices, as well as in publications of individual field studies (USFWS 1994). Some sites have rich assemblages of shrubs, trees, cacti, and native bunch grasses, whereas others are low in shrub and grass diversity. Tortoises occur in very low densities or are absent where shrub cover is sparse, precipitation is low and timing erratic, and annual food plants are available only intermittently (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 in deteriorated habitat.

Adaptations. — Tortoises have several adaptations or exaptations for dealing with environmental extremes found within the geographic range, including behavioral responses, such as use of the burrow, cave, or den to escape extremes in environmental temperatures (e.g., Woodbury and Hardy 1948; Mack et al. 2015). They also exhibit physiological, hematologic and plasma biochemical responses for coping with lack of water, food, and shelter, and reduction in annual output of eggs in response to drought. We review these subjects below (Morafka and Berry 2002).

The Tortoise Burrow. — Tortoises spend >90% of their lives inactive and underground in burrows, pallets, caves, or other cover. For example, in the northern part of the range in Rock Valley, Nevada, where numbers of freezing days/year are high, Nagy and Medica (1986) reported that tortoises spent 98.3% of time underground. We define pallets as scrapes, often under a shrub, potentially the beginning ofa burrow, covering only part of the shell; they are often used in spring as a temporary refuge. Burrows are dug in soil, are often 3 m or more in length with a soil cover of a meter or more in the deepest part, and have a downward slope. Dens occur in areas with well-developed calcic layers, are often in washes, the tunnels are generally horizontal and may have side rooms and chambers that can be used by multiple tortoises. Caves are similar to dens, larger 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 and food, and when in a deep burrow, tortoises reduce their metabolic rates (Henen et al. 1998).

Types of cover site or shelter (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 cave 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 and Hardy 1948). Wild juvenile and small immature tortoises also use small, half-moon shaped burrows matching their sizes at several Mojave and western Sonoran Desert sites (Berry and Turner 1986). In a study of head-started tortoises, most neonates (83%) hatched in pens constructed their own burrows within a few days of emergence from the nest; others used rodent burrows or shared artificial burrows constructed for adults (Morafka et al. 1997).

In the 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 gravels and sand and with well-developed calcite cementation (Woodbury and Hardy 1948; Mack et al. 2015). These retreats can be several meters in length and used by multiple tortoises. In the northeastern Mojave Desert, caves or dens were usually 2.4 to 4.6 m in length, occasionally 6.1 to 9.1 m with multiple side tunnels and rooms supporting as many as 17 tortoises simultaneously (Woodbury and Hardy 1948). Tortoises can use a combination of burrows, caves, and dens (Woodbury and Hardy 1948; Mack et al. 2015). In contrast, in the northwestern, western, and southern Mojave and Colorado deserts, tortoises primarily use burrows (Berry et al. 2006, 2013, 2014; Krzysik 2002; Harless et al. 2009).

Most cover sites were found beneath the canopies of large shrubs, regardless of size of the tortoise (Burge 1978; Berry and Turner 1986). At the Arden site in Nevada, Burge (1978) reported that 72% of large and small burrows were placed under shrubs with the greatest shade-giving properties (i.e., catclaw, *Senegalia greggii* [*Acacia greggii*], Mojave yucca and creosote bush). For wild juveniles and small immature tortoises, 79% of burrows were under canopies or basal branches of live or dead shrubs; creosote and white bur-sage were the most common species (Berry and Turner 1986).

The burrows of head-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; Harless et al. 2009). The patterns of shelter type and tunnel length varied by season (Woodbury and Hardy 1948; Rautenstrauch et al. 2002), with tortoises tending to use shallower sites in spring and deeper and longer tunnels in fall and winter. Tortoises exhibited fidelity to specific burrows, repeatedly returning to burrows used from season to 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 et al. (2000) reported fidelity to the vicinity of a site, rather than to a specific burrow (i.e., 75% of all captures were within 300 m of a previous location). Woodbury and Hardy (1948) noted that tortoises tend to stay in familiar areas.

Tortoise dens, caves, and burrows are potentially important as home sites and temporary refuges from extremes of temperature or predation for many species of vertebrates and invertebrates. Woodbury and Hardy (1948) physically entered dens occasionally and thus were able to learn more about commensals and predators than the incidental observations reported more recently by others. We do not know the extent of use by commensals or transients. However, the following compiled list, while not comprehensive and excluding invertebrates, suggests that burrows, dens, and caves occupied by tortoises are critically important to desert ecosystems. They are shared by many other vertebrates, including mammals, birds, and reptiles.

Lizards observed in burrows or dens include the Gila Monster, *Heloderma suspectum* (Gienger and Tracy 2008), Desert Spiny Lizard (*Sceloporus magister*), Long-nosed Leopard Lizard (*Gambelia wislizenii*), and Desert Banded Gecko (*Coleonyx variegatus*) (Woodbury and Hardy 1948; Walde and Currylow 2015; Walde et al. 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 lutosus*), Red Diamond (*C. ruber*), Speckled (*C. mitchellii*), and Mojave (*C. scutulatus*) (Woodbury and Hardy 1948; Burge 1978; Lovich 2011; Walde et al. 2014; Agha et al. 2017; Berry et al., pers. obs.). Birds observed in dens or burrows include the Burrowing Owl (*Athene cunicularia*), Cactus Wren (*Campylorhynchus brunneicapillus*), Roadrunner (*Geococcyx californianus*), and Horned Lark (*Eremophila alpestris*) (Woodbury and Hardy 1948; Burge, 1978; Walde et al. 2009; Agha et al. 2017). Mammals observed were the Desert Woodrat (*Neotoma lepida*), Merriam's Kangaroo Rat (*Dipodomys merriami*), White-footed Mouse (*Peromyscus* spp.), Antelope Ground Squirrel (*Ammospermophilus leucurus*), Desert Cottontail (*Sylvilagus audubonii*), and Black-tailed Jackrabbit (*Lepus californicus*) (Woodbury and Hardy 1948; Burge 1978; Agha et al. 2017), as well as Desert Kit Fox (*Vulpes macrotis*; Berry, pers. obs.) and American Badger (*Taxidea taxus*) (Germano and Perry 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 the entrances of tortoise burrows with several additional species of mammals, birds, and reptiles. Excluding large vertebrates (e.g., Bighorn Sheep, Black Bears), additional mammals seen were Desert Kangaroo Rat (*Dipodomys deserti*), Desert Pocket Mouse (*Chaetodipus penicillatus*), and California Ground Squirrel (*Otospermophilus beecheyi*). Additional birds seen were Rock Wren (*Salpinctes obsoletus*), California Towhee (*Melozone crissalis*), Black-throated Sparrow (*Amphispiza bilineata*), Loggerhead Shrike (*Lanius ludovicianus*), Chukar Partridge (*Alectoris chukar*), Bewick's Wren (*Thryomanes bewickii*), California Quail (*Callipepla californica*), White-crowned Sparrow (*Zonotrichia leucophrys*), California Thrasher (*Toxostoma redivivum*), Common Raven (*Corvus corax*), and Verdin (*Auriparus flaviceps*). Additional reptiles seen were Great Basin Whiptail (*Aspidoscelis tigris tigris*), Western Side-blotched Lizard (*Uta stansburiana*), Sagebrush Lizard (*Sceloporus graciosus*), and Long-nosed Snake (*Rhinocheilus lecontei*).

Seasonal and Daily Activities. — Ambient temperatures above and below ground are an important factor in determining activity, but not the only factor. Tortoises primarily regulate body temperature by behavior, avoiding excess heat and cold by retreating to burrows, pallets, and dens. Early studies indicated that body temperatures of active tortoises were between 19.0 and 37.8°C, and that tortoises retreated to shade at 37–38°C; the critical thermal maximum of internal body temperatures was between 39.5 and 43.0°C, and the lethal maximum was 43.0°C (Brattstrom 1961, 1965). At the lower limit of the lethal range (39.5°C), a tortoise will produce copious amounts of saliva, which spread along the neck and axillary area in an effort at cooling (McGinnis and Voigt 1971).

Temperatures inside burrows and dens are cooler than on the mound or outside. Year-round temperatures 5.3 m inside deep dens on the Beaver Dam Slope of Utah (northeastern Mojave Desert) were between 10.0 to 15.6°C (Woodbury and Hardy 1948). In a study in the central Mojave Desert, Mack et al. (2015) compared annual temperatures under shrubs, and at the entrance to and inside caves and burrows dug in soils. Average maximum summer and winter temperatures ca. 1.5 m inside 24 caves were 33.7°C (range = 29.2–38.3°C) and 13.5°C, respectively. They did not place temperature probes as deeply as Woodbury and Hardy (1948) did to avoid disturbing the tortoises. Tunnel length had the greatest influence on temperatures: they were warmer in winter and cooler in summer compared to outside the burrow or cave

(Mack et al. 2015). Cover sites in consolidated gravels and soils were warmer than caves in summer, but not significantly cooler in winter.

The microhabitats of burrows and dens and length of tunnels affected humidity and thus water loss (Bulova 2002). Longer burrows with smaller entries tended to be cooler and more humid. Wilson et al. (2001) showed experimentally that hibernating juveniles lost body mass 1/20th as quickly as active juveniles. Juveniles in shorter burrows in the field lost body mass faster than those in the longer tunnels.

Time spent underground or in above-ground activities differed by year, individual, sex, size, and region (e.g., Berry and Turner 1986; Zimmerman et al. 1994; Rautenstrauch et al. 1998; Nussear et al. 2007; Agha et al. 2015a). All seasonal and daily activities were influenced by temperature tolerances of tortoises, temperature extremes in the environment, timing and amounts of precipitation, availability of free water to drink, and available forage (Woodbury and Hardy 1948; 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 forage was available) and interacting with other tortoises, 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; they were active intermittently until mid- to late October or November, when they retreated underground for hibernation (Woodbury and Hardy 1948; Rautenstrauch et al. 2002). However, tortoises sometimes emerged from underground retreats to drink free water and change shelter sites at any time of year; they were especially likely to emerge with rainfall events during or after droughts (Medica et al. 1980; Henen et al. 1998). Males tended to be more active than females (Agha et al. 2015a).

Surface and air temperatures affected daily and seasonal emergence from and retreat to burrows for adult tortoises (Woodbury and Hardy 1948; McGinnis and Voigt 1971; Zimmerman et al. 1994). In 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 emerging earlier in the morning from burrows and retreating earlier to burrows, emerging again in afternoon or evening. In summer, some tortoises emerged in late afternoon or evening and remained above ground all night when burrow temperatures were warmer than the outside 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, and June than larger juveniles and small immature tortoises regardless of the month of observation in spring, e.g., 17.2°C (range 10.1–25.6°) in March (Berry and Turner 1986). Some head-started juveniles in pens were also active in winter (Wilson et al. 1999b). The small size and ability to 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 influenced seasonal and daily activities. In years when precipitation was above the long-term 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 et al. 1999; Freilich et al. 2000; Krzysik 2002; Jennings and Berry 2015). During drought years, home range size, numbers of burrows used, and distances traveled 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 et al. (1998) summarized several years of study concerning the effects of climate, specifically variation in rainfall and food availability, on metabolic rates and water flux rates in adult tortoises in western, eastern, and northeastern regions of the Mojave Desert. Availability of water (and forage) varied substantially from year to year and thus affected metabolic rates. Water flux-rates and availability of free water for drinking also varied highly. In years of high rainfall, metabolic rates and water flux-rates 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 were due to season, rainfall was the critical factor in rates of metabolism and rates of water influx. 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 tortoises have both physiological and behavioral flexibilities 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 their mass (Peterson 1996). When droughts occur, tortoises can lose up to 40% of initial body mass. They can resorb water from their bladders and store wastes (sodium, chloride, and urea) both in blood plasma and the bladder.

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

Figure 10. Adult *Gopherus agassizii* eating blue dicks (*Dichelostemma apitatum*) in the Western Mojave Recovery Unit. Photo courtesy of Desert Tortoise Preserve Committee.

Tortoises may also void their bladders when handled or when approached by a human. Agha et al. (2015b), 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 to higher probabilities of voiding were increased handling time regardless of size or sex and increased precipitation for juveniles and females. Models indicated a negligible effect of voiding behavior and sex on survivorship.

Christopher et al. (1999) reported seasonal differences in hematologic and plasma biochemical responses of adult tortoises in a five-year study in three Mojave Desert regions (western, eastern, northeastern). The authors reported yearly 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 blood urea nitrogen [BUN] and increased uric acid), nutrient intake (increased concentrations of glucose, total protein, albumin, phosphorus, cholesterol, iron, and potassium concentrations), and increased metabolic activity (increased alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase activities). 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 CO_2. Males and females differed in packed cell volume, aspartate transaminase activity, and concentrations of hemoglobin, cholesterol, triglycerides, calcium, and phosphorus.

Wild tortoises that were moribund from dehydration 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 95th percentiles for four or 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 more pliable, muscle mass was below normal, and osteopenia of some bones was evident. Handling and certain research activities also had 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 native bush muhly (*Muhlenbergia porteri*) and the non-native red brome and cheat grass (*Bromus madritensis* ssp. *rubens* and *B. tectorum*); the non-native redstem filaree (*Erodium cicutarium*) was observed to be eaten in winter. During spring, tortoise ate wildflowers until domestic sheep 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). This conflict over food availability in spring was first described by Woodbury and Hardy (1948) and was later observed and studied elsewhere in the Mojave 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 (1976) observed foraging behavior of 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 et al. 2002; Jennings and Berry 2015). Results indicated that tortoises select species and plant parts, and that favored species differed by season, region, and availability. In late winter and spring of a highly productive year, tortoises prefer natives to non-natives, forbs to grasses, and succulent green plants 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 few herbaceous perennials, succulents (cacti), and flowers and leaves of a few perennial shrubs. Tortoises favored species of forbs or herbaceous perennials from several plant families: Asteraceae, Boraginaceae, Cactaceae, Fabaceae, Malvaceae, Nyctaginaceae, Onagraceae, and Plantaginaceae (Burge and Bradley 1976; Avery and Neibergs 1997; Jennings and 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 high in water and protein but low in potassium. In 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 (Oftedal et al. 2002). The juveniles bypassed the abundant non-native Mediterranean grasses, *Schismus* spp.

Non-native forbs (e.g., redstem filaree) and grasses (Mediterranean grasses, red brome, and cheat grass) invaded and became established throughout the Mojave Desert and form >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 the Mojave Desert (Brooks and Berry 2006). Other non-native species, such as Sahara or African mustard (*Brassica tournefortii*), invaded and proliferated rapidly in the western Sonoran Desert and appear to be displacing native annual forbs (Berry 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 and perennial sand rice grass (*Stipa* [*Oryzopsis*] *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 they 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 juveniles. 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 (Hazard et al. 2009, 2010). 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 octoflora*), invasive red brome grass, and native forbs combined with either native or invasive grass—on growth, body condition, immunological responses, and survival on 100 captive neonate and juvenile tortoises. Tortoises fed native forbs had better body condition, growth, immune functions, and higher survival (>95%) than those fed the grass diets. About one-third 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. In addition, tortoises consuming red brome were observed with persisting injuries to their jaws from seeds, and seeds were also embedded in a nostril and corner of an eye (Medica and Eckert 2007). Drake et al. (2016) made similar observations and noted inflammation. Collectively, these studies point out the importance of selected native forbs to the health and overall condition of tortoises. Tortoises also 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 techniques (e.g., Woodbury and Hardy 1948; O'Connor et al. 1994; Duda et al. 1999; Freilich et al. 2000; McLuckie and Fridell 2002; Harless et al. 2009, 2010; 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 home range for both male and female adult tortoises were derived from radio-transmittered individuals, males had larger home ranges than females (Burge 1977a; O'Connor et al. 1994; Duda et al. 1999; Freilich et al. 2000; Harless et al. 2009). For example, Harless et al. (2009), in a 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 polygons. 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 Niño Southern Oscillation (Duda et al. 1999; Freilich et al. 2000; Ennen et al. 2012). O'Connor et al. (1994) noted that home ranges were not exclusive for individuals, in contrast to a study by Harless et al. (2009), who reported that home ranges of males overlapped but those of females did not. Tortoises exhibited fidelity to home ranges and activity areas; even after a fire when parts of home ranges were burned, tortoises continued to use the same areas (Drake et al. 2015; Lovich et al. 2018a).

Female Reproductive Cycle. — Female and male reproductive cycles are not synchronized (Rostal et al. 1994; Lance and Rostal 2002). In April, after emergence from hibernation, plasma estradiol, testosterone, corticosterone, and lipids in females were elevated but declined to low levels after eggs were laid. When nesting 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 vitellogenin levels) increased and were associated with vitellogenesis and growth of ovarian follicles. Ovarian follicles increased to ovulatory size before hibernation. Testosterone levels were high (mean 6.22 ng/mL) during spring courtship (April), declining to a mean of 0.37 ng/mL at the end of the nesting period (July), but again rose between July and October during the late summer and fall courtship and mating period.

Size and age at first reproduction vary across the geographic range. However, long-term studies have not been conducted for wild, free-ranging female tortoises for all regions. Woodbury and Hardy (1948) estimated age at first reproduction as 15–20 years in the northeastern Mojave Desert, whereas Turner et al. (1987) estimated 12 to 20 years for females in the eastern Mojave Desert, drawing on a multi-year study to develop a life table for the species. Curtin et al. (2009), in a study based on skeletochronology, estimated that females from the western Mojave Desert 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 the far northern part of the range in Nevada, the smallest tortoise to produce eggs was 209 mm CL; 11 smaller tortoises estimated to be 15–26 years old did not produce eggs (Mueller et al. 1998). Generation time for *G. agassizii* has been estimated to be approximately 20–25 years (Turner et al. 1987; USFWS 1994), but this appears to need revision 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 shrubs (Woodbury and Hardy 1948; Roberson et al. 1985; Turner et al. 1986; Baxter et al. 2008; Ennen et al. 2012; Lovich et al. 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 et al. 1999; McLuckie and Fridell 2002; Ennen et al. 2012; Lovich et al. 2018a). Nesting may occur earlier in the western Sonoran Desert — Lovich et al. (2018a) noted nesting April 6 at a study site in Joshua Tree National Park, two weeks earlier than published previously. Lovich et al. (2012) 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., appearance of clutches was later in cool years.

Some females showed nest-guarding behaviors to Gila Monsters and humans (Henen 1999; Gienger and Tracy 2008; Agha et al. 2013). Beck (1990) studied Gila Monsters in southwestern Utah; 29% of their scats and observations were of predation on tortoise nests. Gienger and Tracy (2008) reported two different observations of Gila Monsters entering shelters with a female tortoise and egg shell fragments later observed at the nest. In one case, the female tortoise bit and chased the lizard. Henen (1999) reported that a 182 mm CL female rammed his leg and field equipment with her epiplastron a few days after laying her first clutch of eggs. In another case report, Agha et al. (2013) described a female tortoise twice resisting a researcher's attempts to remove her 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 after 98–101 days in southern Nevada (Burge 1977b) and of 12 wild females after 67–104 days with a mean incubation time of 89.7 days (±3.25 days SE) in southwestern Utah (McLuckie and Fridell 2002). Ennen et al. (2012) reported hatching from 74 to 100 days (mean, 84.6 days) at a site in the western Sonoran Desert. Incubation time was significantly longer in the first than in second clutches. Nest predation occurred commonly (Roberson et al. 1985; Turner et al. 1986; Ennen et al. 2012). Nests placed in cages 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, and whether measured directly or from radiographs. Measurements from radiographs may underestimate egg sizes slightly (Wallis et al. 1999). Burge (1977b) reported dimensions of four eggs from tortoises at Arden, Nevada (43.0 × 33.0, 45.0 × 36.0, 46.0 × 33.0, 47.0 × 34.0 mm). Using X-rays to measure eggs, Wallis et al. (1999) described egg sizes for first and second clutches and for two different 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. Eggs from 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 width. 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 area in the western Colorado Desert, and Lovich et al. (2018b) reported average x-ray egg widths of 36.5 ± 1.56 mm from a study area in Joshua Tree 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 the eastern Mojave Desert, the eastern females produced eggs that were significantly narrower and shorter than females from the western site, even after accounting for body sizes (Wallis et al. 1999).

The numbers of eggs laid per clutch range from 1 to 10, with females laying from 0 to 3 clutches per year (Turner et al. 1986; Mueller et al. 1998; McLuckie and Fridell 2002; Lovich et al. 2015). Studies undertaken at different sites and years described mean clutch sizes ranging from 3.25 to 5.91 eggs and clutch frequencies from 1.33 to 2.36 clutches/female/year (Turner et al. 1986; Mueller et al. 1998; Wallis et al. 1999; McLuckie and Fridell 2002; Bjurlin and Bissonette 2004; Baxter et al. 2008; Lovich et al. 2015, 2018b). At some sites, researchers reported that larger females produced larger clutches (Turner et al. 1986; Wallis et al. 1999; McLuckie and Fridell 2002) and females producing a single clutch laid larger eggs (Turner et al. 1986; Mueller et al. 1998). Clutch frequencies were correlated positively with carapace length (McLuckie and Fridell 2002), and annual fecundity was positively correlated with female size (Mueller et al. 1998; Wallis et al. 1999; McLuckie and Fridell 2002). Wallis et al. (1999) observed females at a western Mojave Desert site that produced fewer but larger eggs than females at an eastern Mojave site, and Sieg et al. (2015) reported that larger females produced larger eggs, but carapace length did not affect clutch size.

Timing and amounts of rainfall and the subsequent production of forbs and grasses consumed by tortoises likely affect one or more aspects of egg production and the effects may differ regionally. For example, precipitation occurred primarily in late fall and winter in the western Mojave Desert compared with precipitation occurring both in fall-winter and summer in the eastern Mojave (Turner et al. 1986). Environmental conditions in the previous year may affect egg production in a subsequent year, because ovarian follicles mature between July and October and the number maturing is dependent on available food and water (Henen 1997; Mueller et al. 1998). Henen (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). In contrast, in the eastern Mojave Desert, eggs were smaller, possibly allowing the juveniles to take advantage of the summer rains and associated food sources. Also, in the eastern Mojave Desert, clutch frequencies were positively correlated with production of annual forbs and grasses (Turner et al. 1986), and Henen (1997) described how the paucity of spring annual plants contributed to lower egg production.

In the Colorado Desert, Lovich et al. (2015) reported that amounts of winter precipitation had no significant effect on clutch frequency or the percentage of reproducing females. Sieg et al. (2015) reported elevation to be a factor in a 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, precipitation was higher and values for species richness of shrubs, total cover of plants, and herbaceous plant biomass were all higher than at lower elevations.

Females appeared to use a breeding strategy intermediate between capital and income breeding with bet hedging (Henen 2002a, 2002b, 2004; Lovich et al. 2015). Desert Tortoises have shown the ability to relax or temporarily relinquish regulation of homeostasis regarding water, electrolytes, nitrogen, and energy. In field studies, females demonstrated extreme physiological tolerance and flexibility in their water and energy budgets (Henen 2002a). They reduced metabolic rates and produced eggs, even during periods of extreme droughts and lack of forage (Henen 2002b). Females exhibited characteristics of both capital and income breeders: they limited egg production during droughts and when body reserves were limited, acquired water and protein reserves prior to winter and used reserves to produce eggs, had full-sized follicles prior to hibernation, and ovulated prior to eating in spring (Henen 2002b). They also responded rapidly by producing more eggs when forage became available after hibernation. This mixed strategy constituted bet-hedging for reproducing in the extremes typical of desert environments. Lovich et 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 were fertile, 93.4% were unbroken, 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 the southern Mojave Desert. Predation rates were high in 1998 (47% of nests), but less so in 1999 (12% of nests). The authors then protected nests with cages 70 days after incubation. Of the remaining 132 caged eggs, 81.6% and 83.0% hatched in 1998 and 1999, respectively. When ill and deformed neonates were excluded, the figures for normal neonates were 73.7% and 67.0% in 1998 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 eggs did not hatch, were infertile or nonviable, and a few hatchlings were ill or deformed in several studies (e.g., Turner et al. 1986; Bjurlin and Bissonette 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 when incubation 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 1:1 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 ranging from 68 to 89 days. When temperatures were lower or higher, survival was lower. Baxter et al. (2008), in a study of females in a head-starting enclosure in the central Mojave Desert, reported that early nests (22 May–2 June) were cooler and produced four all-male nests and two nests of mixed sexes. In contrast, six later nests (17 June–16 July) were significantly warmer and produced only females.

Adult female tortoises store sperm, potentially in the sperm-storage tubules within the albumen-secreting gland region of the oviduct (Palmer et al. 1998). In an experimental study, hatching success was 97.1% in females with sperm stored >2 years. Five of 12 clutches showed tentative evidence of multiple paternities. Davy et al. (2011) confirmed both polyandry and multiple paternities in clutches from females: of 28 clutches from 26 females with an average of six neonates per clutch, a minimum of 64% of females were polyandrous and a minimum of 57% of clutches had multiple sires.

Male Reproductive Cycle. — Testosterone primarily controls changes in the male cycle (Rostal et al. 1994; Lance and Rostal 2002). Testosterone levels were low when males emerged from hibernation and continued to decline until May, but then rose from late May to August and September, reaching a peak at a mean of 243.60 ng/mL, and then declined prior to hibernation. The low in testosterone levels (mean 18.37 ng/mL) occurred when females were nesting in May. Changes in the testes followed this cycle: when males emerged from hibernation, the seminiferous 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 early fall, spermatogenesis was at a maximal level. Corticosterone levels were high when testosterone was high but higher than in females at any time of year. Body mass tracked these changes and was significantly higher from June to September than at other times during the year. The fall mating period may be more important than courtship activity in spring and may be associated with sperm storage in females (Palmer et al. 1998).

Table 2. Demographic data from early surveys of populations of *Gopherus agassizii*, primarily from 60-day spring studies on 2.59 km^2 plots in California, Nevada, Utah, and Arizona. Adults are defined as ≥180 mm carapace length. For most plots, data were summarized in Berry (1984), a compilation of plot data from 1948 through 1981. The population at Beaver Dam Slope population, Utah, was studied by Woodbury and Hardy (1948) and Hardy (1976), the population in the Pinto Basin, California, by Barrow (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 counts	Counts of adults	Counts of adults (per km^2)	Sex 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	52:48
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	7.80	1979	Spring, 180d	574	382	49.0	215:167*	67:33
Fremont Peak, CA	2.59	1980	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	27.0	34:36	72:28
Lucerne Valley, CA	2.59	1980	Spring, 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
Ivanpah Valley, CA	2.59	1979	Spring, 60d	155	87	30.1	41:46	56:44
Goffs, Fenner Valley, CA	2.59	1979	Spring, 60d	296	186	62.8	74:112*	63:37
Upper Ward Valley, CA	2.59	1980	Spring, 60d	140	81	31.3	31:50*	58:42
Pinto Basin, CA	2.59	1978	Spring & fall, 19+4d	41	29	11.2	12:17	71:29
Chemehuevi Valley, CA	4.66	1979	Spring, 60d	149	100	21.5	43:57	67:33
Chuckwalla Bench, CA	2.59	1979	Spring, 60d	265	166	64.1	81:85	63:37
Chuckwalla Valley II, CA	2.59	1980	Spring, 60d	91	50	19.3	27:23	55:45
Arden, NV	3.03	1974–1975	Multi-season	127	90	29.7	57:53	71:29
Last 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	18.5	26:22	61:39
Sheep Mountain, NV	2.59	1979	Spring, 60d	31	22	8.5	10:12	71:29
Beaver Dam Slope, UT	4.86	1930–1946	Primarily fall-winter	281	n/d	23.9	151:101*	99:01

Figure 11. Adult male *Gopherus agassizii* with enlarged chin glands, a secondary sexual characteristic during the high testosterone season (August to October). Photo by Michael Tuma.

Physical changes in male chin glands occurred in association with the seasonal rise and fall of testosterone (Alberts et al. 1994). Chin gland volume changed seasonally, reaching a maximum in late summer when testosterone levels were highest. In experimental studies, socially dominant individuals tended to have larger chin glands than subordinates. Both sexes were able to discriminate between chin gland secretions of familiar and unfamiliar males.

Population Structure. — Tortoises have been evaluated for size-class structure in populations using CL and grouped into seven size classes: juvenile 1, <60 mm; juvenile 2, 60–99 mm; immature 1, 100–139 mm; immature 2, 140–179 mm; subadult (small adult or young or both), 180–207 mm; adult 1, 208–239 mm; and adult 2, ≥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 efforts on removing tortoises from dens in late fall and winter (November–February) in Utah. They marked 281 tortoises and published metrics for 117. Of the 117 reported animals, 85 (72.7%) were very large adults (adult 2 class), 25 (21.4%) were in the adult 1 class, 6 (5.1%) were subadults, and 1 (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 June using two censuses, produced a higher proportion of populations in the juvenile and immature classes, especially when the surveyors focused on finding small tortoises (Berry and Turner 1986). Examples of study results where different survey techniques were used between the 1930s and early 1980s when tortoises were more common are presented in Table 2 (e.g., Berry 1984). With few exceptions, when two censuses were conducted in spring and efforts focused on finding juveniles, more juvenile and immature tortoises (28–48%) were located.

McLuckie et al. (2002) reported finding 850 tortoises over a 4-year period at the Red Cliffs Desert Reserve, Utah, in a distance sampling effort focused on subadults and adults. The size-age structure was 7.1% juveniles, 10.4% immatures, and 82.59% subadults and adults. Keith et al. (2008) described a 187.7 km^2 site (where tortoises were rare) and only four adults were observed in 760 one-ha, randomly located plots. Berry et al. (2008) described surveys of a 4 km^2 site within a western Mojave State Park; 9 tortoises (4 immature, 1 subadult, and 4 adults) were observed. Lovich et al. (2011a) studied a population in the western Sonoran Desert with 69 marked tortoises of which 72.5% were adults. Berry et al. (2013) evaluated a 5.42 km^2 site in the northwestern Mojave Desert and located 28 tortoises, of which 46.5% were adults and 53.6% were immature and juvenile tortoises. Berry et al. (2014a), in a study using randomly placed 1 ha plots in three management areas in the western Mojave Desert, located 17 tortoises; adults formed 76.5% of the sample.

Sex Ratios. — In studies conducted between the 1930s and early 1980s, sex ratios of adults in most populations were not significantly different than the expected 1:1 ratio (female:male; Table 2). Since the 1990s, sample sizes for adults in some studies were small and results varied by location. In the central Mojave Desert, Berry et al. (2006) reported that sex ratios differed significantly from the expected 1:1 ratio at 1 of 7 sites; the single site had 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 1:3 and 3:1 with one unidentified individual at each site (Berry et al. 2008; Keith et al. 2008). In the northwestern Mojave Desert, Berry et al. (2013) reported a 10:3 ratio, which differed significantly from the expected 1:1 ratio. In a western Mojave research project comparing three management areas, the sex ratio for the combined areas was 9:4, but did not differ significantly from the expected 1:1 ratio (Berry et al. 2014a). Berry et al. (2015a) evaluated 1,004 adult tortoises in an epidemiological study in the central Mojave Desert: the female to male sex ratio was 1:1.58. In the western Sonoran Desert, Lovich et al. (2011a) reported that a sex ratio of 51 marked tortoises did not differ from the expected 1:1 ratio.

Growth Rates. — Early studies on growth of wild adult tortoises revealed a range of rates. Woodbury and Hardy (1948) reported negligible growth in some adults over periods of ≤7 years; however, one male grew from 206 to 302 mm in 4.3 years and 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 years for four males and two females. Males grew <0.5 mm per year and females grew 0.36 mm and 0.04 mm per year.

Medica et al. (2012) conducted a 47-year study under semi-wild conditions in 9 ha pens in the northern part of the geographic range. They tracked growth in 17 hatchling and juvenile tortoises to adulthood and death. Growth (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 that female growth was limited and males continued to grow slowly. One small female was stunted and 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 growth of 9.6 mm/year in wild juvenile and immature tortoises at the Desert Tortoise Research Natural Area over multiple years.

Morbidity and 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.

Drought, Dehydration, Starvation, and Temperature Extremes: – Tortoises of all sizes are vulnerable to death from dehydration and starvation during or shortly after droughts, and especially if droughts are prolonged (Peterson 1996; Berry et al. 2002; Longshore et al. 2003; Field et al. 2007; Lovich et al. 2014b; Nagy et al. 2015a). Necropsies of starving and dehydrated tortoises have revealed several potential bacterial pathogens, e.g., *Bordetella bronchiseptica*, *Pasteurella testudinis*, and *Pseudomonas cepacia* (Berry et al. 2002). Head-started juveniles released from pens and translocated adults have provided valuable information on sources 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: – Infectious diseases described as contributing to illness and death in wild tortoises were upper respiratory tract diseases caused by *Mycoplasma agassizii* or *M. testudineum* or both (Brown et al. 1994, 1999; Christopher et al. 2003; Jacobson et al. 1991, 2014) and herpesviruses (Christopher et al. 2003; Jacobson et al. 2012). Johnson et al. (2006) reported high levels 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 close to human households in the central Mojave Desert for both *M. agassizii* and *M. testudineum*. The distribution of tortoises with *M. agassizii* and *M. testudineum* differed within the study area. Aiello et al. (2016) designed an experiment to model risk of 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. In another experimental study with captive tortoises, Aiello et al. (2018) discovered that tortoises were shedding bacteria regardless of the severity of clinical signs, although tortoises with severe clinical signs (nasal discharge) generally tended to shed more bacteria. Germano et al. (2014) conducted an experimental study to determine effects of *M. agassizii* on olfaction; the presence of a nasal discharge reduced smell and thus the ability to find food.

Bacterial and fungal pneumonia were reported in 3 of 24 necropsied wild tortoises (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 study 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 declines in the eastern Mojave and Colorado deserts (Jacobson et al. 1994; Homer et al. 1998; Christopher et al. 2003). Nutritional deficiencies or elemental toxicants may have caused this disease. Jacobson et al. (2009) described oxalosis, a disease of calcium oxalate crystals in the kidney and thyroid. Renal and articular gout occurred in a tortoise experiencing starvation and dehydration (Berry et al. 2002) and polyarticular and visceral gout was seen in a translocated tortoise (Jacobson and Berry 2012). Urolithiasis 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 osteopenia in bones of 24 tortoises from the Beaver Dam Slope, Utah, and northwestern Arizona; malnutrition was identified as responsible for the condition.

Elemental Toxicants and Toxicosis: – Elemental toxicants may affect health and contribute to responses to diseases (Jacobson et al. 1991; Jacobson et al. 1994; Selzer and Berry 2005; Chaffee and Berry 2006). Jacobson et al. (1991) reported that mercury concentrations in livers of tortoises with upper respiratory tract disease were significantly higher than in controls. Toxicosis was noted as a potential cause of cutaneous dyskeratosis (Jacobson 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 but not in the control. Selzer and Berry (2005) detected arsenic in scutes using ICP-MS analyses and obtained results similar to Homer et al. (1998).

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

Figure 12. Rainwater catchment guzzler for wildlife at Mojave National Preserve, California; tortoises can become entrapped in guzzlers. Photos courtesy of Mojave National Preserve.

Sarcocystis-like protozoa in skeletal tissues, pinworms, and *Balantidium*-like protozoa in 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 livestock grazing, vehicle use) or heavy winter precipitation. Nicholson and Humphreys (1981) observed sheep grazing on a Desert Tortoise study area in the western Mojave Desert; they reported damage and collapse of tortoise burrows and entrapment of a marked juvenile tortoise in its burrow (they dug out the burrow because the tortoise was unlikely to escape without assistance). Homer 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 when burrows collapse from heavy rains and flooding (Homer et al. 1998; Christopher 1999; Field et al. 2007; Lovich et al. 2011b; Nussear et al. 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 Desert and in the Colorado Desert. He found remains of 27 tortoises and one live tortoise in 18 guzzlers. Tortoises were trapped in the guzzlers and remains were found in all four desert regions. Later, Andrews et al. (2001) examined 13 tanks and guzzlers in the Colorado Desert, but did not find tortoise remains. Cattle guards are another source of entrapment for juvenile tortoises; they fall 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, casings from shotgun shells, and ordnance are common in Desert Tortoise habitats (Berry et al. 2006, 2008, 2013, 2014a; Walde et al. 2007b; Keith et al. 2008). Some studies 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 sign and 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 balloons and other detritus that can negatively affect health and cause deaths (Donoghue 2006; Wyneken et al. 2006; Walde et al. 2007b). Trash, especially edible items, also has attracted subsidized predators of tortoises, such as the Common Raven (*Corvus corax*) and Coyotes (*Canis latrans*) 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, trampling, 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 well 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, 10% of 164 monitored burrows were damaged, 4% were destroyed, and one juvenile was trapped inside a trampled burrow. Nussear et al. (2012), in a study of both resident and translocated tortoises, noted that one tortoise died when livestock collapsed the burrow.

Predation: – Tortoise eggs are a food source for carnivorous vertebrates. Among reptiles, the Gila Monster consumes 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. 2010a; Berry et

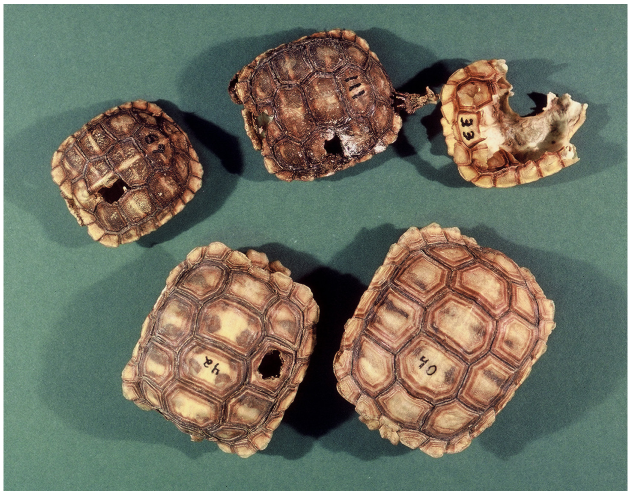

Figure 13. Juvenile *Gopherus agassizii*, killed by Common Ravens with typical peck holes in shells. Photo by Bev Steveson.

al. 2006; Lovich et al. 2014a; Sieg et al. 2015), American Badger, *Taxidea taxus*, and Spotted Skunks, *Spilogale gracilis* (Roberson et al. 1985; Sieg et al. 2015).

Neonates and juveniles may be attacked and killed by ants, including Fire Ants, *Solenopsis* spp. (Nagy et al. 2015a; Mack et al. 2018), Common Ravens (Campbell 1983; Farrell 1989; Lovich et al. 2011a; Berry et al. 2013; Hazard et al. 2015; Nagy et al. 2015a,b), Bobcats, *Lynx rufus* (Nagy et al. 2015b), Desert Kit Fox (Kelly 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; Boarman and Berry 1995). Multiple kills of juveniles by Common Ravens have been described along fence lines, 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 were found in scats or pellets collected from the nests of Common Ravens (Camp et al. 1993).

Populations of Common Ravens have grown rapidly in the Mojave and western Sonoran deserts, supported by perennial food sources and water in urban and agricultural areas, small towns, and settlements (e.g., Knight et al. 1993; Boarman and Berry 1995; Boarman et al. 2006). The expansion of transportation and utility corridors, energy developments, livestock allotments, and recreational areas has supported growth of Common Raven populations, such that they are now considered subsidized predators—subsidized by anthropogenic activities (e.g., Kristan and Boarman 2003, 2007; Kristan et al. 2004; Webb et al. 2004, 2009; Boarman et al. 2006). These developments have not only provided food and water to allow Ravens to survive and thrive, but also enabled their perching and nesting in hitherto inaccessible areas, thus penetrating into Desert Tortoise range areas previously inaccessible to Ravens.

Remains of juvenile tortoises also were observed in pellets of Red-tailed Hawks (*Buteo jamaicensis*) nesting on transmission line towers in the Colorado Desert (Anderson and Berry 2019). Red-tailed Hawks may be a subsidized predator, expanding perch and nest sites using transmission line towers throughout the range of the tortoise. Spenceley et al. (2015) described a failed attempt of a Glossy Snake (*Arizona elegans*) to kill a juvenile, head-started tortoise. Coyotes and Bobcats preyed on immature tortoises (Nagy et al. 2015b).

Carnivorous avian and mammalian predators have attacked and eaten wild and free-living adult tortoises. 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 (Berry, unpubl. data). Mammalian predators include Coyotes (Peterson 1994; Esque et al. 2010a; Lovich et al. 2014b), Bobcats and Mountain Lions (*Puma concolor*; Woodbury and Hardy 1948; Field et al. 2007; Medica and Greger 2009), American Badgers (Emblidge et al. 2015), and domestic dogs (*Canis lupus familiaris*; Berry et al. 2014b). Both dogs and Coyotes were considered subsidized predators (Esque et al. 2010a; Cypher et al. 2018).

Collecting: – People have collected Desert Tortoises for food, commercial sale, and pets, and these activities have resulted in losses to wild populations, which we view as equivalent to deaths. Some Native American tribes, early settlers, and later residents engaged in collecting (e.g., Anonymous 1881; James 1906; Stephens 1914; Camp 1916; Jaeger 1922; Battye 1924; Grant 1936; Miller 1932, 1938; Woodbury and Hardy 1948; Schneider and Everson 1989).

In 1939, the California Fish and Game Commission published a regulation stating sale or purchase of any Desert Tortoise was unlawful (California 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 demonstrate possession of a Desert Tortoise prior to publication of the 1972 regulations could retain the tortoise under certain conditions. Further constraints on possessing tortoises 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 et al. (1996) summarized incidents of illegal take of tortoises using multiple data sources: law enforcement records, visual observations of poachers, signs of tortoise burrows dug up with shovels on transects and a long-term mark-recapture plot, demographic data from two long-term mark-recapture plots, and other information. The observations occurred between the mid-1980s and mid-1990s; in retrospect, the observations appeared linked with the Asian Turtle Trade (see van Dijk et al. 2000). Several Cambodian nationals were arrested with 29 tortoises from a long-term plot, and several other Asians were observed in suspicious activities associated with collecting tortoises. Glenn Stewart (pers. obs.) reported the disappearance of 29% of radio-transmittered tortoises between 1986 and 1990 on his project; they were probably collected. Berry et al. (1996) estimated >2000 tortoises were removed from four study areas over a 10-year period.

Illegal collecting has continued, e.g., from highways and roads, and some of these collected tortoises were transported to urban communities, parks, preserves, Natural Areas, and out of their native states. Grandmaison and Frary (2012) conducted a study on the probability of decoy Sonoran Desert Tortoises (*G. morafkai*) 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 when 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 distances of non-paved roads.

In a genetic study comparing captive tortoises from three desert communities in California and Nevada, only 44% of the captives were from the local communities and one was a *G. morafkai* (Edwards and Berry 2013). Studies of captive tortoises in desert communities in Arizona within the range of *G. morafkai* revealed that a high proportion of captives (25%) were *G. agassizii* and an additional 14% were hybrid *G. agassizii* x *G. morafkai* (Edwards et al. 2010). These findings indicated transport of *G. agassizii* into the geographic range of *G. morafkai*. In the last decade, 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 Texas Tortoise (*Gopherus berlandieri*) and a Box Turtle at the Desert Tortoise Research Natural Area (Berry et al. 1986). Several African Spurred Tortoises (*Centrochelys sulcata*), commonly sold as pets in the Southwest, were released illegally, discovered, and then removed from the Mojave and Sonoran deserts of California, Utah, and Arizona (e.g., Nelson 2010; Goolsby 2016; Anonymous 2018). This species can grow to a very large size (68 kg). Two African Spurred Tortoises were discovered and removed in October 2018 inside the Red Cliffs Desert Reserve, and officials at the Reserve expressed concern about the non-natives spreading disease and damaging habitat (Anonymous 2018).

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

Figure 15. Unauthorized motorcycle race across the Desert Tortoise Research Natural Area, western Mojave Desert, California, creating new destructive trails. Photo by Kristin H. Berry.

The introduction of infectious and other diseases by turtles and tortoises from other parts of the United States and other countries has the potential for devastating effects on naïve *G. agassizii*. For example, in 2013, an ill Central Asian Tortoise (*Testudo horsfieldii*) was found and removed from the central Mojave Desert (Western Expansion Area of Fort Irwin), California. It was necropsied and tested positive for *Mycoplasma agassizii* using ELISA and also tested positive for a new herpesvirus using PCR, previously unreported in *G. agassizii* or *T. horsfieldii* (Jacobson et al. 2013; J. Wellehan, pers. obs.). The predominant bacteria in the nasal discharge was *Mannheimia haemolytica*, the cause of the epizootic pneumonia in cattle 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). Berry (1986) evaluated 635 carcasses collected between 1976 and 1982 from 11 sites in the Mojave and western Sonoran deserts of California; 91 (14.3%) remains showed evidence of gunshot. Gunshot deaths were more common in the western Mojave

Desert (14.6–28.9%) than in the eastern 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 east and south. Evidence of gunshot deaths was seen at Goldstone and within the southern edge of the Fort Irwin National Training Center (Berry et al. 2006). On the Alvord Slope, 8.5% of 47 shell remains showed evidence of 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).

Vehicular Impacts: – Records of tortoise injuries 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. In a study of paved roads, von Seckendorff 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 km of paved and two-lane roads in the Mojave National Preserve, estimated a minimum of 5.3 deaths of tortoises annually. Lovich et al. (2011a) found 11 dead tortoises over a 13-year period at a wind energy study site in the western Colorado Desert; one of the dead tortoises was killed by a vehicle.

Four studies have been undertaken to define the zone of influence of roads of different ages and traffic volumes on tortoises, with the assumption that roads serve as mortality sinks for adjacent tortoise populations. von Seckendorff Hoff 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 per day) and during different seasons. They found effects (reduction in abundance of tortoise sign) at distances of >4,000 m from the road at the highest traffic level. However, the zone of 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 distant from the highway. Nafus et al. (2013) studied road effects in the Mojave National Preserve, California, 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 vehicles/day) and high traffic volumes (320–1100 vehicles/day). Importantly, tortoise size negatively correlated with traffic volume. Highways and roads could affect the potential for population growth rates because reproductive tortoises were absent near the roads.

Hughson and Darby (2013), using the techniques of Boarman and Sazaki (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 windfarm facility in the western Colorado Desert; however in an earlier study 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 maneuvers and represented from 2.1 to 45.5% of deaths on 20 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-related maneuvers occurred; the models included paved roads, denuded areas, ordnance, signs of mammalian

Figure 16. Adult *Gopherus agassizii* standing in burned habitat soon after the 2005 fire at the Red Cliffs Desert Reserve in Utah. Photo by Ann McLuckie.

Figure 17. Impacts from fire and the resulting invasion of red brome grass (*Bromus madritensis* ssp. *rubens*) in the Red Cliffs Desert Reserve, Utah, two years post-fire (2007). Photo by Ann McLuckie.

predators, and observations of Common Ravens. The models suggested that densities of tortoises increased with distances from paved roads and denuded areas, as well as some other variables.

Bury and Luckenbach (2002) found an immature tortoise crushed on a vehicle trail in a recreational vehicle use area. Remains of tortoises likely killed by unauthorized vehicle use were found in the Desert Tortoise Research Natural Area, an area closed to recreational vehicles (Berry et al. 2014a).

Fires: – Wildfires injure and kill 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 deaths of about 14 tortoises from a fire covering ca. 5.2 km^2 on part of the Beaver Dam Slope south of Bunkerville in 1942. In a post-fire study, Lovich et al. (2011c) described a fire in the western 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 of translocated and resident tortoises. In the Red Cliffs Desert Reserve and critical habitat in Utah, 687 tortoises died in 2005 in a fire that burned ca. 23% of the approximately 251 km^2 habitat (A. McLuckie, pers. comm.). Drake et 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 Sonoran Desert, revealed that activity areas of tortoises remained unchanged in the first few years after a burn, indicating site fidelity, regardless of habitat condition (Lovich et al. 2018b). However, Drake et al. (2015) reported that six to seven years post-fire, tortoises contracted areas of activity because the post-fire growth of herbaceous perennial species (globemallow, *Sphaeralcea ambigua*) declined.

Mining: – Tortoises have been found alive and dead in mining shafts and pits, often in mining 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 of 30 translocated and resident tortoises under study in the northeastern part of the geographic range were found dead in mineshafts.

Rattlesnake Bites: – An adult male tortoise, translocated 17 days previously as part of a mass translocation 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,* or Panamint Rattlesnake, *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 confirming necropsy would be unlikely, unless a tortoise was under observation or being tracked.

Mortality Rates. — Death rates are summarized following the reporting styles of the authors. Most studies focused on annualized death rates of subadult and adult tortoises (CL ≥180 mm). In some cases, but not all, sites with little human use had lower mortality rates than sites with human-related activities. In their study of Desert Tortoises on the Beaver Dam Slope, Woodbury and Hardy (1948) reported a 1% annual death rate for a large sample of mostly adults. In a demographic study of tortoises on 21 study plots sampled between 1997 and 2003 in a military installation in the central Mojave Desert, adult (≥180 mm CL) death rates (adults dying / [yr km^{-2}]) differed by location, and current and historical uses; death rates ranged from 1.9 to 95.2% annually (Berry et al. 2006). Fifteen plots within the Goldstone area had the highest death rate at 95.2%. Sites with recent military vehicle use ranged from 4.7 to 13.3% and those with ongoing military vehicle-oriented war games ranged from 1.9 to 23.8%. The single site surveyed adjacent to and outside of the military base had an annual death rate of 9.7% (Berry et al. 2006).

In the western Mojave Desert, Berry et al. (2008) studied a population within Red Rock Canyon State Park and 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 km^2 plot on a naval test facility in the northwestern Mojave Desert, Berry et al. (2013) described a crude annual death rate of 1.8% for adults during the period 2006–2010. This site had limited public access with no livestock and no vehicle-oriented recreation. Berry et al. (2014a) compared demographic attributes of tortoises in three differently managed areas in the western Mojave Desert and provided crude annual death rates for adults for the 4 years preceding the survey. Death rates were lowest (2.8%/yr) for the most protected area, the 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).

Survival. — Few substantive studies have provided estimates of survival rates of Mojave Desert Tortoise populations. The most comprehensive of these was a study in the eastern Mojave Desert of California by Turner et al. (1987), covering the period 1977–1985. The study drew on 11 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 smallest three classes (juveniles) had geometric annual survival rates of 0.767 to 0.804, and the immature tortoises (100–179 mm CL) had rates of 0.821 to 0.861. Estimates for adult females were 0.901 to 0.944 and for adult males were 0.876 to 0.907. All estimates had wide confidence intervals. Using this and other information, 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 due to disease and other factors (Christopher et al. 2003). Freilich et al. (2000), in a 1991–1995 mark-recapture study in Joshua Tree National Park, reported survival rate estimates of 0.84 or 0.901, depending on method used, for both sexes of adult tortoises.

In the western edge of the Sonoran Desert, Agha et al. (2015c) compared apparent annual survival rates of adult tortoises over 18 years at two sites: 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.

In Nevada, Longshore et al. (2003) studied tortoises at two sites at Lake Meade National Recreation Area between 1994 and 2001. These authors reported annual survival rates of 0.985 at Grapevine and 0.829 at Cottonwood sites, where drought conditions existed from 1996 to 1999.

Population Status. — Historic 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. For example, Grant (1936) described tortoises collected near Helendale in the western Mojave Desert.

Since the Woodbury and Hardy (1948) study until the early 2000s, mark-recapture studies on plots of various sizes have measured population attributes (structure, densities, sex ratios, growth, survival, causes of death), and some plots became long-term plots of about 2.6–7.8 km^2 (Berry 1984). Selection of sites to study demography differed from one investigator to another and from state to state. In California, most sites represented habitat in valleys throughout the Mojave and Colorado deserts, whereas in Nevada, sites were chosen where belt transects indicated high counts of tortoise sign (Berry 1984). Mark-recapture surveys often spanned multiple years. Densities, one of several critical measures of population status and trends for the species, were frequently assessed through two or more mark-recapture surveys within a season. Data were analyzed using the Lincoln-Peterson index, stratified Lincoln index, Schnabel method, and other analytical techniques. In some cases, professional judgment was used to estimate densities. In addition, amounts of effort per unit area differed as well as season of survey. Changes in densities coupled with data on short-term trends in death rates or annualized mortality rates and survival for adults also provide supporting information and are presented above.

To summarize datasets on live tortoises from 1936 through 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/km^2; sites with lower densities were not included but are available in Berry (1984). Plot sizes ranged from 2.59 to 13.7 km^2, with most plots 2.59 km^2 and receiving two censuses or complete surveys in spring, when tortoises were likely to be above ground (Zimmerman et al. 1994). Counts of tortoises were converted to adults/km^2 for rough comparisons between sites and over time, and ranged from 2.31 to 71.8 adults/km^2 (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 the studies were initiated (e.g., Woodbury and Hardy 1948; Hardy 1976; Berry 1984; Jacobson et al. 1991, 1994; Berry and Medica 1995; Brown et al. 1999; Berry et al. 2002; Christopher et al. 2003). The population studied by Woodbury and Hardy (1948) on the Beaver Dam Slope was federally listed as Threatened in 1980 because of population declines and other factors (USFWS 1980). The listing of the entire metapopulation 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 in the Desert Tortoise Research Natural Area between 1982 and 1992, a decline of ca. 94% to about 6 tortoises/km^2 (Brown et al. 1999). The population (all sizes) in the western Sonoran Desert at Chuckwalla Bench also experienced a marked decline between 1979 and 1992. In contrast, adult densities remained relatively high during three surveys in Ivanpah Valley conducted between 1979 and 1994 (between 80 and 100/km^2 per survey) and during four surveys conducted at Goffs between 1980 and 1994 (between 145 and 190/km^2 per survey) (Berry and Medica 1995; Berry et al. 2002). The Goffs population experienced 92–96% decreases between 1994 and 2000 (Christopher et al. 2003). In Nevada, four populations with densities of adults <50/km^2 either remained stable, increased slightly, or decreased in the 1980s or between the 1980s and early 1990s (Berry and Medica 1995).

At least two mark-recapture plots listed in Table 2, Arden in Nevada and Fremont Peak in California, no longer have tortoises. Arden became urbanized shortly after the surveys were completed and is now part of Las Vegas (B.L. Burge, pers. obs), and Fremont Peak experienced sheep grazing and intensive vehicle-oriented recreation (Berry, pers. obs.).

Brief or one-time surveys of plots or study areas produced snapshots in time of both densities and mortality rates of breeding adults for the four years prior to each study (e.g., Berry et al. 2006, 2008, 2014a). While limited in time, these types of studies supplement long-term mark-recapture research and monitoring of changes in density conducted at a landscape scale. For example, one-time surveys undertaken at 15 plots on Goldstone and an additional six plots on the National Training Center at Fort Irwin revealed mean densities of adults of 0.79/km^2 with a very high death rate of 95.2% annually for adults on the 15 Goldstone plots. In contrast, adult densities ranged from 1.4 to 15 adults/km^2 and death rates of adults from 1.9 to 23.8% annually on six Fort Irwin plots. In a health and disease research project spanning five years (1990–1995), annualized mortality rates for adult tortoises with radio transmitters were available for three sites: the western (2.5%), northeastern (2.4%), and eastern (5.1%) Mojave Desert regions (Christopher et al. 2003). Tortoises missing (some were potentially dead) at each site ranged from 22.9% (eastern Mojave) to 37.5% (western Mojave) over the 5-year study. One-time studies using hectare plots or study areas also indicated high mortality rates in some areas (Berry et 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; Keith et al. 2008). Death rates of adults tracked with radio-transmitters were high in some studies (Longshore et al. 2003; Christopher et al. 2003), but not in others (Agha et al. 2015c).

Surveys at 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 to maintaining long-term plots, where appropriate (USFWS 1994a). After testing different approaches, in 2004 the USFWS implemented annual distance sampling of adults (≥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 McLuckie 2018). The primary population attribute published from distance sampling was density of adults within critical habitat units or TCAs (Table 3). The first Recovery Plan also recommended separating populations into six Recovery Units, each of which contained one or more populations (e.g., critical habitat units), with a total of >25,000 km^2 (USFWS 1994). In the revised Recovery Plan, the USFWS (2011) reduced the number of Recovery Units to five and realigned boundaries based solely on genetic information in Hagerty and Tracy (2010).

Range-wide, the five Recovery Units contain 17 TCAs scattered in the Mojave and western Sonoran deserts of the four states (Table 3). Grouped data for all TCAs showed a decline of 32.18% in adult tortoises between 2004 and 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 of 10-year trend data for five Recovery Units and 17 Tortoise Conservation Areas within the Recovery Units for the Mojave Desert Tortoise, *Gopherus agassizii*, between 2004 and 2014 (modified from Table 10 in USFWS 2015). This table includes the area of each Recovery Unit and Tortoise Conservation Area (= critical habitat), the percent of total habitat in each of the five Recovery Units and 17 Tortoise Conservation Areas, density (number of breeding adults/km^{2}and standard errors, SE), and the percent 10-year change between 2004–2014. Note: according to Table 2 in the revised recovery plan (USFWS 2011), the total critical habitat is 26,039 km^2, whereas the text states 24,281 km^2. Numbers in bold represent the totals for each Recovery Unit. * = Populations falling below the viable level of 3.9 breeding individuals/km^2. [1]Chocolate Mountains Aerial Gunnery Range.

Recovery Unit Tortoise Conservation Area	Surveyed area (km^2)	% of total habitat in Recovery Unit & 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, CA	2,347	9.14	*2.6 (1.0)	–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)	–61.5
Colorado Desert (1° CA)	**11,663**	**45.42**	**4.0 (1.4)**	**–36.3 decline**
Chocolate MAGR[1], CA	713	2.78	7.2 (2.8)	–29.8
Chuckwalla, CA	2,818	10.97	*3.3 (1.3)	–37.4
Chemehuevi, CA	3,763	14.65	*2.8 (1.1)	–64.7
Fenner, CA	1,782	6.94	4.8 (1.9)	–52.9
Joshua Tree, CA	1,152	4.49	*3.7 (1.5)	+178.6
Pinto Mountain, CA	508	1.98	*2.4 (1.0)	–60.3
Piute Valley, 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**
Beaver Dam S., NV, UT, AZ	750	2.92	6.2 (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)	+ 217.8
Eastern Mojave, NV & CA	**3,446**	**13.42**	***1.9 (0.7)**	**–67.3 decline**
El Dorado Valley, NV	999	3.89	*1.5 (0.6)	–61.1
Ivanpah Valley, CA	2,447	9.53	*2.3 (0.9)	–56.1
Upper Virgin River, UT	**115**	**0.45**	**15.3 (6.0)**	**–26.6 decline**
Red Cliffs Desert Reserve, UT	115	0.45	15.3 (6.0)	–26.6
Total Amount of Land	**25,678**	**100.00**		**–32.2 decline**

to 384.37%. Ten TCAs were below a density of 3.9 adult tortoises/km^2, a figure established for population viability described in the first Recovery Plan (USFWS 1994). No data are available on the sex ratios of females to males in the 17 TCAs.

Most TCAs (10 of 17, 75.9%) occur in California. Nine of these 10 populations declined by 29.77 to 64.70% between 2004 and 2014, and eight were below the numeric level of viability (not considering the Standard Error, Table 3). The two populations that were above viability also declined, and one population, Joshua Tree, showed an increase (USFWS 2015).

Nevada, with 17.9% of TCAs, has parts or all of six populations and five of these show increases; two of the six 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 viability. Utah has <2% of populations in TCAs: the Beaver Dam Slope which is showing an increase, and the Red Cliffs Desert Reserve which is declining. In addition, observations of juveniles have decreased (Allison and McLuckie 2018). Reviewing all these results, Allison and McLuckie (2018) concluded that "The negative population trends in most of the TCAs [critical habitat units] for Mojave Desert Tortoises indicate that this species is on the path to extinction under current conditions."

Populations in protected or partially protected areas (State Parks, National Park system, Research Natural Areas, Reserves, Areas of Critical Environmental Concern) experienced downward trends and/or high mortality rates with few exceptions (Berry and Medica 1995; Longshore et al. 2003; Berry et al. 2008; Lovich et al. 2014b; USFWS 2015 [Red Cliffs Desert Reserve]). A one-season study undertaken in the western Mojave in 2011 compared effects of different management practices on population status in a fenced and protected area (Desert Tortoise Research Natural Area), adjacent unfenced private land, and critical habitat (Berry et al. 2014a). Significantly higher density of tortoises occurred in the protected area (10.2 adults/km^2, 95% Confidence Interval [CI]: 9.9–10.4) compared with adjacent private land (3.7 adults/km^2; 95% CI: 3.6–3.8) and critical habitat (2.4 adults/km^2, 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 death 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 declines vary locally and regionally within the geographic range and by critical habitat unit or TCA (e.g., Jacobson et al. 1991; Berry et al. 2014a; Tuma et al. 2016). Overall, the causes are multiple, cumulative, and often synergistic, but the most important drivers are anthropogenic activities. The same and similar anthropogenic drivers are the basis for environmental change and degradation elsewhere 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 tortoises to populations. High on this list of 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 be discounted or minimized, especially because tortoise population densities 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 range for *G. agassizii* (e.g., Hughson 2009), we expect that 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 towns and cities and land was converted to agriculture, ranching, and scattered mining operations. Transportation and utility corridors developed, and recreational focal points became popular.

As of 2018, the southwestern part of the geographic range in Antelope, Victor, Apple, and parts of Brisbane and Peerless valleys were in urban, ex-urban, industrial, and agricultural developments. The western edge of the range was similarly compromised. Habitat across the southern, central, eastern, and northeastern regions of the Mojave and Colorado deserts experienced similar losses and fragmentation of habitat until and after the time of the federal listing in 1990 (e.g., Norris 1982; Hughson 2009; USFWS 2010). Subsequently, the area of tortoise habitat (including critical habitat) has continued to decrease, with development of private and federal lands for urban, ex-urban, agricultural, 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 1992 and 2001, 4.57 km^2 of critical habitat was lost from agricultural development, a small amount compared to the past, but nevertheless a continuing issue. Range-wide, 1,802 km^2 of critical habitat occurred on U.S. Department of Defense lands (USFWS 2010). 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 km^2 of this loss was part of critical habitat (USFWS 2010). The expansion of the Marine Corps Air Ground Combat Center at Twentynine Palms in the southern Mojave Desert has had and is likely to have continued and profound effects on tortoise populations within and outside critical habitat units (USDD 2017; Henen 2018). Since 2000, 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 km^2 of marginal habitat in the Colorado Desert (Mark Massar, U.S. Bureau of Land Management, in litt. 25 Oct 2018).

Transportation, energy and utility corridors, 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 length of 13,350 km of paved roads and highways in critical habitat in 1990, with a slight difference in 2008. If the 13,350 km are treated solely as two-lane highways with shoulders (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 substantially fewer kilometers of roads where fencing is needed, but does not resolve discrepancies with the 2010 report (USFWS 2010, 2011). The USFWS (2010) also noted 1,634 km of utility lines within corridors encompassing 1,743 km^2 (width of utility corridors = 1.067 km). Utility corridors have one or more access roads, often dirt with berms, and the roads have increased in length and area with development of renewable energy facilities on public and private lands. Data on other linear disturbances are 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, chromium, lead, nickel, petroleum products, and organic compounds (Forman et al. 2003; Chaffee and Berry 2006).

Solar and wind energy developments are present in Desert Tortoise habitat (habitat modeled by Nussear et al. 2009). For example, as of 2010, solar development was implemented on 114 km^2 of all modelled habitat, with additional solar and wind projects pending for 230 km^2 (USFWS 2011). As of 2018, more solar and wind sites are proposed or in development, generally not in critical habitat, but occasionally close to or adjacent to critical habitat or protected areas.

The U.S. Bureau of Land Management has received pressure from users of off-highway vehicles since the early 1970s to provide easy access to the desert, and places for unrestricted play (e.g., USBLM 1973, 1980, 2019). Several off-highway vehicle "Open Areas" where unrestricted vehicle use occurs were designated in California in 1980 and 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).

The pressure for vehicle-oriented recreation off-highways and off-roads came from thousands of users and continues to have a growing influence on degrading tortoise habitat through thousands of routes, trails, congregating areas for races (called pit areas), and the proliferation of unauthorized, cross-country use (e.g., Bury and Luckenbach 2002; Berry et al. 2014a). Numerous research articles on effects of vehicle travel off-road on soils and vegetation in the Mojave 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). Although several management plans designed to limit off-highway or off-road use were published, proliferation of these uses into unauthorized areas has continued on both federal and private lands (USBLM 1973, 1980, 2016, 2019). In parts of critical habitat in the western, central, and southern Mojave Desert, visits and visitor days recorded annually from 2008 to 2018 ranged from 55,874 to 94,474 visits and from 26,218 to 90,445 visitor days per year (USBLM 2019, Table 3.6-4). Off-highway and off-road use has also grown in the Colorado Desert in the Chuckwalla Bench critical habitat, where some vehicle users have pushed down signs indicating "closed to vehicle use" and driven into sensitive areas, such as washes (Berry, pers. obs., 2018).

As of 2017, existing routes and trails developed by off-highway vehicle users covered an estimated 3,765 km in critical habitat in the Western Mojave Recovery Unit alone, with an additional 148 km^2 negatively affected by stopping, 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, both authorized and unauthorized, in critical habitat and other sensitive areas for rare, threatened, and endangered species in this region continues to be of concern to nonprofit organizations and government agencies and is the subject of court cases (USDC 2009, 2011). The final management plan developed by the U.S. Bureau of Land Management for federal lands (USBLM 2019) indicates only 3,314 km of open and limited routes for 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 4,173 km (USBLM 2019, Alternative 5). Therefore, density of existing linear disturbances from OHV routes and other linear transportation features in critical habitat in the Western Mojave Recovery Unit is 1.05 km/km^2 (4173 km/3963 km^2 of critical habitat). These figures do not include individual tracks or areas degraded from parking, camping, and stopping of OHVs, mining, piospheres created by livestock grazing, and other land uses. Although figures are not available for other Recovery Units, the Colorado Recovery Unit faces increasing and new pressures from unauthorized cross-country vehicular travel.

Subsidized Predators. — 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. This also involves transportation corridors (roads, railroads, utility corridors), renewable energy facilities, and recreation vehicle use areas (Boarman 1993; Knight and Kawashima 1993; Knight et al. 1993, 1999; Fedriani et al. 2001; Kristan et al. 2004; Esque et al. 2010a; Cypher et al. 2018). Utility poles and transmission line towers serve as perches for foraging and nest sites for Common Ravens, allowing access to previously uninhabited or rarely used and remote parts of the desert.

In surveys conducted in the eastern Mojave Desert, the Common Raven was the most commonly observed bird (Knight et al. 1999); it also was the most common species observed over seven survey years at the Desert Tortoise Research Natural Area in the western Mojave Desert between 1979 and 2012 (Berry et al., in review). Ravens form small and large flocks (250 to 5,900 individuals) at roosts in trees and along utility lines in or near desert towns and ex-urban areas in the western, southern, and eastern Mojave Desert (Tim Shields, pers. obs. 2011 to 2018; Debra Hughson, pers. obs.). One such roost covered an area of 0.8 x 0.8 km 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 Mojave Desert described patterns of spillover predation and hyperpredation and stated that "anthropogenic resources for ravens could 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 eats tortoises. In a study of nine sites in the Mojave Desert, Esque et al. (2010a) reported that high mortality of adult tortoises correlated 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 were more likely to be killed during and after droughts, when populations of typical prey—hares and rodents—were low. Mortality rates at the nine sites ranged from 0 to 43.5%; two sites experienced no deaths. In a 5-year study of Coyote diets in the central Mojave Desert, Cypher et al. (2018) reported that in years of low precipitation, the diet of Coyotes included more anthropogenic food items. They also observed higher frequencies of tortoise remains in Coyote scats in the two years following releases of translocated tortoises.

Domestic dogs, also subsidized predators, attack, injure, and kill captive tortoises and were observed to attack wild tortoises (Boyer and Boyer 2006; Berry et al. 2014a; Berry, pers. obs.). Dogs occur singly and in large packs (e.g., 12–35 dogs) and have been observed in the western, central, and southern Mojave Desert (Berry, Rhys Evans, Michael Tuma, Mark Bratton, pers. obs.). Without exception, dog packs were close to military 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 tortoise habitat. During World War II, between 1942 and 1944, General Patton trained an estimated one million troops for North Africa on 50,000 km^2 in southeastern California, southern Nevada, and western Arizona, using thousands of tanks and other vehicles (Prose 1986; Prose and Wilshire 2000). In 1964, Operation Desert Strike trained in much of the same area and covered 2,000 km^2. The affected habitats extend from the central Mojave Desert in the Western Mojave Recovery Unit east into the Eastern Mojave Recovery Unit, and south to the entire Colorado Desert Recovery Unit.

Depending on site and year of 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 Wilshire 2000). Examples include, but are not limited 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 Wilshire 2000). Cover and density of creosote bushes were greatly reduced where significant alterations occurred in the substrate; pioneer species of shrubs dominated in most disturbed areas (Prose et al. 1987). Cover of some annual forbs consumed by tortoises, e.g., desert dandelion (*Malacothrix glabrata*) and Fremont's pincushion (*Chaenactis fremontii*) was lower in tank tracks (Prose and Wilshire 2000). However, annual forbs were often in higher densities in tank tracks than in control areas, but plants were smaller in size. Grasses also were in greater densities in tank tracks. As of 2018, the scars of the tracked vehicles from the 1942 maneuvers remained evident on desert pavement (Berry, pers. obs.).

Grazing by cattle, sheep, horses, and feral burros began in the mid-1800s in the 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 time of the federal listing in 1990; subsequently 8,479.9 km^2

of the allotments and leases involved were closed, leaving 4,401.7 km^2 (17.1%) of critical habitat still with allotments and leases. Recently, some allotments were renewed for 10 years in the West Mojave Recovery Unit.

Fleischner (1994) described three broad categories of negative effects of grazing to habitat, including alteration of species composition in vegetation associations, disruption of ecosystem functioning, and changes to ecosystem structure. Reduction in biomass and diversity of native annual and herbaceous perennial species has remained a critical issue for the Desert Tortoise, a selective forager, as has competition for forage (e.g., Avery and Neibergs 1997; Oftedal 2002; Oftedal et al. 2002; Jennings and Berry 2015).

The U.S. Bureau of Land Management, responsible for issuing 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 the boundaries. In 1990, the year the Desert Tortoise was listed as a Threatened species, sheep grazing was removed from areas expected to become critical habitat. Tuma et al. (2016), in a model of anthropogenic impacts to two study sites within the geographic range, listed grazing livestock and feral burros as the most important disturbances contributing to severe declines in tortoise populations. Some cattle grazing allotments 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-lived, weedy species (Webb and Steilstra 1979; Brooks et al. 2006). The composition and biomass of annual and perennial vegetation changes at sites where livestock concentrate: water sources, bedding areas, and loading and unloading areas (Webb and Steilstra 1979; Nicholson and Humphreys 1981; Brooks et al. 2006). Short-lived, colonizing shrubs and non-native grasses, tolerant of disturbances and inedible or less desirable as forage by livestock, are more common than in relatively undisturbed areas. Brooks et al. (2006) described piospheres, a disturbance gradient associated with watering sites for domestic grazers. Vegetation was denuded and soils compacted within 15 to 70 m of the tanks and troughs, with significant effects extending up to 200 m from the watering sites. Densities of the 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. Cover and species richness of shrubs also decreased with increasing proximity to sources of water. Livestock prefer certain forbs, when they are available, and can rapidly deplete available favored food plants of 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 are disturbed and clouds 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 removing or reducing livestock and feral burros and horses across public lands to make the lands less vulnerable to climate change.

Miners came to the Mojave and Colorado deserts seeking riches in the 1800s (e.g., Spears 1892; Vredenberg et al. 1981) and mining continues to be a source of loss, disturbance, and deterioration to tortoise habitat (e.g., Chaffee and Berry 2006; Kim et al. 2012, 2014). Early miners left pits, diggings, and shafts that trapped tortoises and that remain today; some shafts and pits are fenced and some are not.

Chaffee and Berry (2006), in an analysis of soil, stream sediments, and food plants of tortoises in the Mojave and Colorado deserts of California, reported anomalies in arsenic desert-wide. In the Rand and Atolia Mining Districts (Western Mojave Recovery Unit) they reported elevated levels in soil of arsenic, gold, cadmium, mercury, antimony, and/or tungsten 15 km from the mining source and plant anomalies for arsenic, antimony, and/or tungsten up to 6 km from the mining source. Elevated levels of mercury occurred as much as 6 km from old tailings piles. Arsenic and mercury were potential causes of illness in tortoises found in the area (Jacobson et al. 1991; Selzer and Berry 2005). Elevated levels of arsenic also occurred in the Goldstone Mining District and extended outward about 8 km. The highest arsenic concentrations occurred in 13 species of plants, 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 transport of arsenic from several mining communities (Western Mojave Recovery Unit). Fluvial transport of arsenic from mining tailings occurred (and still occurs) in 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 toxicants can enter tortoises through breathing dust, consumption of contaminated plants, and contact with the skin. Foster et al. (2009) identified endogenous sources of arsenic in both shell and lung tissues.

Invasive Plants. — As a result of the disturbances to soil and vegetation described above, tortoise 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 great threats to remaining tortoises. Several authors (e.g., D'Antonio and Vitousek 1992; Kemp and Brooks1998) suggested that most exotic species arrived in the desert during the middle-to-late 18th century after the Gold Rush of 1849 and became established with livestock grazing and construction of roads and railroads. Later land-disturbing uses such as agriculture, ranching, settlements, cities, and towns were additional contributors (Brooks 2009).

The following non-native species of grasses and a forb composed most of the annual biomass in tortoise habitats in the early 2000s: Mediterranean grasses, red brome, cheat grass, and redstem filaree (Hunter 1991; Kemp and Brooks 1998), until the more recent appearance of Sahara mustard (*Brassica tournefortii*) (see below). In critical habitat 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 plant species and density of dirt roads in a wet year and with nitrogen in the soil during a dry year (Brooks and Berry 2006). During a wet year, total alien biomass correlated positively with proximity to the nearest urban area or paved roads and area and numbers of recent fires. During a dry year, total alien biomass was negatively correlated with diversity of annuals and positively correlated with biomass of native annuals, and the history of off-highway, recreational vehicle use. Total alien annual biomass, especially grasses, correlated positively with numbers of fires and area burned between 1980 and 1994 within 5 km of sampled plots in both wet and dry years, likely due to the flammability of alien grasses. Further, Brooks (2000, 2003) found that non-native grasses were especially effective in competing with native forbs and the exotic forb redstem filaree.

Increased atmospheric nitrogen deposited in soils from urban or other areas enhances dominance of alien annual plants, which in turn contributes to increases in frequency of fires (e.g., Brooks 2003; Rao and Allen 2010). Rao et al. (2011) followed with additional studies, and reported that large-scale patterns in disturbance and exotic species negatively affected diversity of native annual plant species; native annuals persisted locally, however. Increases in atmospheric CO_2, an effect and cause of global climate change, may enhance the long-term success and dominance of exotic annual grasses (e.g., red brome) in the Mojave Desert (Smith et al. 2000).

Seed banks reflected the status of habitat disturbance and invasion of alien species. At the Desert Tortoise Research Natural Area (fenced to exclude off-road vehicle use and grazing), Brooks (1995) reported that seed biomass was two to four times greater inside the fence than 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, redstem filaree, and plantain, *Plantago* spp.) composed >95% of the seed bank following experimental fires of moderate temperatures in the Parashant National Monument of Arizona.

The non-native and invasive Sahara mustard was observed first in the Colorado Desert in the 1920s (Minnich and Sanders 2000). Subsequently, it spread rapidly northward and westward into the Mojave Desert (museum records, Jepson Flora Project 2018; Berry, pers. obs.). It has invaded most Recovery Units and is well established desert-wide. It can grow up to >1.5 m in height, produce large numbers of seeds, become a "tumble mustard" that 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; Barrows et al. 2009; Berry et al. 2014b). Sahara mustard is a highly successful invader that probably poses a considerable threat to native annuals because of early germination and rapid phenology, and its ability to disperse quickly across valleys and fans and in ephemeral stream channels (Bangle et al. 2008; Marushia et al. 2012; Suazo et al. 2012; Berry et al. 2014b). Desert Tortoises do not forage on Sahara mustard.

Fires. — Fires and invasive annual grasses are closely linked (D'Antonio 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 2011). With the invasion and establishment of alien grasses, fuels became available and created an unnatural and destructive grass-fire cycle in which fires increased in frequency and area, potentially in intensity, and were followed 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 fires was the most significant 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 Mediterranean grasses and more rapidly and continuously with bromes (Brooks 1999). The results suggested that red brome and cheat grass fueled faster moving, hotter fires, while Mediterranean grasses 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 that 8,699 fires burned 2,920 km^2 between 1980 and 2004. Most fires occurred in shrub associations at middle elevations where typical tortoise habitat occurs, e.g., creosote bush, Joshua tree, and blackbrush vegetation associations. In 2005, a total of 576 km^2 burned in the northeastern Mojave Desert and Upper

Virgin River (USFWS 2010). The percentages of critical habitat burned varied: 3% of Mormon Mesa, 13% of Gold Butte-Pakoon, 25% of Beaver Dam Slope in the Northeastern Mojave Recovery Unit, and 19% of the Upper Virgin River Recovery Unit. Many tortoises died, but numbers were not provided in the USFWS (2010) report. According to Brooks and Matchett (2006), the trend from the 1990s and on for human-caused fires was toward a decreasing number of ignitions and a greater area burned.

Burned habitat affects the tortoises living there. Drake et al. (2015) 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-fire, but returned to the unburned area for cover. One of the important forage plants common after the burn, globemallow, declined 6–7 years after the burn. At that time, tortoises reduced use of the burned area. In spite of damage from the fire, tortoises maintained reproductive output and health during the study. Lovich et al. (2018a) compared populations of tortoises in burned and unburned areas after a wind turbine fire; tortoises in the burned area continued use of the same activity areas after the fire.

Briefly, the many sources of habitat loss and degradation continue to have profound negative 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. agassizii*. This pattern of changes and loss to the flora are not confined to the tortoise (Minnich 2008).

Climate Change and Projected Effects. — Global warming and changes in rainfall patterns are added negative impacts (Seager et al. 2007, Garfin et al. 2014; Allen et al. 2018; Sarhadi et al. 2018) and are 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 winter and spring precipitation in the American Southwest. Reduced precipitation in winter and spring (droughts) and higher temperatures contribute to deterioration in composition, structure, diversity, and biomass of trees and shrubs (Munson et al. 2016). Annual and herbaceous perennial plants would be similarly affected. Forage of native food plants is likely to become more limited in dry years (see Brooks and Berry 2006).

Models of the effects of climate change and warming on tortoises at the Mojave-Sonoran interface indicated that some available habitat will be lost (Barrows 2011). Tortoises may respond by shifting distribution to 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 et al. 2002; Longshore et al. 2003; Lovich et al. 2014b). Climate refugia can be modeled to identify areas where existing populations may survive at warmer 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. 2019).

Consequences of Fragmentation. — The many land uses described above have resulted in degradation, fragmentation, and loss of connectivity between populations within the 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 extinction vortex (Gilpin and Soulé 1986; Fagan and Holmes 2006). With the rapid decline in densities of tortoises in critical habitat units between 2004 and 2014, and the non-viability of many populations in critical habitat (USFWS 1994, 2011), the remaining populations are increasingly vulnerable to additional 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 (Hughson 2009).

Recovery of Habitat after Disturbance. — Tortoise habitats are likely to require centuries, if not thousands of years for recovery. Creosote bushes, a prominent species in tortoise habitat, form long-lived clones in the Mojave Desert and some very large clones are estimated to be as much as 11,700 years old (Vasek 1980). Over the past approximately 70 years, scientists have investigated how quickly vegetation can recover naturally 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) after disturbances from pipelines, aqueducts, borrow pits, and old military activities (e.g., Lathrop and Archbold 1980a,b; Vasek et al. 1975a,b; Prose et al. 1987; Abella 2010; Berry et al. 2016b). The composition of perennial shrubs goes through successional stages in the recovery process. Estimates for the time required for recovery to pre-disturbance values for canopy cover of shrubs may be decades, whereas a return to pre-disturbance levels for floristic structure and composition may require centuries.

Few publications exist on natural 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; Hessing and Johnson 1982; Prose and Wilshire 2000; Berry et al. 2015b). Vasek (1983) suggested that "some constellations of annual species may be members of stable old communities [referencing creosote bush scrub associations] and therefore probably have evolved intricate highly integrated adaptations for long persistence in stable desert conditions." Estimated recovery times for cover, floral 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 require many centuries in their study of annuals recovering after 36 years of disturbance along a utility corridor in the western Mojave Desert. During the recovery process, annual communities may go through several seral stages (Hessing and Johnson 1982; Berry et al. 2015b).

Cumulative and Synergistic Impacts. — We have reviewed numerous causes of declines and how many of these causes are linked to each other and to human activities. In response to requests from managers to identify the most important cause(s), some scientists have quantified and modelled negative impacts in specific areas (e.g., Keith et al. 2008; Berry et al. 2008, 2014a; Tuma et al. 2016). Berry et al. (2014a) reported that in critical habitat with recent exclusion of livestock, limited vehicular traffic, and a partial fence, tortoise abundance (counts of live and dead tortoises and tortoise sign) was negatively associated with vehicle tracks and positively associated with mammalian predators and debris from firearms. Tuma et al. (2016) modelled severity of population decline rates at two sites, one in the central Mojave Desert and another in the northeastern Mojave Desert. In the central Mojave Desert, models indicated that the most severe decline rates were associated with human presence, followed by subsidized predators, and habitat degradation on inholdings. In contrast, in the northeastern Mojave Desert (Gold-Butte Pakoon critical habitat), livestock and feral burros were associated with the most significant declines, followed by human presence, subsidized predators, and wildfires.

Conservation Measures Taken. — *Gopherus agassizii* has been listed as federally Threatened under the U.S. Endangered Species Act (US ESA) since 1990. It was assessed as Vulnerable for the IUCN Red List in 1996 and provisionally re-assessed for the Red List as Critically Endangered by the IUCN Tortoise and Freshwater Turtle Specialist Group in 2011 and again in 2018 (TCC 2018; Rhodin et al. 2018). It has been listed on Appendix II of CITES (2017) since 1975 as part of the genus listing of *Gopherus*, and since 1977 as part of the family listing of Testudinidae.

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 protection is available in three national parks, especially in remote areas and where suitable habitat exists (Joshua Tree National Park and Mojave National Preserve in California, and Death Valley National Park in California and Nevada) and eight state parks (Red Rock Canyon State Park, Anza Borrego State Park, and Providence Mountains State Recreation Area in California; Red Rock Canyon National Recreation Area, Valley of Fire State Park, Lake Mead National Recreation Area, and the Desert National Wildlife Range in Nevada; and Snow Canyon in Utah). None of the national or state parks protect tortoises from paved or dirt roads with exclusion fencing, and at least one of the national parks (Mojave National Preserve) still maintains a cattle grazing allotment and feral burros within critical habitat.

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 Preserve contains two critical habitat units (Ivanpah and Fenner); in both, tortoise populations are declining (Table 3). Visitor use in the Preserve between 2004 and 2018 ranged from 537,250 to a high of 787,404 per year in 2018. In contrast, Joshua Tree National Park had a low density of tortoises, but the population was increasing (Table 3); visitor use in the Park was 2,942,382 in 2018. Lake Mead National Recreation Area has had over one million visitors per year since 1946 and growing; in 2018, 7.6 million visits occurred.

As noted in the section on Threats, the State of California took incremental protective measures for tortoises beginning in 1939. Grass-roots efforts advocating greater protection for a site with high densities began in the early1970s with the establishment of the Desert Tortoise Research Natural Area in the western 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 efforts on public education, land acquisition and protection, fencing of protected areas, removing livestock grazing and recreational vehicle use from the Desert Tortoise Research Natural Area and other acquired lands, and research. The Desert Tortoise Council's goals and objectives include education through annual symposia and workshops, grants for 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. After the Beaver Dam Slope population of Desert Tortoises was federally listed as Threatened in 1980 under the U.S. Endangered Species Act (USFWS 1980), the Desert Tortoise Council submitted a comprehensive report to the U.S. Fish and Wildlife Service in 1984 to also list the tortoise 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 early 1970s and continued intermittently thereafter.

In 1980, the U.S. Bureau of Land Management, the agency managing substantial amounts of tortoise habitat range-wide, published the *California Desert Plan, 1980*. The Plan described the Desert Tortoise as a sensitive species, identified several crucial habitats (precursors to critical habitat units), established Areas of Critical Environmental Concern for the tortoise, and outlined expansive areas for future habitat management plans for the species (USBLM 1980). The Desert Tortoise Research Natural Area was formally designated in this Plan, a protective fence surrounding the area and a kiosk for visitors were completed, and a long-term mark-recapture study was initiated. In 1989, California designated the Desert Tortoise as a Threatened species (California Department of Fish and Wildlife 2016). The U.S. Fish and Wildlife Service listed the tortoise as Endangered on an interim basis in August of 1989 and issued a final rule as Threatened in April of 1990 (USFWS 1990). The U.S. Fish and Wildlife Service published a Recovery Plan in 1994 and designated >25,000 km^2 of critical habitat units north and west of the Colorado River in the same year (USFWS 1994). In response to the pending listing and designation of critical habitat, federal, state, and county governments formed a Management Oversight Group composed of senior managers who address a wide variety of topics associated with recovery of the species at meetings held at least once a year.

The 1994 Recovery Plan contained numerous recommended management actions for Desert Wildlife Management Areas (defined as the best examples of Desert Tortoise habitat within regions): secure habitat, develop and implement reserve-level management, monitor tortoise populations within recovery areas, and develop environmental education programs (USFWS 1994). Several examples highlight recommended regulations and activities to be prohibited: all vehicle activity off designated roads and all competitive and organized events on designated roads; habitat-destructive surface disturbance that diminishes capacity of land to support tortoises; domestic livestock grazing and grazing by feral burros and horses; vegetation harvest, except by permit; collection of biological specimens, except by permit; dumping and littering; deposition of captive or displaced tortoises except under authorized translocation research projects; uncontrolled dogs out of vehicles; and discharge of firearms, except for hunting of game from September through February. The recommended actions included the following: control vehicular access; enforce regulations, restore disturbed areas; sign and fence Desert Wildlife Management Areas; implement appropriate administration; 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 important recommendation was to monitor 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 land 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 Desert Tortoise. In 2011, the USFWS published a revised Recovery Plan which incorporated many actions described in the first Recovery Plan (USFWS 1994, 2011). The revised Recovery Plan described numerous recommendations for future research. One important issue, hyper-predation by ravens, was the topic of a special plan, which has involved surveys, selected removal of limited numbers of ravens, and egg-oiling (USFWS 2008). Part of the revised Recovery Plan was development of regional Recovery Implementation Teams composed of representatives from government agencies and non-profit organizations. Participants in these teams prepare proposals for recovery actions, seek funding to support the proposals, and assist with implementation when funding becomes available.

In the nearly 30 years since the Desert Tortoise was first listed range-wide in 1990, much has been accomplished by changes in land use. Unfortunately, positive actions have remained insufficient in amount and extent to stabilize tortoise populations in the designated critical habitat units (USFWS 2015; Table 3; Allison and McLuckie 2018). Land acquisition for the Desert Tortoise Research Natural Area, which began in the late 1970s, has continued. The U.S. Bureau of Land Management and other government agencies and conservation organizations have acquired substantial amounts of private lands in small and large parcels to convert critical habitat and other protected areas to federal and conservation management.

Sheep grazing has been removed from critical habitat, but cattle continue to graze on about 17% 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 kilometers of roads and railroads remained unfenced (USFWS 2010). Experimental efforts to reduce vehicle speed on roads within the Mojave National Preserve to reduce road kills were unsuccessful (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-wheeled vehicles, and the negative effects on tortoises and their habitats (Goodlett and Goodlett 1992; Egan et al. 2012; Piechowski 2015; USBLM 2019).

The federal (and state) listings of the Desert Tortoise as Threatened stimulated a great deal of interest and effort in addressing basic questions about the species, such as status and distribution of populations, ecology, genetics, and diseases, as well as solving conflicts with the many users of Desert Tortoise habitats. Conflicts existed over degradation of habitat and threats to Desert Tortoises from historical users (livestock grazing, mining, and recreation), developers, and some government agencies. Other agencies, academicians, and non-profit organizations held more conservation-oriented views. As a result, 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 DeFalco 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 the Interior (U.S. Bureau of Land Management, U.S. Geological 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.

Two current conservation research topics are 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 and their habitat requirements, to determine factors affecting survival both before and after release, and to augment depleted populations (e.g., Morafka et al. 1997; Wilson et al. 1999a,b, 2001; Nagy et al. 2015a,b, 2016; Todd et al. 2016; Mack et al. 2018). However, caution needs to be exercised, as some research manipulations, such as crowding in head-start pens and cystocentesis of adults, can lead to increased morbidity and mortality (Berry et al. 2002; Mack et al. 2018).

Translocations to remove Desert Tortoises from areas scheduled for development continue and are important research topics (e.g., Field et al. 2007; Nussear et al. 2012; Farnsworth et al. 2015; Hinderle et al. 2015; Brand et al. 2016; Nafus et al. 2016; Mulder et al. 2017; Henen 2018). Most research topics on translocation were short term (1–3 years). The research undertaken by Farnsworth et al. (2015), Brand et al. (2016), and others were for short-distance translocations covering five years. When all elements of this study are published, they will provide a valuable addition to the topic. Publications preparatory for and during mixed long and short-distance translocations include Esque et al. (2010a), Berry et al. (2015a), and Mulder et al. (2017). When these longer-term projects (10 years) are published, more information will be available on survival of translocated animals. In an important paper, Mulder et al. (2017) reported on genetic integration of tortoises translocated long distances. After four years, translocated males produced significantly fewer off-spring than resident males in the same area. The length of delay in integration of translocated males into resident populations needs to be addressed through future research.

Another important recovery objective is restoration of disturbed and burned Desert Tortoise habitats (e.g., Abella 2010; Abella and Newton 2009; Abella and Berry 2016; Abella et al. 2009, 2015a,b). Topics being addressed 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 alive and growing, and planting forage species for tortoises.

Conservation Measures Proposed. — Most of the >400 papers published on Desert Tortoises and their habitats after the federal 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 populations and habitat, augmenting depleted populations, conducting applied research and 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 trash (a source of food for subsidized predators), control of invasive plants, fencing of major highways, and many other topics.

Research on genetics of tortoises provides a framework for changes in management. The most detailed genetic analyses of tortoise populations published to date (Sánchez-Ramírez et al. 2018) provided data on population differences within and between recovery units, as well as identification of 12 genes likely involved in adaptations. The results of this paper suggested that the Western Mojave Recovery Unit could defensibly be divided into three separate Recovery Units: western, central, and southern, since these three subunits are genetically equivalent to each of the other four Recovery Units. The results also suggested that it could be valuable to update Averill-Murray and Hagerty (2014), who had used Hagerty and Tracy (2010) and Hagerty et al. (2011) as a basis to suggest that tortoises could be translocated within a 200–276 km straight-line radius of their native sites without moving animals between different genetic subunits. The results of Sánchez-Ramírez et al. (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 clinical and classic blood diagnostics with gene transcription profiles in ill and normal tortoises. These findings indicate promise for more robust diagnostic procedures in evaluating ill and healthy tortoises and for tortoises subjected to disturbances. Publications of the genome sequences for *G. agassizii* and *Mycoplasma testudineum* 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 techniques for the pathogen *M. agassizii* with range-wide sampling.

Captive Husbandry. — Captive husbandry falls into two categories: research associated with head-starting and augmenting wild populations (see above), and management of tortoises kept as pets, in many cases for decades. In California, 13 chapters of the California Turtle and Tortoise Club manage adoption programs for domestic or pet *G. agassizii* and other chelonian species under agreements with the California Department of Fish and Wildlife (https://tortoise.org/). In Nevada, this function is accomplished by Tortoise Group (https://tortoisegroup.org/). These organizations (and others) provide information on husbandry, state and federal regulations, 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 of anthropogenic activities on tortoises, augmentation of populations, and effects of drought and global climate 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 focuses on a wide array of topics, such as effectiveness of different augmentation strategies, including head-starting and translocation, control and management of subsidized predators, and restoration of habitats degraded by livestock grazing, recreational vehicle use, and industrial and energy developments. 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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NATIONAL SYSTEM OF PUBLIC LANDS

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ePLANNING

Comment Submission

Project: DOI BLM NV S030 2022 0009 EIS Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS Copper Rays Solar Project.pdf

Submission ID: SC-1-500304529

Comment

I am opposed to the damage this project would do to the environment and the quality of life in the general area.

Submitter(s)

Submitter 1

Name:[redacted]
Address: Not Provided
Group or Organization Name: Not Provided

Submitter 2

Name: Not Provided
Address: Not Provided
Group or Organization Name: Not Provided

Disclaimer

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment - including your personal identifying information - may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Withhold my personally identifying information from future publications on this project) - ***NO***

ePLANNING

Comment Submission

Project: DOI-BLM-NV-S030-2022-0009-EIS - Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS - Copper Rays Solar Project.pdf

Submission ID: SC-1-500312514

Comment

I support solar energy but I oppose the needless destruction of pristine desert areas. Already disturbed lands should always be strongly preferred.

There should also be full mitigation for any destroyed or degraded desert areas. This should include buying out existing livestock grazing permits and permanently retiring those allotments. And closing and reclaiming harmful OHV routes in sensitive tortoise habitat. And oiling eggs in raven nests.

It is essential that BLM do more to solve environmental problems instead of making them worse.

Submitter(s)

Submitter 1

Name: American who loves public lands
Address: Not Provided
Group or Organization Name: Not Provided

Disclaimer

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment - including your personal identifying information - may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Withhold my personally identifying information from future publications on this project) - ***NO***

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ePLANNING

Comment Submission

Project: DOI-BLM-NV-S030-2022-0009-EIS - Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS - Copper Rays Solar Project.pdf

Submission ID: SC-1-500314509

Comment

I am very concerned that this proposed project would contribute to the "death by a thousand cuts" that continues to cumulatively cause the rapid decline of most threatened Mojave desert tortoise populations. These declines are scientifically documented in the relevant attachment. Please review this attachment and include it in this scoping file.

If this project is approved and implemented, there should be full and permanent mitigation for this loss of high quality tortoise habitat. Even if affected tortoises are relocated, many of them will likely die. Commercial livestock grazing is a documented threat to tortoises. Where such grazing continues in tortoise habitats, proper mitigation should include buying out those BLM grazing permits in conjunction with BLM amending those RMPs to permanently retire those grazing allotments. This type of mitigation has already successfully occurred including for tortoises in California and sage grouse in Nevada.

Please review the four attachments describing the climate change related and other significant adverse impacts from livestock grazing on public lands in the West. And please include these attachments in this scoping file.

The bottom line is that BLM should actively strive for this proposed project and all others for solutions that will help to reverse the worsening climate and extinction crises. The old, ad hoc ways of BLM doing business are no longer appropriate or sustainable. New, better ways must be found and urgently implemented.

Thank you very much for considering my comments and these important attachments.

Upload File(s)

Files
Million Cattle Graze on Federal Land for Almost Nothing.pdf
Climate & livestock on public lands_Beschta et al_2013.pdf
DTC Allison and McLuckie.2018.Popln trends in MDT.pdf
Climate Change and Livestock Use on Public Lands 2022.pdf
Livestock Use on Public Lands in the Western USA.pdf

Submitter(s)

Submitter 1

Name:A highly concerned American
Address: Not Provided
Group or Organization Name: Not Provided

Disclaimer

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment - including your personal identifying information - may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Withhold my personally identifying information from future publications on this project) - ***NO***

https://insideclimatenews.org/news/25072022/the-bureau-of-land-management-lets-1-5-million-cattle-graze-on-federal-land-for-almost-nothing-but-the-cost-to-the-climate-could-be-high/

Million Cattle Graze on Federal Land for Almost Nothing, but the Cost to the Climate Could Be High

Scientists say overgrazing deteriorates rangelands' ability to store climate-warming carbon, while the livestock industry claims feeding animals improve the land.

By Georgina Gustin
July 25, 2022

The hundreds of thousands of cattle dotting the vast sweeps and ranges of the West have become archetypal features of the American landscape, essentially entwined with a story the nation tells itself of cowboys and destiny.

But for decades environmental groups and ecologists have argued that cattle are destroying the West's arid pine and sagebrush-covered rangelands—the very landscape supporting a national mythology—turning thousands of acres into moonscapes. Livestock groups, meanwhile, argue the opposite, saying that cattle are critical for the health of that land.

Now, the long standing conflict is getting amplified as climate change heats up the West and rangelands lose their ability to store heat-trapping carbon, in part because they're being trampled and degraded by livestock, scientists say.

Cattle are well known emitters of methane, through belching and manure. But in the arid and fragile West, they're also destroying an important carbon sink, largely by churning up soil and vegetation, scientists say. This is happening, some research says, in a kind of vicious cycle, where the effects of grazing are heating a landscape that's already becoming hotter and drier.

On Monday, the environmental group Public Employees for Environmental Responsibility (PEER) sent a complaint letter to Interior Secretary Deb Haaland, accusing the department's Bureau of Land Management (BLM) of failing to take into account the climate impacts of its commercial grazing program, which covers giant stretches of the West.

"We're in a climate emergency," said Tim Whitehouse, PEER's executive director. "Grazing has been a third rail at BLM. It's a program they don't want to touch. They don't want to address the consequences of overgrazing, or for that matter, understand them."

The group argues that the Interior Department's failure to consider climate impacts could make the agency vulnerable to lawsuits. Groups have successfully sued the department recently for failing to evaluate climate impacts when granting oil and gas leases. The same could happen with grazing permits, PEER warns. Already, one such lawsuit is underway.

PEER notes that Haaland established a Departmental Climate Task Force in 2021 and instructed it to develop a strategy to reduce climate pollution and improve climate resiliency on lands managed by the department. The agency's continued reluctance to update its grazing program—the department's largest operation—runs contrary to that strategy, PEER says.

"BLM is on the losing side of the climate equation," Whitehouse said. "It needs to change the way it manages public lands to consider climate impacts. It's a very simple request."

Livestock grazing, mostly by cattle, is the single largest use of publicly owned lands in the West, and nearly all of that grazing is authorized by the BLM and the Interior Department's Fish and Wildlife Service. The BLM issues 18,000 grazing permits, covering 21,000 allotments across 155 million acres in 13 states—an area the size of California and Oregon combined. Though the department doesn't release a head count, researchers and advocacy groups say those permits represent about 1.5 million heads of cattle.

"The primary cause of desertification in the arid lands of the West, whether on public or private lands, has been livestock grazing and continues to be so," said J. Boone Kauffman, a professor in the the department of Fisheries, Wildlife and Conservation Sciences at Oregon State University. "It's irrefutable. Grazing on public lands has resulted in soil carbon loss, and at the same time we're seeing lower water holding capacity, less root mass to actually exploit the available water, a loss of species—all of these are exacerbated by the impact of climate change. In other words, we're accelerating the impact of climate change and we've shifted these rangelands from net sinks to net sources of greenhouse gas emissions."

In a paper published in April**, Kaufmann and his colleagues found that grazing on public land in the West emits 12.4 million metric tons of carbon dioxide equivalent a year —roughly the emissions of 3.3 million passenger vehicles.**

Century-Old Program With Rarely Updated Fee

The BLM's commercial grazing program has its roots in laws established a century ago that aimed to rein in the rampant overgrazing of the American West, but also recognized the economic and food production benefits of the livestock business. Congress has tweaked elements of the program over the decades, but one part has remained largely unchanged for nearly 40 years. In 1986, President Ronald Reagan signed an executive order establishing a minimum grazing fee of $1.35, paid by ranchers for every "animal unit month." (This unit is based on the estimated forage needed to sustain a cow and her calf, one horse, five sheep or five goats, grazing on public land for a month.)

This statutory minimum fee is still the current going rate.

"I understand [ranchers] have other expenses, but what they're paying the federal government is less than you'd pay to feed your goldfish," said John Janicek, a Dallas-based attorney who has written about the impacts of the grazing program on climate change. "The agencies are running these programs at $100-million-plus deficits, all the while, in my opinion, deteriorating the rangeland."

Critics say this means taxpayers are subsidizing a program that's a bad deal financially and environmentally, and as PEER writes in its letter, is "designed to magnify rather than minimize adverse climates impacts on these rangelands."

Collectively, the thousands of grazing permits granted by the BLM in the West constitute a "major federal action" that, like major infrastructure projects, requires mandatory environmental reviews under the National Environmental Policy Act (NEPA), the letter notes.

But PEER and other critics of the program say the Interior Department is failing to conduct these reviews or, when it does do them, is ignoring the climate impacts when renewing a grazing permit. In these assessments, the department often cites its inability to conduct an adequate analysis of the climate impacts.

"It is currently beyond the scope of existing science to identify a specific source of greenhouse gas emissions or sequestration and designate it as the cause of specific climate or resource impacts at a specific location," one such assessment said.

In March PEER released an updated database and map of the BLM's grazing permits, based on data the group obtained from public records requests. The data show that more than half of BLM-managed land failed the agency's own standards for land health and indicate that grazing is a significant cause of degradation on nearly three-quarters of that land. The data also show that the agency has not yet evaluated more than one quarter of its grazing land, or 41 million acres.

"You have whole high-desert regions in the Rockies where most of the allotments are failing or haven't been assessed and that's going to create serious climate impacts," Whitehouse said, noting that the data the group presented was BLM's own.

Also in March, another group that's highly critical of BLM's grazing management, the Western Watersheds Project, issued an analysis saying that BLM had failed to conduct any on-site environmental analysis of more than half of the grazing permits it authorized.

Industry Says Cattle Improve Rangeland Health

The cattle industry strongly disputes these numbers and points to research showing that cattle are important components of healthy rangeland.

"They make that claim with creative and dishonest use of BLM data," said Kaitylynn Glover, executive director of the Public Lands Council, a group representing 22,000 ranchers who hold grazing permits.

Glover, who is also the executive director of natural resources at the cattle industry's largest lobby group, the National Cattlemen's Beef Association (NCBA), said the environmental groups are using datasets that don't paint an accurate picture of rangeland conditions and are cherry-picking data to support their claims.

One problem, she explained, is that environmental analyses are done based on a single point in an allotment and may not reflect an accurate picture across the broader acreage. Glover said that the BLM's determination that land fails the agency's own standards for its health does not make a "causal link" to grazing, but encompasses other causes of land destruction, including development and roads.

"There's a wealth of research that demonstrates the critical role of grazing in rangeland health," Glover said. "We're not saying that grazing is appropriate at every level in every ecosystem at every point in the year. But there is an immense value to grazing that can't be replaced with any other kind of treatment."

Glover said that grazing cattle is one of the best ways to limit the increasing wildfire risk in the West because the action of hooves in the soil helps destroy the tinder-dry vegetation that acts as fuel on millions of acres. The U.S. Department of

Agriculture has also said that strategic grazing can remove fire-prone grasses.

These benefits of cattle grazing in the fire-prone Western are being touted by the Public Lands Council and the NCBA, via a jointly supported website, grazingpreventswildfires.com.

The industry's argument that grazing cattle clears wildfire fuel runs counter to much scientific research that argues the overgrazing makes wildfires worse. That's largely because trampling damages soils, causing erosion and allowing more fire-prone invasive grasses to flourish. And forests that were once kept thin by ground fires fueled by native grasses can grow more dense and flammable when their understories are grazed bare.

The livestock industry groups reject any suggestion that climate impacts should be incorporated into environmental reviews of grazing permits, saying that accounting for greenhouse gas emissions from grazing doesn't adequately capture the environmental health of rangelands.

"It's a fallacy to limit the climate conversation to methane or carbon," Glover said. "It has to encompass all these different things that impact the natural resource health of these landscapes."

The Interior Department did not respond to questions from Inside Climate News.

Critics accuse the Interior Department of capitulating to the cattle industry at the expense of rangeland health for much of its history. Just over a decade ago, for example, PEER found that the BLM was pressured by the industry into removing

grazing impacts from a sweeping ecological assessment of the West.

Some critics point out the inherent conflict in an agency that is tasked with both authorizing grazing and assessing its environmental impacts.

"Yes, they do an environmental analysis, but it's usually insufficient and designed just to rubber stamp the permits," said George Wuerthner, an ecologist and co-author of Welfare Ranching: The Subsidized Destruction of the American West. "The decisions about grazing on public lands are made by the BLM or the Forest Service's range conservationists. Their job is to give grazing permits. If there's no cattle, there's no job, so there's a perverse incentive to accommodate grazing."

With the all-government effort needed to tackle the climate challenge, ecologists, climate scientists and critics of federal grazing programs are becoming increasingly focused on ensuring that climate impacts are scrutinized. Some point out that, contrary to the public's imagining of cattle in the West, they were never supposed to be there in the first place.

"I approach this, and I always have, as a pure ecologist," said Chris Bugbee, a wildlife conservationist with the advocacy group, the Center for Biological Diversity. "There's no place for cows in these western ecosystems. It never was a good idea to open up millions of acres to grazing. And especially now, with drought and climate change advancing, it's a really, really bad idea."

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Adapting to Climate Change on Western Public Lands: Addressing the Ecological Effects of Domestic, Wild, and Feral Ungulates

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Abstract Climate change affects public land ecosystems and services throughout the American West and these effects are projected to intensify. Even if greenhouse gas emissions are reduced, adaptation strategies for public lands are needed to reduce anthropogenic stressors of terrestrial and aquatic ecosystems and to help native species and ecosystems survive in an altered environment. Historical and contemporary livestock production—the most widespread and long-running commercial use of public lands—can alter vegetation, soils, hydrology, and wildlife species composition and abundances in ways that exacerbate the effects of climate change on these resources. Excess abundance of native ungulates (e.g., deer or elk) and feral horses and burros add to these impacts. Although many of these consequences have been studied for decades, the ongoing and impending effects of ungulates in a changing climate require new management strategies for limiting their threats to the long-term supply of ecosystem services on public lands. Removing or reducing livestock across large areas of public land would alleviate a widely recognized and long-term stressor and make these lands less susceptible to the effects of climate change. Where livestock use continues, or where significant densities of wild or feral ungulates occur, management should carefully document the ecological, social, and economic consequences (both costs and benefits) to better ensure management that minimizes ungulate impacts to plant and animal communities, soils, and water resources. Reestablishing apex predators in large, contiguous areas of public land may help mitigate any adverse ecological effects of wild ungulates.

Keywords Ungulates · Climate change · Ecosystems · Public lands · Biodiversity · Restoration

Introduction

During the 20th century, the average global surface temperature increased at a rate greater than in any of the previous nine centuries; future increases in the United States (US) are likely to exceed the global average (IPCC 2007a; Karl and others 2009). In the western US, where most public lands are found, climate change is predicted to

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intensify even if greenhouse gas emissions are reduced dramatically (IPCC 2007b). Climate-related changes can not only affect public-land ecosystems directly, but may exacerbate the aggregate effects of non-climatic stressors, such as habitat modification and pollution caused by logging, mining, grazing, roads, water diversions, and recreation (Root and others 2003; CEQ 2010; Barnosky and others 2012).

One effective means of ameliorating the effects of climate change on ecosystems is to reduce environmental stressors under management control, such as land and water uses (Julius and others 2008; Heller and Zavaleta 2009; Prato 2011). Public lands in the American West provide important opportunities to implement such a strategy for three reasons: (1) despite a history of degradation, public lands still offer the best available opportunities for ecosystem restoration (CWWR 1996; FS and BLM 1997; Karr 2004); (2) two-thirds of the runoff in the West originates on public lands (Coggins and others 2007); and (3) ecosystem protection and restoration are consistent with laws governing public lands. To be effective, restoration measures should address management practices that prevent public lands from providing the full array of ecosystem services and/or are likely to accentuate the effects of climate change (Hunter and others 2010). Although federal land managers have recently begun considering how to adapt to and mitigate potential climate-related impacts (e.g., GAO 2007; Furniss and others 2009; CEQ 2010; Peterson and others 2011), they have not addressed the combined effects of climate change and ungulates (hooved mammals) on ecosystems.

Climate change and ungulates, singly and in concert, influence ecosystems at the most fundamental levels by affecting soils and hydrologic processes. These effects, in turn, influence many other ecosystem components and processes—nutrient and energy cycles; reproduction, survival, and abundance of terrestrial and aquatic species; and community structure and composition. Moreover, by altering so many factors crucial to ecosystem functioning, the combined effects of a changing climate and ungulate use can affect biodiversity at scales ranging from species to ecosystems (FS 2007) and limit the capability of large areas to supply ecosystem services (Christensen and others 1996; MEA 2005b).

In this paper, we explore the likely ecological consequences of climate change and ungulate use, individually and in combination, on public lands in the American West. Three general categories of large herbivores are considered: livestock (largely cattle [*Bos taurus*] and sheep [*Ovis aries*]), native ungulates (deer [*Odocoileus* spp.] and elk [*Cervus* spp.]), and feral ungulates (horses [*Equus caballus*] and burros [*E. asinus*]). Based on this assessment, we propose first-order recommendations to decrease these consequences by reducing ungulate effects that can be directly managed.

Climate Change in the Western US

Anticipated changes in atmospheric carbon dioxide (CO_2), temperature, and precipitation (IPCC 2007a) are likely to have major repercussions for upland plant communities in western ecosystems (e.g., Backlund and others 2008), eventually affecting the distribution of major vegetation types. Deserts in the southwestern US, for example, will expand to the north and east, and in elevation (Karl and others 2009). Studies in southeastern Arizona have already attributed dramatic shifts in species composition and plant and animal populations to climate-driven changes (Brown and others 1997). Thus, climate-induced changes are already accelerating the ongoing loss of biodiversity in the American West (Thomas and others 2004).

Future decreases in soil moisture and vegetative cover due to elevated temperatures will reduce soil stability (Karl and others 2009). Wind erosion is likely to increase dramatically in some ecosystems such as the Colorado Plateau (Munson and others 2011) because biological soil crusts—a complex mosaic of algae, lichens, mosses, microfungi, cyanobacteria, and other bacteria—may be less drought tolerant than many desert vascular plant species (Belnap and others 2006). Higher air temperatures may also lead to elevated surface-level concentrations of ozone (Karl and others 2009), which can reduce the capacity of vegetation to grow under elevated CO_2 levels and sequester carbon (Karnosky and others 2003).

Air temperature increases and altered precipitation regimes will affect wildfire behavior and interact with insect outbreaks (Joyce and others 2009). In recent decades, climate change appears to have increased the length of the fire season and the area annually burned in some western forest types (Westerling and others 2006; ITF 2011). Climate induced increases in wildfire occurrence may aggravate the expansion of cheatgrass (*Bromus tectorum*), an exotic annual that has invaded millions of hectares of sagebrush (*Artemisia* spp.) steppe, a widespread yet threatened ecosystem. In turn, elevated wildfire occurrence facilitates the conversion of sagebrush and other native shrub-perennial grass communities to those dominated by alien grasses (D'Antonio and Vitousek 1992; Brooks 2008), resulting in habitat loss for imperiled greater sage-grouse (*Centrocercus urophasianus*) and other sagebrush-dependent species (Welch 2005). The US Fish and Wildlife Service (FWS 2010) recently concluded climate change effects can exacerbate many of the multiple threats to sagebrush habitats, including wildfire, invasive plants, and heavy ungulate use. In addition, the combined effects of increased air temperatures, more frequent fires, and elevated CO_2 levels apparently provide some invasive species with a competitive advantage (Karl and others 2009).

By the mid-21st century, Bates and others (2008) indicate that warming in western mountains is very likely to cause large decreases in snowpack, earlier snowmelt, more winter rain events, increased peak winter flows and flooding, and reduced summer flows. Annual runoff is predicted to decrease by 10–30 % in mid-latitude western North America by 2050 (Milly and others 2005) and up to 40 % in Arizona (Milly and others 2008; ITF 2011). Drought periods are expected to become more frequent and longer throughout the West (Bates and others 2008). Summertime decreases in streamflow (Luce and Holden 2009) and increased water temperatures already have been documented for some western rivers (Kaushal and others 2010; Isaak and others 2012).

Snowmelt supplies about 60–80 % of the water in major western river basins (the Columbia, Missouri, and Colorado Rivers) and is the primary water supply for about 70 million people (Pederson and others 2011). Contemporary and future declines in snow accumulations and runoff (Mote and others 2005; Pederson and others 2011) are an important concern because current water supplies, particularly during low-flow periods, are already inadequate to satisfy demands over much of the western US (Piechota and others 2004; Bates and others 2008).

High water temperatures, acknowledged as one of the most prevalent water quality problems in the West, will likely be further elevated and may render one-third of the current coldwater fish habitat in the Pacific Northwest unsuitable by this century's end (Karl and others 2009). Resulting impacts on salmonids include increases in virulence of disease, loss of suitable habitat, and mortality as well as increased competition and predation by warmwater species (EPA 1999). Increased water temperatures and changes in snowmelt timing can also affect amphibians adversely (Field and others 2007). In sum, climate change will have increasingly significant effects on public-land terrestrial and aquatic ecosystems, including plant and animal communities, soils, hydrologic processes, and water quality.

Ungulate Effects and Climate Change Synergies

Climate change in the western US is expected to amplify "combinations of biotic and abiotic stresses that compromise the vigor of ecosystems—leading to increased extent and severity of disturbances" (Joyce and others 2008, p. 16). Of the various land management stressors affecting western public lands, ungulate use is the most widespread (Fig. 1). Domestic livestock annually utilize over 70 % of lands managed by the Bureau of Land Management (BLM) and US Forest Service (FS). Many public lands are also used by wild ungulates and/or feral horses and burros, which are at high densities in some areas. Because ungulate groups can have different effects, we discuss them individually.

Livestock

History and Current Status

Livestock were introduced to North America in the mid-sixteenth century, with a massive influx from the mid-1800s through early 1900s (Worster 1992). The deleterious effects of livestock—including herbivory of both herbaceous and woody plants and trampling of vegetation, soils, and streambanks—prompted federal regulation of grazing on western national forests beginning in the 1890s (Fleischner 2010). Later, the 1934 Taylor Grazing Act was enacted "to stop injury to the public grazing lands by preventing overgrazing and soil deterioration" on lands subsequently administered by the BLM.

Total livestock use of federal lands in eleven contiguous western states today is nearly 9 million animal unit months (AUMs, where one AUM represents forage use by a cow and calf pair, one horse, or five sheep for one month) (Fig. 2a). Permitted livestock use occurs on nearly one million square kilometers of public land annually, including 560,000 km^2 managed by the BLM, 370,000 km^2 by the FS, 6,000 km^2 by the National Park Service (NPS), and 3,000 km^2 by the US Fish and Wildlife Service (FWS).

Livestock use affects a far greater proportion of BLM and FS lands than do roads, timber harvest, and wildfires combined (Fig. 3). Yet attempts to mitigate the pervasive effects of livestock have been minor compared with those aimed at reducing threats to ecosystem diversity and productivity that these other land uses pose. For example, much effort is often directed at preventing and controlling wildfires since they can cause significant property damage and social impacts. On an annual basis, however, wildfires affect a much smaller portion of public land than livestock grazing (Fig. 3) and they can also result in ecosystem benefits (Rhodes and Baker 2008; Swanson and others 2011).

The site-specific impacts of livestock use vary as a function of many factors (e.g., livestock species and density, periods of rest or non-use, local plant communities, soil conditions). Nevertheless, extensive reviews of published research generally indicate that livestock have had numerous and widespread negative effects to western ecosystems (Love 1959; Blackburn 1984; Fleischner 1994; Belsky and others 1999; Kauffman and Pyke 2001; Asner

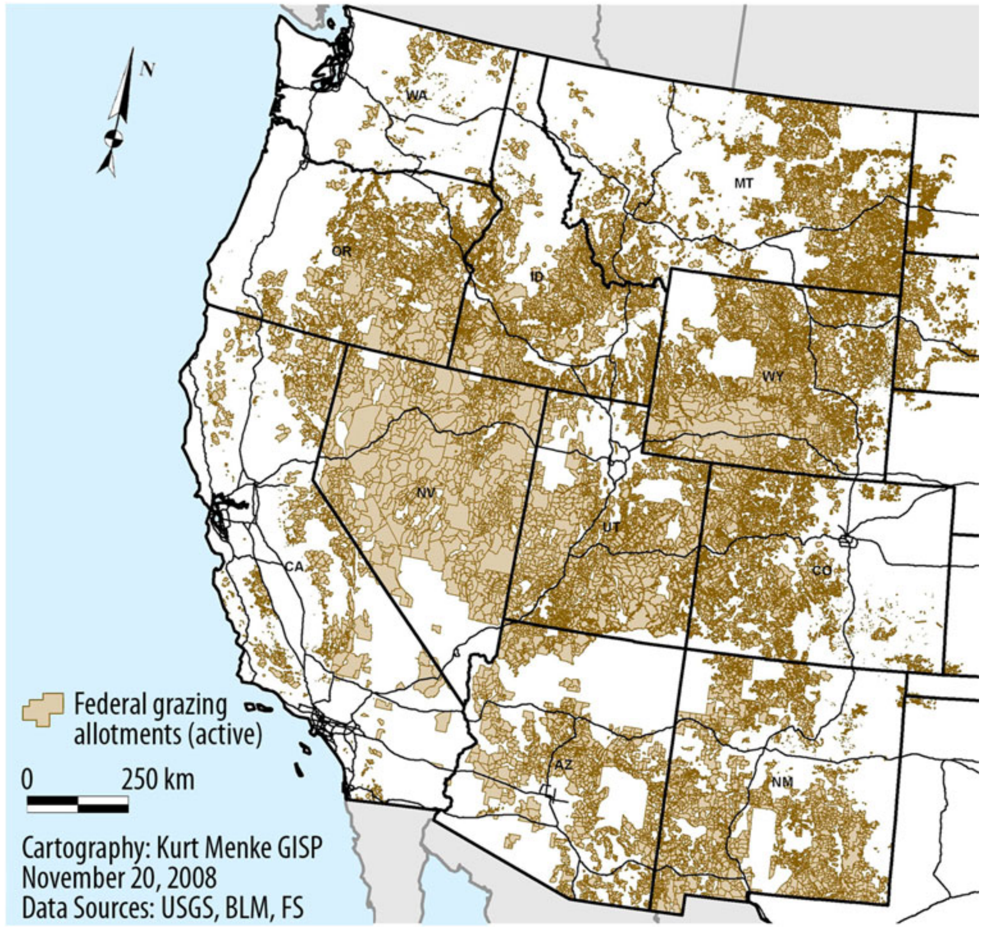

Fig. 1 Areas of public-lands livestock grazing managed by federal agencies in the western US (adapted from Salvo 2009)

and others 2004; Steinfeld and others 2006; Thornton and Herrero 2010). Moreover, public-land range conditions have generally worsened in recent decades (CWWR 1996, Donahue 2007), perhaps due to the reduced productivity of these lands caused by past grazing in conjunction with a changing climate (FWS 2010, p. 13,941, citing Knick and Hanser 2011).

Plant and Animal Communities

Livestock use effects, exacerbated by climate change, often have severe impacts on upland plant communities. For example, many former grasslands in the Southwest are now dominated by one or a few woody shrub species, such as creosote bush (*Larrea tridentata*) and mesquite (*Prosopis glandulosa*), with little herbaceous cover (Grover and Musick 1990; Asner and others 2004; but see Allington and Valone 2010). Other areas severely affected include the northern Great Basin and interior Columbia River Basin (Middleton and Thomas 1997). Livestock effects have also contributed to severe degradation of sagebrush-grass ecosystems (Connelly and others 2004; FWS 2010) and widespread desertification, particularly in the Southwest (Asner and others 2004; Karl and others 2009). Even absent desertification, light to moderate grazing intensities can promote woody species encroachment in semiarid and mesic environments (Asner and others 2004, p. 287). Nearly two decades ago, many public-land ecosystems, including native shrub steppe in Oregon and Washington, sagebrush steppe in the Intermountain West, and riparian plant communities, were considered threatened, endangered, or critically endangered (Noss and others 1995).

Simplified plant communities combine with loss of vegetation mosaics across landscapes to affect pollinators, birds, small mammals, amphibians, wild ungulates, and other native wildlife (Bock and others 1993; Fleischner 1994; Saab and others 1995; Ohmart 1996). Ohmart and Anderson (1986) suggested that livestock grazing may be the major factor negatively affecting wildlife in eleven western states. Such effects will compound the problems of adaptation of these ecosystems to the dynamics of climate change (Joyce and others 2008, 2009). Currently, the widespread and ongoing declines of many North American bird populations that use grassland and grass–shrub habitats affected by grazing are "on track to become a prominent wildlife conservation crisis of the 21st century" (Brennan and Kuvlesky 2005, p. 1).

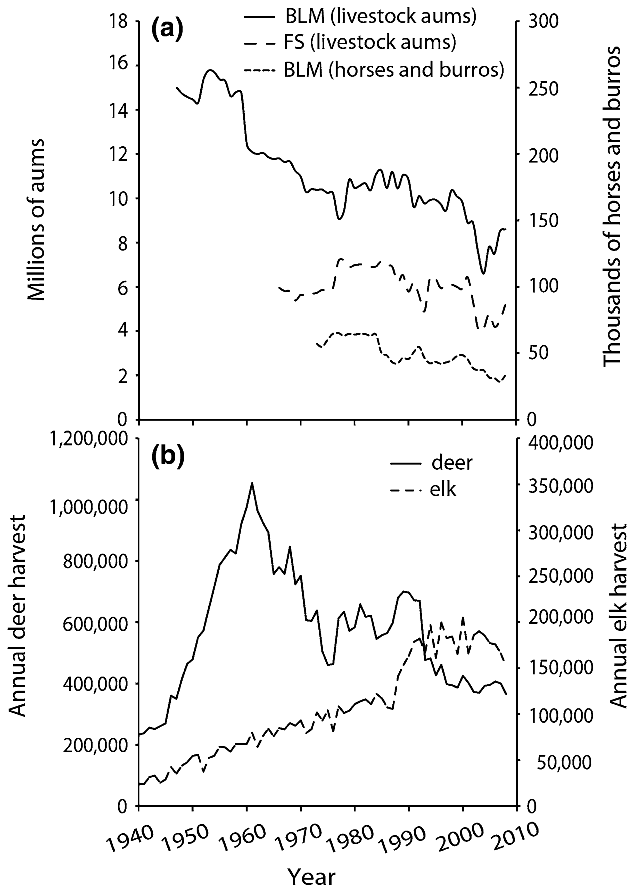

Fig. 2 **a** Bureau of Land Management (BLM) and US Forest Service (FS) grazing use in animal unit months (AUMs) and number of feral horses and burros on BLM lands, and **b** annual harvest of deer and elk by hunters, for eleven western states. *Data sources* **a** BLM grazing and number of horses and burros reported annually in Public Land Statistics; FS grazing reported annually in Grazing Statistical Summary; **b** deer and elk harvest records from individual state wildlife management agencies

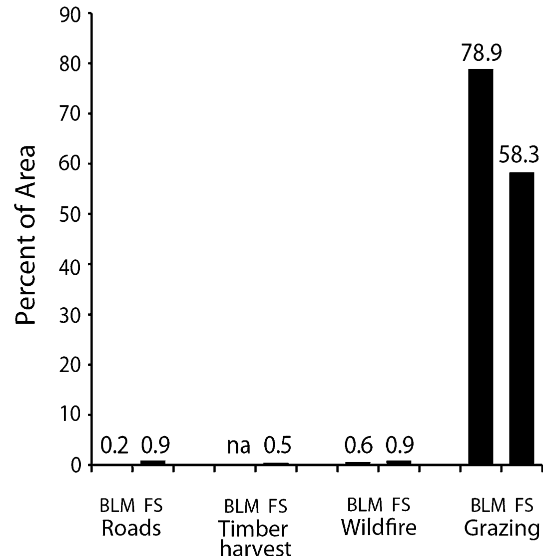

Fig. 3 Percent of Bureau of Land Management (BLM) and US Forest Service (FS) lands in eleven western states that are occupied by roads or are affected annually by timber harvest, wildfire, and grazing. *Data sources* Roads, BLM (2009) and FS, Washington Office; Timber harvest (2003–09), FS, Washington Office; Wildfire (2003–09), National Interagency Fire Center, Missoula, Montana; Grazing, BLM (2009) and GAO (2005). “na” = not available

Soils and Biological Soil Crusts

Livestock grazing and trampling can damage or eliminate biological soil crusts characteristic of many arid and semiarid regions (Belnap and Lange 2003; Asner and others 2004). These complex crusts are important for fertility, soil stability, and hydrology (Belnap and Lange 2003). In arid and semiarid regions they provide the major barrier against wind erosion and dust emission (Munson and others 2011). Currently, the majority of dust emissions in North America originate in the Great Basin, Colorado Plateau, and Mojave and Sonoran Deserts, areas that are predominantly public lands and have been grazed for nearly 150 years. Elevated sedimentation in western alpine lakes over this period has also been linked to increased aeolian deposition stemming from land uses, particularly those associated with livestock grazing (Neff and others 2008).

If livestock use on public lands continues at current levels, its interaction with anticipated changes in climate will likely worsen soil erosion, dust generation, and stream pollution. Soils whose moisture retention capacity has been reduced will undergo further drying by warming temperatures and/or drought and become even more susceptible to wind erosion (Sankey and others 2009). Increased aeolian deposition on snowpack will hasten runoff, accentuating climate-induced hydrological changes on many public lands (Neff and others 2008). Warmer temperatures will likely trigger increased fire occurrence, causing further reductions in cover and composition of biological soil crusts (Belnap and others 2006), as well as vascular plants (Munson and others 2011). In some forest types, where livestock grazing has contributed to altered fire regimes and forest structure (Belsky and Blumenthal 1997; Fleischner 2010), climate change will likely worsen these effects.

Water and Riparian Resources

Although riparian areas occupy only 1–2 % of the West’s diverse landscapes, they are highly productive and ecologically valuable due to the vital terrestrial habitats they provide and their importance to aquatic ecosystems (Kauffman and others 2001; NRC 2002; Fleischner 2010). Healthy riparian plant communities provide important corridors for the movement of plant and animal species

(Peterson and others 2011). Such communities are also crucial for maintaining water quality, food webs, and channel morphology vital to high-quality habitats for fish and other aquatic organisms in the face of climate change. For example, well-vegetated streambanks not only shade streams but also help to maintain relatively narrow and stable channels, attributes essential for preventing increased stream temperatures that negatively affect salmonids and other aquatic organisms (Sedell and Beschta 1991; Kondolf and others 1996; Beschta 1997); maintaining cool stream temperatures is becoming even more important with climate change (Isaak and others 2012). Riparian vegetation is also crucial for providing seasonal fluxes of organic matter and invertebrates to streams (Baxter and others 2005). Nevertheless, in 1994 the BLM and FS reported that western riparian areas were in their worst condition in history, and livestock use—typically concentrated in these areas—was the chief cause (BLM and FS 1994).

Livestock grazing has numerous consequences for hydrologic processes and water resources. Livestock can have profound effects on soils, including their productivity, infiltration, and water storage, and these properties drive many other ecosystem changes. Soil compaction from livestock has been identified as an extensive problem on public lands (CWWR 1996; FS and BLM 1997). Such compaction is inevitable because the hoof of a 450-kg cow exerts more than five times the pressure of heavy earth-moving machinery (Cowley 2002). Soil compaction significantly reduces infiltration rates and the ability of soils to store water, both of which affect runoff processes (Branson and others 1981; Blackburn 1984). Compaction of wet meadow soils by livestock can significantly decrease soil water storage (Kauffman and others 2004), thus contributing to reduced summer base flows. Concomitantly, decreases in infiltration and soil water storage of compacted soils during periods of high-intensity rainfall contribute to increased surface runoff and soil erosion (Branson and others 1981). These fundamental alterations in hydrologic processes from livestock use are likely to be exacerbated by climate change.

The combined effects of elevated soil loss and compaction caused by grazing reduce soil productivity, further compromising the capability of grazed areas to support native plant communities (CWWR 1996; FS and BLM 1997). Erosion triggered by livestock use continues to represent a major source of sediment, nutrients, and pathogens in western streams (WSWC 1989; EPA 2009). Conversely, the absence of grazing results in increased litter accumulation, which can reduce runoff and erosion and retard desertification (Asner and others 2004).

Historical and contemporary effects of livestock grazing and trampling along stream channels can destabilize streambanks, thus contributing to widened and/or incised channels (NRC 2002). Accelerated streambank erosion and channel incision are pervasive on western public lands used by livestock (Fig. 4). Stream incision contributes to desiccation of floodplains and wet meadows, loss of floodwater detention storage, and reductions in baseflow (Ponce and Lindquist 1990; Trimble and Mendel 1995). Grazing and trampling of riparian plant communities also contribute to elevated water temperatures—directly, by reducing stream shading and, indirectly, by damaging streambanks and increasing channel widths (NRC 2002). Livestock use of riparian plant communities can also decrease the availability of food and construction materials for keystone species such as beaver (*Castor canadensis*).

Livestock effects and climate change can interact in various ways with often negative consequences for aquatic species and their habitats. In the eleven ecoregions encompassing western public lands (excluding coastal regions and Alaska), about 175 taxa of freshwater fish are considered imperiled (threatened, endangered, vulnerable, possibly extinct, or extinct) due to habitat-related causes (Jelks and others 2008, p. 377; GS and AFS 2011). Increased sedimentation and warmer stream temperatures associated with livestock grazing have contributed significantly to the long-term decline in abundance and distribution and loss of native salmonids, which are imperiled throughout the West (Rhodes and others 1994; Jelks and others 2008).

Water developments and diversions for livestock are common on public lands (Connelly and others 2004). For example, approximately 3,700 km of pipeline and 2,300 water developments were installed on just 17 % of the BLM's land base from 1961 to 1999 in support of livestock operations (Rich and others 2005). Such developments can reduce streamflows thus contributing to warmer stream temperatures and reduced fish habitat, both serious problems for native coldwater fish (Platts 1991; Richter and others 1997). Reduced flows and higher temperatures are also risk factors for many terrestrial and aquatic vertebrates (Wilcove and others 1998). Water developments can also create mosquito (e.g., *Culex tarsalis*) breeding habitat, potentially facilitating the spread of West Nile virus, which poses a significant threat to sage grouse (FWS 2010). Such developments also tend to concentrate livestock and other ungulate use, thus locally intensifying grazing and trampling impacts.

Greenhouse Gas Emissions and Energy Balances

Livestock production impacts energy and carbon cycles and globally contributes an estimated 18 % to the total anthropogenic greenhouse gas (GHG) emissions (Steinfeld and others 2006). How public-land livestock contribute to

Fig. 4 Examples of long-term grazing impacts from livestock, unless otherwise noted: **a** bare soil, loss of understory vegetation, and lack of aspen recruitment (i.e., growth of seedlings/sprouts into tall saplings and trees) (Bureau of Land Management, Idaho), **b** bare soil, lack of ground cover, lack of aspen recruitment and channel incision (US Forest Service, Idaho), **c** conversion of a perennial stream to an intermittent stream due to grazing of riparian vegetation and subsequent channel incision; channel continues to erode during runoff events (Bureau of Land Management, Utah), **d** incised and widening stream due to loss of streamside vegetation and bank collapse from trampling (Bureau of Land Management, Wyoming), **e** incised and widening stream due to loss of streamside vegetation and bank collapse from trampling (US Forest Service, Oregon), and **f** actively eroding streambank from the loss of streamside vegetation due to several decades of excessive herbivory by elk and, more recently, bison (National Park Service, Wyoming). *Photographs* **a** J Carter, **b** G Wuerthner, **c** and **d** J Carter, **e** and **f** R Beschta

these effects has received little study. Nevertheless, livestock grazing and trampling can reduce the capacity of rangeland vegetation and soils to sequester carbon and contribute to the loss of above- and below-ground carbon pools (e.g., Lal 2001b; Bowker and others 2012). Lal (2001a) indicated that heavy grazing over the long-term may have adverse impacts on soil organic carbon content, especially for soils of low inherent fertility. Although Gill (2007) found that grazing over 100 years or longer in subalpine areas on the Wasatch Plateau in central

Utah had no significant impacts on total soil carbon, results of the study suggest that "if temperatures warm and summer precipitation increases as is anticipated, [soils in grazed areas] may become net sources of CO_2 to the atmosphere" (Gill 2007, p. 88). Furthermore, limited soil aeration in soils compacted by livestock can stimulate production of methane, and emissions of nitrous oxide under shrub canopies may be twice the levels in nearby grasslands (Asner and others 2004). Both of these are potent GHGs.

Reduced plant and litter cover from livestock use can increase the albedo (reflectance) of land surfaces, thereby altering radiation energy balances (Balling and others 1998). In addition, widespread airborne dust generated by livestock is likely to increase with the drying effects of climate change. Air-borne dust influences atmospheric radiation balances as well as accelerating melt rates when deposited on seasonal snowpacks and glaciers (Neff and others 2008).

Other Livestock Effects

Livestock urine and feces add nitrogen to soils, which may favor nonnative species (BLM 2005), and can lead to loss of both organic and inorganic nitrogen in increased runoff (Asner and others 2004). Organic nitrogen is also lost via increased trace-gas flux and vegetation removal by grazers (Asner and others 2004). Reduced soil nitrogen is problematic in western landscapes because nitrogen is an important limiting nutrient in most arid-land soils (Fleischner 2010).

Managing livestock on public lands also involves extensive fence systems. Between 1962 and 1997, over 51,000 km of fence were constructed on BLM lands with resident sage-grouse populations (FWS 2010). Such fences can significantly impact this wildlife species. For example, 146 sage-grouse died in less than three years from collisions with fences along a 7.6-km BLM range fence in Wyoming (FWS 2010). Fences can also restrict the movements of wild ungulates and increase the risk of injury and death by entanglement or impalement (Harrington and Conover 2006; FWS 2010). Fences and roads for livestock access can fragment and isolate segments of natural ecological mosaics thus influencing the capability of wildlife to adapt to a changing climate.

Some have posited that managed cattle grazing might play a role in maintaining ecosystem structure in shortgrass steppe ecosystems of the US, if it can mimic grazing by native bison (*Bison bison*) (Milchunas and others 1998). But most public lands lie to the west of the Great Plains, where bison distribution and effects were limited or nonexistent; livestock use (particularly cattle) on these lands exert disturbances without evolutionary parallel (Milchunas and Lauenroth 1993; MEA 2005a).

Feral Horses and Burros

Feral horses and burros occupy large areas of public land in the western US. For example, feral horses are found in ten western states and feral burros occur in five of these states, largely in the Mojave and Sonoran Deserts and the Great Basin (Abella 2008; FWS 2010). About half of these horses and burros are in Nevada (Coggins and others 2007), of which 90 % are on BLM lands. Horse numbers peaked at perhaps two million in the early 1900s, but had plummeted to about 17,000 by 1971, when protective legislation (Wild, Free-Ranging Horses and Burros Act [WFRHBA]) was passed (Coggins and others 2007). Protection resulted in increased populations and today some 40,000 feral horses and burros utilize $\sim$ 130,000 km^2 of BLM and FS lands (DOI-OIG 2010; Gorte and others 2010). Currently, feral horse numbers are doubling every four years (DOI-OIG 2010); burro populations can also increase rapidly (Abella 2008). Unlike wild ungulates, feral equines cannot be hunted and, unlike livestock, they are not regulated by permit. Nor are their numbers controlled effectively by existing predators. Accordingly, the BLM periodically removes animals from herd areas; the NPS also has undertaken burro control efforts (Abella 2008).

In sage grouse habitat, high numbers of feral horses reduce vegetative cover and plant diversity, fragment shrub canopies, alter soil characteristics, and increase the abundance of invasive species, thus reducing the quality and quantity of habitat (Beever and others 2003; FWS 2010). Horses can crop plants close to the ground, impeding the recovery of affected vegetation. Feral burros also have had a substantial impact on Sonoran Desert vegetation, reducing the density and canopy cover of nearly all species (Hanley and Brady 1977). Although burro impacts in the Mojave Desert may not be as clear, perennial grasses and other preferred forage species likely require protection from grazing in burro-inhabited areas if revegetation efforts are to be successful (Abella 2008).

Wild Ungulates

Extensive harvesting of wild (native) ungulates, such as elk and deer, and the decimation of large predator populations (e.g., gray wolf [*Canis lupus*], grizzly bear [*Ursus arctos*], and cougar [*Puma concolor*]) was common during early EuroAmerican settlement of the western US. With continued predator control in the early 1900s and increased protection of game species by state agencies, however, wild ungulate populations began to increase in many areas. Although only 70,000 elk inhabited the western US in the early 1900s (Graves and Nelson 1919), annual harvest data indicate that elk abundance has increased greatly since the about the 1940s (Fig. 2b), due in part to the loss of apex predators (Allen 1974; Mackie and others 1998). Today, approximately one million elk (Karnopp 2008) and unknown numbers of deer inhabit the western US where they often share public lands with livestock.

Because wild ungulates typically occur more diffusely across a landscape than livestock, their presence might be expected to cause minimal long-term impacts to vegetation. Where wild ungulates are concentrated, however, their browsing can have substantial impacts. For example, sagebrush vigor can be reduced resulting in decreased cover or mortality (FWS 2010). Heavy browsing effects have also been documented on other palatable woody shrubs, as well as deciduous trees such as aspen (*Populus tremuloides*), cottonwood (*Populus* spp.), and maple (*Acer* sp.) (Beschta and Ripple 2009).

Predator control practices that intensified following the introduction of domestic livestock in the western US resulted in the extirpation of apex predators or reduced their numbers below ecologically effective densities (Soulé and others 2003, 2005), causing important cascading effects in western ecosystems (Beschta and Ripple 2009). Following removal of large predators on the Kaibab Plateau in the early 20th century, for example, an irruption of mule deer (*O. hemionus*) led to extensive over-browsing of aspen, other deciduous woody plants, and conifers; deterioration of range conditions; and the eventual crash of the deer population (Binkley and others 2006). In the absence of apex predators, wild ungulate populations can significantly limit recruitment of woody browse species, contribute to shifts in abundance and distribution of many wildlife species (Berger and others 2001; Weisberg and Coughenour 2003), and can alter streambanks and riparian communities that strongly influence channel morphology and aquatic conditions (Beschta and Ripple 2012). Numerous studies support the conclusion that disruptions of trophic cascades due to the decline of apex predators constitute a threat to biodiversity for which the best management solution is likely the restoration of effective predation regimes (Estes and others 2011).

Ungulate Herbivory and Disturbance Regimes

Across the western US, ecosystems evolved with and were sustained by local and regional disturbances, such as fluctuating weather patterns, fire, disease, insect infestation, herbivory by wild ungulates and other organisms, and hunting by apex predators. Chronic disturbances with relatively transient effects, such as frequent, low-severity fires and seasonal moisture regime fluctuations, helped maintain native plant community composition and structure. Relatively abrupt, or acute, natural disturbances, such as insect outbreaks or severe fires were also important for the maintenance of ecosystems and native species diversity (Beschta and others 2004; Swanson and others 2011). Livestock use and/or an overabundance of feral or wild ungulates can, however, greatly alter ecosystem response to disturbance and can degrade affected systems. For example, high levels of herbivory over a period of years, by either domestic or wild ungulates, can effectively prevent aspen sprouts from growing into tall saplings or trees as well as reduce the diversity of understory species (Shepperd and others 2001; Dwire and others 2007; Beschta and Ripple 2009).

Natural floods provide another illustration of how ungulates can alter the ecological role of disturbances. High flows are normally important for maintaining riparian plant communities through the deposition of nutrients, organic matter, and sediment on streambanks and floodplains, and for enhancing habitat diversity of aquatic and riparian ecosystems (CWWR 1996). Ungulate effects on the structure and composition of riparian plant communities (e.g., Platts 1991; Chadde and Kay 1996), however, can drastically alter the outcome of these hydrologic disturbances by diminishing streambank stability and severing linkages between high flows and the maintenance of streamside plant communities. As a result, accelerated erosion of streambanks and floodplains, channel incision, and the occurrence of high instream sediment loads may become increasingly common during periods of high flows (Trimble and Mendel 1995). Similar effects have been found in systems where large predators have been displaced or extirpated (Beschta and Ripple 2012). In general, high levels of ungulate use can essentially uncouple typical ecosystem responses to chronic or acute disturbances, thus greatly limiting the capacity of these systems to provide a full array of ecosystem services during a changing climate.

The combined effects of ungulates (domestic, wild, and feral) and a changing climate present a pervasive set of stressors on public lands, which are significantly different from those encountered during the evolutionary history of the region's native species. The intersection of these stressors is setting the stage for fundamental and unprecedented changes to forest, arid, and semi-arid landscapes in the western US (Table 1) and increasing the likelihood of alternative states. Thus, public-land management needs to focus on restoring and maintaining structure, function, and integrity of ecosystems to improve their resilience to climate change (Rieman and Isaak 2010).

Federal Law and Policy

Federal laws guide the use and management of public-land resources. Some laws are specific to a given agency (e.g., the BLM's Taylor Grazing Act of 1934 and the FS's

Table 1 Generalized climate change effects, heavy ungulate use effects, and their combined effects as stressors to terrestrial and aquatic ecosystems in the western United States

Climate change effects	Ungulate use effects	Combined effects
Increased drought frequency and duration	Altered upland plant and animal communities	Reduced habitat and food-web support; loss of mesic and hydric plants, reduced biodiversity
Increased air temperatures, decreased snowpack accumulation, earlier snowmelt	Compacted soils, decreased infiltration, increased surface runoff	Reduced soil moisture for plants, reduced productivity, reductions in summer low flows, degraded aquatic habitat
Increased variability in timing and magnitude of precipitation events	Decreased biotic crusts and litter cover, increased surface erosion	Accelerated soil and nutrient loss, increased sedimentation
Warmer and drier in the summer	Reduced riparian vegetation, loss of shade, increased stream width	Increased stream temperatures, increased stress on cold-water fish and aquatic organisms
Increased variability in runoff	Reduced root strength of riparian plants, trampled streambanks, streambank erosion	Accelerated streambank erosion and increased sedimentation, degraded water quality and aquatic habitats
Increased variability in runoff	Incised stream channels	Degraded aquatic habitats, hydrologically disconnected floodplains, reduced low flows

National Forest Management Act [NFMA] of 1976), whereas others cross agency boundaries (e.g., Endangered Species Act [ESA] of 1973; Clean Water Act [CWA] of 1972). A common mission of federal land management agencies is "to sustain the health, diversity, and productivity of public lands" (GAO 2007, p. 12). Further, each of these agencies has ample authority and responsibility to adjust management to respond to climate change (GAO 2007) and other stressors.

The FS and BLM are directed to maintain and improve the condition of the public rangelands so that they become as productive as feasible for all rangeland values. As defined, "range condition" encompasses factors such as soil quality, forage values, wildlife habitat, watershed and plant communities, and the present state of vegetation of a range site in relation to the potential plant community for that site (Public Rangelands Improvement Act of 1978). BLM lands and national forests must be managed for sustained yield of a wide array of multiple uses, values, and ecosystem services, including wildlife and fish, watershed, recreation, timber, and range. Relevant statutes call for management that meets societal needs, without impairing the productivity of the land or the quality of the environment, and which considers the "relative values" of the various resources, not necessarily the combination of uses that will give the greatest economic return or the greatest unit output (Multiple-Use Sustained-Yield Act of 1960; Federal Land Policy and Management Act of 1976 [FLPMA]).

FLPMA directs the BLM to "take any action necessary to prevent unnecessary or undue degradation" of the public lands. Under NFMA, FS management must provide for diversity of plant and animal communities based on the suitability and capability of the specific land area. FLMPA also authorizes both agencies to "cancel, suspend, or modify" grazing permits and to determine that "grazing uses should be discontinued (either temporarily or permanently) on certain lands." FLPMA explicitly recognizes the BLM's authority (with congressional oversight) to "totally eliminate" grazing from large areas (> 405 km^2) of public lands. These authorities are reinforced by law providing that grazing permits are not property rights (*Public Lands Council v. Babbitt* 2000).

While federal agencies have primary authority to manage federal public lands and thus wildlife *habitats* on these lands, states retain primary management authority over resident *wildlife*, unless preempted, as by the WFRHBA or ESA (*Kleppe v. New Mexico* 1976). Under WFRHBA, wild, free-roaming horses and burros (i.e., feral) by law have been declared "wildlife" and an integral part of the natural system of the public lands where they are to be managed in a manner that is designed to achieve and maintain a thriving natural ecological balance.

Restoring Ungulate-Altered Ecosystems

Because livestock use is so widespread on public lands in the American West, management actions directed at ecological restoration (e.g., livestock removal, substantial reductions in numbers or length of season, extended or regular periods of rest) need to be accomplished at landscape scales. Such approaches, often referred to as passive restoration, are generally the most ecologically effective and economically efficient for recovering altered ecosystems because they address the root causes of degradation and allow natural recovery processes to operate (Kauffman and others 1997; Rieman and Isaak 2010). Furthermore, reducing the impact of current stressors is a "no regrets" adaptation strategy that could be taken now to help enhance

Fig. 5 Examples of riparian and stream recovery in the western United States after the removal of livestock grazing: Hart Mountain National Antelope Refuge, Oregon, in **a** October 1989 and **b** September 2010 after 18 years of livestock removal; Strawberry River, Utah, in **c** August 2002 after 13 years of livestock removal and **d** July 2003 illustrating improved streambank protection and riparian productivity as beaver reoccupy this river system; and San Pedro River, Arizona in **e** June 1987 and **f** June 1991 after 4 years of livestock removal. *Photographs* **a** Fish and Wildlife Service, Hart Mountain National Antelope Refuge, **b** J Rhodes, **c** and **d** US Forest Service, Uintah National Forest, **e** and **f** Bureau of Land Management, San Pedro Riparian National Conservation Area

ecosystem resilience to climate change (Joyce and others 2008). This strategy is especially relevant to western ecosystems because removing or significantly reducing the cause of degradation (e.g., excessive ungulate use) is likely to be considerably more effective over the long term, in both costs and approach, than active treatments aimed at specific ecosystem components (e.g., controlling invasive plants) (BLM 2005). Furthermore, the possibility that passive restoration measures may not accomplish all ecological goals is an insufficient reason for *not* removing or reducing stressors at landscape scales.

For many areas of the American West, particularly riparian areas and other areas of high biodiversity, significantly reducing or eliminating ungulate stressors should, over time, result in the recovery of self-sustaining and ecologically robust ecosystems (Kauffman and others 1997; Floyd and others 2003; Allington and Valone 2010; Fig. 5). Indeed, various studies and reviews have concluded that the most effective way to restore riparian areas and aquatic systems is to exclude livestock either temporarily (with subsequent changed management) or long-term (e.g., Platts 1991;BLM and FS 1994; Dobkin and others

1998; NRC 2002; Seavy and others 2009: Fleischner 2010). Recovering channel form and riparian soils and vegetation by reducing ungulate impacts is also a viable management tool for increasing summer baseflows (Ponce and Lindquist 1990; Rhodes and others 1994).

In severely degraded areas, initiating recovery may require active measures in addition to the removal/reduction of stressors. For example, where native seed banks have been depleted, reestablishing missing species may require planting seeds or propagules from adjacent areas or refugia (e.g., Welch 2005). While active restoration approaches in herbivory-degraded landscapes may have some utility, such projects are often small in scope, expensive, and unlikely to be self-sustaining; some can cause unanticipated negative effects (Kauffman and others 1997). Furthermore, if ungulate grazing effects continue, any benefits from active restoration are likely to be transient and limited. Therefore, addressing the underlying causes of degradation should be the first priority for effectively restoring altered public-land ecosystems.

The ecological effectiveness and low cost of wide-scale reduction in ungulate use for restoring public-land ecosystems, coupled with the scarcity of restoration resources, provide a forceful case for minimizing ungulate impacts. Other conservation measures are unlikely to make as great a contribution to ameliorating landscape-scale effects from climate change or to do so at such a low fiscal cost. As Isaak and others (2012, p. 514) noted with regard to the impacts of climate change on widely-imperiled salmonids: "…conservation projects are likely to greatly exceed available resources, so strategic prioritization schemes are essential."

Although restoration of desertified lands was once thought unlikely, recovery in the form of significant increases in perennial grass cover has recently been reported at several such sites around the world where livestock have been absent for more than 20 years (Floyd and others 2003; Allington and Valone 2010; Peters and others 2011). At a desertified site in Arizona that had been ungrazed for 39 years, infiltration rates were significantly (24 %) higher (compared to grazed areas) and nutrient levels were elevated in the bare ground, inter-shrub areas (Allington and Valone 2010). The change in vegetative structure also affected other taxa (e.g., increased small mammal diversity) where grazing had been excluded (Valone and others 2002). The notion that regime shifts caused by grazing are irreversible (e.g., Bestelmeyer and others 2004) may be due to the relative paucity of large-scale, ungulate-degraded systems where grazing has been halted for sufficiently long periods for recovery to occur.

Removing domestic livestock from large areas of public lands, or otherwise significantly reducing their impacts, is consistent with six of the seven approaches recommended for ecosystem adaptation to climate change (Julius and others 2008, pp. 1-3). Specifically, removing livestock would (1) protect key ecosystem features (e.g., soil properties, riparian areas); (2) reduce anthropogenic stressors; (3) ensure representation (i.e., protect a variety of forms of a species or ecosystem); (4) ensure replication (i.e., protect more than one example of each ecosystem or population); (5) help restore ecosystems; and (6) protect refugia (i.e., areas that can serve as sources of "seed" for recovery or as destinations for climate-sensitive migrants). Although improved livestock management practices are being adopted on some public lands, such efforts have not been widely implemented. Public land managers have rarely used their authority to implement landscape-scale rest from livestock use, lowered frequency of use, or multi-stakeholder planning for innovative grazing systems to reduce impacts.

While our findings are largely focused on adaptation strategies for western landscapes, reducing ungulate impacts and restoring degraded plant and soil systems may also assist in mitigating any ongoing or future changes in regional energy and carbon cycles that contribute to global climate change. Simply removing livestock can increase soil carbon sequestration since grasslands with the greatest potential for increasing soil carbon storage are those that have been depleted in the past by poor management (Wu and others 2008, citing Jones and Donnelly 2004). Riparian area restoration can also enhance carbon sequestration (Flynn and others 2009).

Socioeconomic Considerations

A comprehensive assessment of the socioeconomic effects of changes in ungulate management on public lands is beyond the scope of this paper. However, herein we identify a few of the *general* costs and benefits associated with implementing our recommendations (see next section), particularly with regard to domestic livestock grazing. The socioeconomic effects of altering ungulate management on public lands will ultimately depend on the type, magnitude, and location of changes undertaken by federal and state agencies.

Ranching is a contemporary and historically significant aspect of the rural West's social fabric. Yet, ranchers' stated preferences in response to grazing policy changes are as diverse as the ranchers themselves, and include intensifying, extensifying, diversifying, or selling their operations (Genter and Tanaka 2002). Surveys indicate that most ranchers are motivated more by amenity and lifestyle attributes than by profits (Torell and others 2001, Genter and Tanaka 2002). Indeed, economic returns from ranching are lower than any other investments with similar risk

(Torrell and others 2001) and public-land grazing's contributions to income and jobs in the West are relatively small fractions of the region's totals (BLM and FS 1994; Power 1996).

If livestock grazing on public lands were discontinued or curtailed significantly, some operations would see reduced incomes and ranch values, some rural communities would experience negative economic impacts, and the social fabric of those communities could be altered (Genter and Tanaka 2002). But for most rural economies, and the West in general, the economic impacts of managing public lands to emphasize environmental amenities would be relatively minor to modestly positive (Mathews and others 2002). Other economic effects could include savings to the US Treasury because federal grazing fees on BLM and FS lands cover only about one-sixth of the agencies' administration costs (Vincent 2012). Most significantly, improved ecosystem function would lead to enhanced ecosystem services, with broad economic benefits. Various studies have documented that the economic values of other public-land resources (e.g., water, timber, recreation, and wilderness) are many times larger than that of grazing (Haynes and others 1997; Laitos and Carr 1999; Patterson and Coelho 2009).

Facilitating adaptation to climate change will require changes in the management of public-land ecosystems impacted by ungulates. *How* ungulate management policy changes should be accomplished is a matter for the agencies, the public, and others. The recommendations and conclusions presented in the following section are based solely on ecological considerations and the federal agencies' legal authority and obligations.

Recommendations

We propose that large areas of BLM and FS lands should become free of use by livestock and feral ungulates (Table 2) to help initiate and speed the recovery of affected ecosystems as well as provide benchmarks or controls for assessing the effects of "grazing versus no-grazing" at significant spatial scales under a changing climate. Further, large areas of livestock exclusion allow for understanding potential recovery foregone in areas where livestock grazing is continued (Bock and others 1993).

While lowering grazing pressure rather than discontinuing use might be effective in some circumstances, public land managers need to rigorously assess whether such use is compatible with the maintenance or recovery of ecosystem attributes such as soils, watershed hydrology, and native plant and animal communities. In such cases, the contemporary status of at least some of the key attributes and their rates of change should be carefully monitored to ascertain whether continued use is consistent with ecological recovery, particularly as the climate shifts (e.g., Karr and Rossano 2001, Karr 2004; LaPaix and others 2009). To the extent possible, assessments of recovering areas should be compared to similar measurements in reference areas (i.e., areas exhibiting high ecological integrity) or areas where ungulate impacts had earlier been removed or minimized (Angermeier and Karr 1994; Dobkin and others 1998). Such comparisons are crucial if scientists and managers are to confirm whether managed systems are attaining restoration goals and to determine needs for intervention, such as reintroducing previously extirpated species. Unfortunately, testing for impacts of livestock use at landscape scales is hampered by the lack of large, ungrazed areas in the western US (e.g., Floyd and others 2003; FWS 2010).

Table 2 Priority areas for permanently removing livestock and feral ungulates from Bureau of Land Management and US Forest Service lands to reduce or eliminate their detrimental ecological effects

Watersheds and other large areas that contain a variety of ecotypes to ensure that major ecological and societal benefits of more resilient and healthy ecosystems on public lands will occur in the face of climate change
Areas where ungulate effects extend beyond the immediate site (e.g., wetlands and riparian areas impact many wildlife species and ecosystem services with cascading implications beyond the area grazed)
Localized areas that are easily damaged by ungulates, either inherently (e.g., biological crusts or erodible soils) or as the result of a temporary condition (e.g., recent fire or flood disturbances, or degraded from previous management and thus fragile during a recovery period).
Rare ecosystem types (e.g., perched wetlands) or locations with imperiled species (e.g., aspen stands and understory plant communities, endemic species with limited range), including fish and wildlife species adversely affected by grazing and at-risk and/or listed under the ESA
Non-use areas (i.e., ungrazed by livestock) or exclosures embedded within larger areas where livestock grazing continues. Such non-use areas should be located in representative ecotypes so that actual rates of recovery (in the absence of grazing impacts) can be assessed relative to resource trend and condition data in adjacent areas that continue to be grazed
Areas where the combined effects of livestock, wild ungulates, and feral ungulates are causing significant ecological impacts

Shifting the burden of proof for continuing, rather than significantly reducing or eliminating ungulate grazing is warranted due to the extensive body of evidence on ecosystem impacts caused by ungulates (i.e., consumers) and the added ecosystem stress caused by climate change. As Estes and others (2011, p. 306) recommended: "[T]he burden of proof [should] be shifted to show, for any ecosystem, that consumers do (or did) not exert strong cascading effects" (see also Henjum and others 1994; Kondolf 1994; Rhodes and others 1994). Current livestock or feral ungulate use should continue only where stocking rates, frequency, and timing can be demonstrated, in comparison with landscape-scale reference areas, exclosures, or other appropriate non-use areas, to be compatible with maintaining or recovering key ecological functions and native species complexes. Furthermore, such use should be allowed only when monitoring is adequate to determine the effects of continued grazing in comparison to areas without grazing.

Where wild native ungulates, such as elk or deer, have degraded plant communities through excessive herbivory (e.g., long-term suppression of woody browse species [Weisberg and Coughenour 2003; Beschta and Ripple 2009; Ripple and others 2010]), state wildlife agencies and federal land managers need to cooperate in controlling or reducing those impacts. A potentially important tool for restoring ecosystems degraded by excessive ungulate herbivory is reintroduction or recolonization of apex predators. In areas of public land that are sufficiently large and contain suitable habitat, allowing apex predators to become established at ecologically effective densities (Soulé and others 2003, 2005) could help regulate the behavior and density of wild ungulate populations, aiding the recovery of degraded ecosystems (Miller and others 2001; Ripple and others 2010; Estes and others 2011). Ending government predator control programs and reintroducing predators will have fewer conflicts with livestock grazing where the latter has been discontinued in large, contiguous public-land areas. However, the extent to which large predators might also help control populations of feral horses and burros is not known.

Additionally, we recommend removing livestock and feral ungulates from national parks, monuments, wilderness areas, and wildlife refuges wherever possible and managing wild ungulates to minimize their potential to adversely affect soil, water, vegetation, and wildlife populations or impair ecological processes. Where key large predators are absent or unable to attain ecologically functional densities, federal agencies should coordinate with state wildlife agencies in managing wild ungulate populations to prevent excessive effects of these large herbivores on native plant and animal communities.

Conclusions

Average global temperatures are increasing and precipitation regimes changing at greater rates than at any time in recent centuries. Contemporary trends are expected to continue and intensify for decades, even if comprehensive mitigations regarding climate change are implemented immediately. The inevitability of these trends requires adaptation to climate change as a central planning goal on federal lands.

Historical and on-going ungulate use has affected soils, vegetation, wildlife, and water resources on vast expanses of public forests, shrublands, and grasslands across the American West in ways that are likely to accentuate any climate impacts on these resources. Although the effects of ungulate use vary across landscapes, this variability is more a matter of degree than type.

If effective adaptations to the adverse effects of climate change are to be accomplished on western public lands, large-scale reductions or cessation of ecosystem stressors associated with ungulate use are crucial. Federal and state land management agencies should seek and make wide use of opportunities to reduce significant ungulate impacts in order to facilitate ecosystem recovery and improve resiliency. Such actions represent the most effective and extensive means for helping maintain or improve the ecological integrity of western landscapes and for the continued provision of valuable ecosystem services during a changing climate.

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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

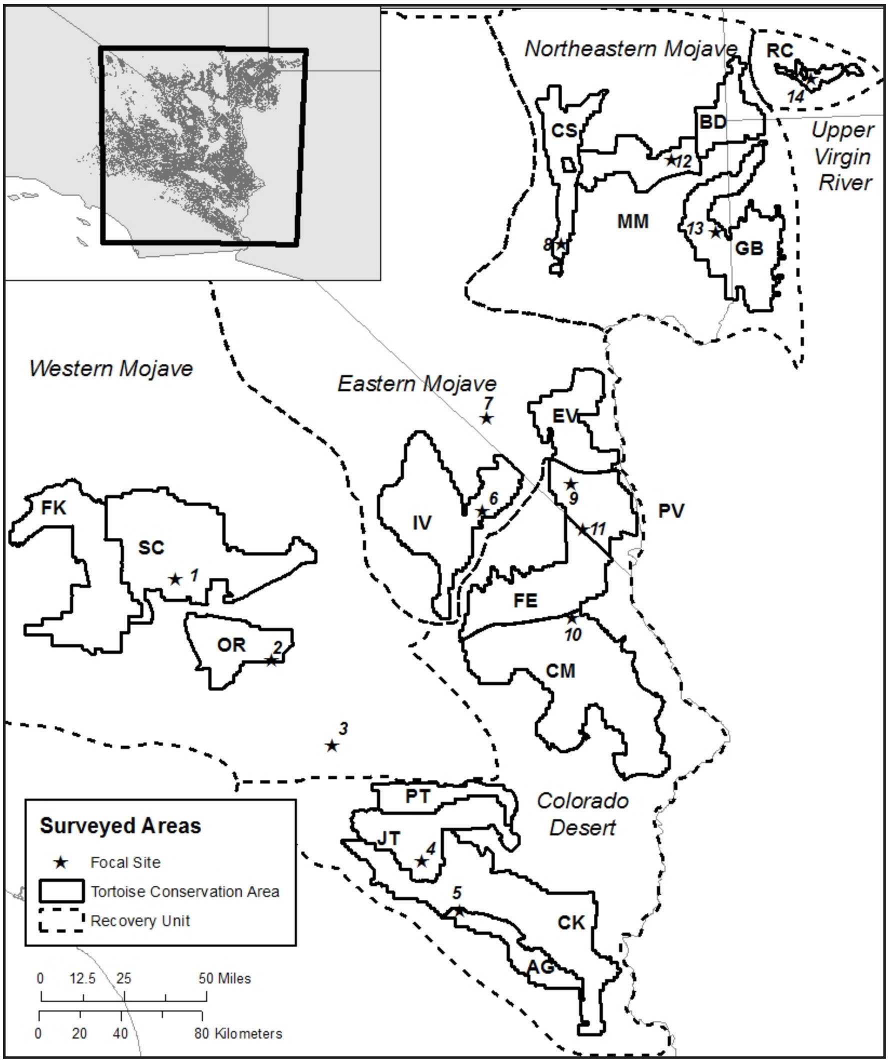

Figure 1. Tortoise Conservation Areas (TCAs, n = 17) for Mojave Desert Tortoises (*Gopherus agassizii*) that were monitored in the Mojave and Colorado deserts, USA. Sites were monitored through 2014 and began in 2004 except in the Red Cliffs Desert Reserve, where surveys started in 1999. TCAs and their 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, 2*wL*, 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:

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

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

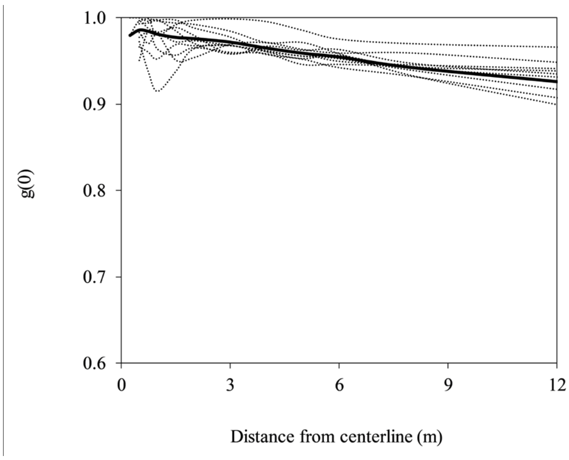

Figure 2. Detection of Mojave Desert Tortoises (*Gopherus agassizii*) at the transect centerline (*g(0)*) based on all two-pass survey observations as remote as x meters from the transect centerline. Dotted lines are annual curves; solid line is overall pattern across years from 2004 through 2014 (no 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 $–\beta_{Year}/2\beta_{Year}{}^2$.

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/

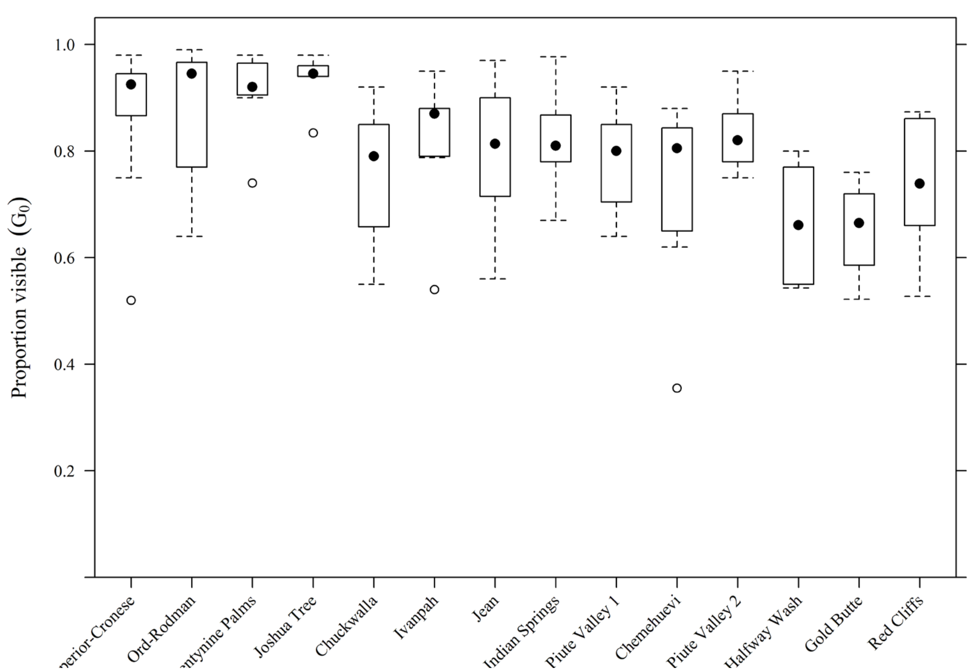

Figure 3. Box and whisker plots indicating the proportion of adult Mojave Desert Tortoises (*Gopherus agassizii*) visible (G_0) at each of 14 focal sites shown in Fig. 1 during transect surveys from 1999 through 2014. Boxes represent the interquartile range (values from the 25th – 75th percentile), crossed 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

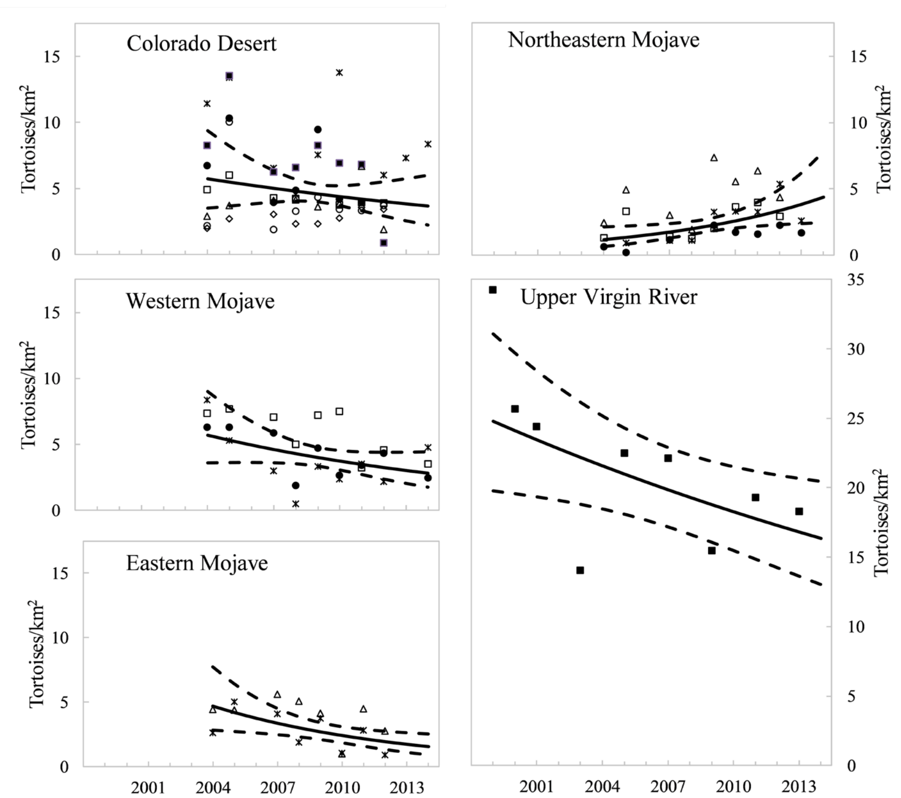

Figure 4. Trends in density (tortoises/km^2) of adult Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit through 2014: since 1999 for Upper Virgin River Recovery Unit and for all others since 2004. Separate markers are used for annual density estimates for each tortoise conservation 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.

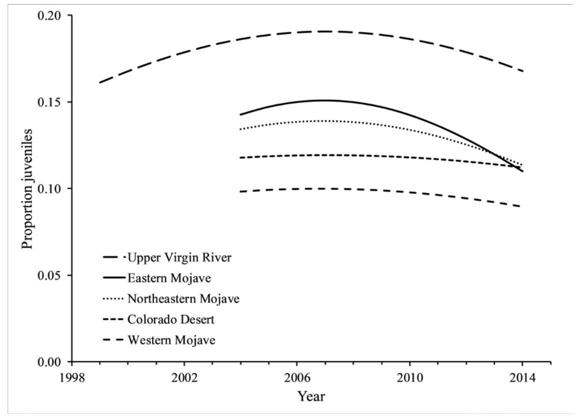

Figure 5. Relative proportion of juvenile Mojave Desert Tortoises (*Gopherus agassizii*) in each recovery unit through 2014: since 1999 for Upper Virgin River Recovery Unit and for all others since 2004.

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, $P(\text{juvenile}_{2007Western\ Mojave}) = 0.099$, CV = 0.067. The probability that an encountered tortoise was a juvenile was also consistently low in the Colorado Desert ($P[\text{juvenile}_{2007Colorado\ Desert}] = 0.119$, CV = 0.131) and lower than in the remaining two recovery units ($P[\text{juvenile}_{2007Eastern\ Mojave}] = 0.149$, CV = 0.187; $P[\text{juvenile}_{2007Northeastern\ Mojave}] = 0.140$, 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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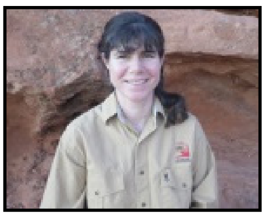

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Appendix A. Annual proportion visible, G_0 (standard error), at each focal site where we monitored transmittered adult Mojave Desert Tortoises (*Gopherus agassizii*). Sites are listed in order from the western-most to the eastern-most and their locations 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

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Livestock Use on Public Lands in the Western USA Exacerbates Climate Change: Implications for Climate Change Mitigation and Adaptation

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Abstract
Public lands of the USA can play an important role in addressing the climate crisis. About 85% of public lands in the western USA are grazed by domestic livestock, and they influence climate change in three profound ways: (1) they are significant sources of greenhouse gases through enteric fermentation and manure deposition; (2) they defoliate native plants, trample vegetation and soils, and accelerate the spread of exotic species resulting in a shift in landscape function from carbon sinks to sources of greenhouse gases; and (3) they exacerbate the effects of climate change on ecosystems by creating warmer and drier conditions. On public lands one cow-calf pair grazing for one month (an "animal unit month" or "AUM") produces 875 kg CO_2e through enteric fermentation and manure deposition with a social carbon cost of nearly $36 per AUM. Over 14 million AUMs of cattle graze public lands of the western USA each year resulting in greenhouse gas emissions of 12.4 Tg CO_2e year^{-1}. The social costs of carbon are > $500 million year^{-1} or approximately 26 times greater than annual grazing fees collected by managing federal agencies. These emissions and social costs do not include the likely greater ecosystems costs from grazing impacts and associated livestock management activities that reduce biodiversity, carbon stocks and rates of carbon sequestration. Cessation of grazing would decrease greenhouse gas emissions, improve soil and water resources, and would enhance/sustain native species biodiversity thus representing an important and cost-effective adaptive approach to climate change.

Introduction

Public lands of the western USA are among the most majestic and biologically diverse landscapes of North America. They are a source of pride and inspiration for the millions of people who visit, recreate, and depend on them, and provide important ecosystem services including clean air and water and vast, unfragmented fish and wildlife habitats and migratory corridors. They also deliver abundant sources of water and other natural resources for agriculture and domestic use. However, the structure and function of these ecosystems are increasingly threatened by the synergistic effects of current land uses and climate change (Remington et al. 2021).

In the coming century, climate change is projected to impact precipitation and temperature regimes worldwide (IPCC 2022), with especially large effects on arid and semiarid landscapes (Palmquist et al. 2016). Predictions for the Intermountain West include increased winter temperatures that will reduce snowpacks and result in earlier spring snowmelt (Barnett et al. 2005; Klos et al. 2014), with important consequences for the amount and timing of soil water recharge (Schlaepfer et al. 2012). In addition, higher temperatures are expected to increase evaporative demand, causing soils to dry out earlier in the year and contributing to longer and drier summer conditions (Palmquist et al. 2016). Shifting patterns of precipitation, increasing temperatures, and rising CO_2 levels are likely to impact western

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Fig. 1 Vegetation change of a riparian ecosystem following cessation of grazing. The left photos are riparian zones on the Hart Mountain National Antelope Refuge, Oregon in 1990 which was the last year of grazing on these public lands. The right photos are the same sites about 24 years after cattle were removed. Wetland vegetation now predominates where there was mostly bare ground and exotic dry grasses. (Photos by W. Pyle and S.Ries)

public lands through alteration of fire regimes and an increased spread of exotic annual grasses (Creutzburg et al. 2015; Mote et al. 2019).

Livestock grazing is the most widespread land use of federally-managed public lands in the western states of the coterminous USA. More than 98 percent of the public lands used for livestock grazing are managed by the Bureau of Land Management (BLM) and the United States Forest Service (USFS) in the western states of the coterminous USA, where a total of 56 million ha and 37 million ha, respectively, are authorized for grazing (GAO 2005; Glaser et al. 2015). This paper focuses on BLM and USFS lands in the western USA where a total of about 93.0 million ha were authorized for grazing (GAO 2005) mostly by beef cattle. However, less than 2.7% of all livestock operators in the USA enjoy the privilege of commercial access to those public lands (Glaser et al. 2015). Rimbey et al. (2015) estimated that only 3.8% of annual livestock forage comes from western US public lands, but this is an overestimate as they only included cows and no other animal type (e.g., bulls, steers). Nor did they account for the increases in beef cattle weights over the past few decades.

Animal agriculture is well understood to be a major source of greenhouse gas emissions due to land clearing for pasture, feed production, manure, and the methane emitted by ruminant livestock (Steinfeld et al. 2006). Emissions from livestock production are the largest source of greenhouse gases from the agricultural sector accounting for 72–78% of total agricultural emissions (Gerber et al. 2013; Springman et al. 2018), and cattle are the dominant ruminant grazing animal producing emissions in the USA and globally (UNEP 2021). Livestock generate more greenhouse gases than the entire transportation sector (Steinfeld et al. 2006). Livestock grazing has also resulted in widespread vegetation and soil degradation including reductions in biological diversity, carbon stocks, net primary productivity, and soil nutrient contents (Kauffman and Pyke 2001; Kauffman et al. 2009; Kauffman et al. 2016). The effects of climate change will likely be exacerbated by livestock (Fig. 1; Beschta et al. 2012).

Because the largest proportion of greenhouse gases produced by the agricultural sector comes from the methane emissions and land use related to livestock production (Lazarus et al. 2021), natural resource agencies and the agricultural sector should address these sources of emissions. Given the innumerable resource and social values associated with public lands, coupled with their relatively low production value for livestock, these areas represent a logical focal point for reducing greenhouse gas emissions in a socially and economically effective manner.

Federal public lands in the Western USA span diverse expanses of forests, shrublands, and grasslands, nearly all of which are grazed by domestic livestock annually. We focus on the interactions of grazing in the sagebrush biome which contains landscapes dominated by diverse assemblages of shrublands, woodlands, grasslands and riparian wetlands. Sagebrush-dominated ecosystems are the most extensive semiarid vegetation type in the western USA, comparable in size to the Great Plains or the eastern deciduous forests (Neilson et al. 2005; Austin et al. 2019). Sagebrush now occupies an estimated 651,316 km^2 over portions of 14 western States (Remington et al. 2021). The sagebrush ecosystem is also among the most vulnerable to loss or degradation in North America (Miller et al. 2011; Chambers and Wisdom 2009). The most widespread dominant species in this varied biome is big sagebrush (*Artemisia tridentata*).

Of the big sagebrush-dominated ecosystems, the Wyoming big sagebrush (*A t. wyomingensis*) is the most xeric and widespread of the subspecies. Other abundant big sagebrush subspecies dominated ecosystems include Basin big sagebrush (*A t. tridentata*) and Mountain big sagebrush (*A.t. vaseyana*).

The first objective of this paper was to review the role that public lands of the sagebrush biome in the western USA—by far the largest biome in the West—could serve in addressing the climate and extinction crisis. We did this by examining (1) the degree to which cattle and associated management exacerbate the effects of a warming and drying climate in this vast biome and (2) the degree to which cattle cause these sagebrush landscapes to shift from significant carbon sinks to significant sources of greenhouse gases. Then, moving beyond the sagebrush biome, our second objective was to undertake a meta-analysis using animal use and enteric and manure emissions data from US and international agencies to determine the importance of cattle grazing on public lands of the western USA as sources of greenhouse gases, and the social costs associated with these emissions.

To examine carbon stock losses associated with conversion of native ecosystems to exotic-dominated grasslands [e.g., annual dominance of cheatgrass (*Bromus tectorum*) or perennial dominance by crested wheatgrass (*Agropyron cristatum*)] we calculated mean aboveground carbon stocks of sagebrush, woodlands, and grasslands from literature values (Supplementary Information Table S1). In order to determine potential greenhouse gas emissions from livestock use on public lands, we conducted a meta-analysis combining datasets of quantities of animal use, emissions from individual animals and the social costs of greenhouse gases coming from cattle.

Cattle Grazing Exacerbates the Effects of Climate Change

Regardless of season of use or grazing intensity, domestic livestock generally influence ecosystems in four direct ways: (1) by removing vegetation through grazing; (2) by trampling soils, biotic soil crusts, streambanks and vegetation; (3) by redistributing nutrients via defecation and urination; and (4) by dispersing or creating favorable conditions for the establishment and dominance of exotic organisms, including noxious plant species and pathogens (Fig. 2; Fleischner 1994; Belsky et al. 1999; Dwire et al. 1999). Grazing by livestock will directly reduce the quantity and quality of available forage for wild grazers while modifying habitat quality for numerous wildlife species. Livestock herbivory also decreases the protective litter layer and the quantity of organic matter (and carbon) that can be incorporated into soils. Physical damage through trampling occurs from soil compaction and physical damage to biotic soil crusts and vegetation. Defecation and urination, especially in riparian zones and near stream channels, can have serious consequences for water quality and aquatic organisms. Feces and rumination also result in production of methane and nitrous oxide. Finally, livestock are vectors for the spread of exotic species and create conditions for their establishment. Grazing spreads invasive annual grasses by removing native perennial grasses (Reisner et al. 2013; Rosentreter 1994; Chambers et al. 2007; Belsky and Blumenthal 1997), by disturbing soils (Olff and Ritchie 1998), and by damaging biological soil crusts (Belnap 2006; Chambers et al. 2014; Reisner et al. 2013; Ponzetti et al. 2007; Warren and Eldridge 2001; Belnap 1995). Livestock also distribute annual grass seeds across the landscape through their hooves, fur, and digestive tracts (Schiffman 1997; Olff and Ritchie 1998; Chambers et al. 2014; Mack 1981; Knapp 1996). Unlike the bunchgrasses native to the Intermountain West and Pacific Northwest of the USA, many exotic plant species that have appeared or proliferated since the introduction of livestock in the mid-nineteenth century evolved under continuous grazing pressure and are well adapted to the disturbed conditions caused by livestock grazing (Mack and Thompson 1982).

These four primary livestock influences interact to result in significant physical and biotic alterations of ecosystem structure and function. Among other shifts in ecosystem structure and function, alterations include modified fire cycles, increased soil erosion, lowered water holding capacities, and decreased infiltration rates in soils (Dwire et al. 1999; Kauffman and Pyke 2001).

The cumulative effect of long-term domestic livestock use of public lands typically results in simplified vegetation and soil structure, dominance of exotic annual plant species, degraded riparian zones and aquatic ecosystems, and lowered carbon stocks (Fig. 2). These effects contribute to desertification, a lowered resistance to the stresses associated with a changing climate, a shift from net carbon sinks to sources of greenhouse gases, biotic impoverishment, and the loss of ecosystem services provided by native plant communities. Further, there are strong reinforcing feedback loops between livestock grazing and climate change. For example, decreased vegetation structure, root mass, and soil organic matter can result in less sequestration of methane (Tang et al. 2013), lowered carbon stocks (Meyer 2011), and less water stored due to declines in water holding capacity (Kauffman et al. 2004). In addition, the loss of deep-rooted sagebrush and other shrub species by fire, overgrazing, or purposeful conversion to exotic grasslands would reduce biotic access to deep soil water which exacerbates climate change effects (Franklin and Dyrness 1973; Rau et al. 2011).

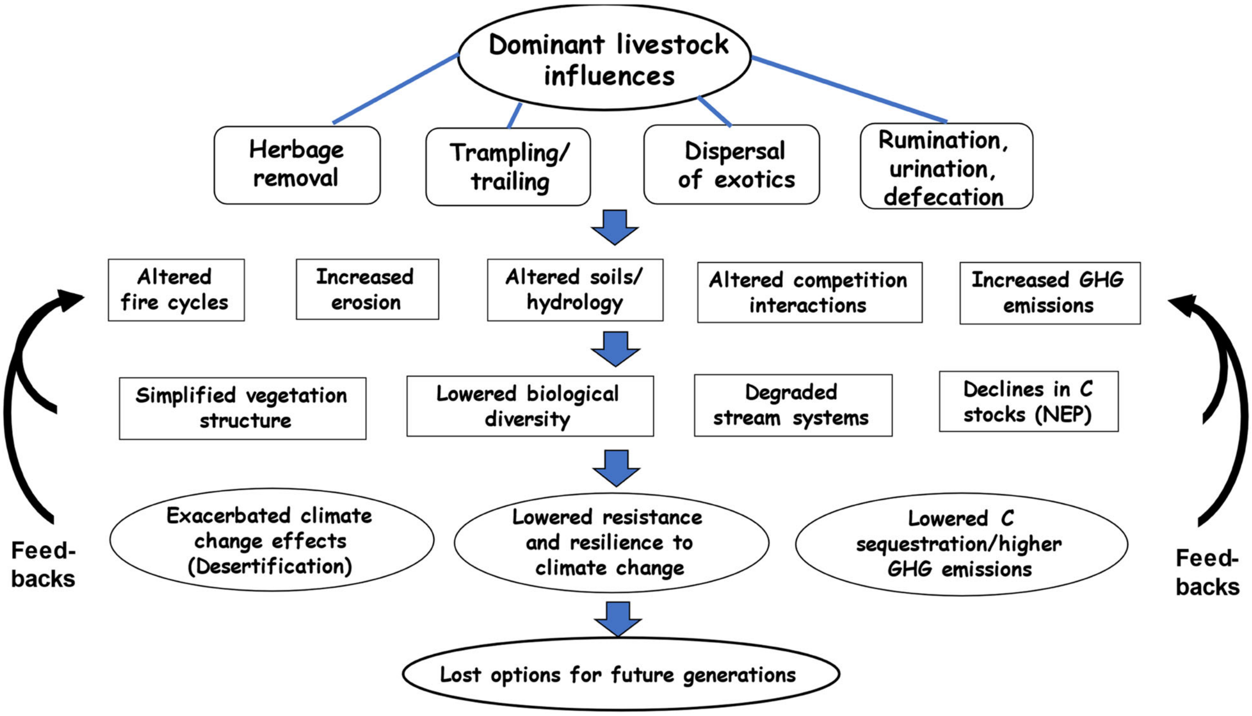

Fig. 2 The interacting effects of livestock grazing and climate change on western rangelands. There are four primary immediate effects of livestock: herbage removal, trailing trampling effects, dispersal of exotics, and creation of metabolic and nonmetabolic waste products. Through time, these effects on native rangelands affect fire regimes, increase erosion, compact soils affecting ecosystem hydrology, and alter competitive relationships between plant species. These actions decrease the net ecosystem productivity (NEP) such that the rangelands shift from carbon sinks to net sources of greenhouse gases. Products of animal metabolism are significant additional sources of greenhouse gases, especially CH_4 and N_2O. Ultimately the results of grazing have led to a simplification of vegetation structure typified by increases in exotic, ruderal, and less palatable species, that are more adapted to the drier conditions created by lower water holding capacities of compacted soils. The shifts in species composition further decrease the capacity of rangeland ecosystems to function as carbon sinks. Other impacts of grazing include a decline in riparian vegetation structure, shifts to drier species dominance, and degraded stream channels which increase stream temperatures, ground surface temperatures and alter stream flows. The consequent shifts in the net ecosystem productivity of the landscape, coupled with GHG additions from livestock, results in additional contributions to the greenhouse gases causing climate change. The effects of livestock accentuate the effects of climate change such as increased stream and air temperatures, loss in biological diversity, and an overall decline in the productivity of rangelands (desertification). There are also strong feedbacks associated with climate change. The warmer and drier temperatures, and reduced snow pack associated with climate change interacts with livestock grazing to negatively affect stream flows, water quality and biological diversity. These factors result in further degradation and a lower capacity for carbon storage, hence higher greenhouse gas emissions

The loss of vegetation structure associated with declines in deciduous woody species in riparian zones, such as palatable quaking aspen (*Populus tremuloides)* and willows (*Salix* spp.), due to herbivory and trampling by livestock, results in warmer microclimates and lower soil water holding capacities, thus exacerbating the warming and drying effects of climate change (Beschta et al. 2012; Kauffman et al. 2022). Furthermore, increased levels of carbon dioxide in arid shrubland ecosystems favor exotic annual grasses at the expense of native vegetation (Mooney and Hobbs 2000).

The cumulative effects of livestock grazing coupled with climate change in semiarid landscapes of the Intermountain and Pacific Northwest of the USA represent lost options for future generations, including losses in biodiversity and clean water, as well as the spiritual, social, recreational, and sustainable economic opportunities these public lands can provide (Fig. 2).

Livestock Grazing Degrades Riparian Zones and Wetlands

Although riparian areas and wetlands cover less than 1–2 % of the western USA landscape, their ecological significance far exceeds their limited physical area (Elmore and Beschta 1987; Kauffman and Krueger 1984). They are highly productive and ecologically valuable due to the vital habitats they provide and their importance to aquatic ecosystems (Kauffman et al. 2001; Fleischner 1994). They are also significant carbon sinks. Wetlands, including riparian zones, are among the largest carbon stocks of any plant community in North America, especially in semi-arid zones. Nahlik and Fennessy (2016) reported that soils of palustrine/riverine wetlands of western USA wetlands stored 236 Mg C ha^{-1}. These stocks are about 3 to 6 times that of upland forests of eastern Oregon (≈61 Mg C ha^{-1}; Law et al. 2018).

Livestock grazing has been found to exacerbate the effects of climate change in riparian ecosystems, leading to warmer and drier conditions in these vital habitats. In a broad study of riparian composition in eastern Oregon, Kauffman et al. (2022) found the abundance of wetland-obligate native sedges (*Carex* spp.) and broad-leaved forbs were significantly greater in ungrazed areas. In contrast, exotic species adapted to grazing, such as Kentucky bluegrass (*Poa pratensis*) and white clover (*Trifolium repens*), were more abundant in grazed stream reaches. However, following cessation of livestock grazing, facultative- and obligate-wetland species replaced ones adapted to drier environments (Kauffman et al. 2022).

Livestock removal has been found to result in significant recovery of soil, hydrological, and vegetation properties of riparian ecosystems that, at watershed scales, can mediate climate change stresses on stream channel morphology, water quality, and the aquatic biota. For example, Kauffman et al. (2004) estimated that under saturated conditions, the pore space measured in wet-meadow communities excluded from livestock grazing would contain 121,000 l ha^{-1} (121 Mg ha^{-1}) more water in only the surface 10 cm of soil than those in grazed wet-meadow communities.

Livestock Grazing Decreases the Sequestration and Storage of Carbon

The total aboveground carbon stocks in sagebrush-dominated communities range from about 2.7 Mg C ha^{-1} for Wyoming big sagebrush to 7.8 Mg C ha^{-1} for Basin big Sagebrush. The aboveground carbon stocks of western juniper (*Juniperus occidentalis*) dominated woodlands are ≈18.3 Mg C ha^{-1}, increasing to about 97 Mg C ha^{-1} for interior coniferous forests (Supplementary Information, Table S2; Law et al. 2018). Degradation of native plant communities to exotic annuals or purposeful type conversion by the seeding of exotic perennial grasses, results in carbon losses (Bradley et al. 2006; Rau et al. 2011; Nagy et al. 2020). The mean aboveground carbon stocks for converted stands were 0.5 Mg C ha^{-1} for crested wheatgrass seedings and 0.23 Mg C ha^{-1} for cheatgrass-dominated stands. Comparing these losses to the most abundant and most xeric of big sagebrush communities (Wyoming big sagebrush) suggests at least an 88% decline in aboveground biomass when they are converted to a cheatgrass-dominated sites and an 84% decline when converted to crested wheatgrass. These losses do not reflect the additional losses coming from declines in soil carbon stocks that would occur with the extirpation of deep-rooted shrubs and grasses (Meyer 2011; Rau et al. 2011).

Cheatgrass exhibits various attributes that makes it extremely tolerant of even highly intensive grazing (Reisner et al. 2013). The expansion of cheatgrass across much of the western USA associated with livestock grazing has long been known (Franklin and Dyrness 1973; Mack and Thompson 1982), but its implications on carbon cycling have been overlooked (Bradley et al. 2006; Meyer 2011). Livestock grazing exacerbates cheatgrass dominance in sagebrush-dominated ecosystems by adversely impacting key mechanisms mediating resistance to invasion (Reisner et al. 2013). This includes losses of biotic soil crusts due to trampling as well as excessive herbivory of grazing-sensitive native bunchgrasses, decreasing their capacity to compete with the exotic annuals. The loss of biotic soil crusts and other aggregated soil surface conditions have several important ecological ramifications because they: (1) inhibit erosion (Belnap 2006); (2) are an important source of nitrogen fixation in sagebrush steppe ecosystems; (3) serve as natural fire breaks, especially in low elevation sagebrush habitats where they can cover over 40% of the soil surface (Rosentreter 1986); and (4) inhibit cheatgrass germination (Reisner et al. 2013; Fig. 3).

Williamson et al. (2020) reported that increased cheatgrass occurrence and prevalence corresponded with livestock grazing regardless of variation in climate, topography, or community composition, and their results provide no support for a hypothesis that contemporary grazing regimes, or grazing in conjunction with fire, can suppress cheatgrass. Meyer (2011) concluded the elimination of perennial understory vegetation and biotic soil crusts were a nearly inevitable consequence of livestock grazing western shrublands, thus opening these systems to annual grass invasion, altered fire regimes, and loss of a major carbon sink. After examining the causes of cheatgrass invasion, Reisner et al. (2013) concluded that if the goal is to conserve and restore resistance of these sagebrush ecosystems, managers should consider maintaining or restoring: (1) high bunchgrass cover and structure characterized by spatially dispersed bunchgrasses and small gaps between them; (2) a diverse assemblage of bunchgrass species to maximize competitive interactions with cheatgrass in time and space; and (3) biological soil crusts to limit cheatgrass establishment. Cessation of livestock grazing is a passive restoration approach that eliminates cumulative effects of cattle use and may well be the most effective means of reducing the degradation of biological diversity of public rangelands where cheatgrass and other exotics are currently prevalent.

There were at least 12.7 million ha of land dominated by cheatgrass in 2000 (Zouhar 2003). Conservatively using mean aboveground carbon stock estimates for Wyoming big sagebrush (2.6 Mg C ha^{-1} and for cheatgrass (0.2 Mg C ha^{-1}; Fig. 4) suggests that by 2000 there was a carbon loss equivalent to at least 111.8 Tg CO_2e due to conversion of native rangelands to cheatgrass in this biome alone.

In addition to livestock grazing, many other proposed vegetation management activities associated with livestock

Fig. 3 Left photo: A long-term grazed site dominated by the annual exotic Cheatgrass (*Bromus tectorum*), Prineville District, BLM, Oregon. In addition to a dominance by exotic species, there is an absence of biotic soil crusts. The site had been burned about three years prior to the time this photo was taken. Right photo: An ungrazed site dominated by native species, Prineville District, BLM, Oregon. The dominant grasses are Bluebunch Wheatgrass (*Pseudoregnaria spicata*). The interspaces are dominated by native forbs, Sandberg's Blue grass (*Poa sandbergii*) and biological soil crusts. Exotic annuals are <1% cover that this site. This site had also burned ≈3 years prior to the taking of this photo (Photos by J.B. Kauffman)

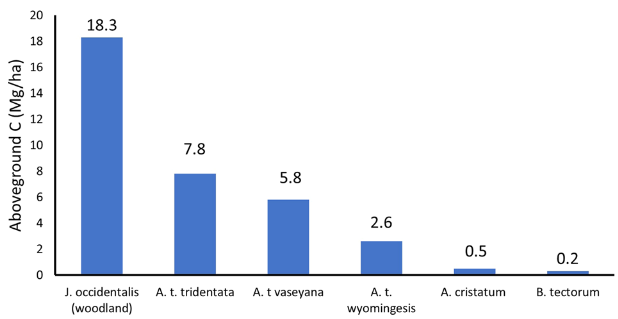

Fig. 4 Total aboveground carbon stocks for non-forested ecosystems occupying public lands of the intermountain West. Total aboveground carbon stocks range from 2.69 (Mg C ha^{-1}) for Wyoming Big sagebrush (*A.t wyomingensis*) communities to 7.8 Mg C ha^{-1} for Basin big sagebrush (*A. t. tridentata*) stands. The aboveground carbon stocks of intermountain woodlands are 18.3 Mg C ha^{-1} and for coniferous forests is about 97 Mg C ha^{-1} (Law et al. 2018). In contrast, mean aboveground carbon stocks for converted stands were 0.5 Mg C ha^{-1} for crested wheatgrass (*Agropyron cristatum*) and 0.2 Mg C ha^{-1} for cheatgrass (*Bromus tectorum*) stands. There is an 84% decline in aboveground biomass when Wyoming Big sagebrush stands are converted to crested wheatgrass and an 88% decline when they are converted to cheatgrass

management will also likely shift rangeland ecosystems from net sinks of atmospheric carbon to net sources of greenhouse gases. These include type conversion through seeding exotic grasses, removing native juniper trees, and constructing large-scale networks of fuel breaks (Jones 2019).

Crested wheatgrass is a nonnative perennial grass species that public land managers continue to seed in an attempt to stabilize landscapes following fire and to facilitate livestock grazing. In the USA, it was first planted in 1898 and gained wide acceptance in the 1930s (Zlatnik 1999). However, there is a growing body of research that suggests crested wheatgrass alters rangeland sites in ways that exacerbate climate change. Seeding a disturbed site with crested wheatgrass may prohibit the establishment of native species and the return to pre-disturbance plant structure and diversity (Zouhar 2003; Zlatnik 1999). Soils in crested wheatgrass stands often have higher bulk density, fewer water stable aggregates, and lower levels of organic matter and nitrogen compared to soils native grass-dominated stands. Dormaar et al. 1995 found that crested wheatgrass seedings could neither return nor maintain the chemical quality of the soils in relation to that of the native rangeland. Crested wheatgrass seedings result in lower water holding capacity and lower nutrient and carbon storage than the native communities they replaced. The continued conversion of native ecosystems and planting of crested wheatgrass or other exotic species is ill advised (Lesicu and DeLuca 1996).

Conversion of native sagebrush grasslands to crested wheatgrass seedings contributes to climate change through a substantial decrease in carbon stocks. The mean carbon stock of Wyoming big sagebrush stands is 2.6 Mg C ha, and for converted stands dominated by the introduced crested wheatgrass, it is 0.5 Mg C ha (Fig. 4; Supplementary Information, Table S1). Crested wheatgrass seedings have been established on 3.2 to as much as 10.4 million ha in North America (Zouhar 2003). Conservatively using the mean aboveground carbon stock of Wyoming big sagebrush as the pre-seeding mass, the carbon losses are estimated to total 24.7 to 80.2 Tg CO_2e through this conversion.

Cessation of Livestock Grazing Increases Carbon Storage

Cessation of grazing is an effective means of increasing carbon storage in both riparian zones and uplands (Fig. 1) as both aboveground and belowground carbon stocks increase with ecosystem recovery. In the western USA, riparian areas and wetlands are focal points for carbon sequestration. Although they cover only 1–2% of the landscape, stream and riparian areas exert an outsized influence on ecosystem function and biodiversity. For example, over a 10-year period of livestock exclusion, surface soils (0–10 cm depth) in ungrazed riparian zones of eastern Oregon sequestered an additional 12.5 Mg C ha^{-1} in dry meadows and 28.5 Mg C ha^{-1} in wet meadows compared to paired grazed sites (Kauffman et al. 2004)

There is also a significant accumulation in root mass following the cessation of livestock grazing, which is a critical influence on stream channel structure as well as carbon sequestration. Kauffman et al. (2004) reported that 10 years of rest from livestock grazing resulted in an increased root mass of 2.1 Mg C ha^{-1} in dry meadows and 4.3 Mg C ha^{-1} in wet meadows (assuming a root carbon concentration of 39%; Kauffman and Donato 2012). Combining differences in root mass and soil organic matter suggests that ungrazed sites have increased carbon sequestration rates of 1.5 Mg C ha^{-1} $year^{-1}$ in dry meadows and 3.3 Mg C ha^{-1} $year^{-1}$ in wet meadows (5.4 and 12.0 Mg CO_2e ha^{-1} $year^{-1}$, respectively) over that of grazed riparian zones.

The quantity of carbon that would be sequestered in the absence of livestock is a sacrificed benefit in favor of livestock grazing. Using the mid-point values of the additional soil and root carbon sequestration from wet and dry riparian meadows through rest from livestock grazing (2.4 Mg C ha^{-1} $year^{-1}$; Kauffman et al. 2004), and conservatively assuming only 1% of the grazed BLM and USFS public lands in the 11 western states are occupied by riparian zones and other wetlands (about 930,000 ha), an additional 2.2 Tg C $year^{-1}$ (8.1 Tg CO_2e $year^{-1}$) of carbon could be sequestered through cessation of livestock grazing in riparian areas alone. Furthermore, cessation of grazing would improve riparian plant functions such as streambank stabilization and stream cover, and hence cooler water temperatures vital to fish and other aquatic species.

Net ecosystem carbon balance (NECB) is the net rate of C accumulation or loss in ecosystems and is important in ascertaining their role as functional carbon sinks or sources of greenhouse gases (Chapin et al. 2006). Although few studies have reported NECB in sagebrush ecosystems, Gilmanov et al. (2006) reported net ecosystem carbon gains of 0.2 Mg C $year^{-1}$ for Wyoming big sagebrush (Oregon) and 0.7 Mg C $year^{-1}$ for three-tip sagebrush (*Artemisia tripartita*) (Idaho). Comparing the riparian zones to uplands suggest that while riparian zone only cover about 1–2% of the landscape they may potentially account for 3–18% of the carbon gain in sagebrush landscapes. The 18% estimate assumes riparian zones occupy 2% of the landscape and the NECB of uplands carbon stocks are those of Wyoming big sagebrush.

Livestock Grazing Will Exacerbate the Effects of Fire in a Changing Climate

Fire seasons in the western USA now average 78 days longer than in 1970, and future climate change could lengthen the period of annual extreme fire-weather conditions (Abatzoglou and Williams 2016). An elevated wildfire occurrence in concert with the current levels of livestock use will likely facilitate an increase in the degradation of sagebrush and other native shrub-perennial grass communities and their conversion to plant communities dominated by exotic grasses (D'Antonio and Vitousek 1992). These will have positive feedbacks accelerating climate change (Fig. 2) through increasing greenhouse gas emissions while diminishing the size of ecosystem carbon sinks.

There is a strong synergism between cheatgrass, fire, and livestock grazing. Cheatgrass is well known to increase following fire in grazed rangelands (Fig. 3A, Zouhar 2003). However, in ungrazed ecosystems native vegetation typically dominates following fire and cheatgrass invasion has been low to non-existent (Fig. 3B). This pattern of native species resilience following fire in ungrazed landscapes has been reported in bunchgrass prairies (Montana; Antos et al. 1983), Wyoming big sagebrush (Oregon and Washington; Ellsworth et al. 2016; Reis et al. 2019; Ponzetti et al. 2007), Mountain big sagebrush (California and Oregon, Ellsworth and Kauffman 2010; Ellsworth and Kauffman 2017), and Basin big sagebrush ecosystems (Oregon; Ellsworth et al. 2020). Furthermore, many native grasses and forbs that are key species in springtime diets of greater sage-grouse (*Centrocercus urophasianus*) exhibit high rates of reproduction following fires (i.e., fire-enhanced flowering) and in the absence of livestock grazing and trampling (Wroblesky and Kauffman 2003).

Home on the Range Where the Deer and Antelope Get 8%

Examination of forage allocation on public lands suggests that management is strongly skewed towards livestock

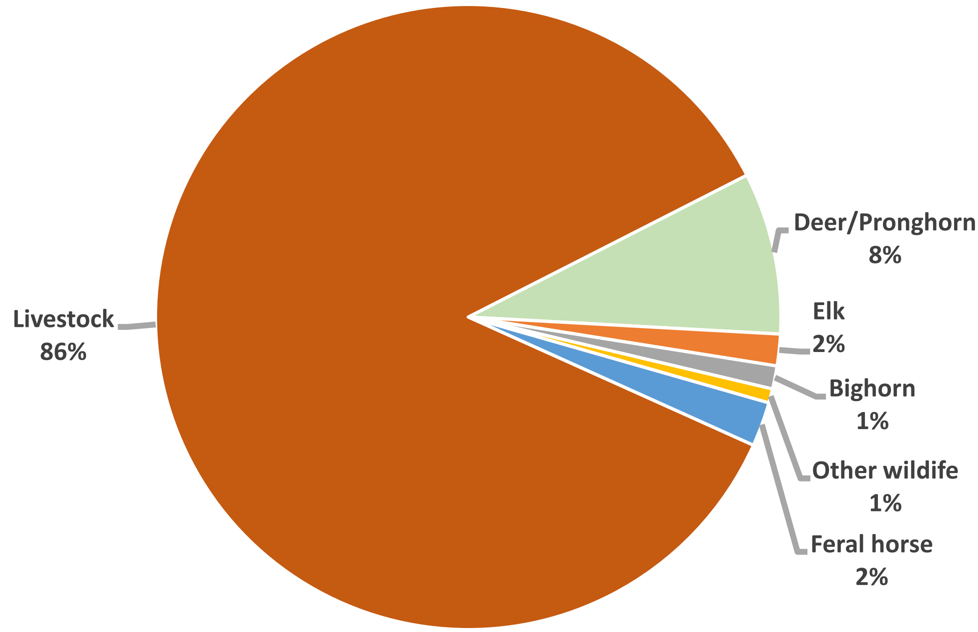

Fig. 5 Forage allocation for domestic livestock, feral horses, and wildlife on the Bureau of Land Management (BLM) Lakeview District, Oregon (USDI BLM 2003a)

production at the expense of other uses especially wildlife and the sustainability of the inherent biological diversity of the land. For example, in the Lakeview, Resource Management Plan (USDI BLM 2003a), which guides land and resource management on about 1.3 million ha of BLM-managed public land in Lake and Harney counties in southeastern Oregon, cattle were allocated 81% of the forage (Fig. 5). Deer and antelope were allocated 8% of the forage. Further, there are about 363 species of wildlife that utilize public lands in Southeast Oregon (Thomas et al. 1979; Kauffman et al. 2001; Kauffman and Krueger 1984; USDI BLM 2003b) and they were allocated only 1% (Fig. 5). These wildlife species provide a number of ecosystem services to people and society including commodity/utilitarian values, ecological process values, recreational values, esthetic values, cultural values and educational values.

While Animal Science Has Advanced, Range Management Has Not

Livestock use on public lands is measured in animal unit months (AUMs); a term developed more than a century ago (Smith 2017). An AUM is defined as the amount of forage required to feed one 1000 lb. (454 kg) cow and calf for one month (Heady 1975; Smith 2017). But the average cattle weight today is significantly greater than 454 kg. The US Environmental Protection Agency (USEPA 2018) reported the mean weight of a cow was 554 kg (1221 lbs) in 1990 and 611 kg (1348 lbs) in 2015. Thus, the same number of domestic animals (cows) on public lands over time represents a *de facto* increase in overall forage use and physical influences (Heady 1975; Smith 2017). Based upon the metabolic weight of modern cattle, a single cow and calf in 2021 would account for ≈1.25 AUMs. Yet, this increase in cattle weight and associated influences (greater feed intake, greater physical damage) are not currently considered in forage allocations, carrying capacities, or stocking rates. If the increase in the average size of cattle were included, the AUMs counted on public lands may have actually increased by 25% over the past two decades.

In 2015, there were about 29 million head of beef cattle in the US (US Department of Agriculture National Agricultural Statistics Service 2021; USEPA 2018) and the mean weight of a cow was 611 kg for that year. Thus, there were 441 million AUMs of forage required for USA beef cows alone. The 14.1 million AUMs arising from western public lands provide about 3.2% of the forage used by all cows in the USA, which is similar to the estimate of 3.8% reported by Rimbey et al. (2015) (Supplementary Table S5). However, this estimate does not account for other types of beef cattle such as bulls, steers, and replacement heifers. Including all beef cattle (except calves) suggests that the total AUMs of forage used by the USA cattle population was ≈860 million AUMs. Therefore, public lands actually provide <1.6% of all forage consumed by beef cattle in the USA.

The grazing practices employed on public lands have changed little over the last century. Common grazing practices such as deferred rotational grazing were first recommended by Arthur Sampson in 1913-14 (Heady 1975), and rest-rotation grazing was developed in the late 1950s (Stoddart et al. 1975). Given the climate changes occurring in the western USA, the grazing systems currently being utilized may no longer have the desired effects they were intended to achieve. For example, the theory behind grazing early in the growing season is that it would allow vegetation to recover through replenishment of stored carbohydrates via regrowth. By removing livestock before most spring and summer precipitation occurs, it was assumed plants would be able to store carbohydrates, set seed, and maintain their vigor (USDI BLM 2003b). But climate change is projected to result in drier summer conditions (Palmquist et al. 2016) where soil moisture will not be available for regrowth. This will affect native plants to a much greater extent than exotic annuals. Thus, spring grazing under conditions of limited soil moisture would exacerbate the effects of climate change on the native flora.

Climate change may also result in lowered suitability of public lands as grazing resources during dormant seasons. In the future, forage quality during summer through the winter months will be lower because of warmer and drier conditions, as well as expected increases in the abundance of exotic annuals. A decrease in forage quality (higher in fiber and lower in digestible energy) will result in a higher emissions intensity (kg of enteric methane emitted per kg of animal gain) from cattle as they increasingly consume poorer quality forage. In addition, with warmer winter conditions and less snow cover it can be assumed that soils will not be frozen and thus will be prone to increased compaction via livestock trampling. This trampling damage would exacerbate the effects of climate change through decreased water holding capacity (Kauffman et al. 2004).

Public Lands Are Sources of Greenhouse Gas Emissions Arising from Livestock Grazing and the Social Cost Is Significant

In this section, we determined greenhouse gas emissions attributed to enteric fermentation and manure deposition originating from cattle grazing the public lands in the western USA. We assumed that AUMs represented cow-calf pairs, although yearling steers grazed at the same stocking level would likely produce similar results.

The relative capacity of a greenhouse gas to trap heat in the global climate system over a given time frame, compared to that of carbon dioxide, is expressed as its global warming potential (GWP). The GWP of methane (with climate-carbon feedbacks) is 86 over a 20-year interval (GWP-20) and 34 for a 100-year interval (GWP-100; IPCC 2013). Nitrous oxide, arising from manure deposition has a GWP of 268 and 298 at 20- and 100-year intervals, respectively (IPCC 2013). Because methane has a comparatively short lifetime in the atmosphere, strategies to reduce methane emissions from livestock provide an opportunity to arrest the rate of anthropogenic global warming more rapidly than strategies focused on reduction of carbon dioxide emissions. Based on the urgent need to reduce methane emissions to avoid catastrophic tipping points in the climate system during the next 15–35 years, Howarth (2014) suggested the 20-year GWP was more relevant than the 100-year GWP. In this section we report both the 20- and 100-year GWPs for identifying the potential greenhouse gas emissions associated with public lands livestock grazing.

GHG emissions were determined using three different approaches. For the first two approaches (20-year and 100-year GWP), the USEPA (2018) national default values for beef cattle were used to calculate the emissions from public lands grazing. This is 95 kg methane year^{-1} for cows and 11 kg methane year^{-1} for calves. Therefore, one cow-calf pair would emit 106 kg methane year^{-1} from enteric fermentation (Supplementary Information, Table S2). To determine methane and nitrous oxide emissions from manure deposition, default values from the IPCC (2006) were used.

The third approach (IPCC default) used global default values of methane emissions from enteric fermentation for beef cattle (IPCC 2006). Methane emissions from enteric fermentation are 53 kg animal^{-1} year^{-1} (Supplementary Information, Table S2). Unlike the USEPA (2018) estimates, these emission values do not account for differences in the class of animal (e.g., bulls, cows, steers, calves). Furthermore, the IPCC estimate used GWP values only for 100 years. The 20-year and 100-year GWP values based upon USA-specific emissions values provide greater precision and lower uncertainty (USEPA 2018). Therefore, these estimates are likely more accurate than those based on IPCC (2006) values.

Unsurprisingly, estimated emissions using the three approaches vary widely. For example, emissions from a single AUM range from 225 kg CO_2e using conservative IPCC global default values to 875 kg CO_2e using a GWP-20 and USA-specific values for cattle (Table 1). Most of the emissions arise from enteric fermentation with lesser amounts arising from manure deposition. The GWP-20 data suggest about 90% of the emissions comes from enteric emissions compared to about 80% using the GWP-100 data.

Livestock numbers on western public lands have not varied greatly in the past 10–20 years (Supplementary Information, Table S3; Glaser et al. 2015). A mean of 15.4 million AUMs of livestock use occurred annually from 2009–2016, and cattle account for over 91% of all domestic animals that graze BLM and USFS lands in the western USA. For the most recent 10-year period in which data are available, an average of 8.0 million AUMs of cattle grazed on public lands managed by the BLM and 6.1 million AUMs of cattle grazed USFS lands (Fig. 6A; Supplementary Information, Table S3).

Livestock grazing on BLM- and USFS-managed public lands generates significant quantities of greenhouse gases

Table 1 The estimated annual greenhouse gas (GHG) emissions (kg) per animal unit month (AUM) arising from emissions of methane (CH_4) and nitrous oxide (N_2O) from enteric fermentation and manure deposition on rangelands

	CH_4 emission/ AUM	20 y GWP (CO_2e)	100 y GWP (CO_2e)	IPCC default (CO_2e)
Methane emission fermentation	9.25	796	315	150
Methane emission manure	0.20	17	6.8	5.7
Total CH_4 emission/AUM	9.45	813	321	156
N_2O emission manure		63	70	70
Total GHG /AUM		875	391	225

GWP-20 are emissions based upon 20-year global warming potential; GWP-100 are based upon 100-year GWPs (IPCC 2013). Average methane emissions are for beef cows from USEPA (2018) except for IPCC default values which are from IPCC (2006). IPCC default values are also based upon a 100-year GWP

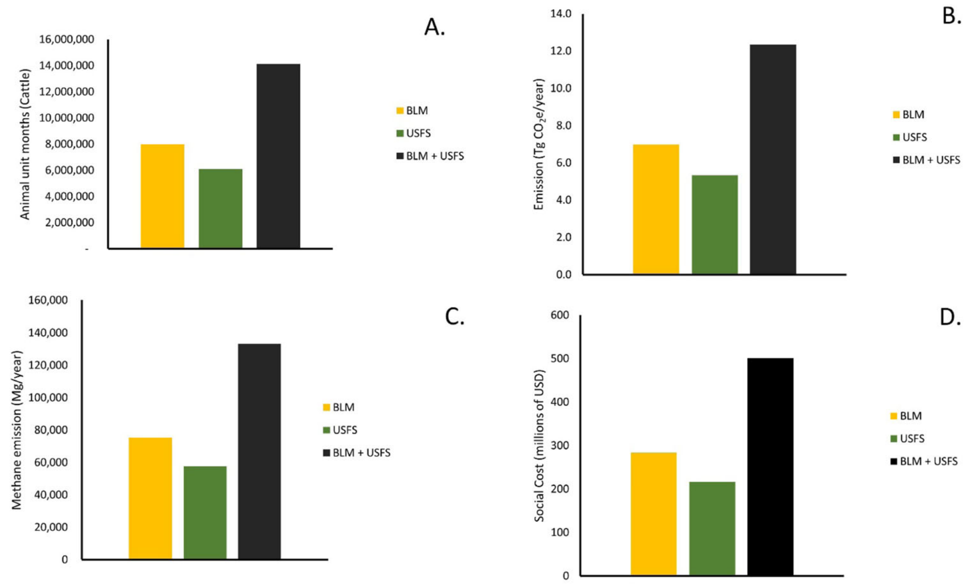

Fig. 6 **A** The average number of animal unit months (AUMs) for cattle that utilized Bureau of Land Management (BLM) lands (2009–2018) and US Forest Service (USFS) lands in the western US (2007–2016). The totals (BLM + USFS) are means from the years 2009–2016. **B** The annual total emissions (Tg CO_2e) from enteric fermentation and manure deposition on western public lands for the same time periods as above. **C** The annual total methane emissions (Mg) from cattle grazing public lands. **D** The annual social cost of carbon from livestock on public lands (millions of US dollars). The standard errors are not included as they were less than 2% of the mean (Supplementary Information, Table S3)

(Fig. 3B, C). Based upon the 20-year GWP, the mean GHG emissions from cattle on BLM-managed lands was 6.98 ± 0.06 Tg CO_2e year^{-1}. The mean GHG emissions from cattle on USFS-managed lands in the western US was 5.34 ± 0.09 Tg CO_2e year^{-1}. In total, about 12.35 ± 0.13 Tg CO_2e year^{-1} arise from cattle grazing public lands in the western USA.

The annual emissions from enteric fermentation and manure deposition on western public lands are equivalent to the emissions from nearly 2.3 million passenger vehicles and are essentially equal to the emissions coming from all passenger vehicles in the western states of Idaho, Nevada, Utah, and Wyoming combined. These emissions are also equivalent to the amount of carbon that would be sequestered by 6.1 million ha of US forests (USEPA 2021). Emissions from methane alone are more than 133,000 Mg year^{-1} (Fig. 6C). Based upon a UNEP (2021) analysis of the effects of methane on the environment and societies, the reduction of methane emissions from removal of cattle on public lands in the western USA would avoid: 186 premature human deaths; 52 million hours of lost labor from extreme heat; and, 18,850 Mg of crop losses each year. In essence, allowing domestic livestock to graze public lands in the western USA results in declines in both human well-being and the productivity of other agricultural sectors. And again, cattle on public lands in the western USA account for <1.6% of all US beef production.

The Social Cost of Carbon Related to Livestock Grazing on Public Lands Is Significant and Far Outweighs Modest Grazing Fee Payments Received by the USA

Recently, US federal agencies have recognized that it is essential for them to capture the full costs of greenhouse gas emissions as accurately as possible, including by taking global damages into account (e.g., Executive Order 13990 (2021) and Interior Secretarial Order 3399 2021). The social cost of carbon (SCC) is a central concept for understanding, evaluating, and implementing climate change policies. The SCC is an estimate of the monetized damages associated

Table 2 The social cost ($USD) per animal unit month (AUM) of methane (CH_4), nitrous oxide (N_2O), and carbon (CO_2e) arising from the enteric fermentation and manure deposition of cattle on rangelands

	N_2O and CH_4	GWP-20	GWP-100	IPCC default
Methane emission—fermentation	$28.68	$40.57	$16.04	$7.66
Methane emission—manure deposition	$2.62	$0.88	$0.35	$0.29
Subtotal social cost CH_4 emission/AUM	$31.30	$41.45	$16.39	$7.95
N_2O emission—manure	$4.20	$3.19	$3.55	$3.55
Total social cost/AUM	$35.50	$44.64	$19.93	$11.49

The N_2O–CH_4 costs are based upon the social cost of N_2O and CH_4 while GWP-20, GWP-100, and IPCC defaults are based upon the social cost of carbon (CO_2e). Data are based upon values determined at a 3% discount rate which is $1500/metric ton for CH_4, $18,000/metric ton for N20, and $51 per metric ton for CO_2e (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government 2021). Calculations of the social costs reported in this text use the N_2O and CH_4 costs

with incremental increases in greenhouse gas emissions. It represents the present value of the marginal social damages of increased GHG emissions in a particular year—including the impacts of global warming on agricultural productivity and human health, loss of property and infrastructure to sea level rise and extreme weather events, diminished biodiversity and ecosystem services, etc.—and therefore it also represents the marginal social benefits of emissions reductions.

The SCC (carbon dioxide) was $51/Mg in 2020 with methane and nitrous oxide emission costs at $1,500/Mg and $18,000/Mg, respectively (Interagency Working Group on Social Cost of Greenhouse Gases 2021). These costs are expected to rise to $85/Mg for carbon dioxide, $3,100/Mg for methane, and $33,000/Mg for nitrous oxide by 2050. The social costs presented here are based on 2020 values.

The SCC for greenhouse gas emissions from cattle was calculated from four different data sets (Table 2). Nitrous oxide and methane costs were calculated from the social cost assigned to these gases. The GWP-20, GWP-100, and IPCC default values arise from the calculated greenhouse gas emissions on a carbon dioxide equivalence basis.

Depending upon the approach used, the social costs of the greenhouse gases from cattle grazing on western US public lands range from about $11 to $45 per AUM (Table 2). The most direct estimate entails using the nitrous oxide and methane emission costs and is therefore suggested to be the estimate with the least uncertainty. Using this approach, the social cost of greenhouse gas emission for a single AUM is approximately $36/AUM.

The social costs of emissions from greenhouse gases from enteric fermentation and manure deposition from western public lands grazing averaged $501 million per year from 2010–2016 (Fig. 6D; Supplementary Information, Table S3). These social costs do not include the values of carbon gain via sequestration if the lands were no longer grazed by cattle. It is probable that the values associated with the lost potential of carbon sequestration due to livestock impacts would be even greater than the benefits from the elimination of emissions via enteric fermentation. Determination of carbon sinks, emissions, and sequestration from public lands would be difficult given the vast area of land involved coupled with the large numbers of cattle that are contributing to, and exacerbating climate change. But the increased carbon storage potential would be great. For example, we predicted that the carbon that could be sequestered though cessation of livestock grazing in riparian areas could be 2.2 Tg C/year (8.1 million Tg CO_2e/year). This is a SCC value of $413 million per year. An estimated 24.7 to 80.2 Tg CO_2e have been lost through purposeful conversion to exotic-dominated grasslands (i.e., a SCC of $1.3 - 4.0 billion). The carbon losses associated with type conversion to cheatgrass dominance would be at least 268.5 Tg CO_2e (a SCC of $13.7 billion). Shifting public lands from sources of greenhouse gases to carbon sinks could be quickly attained via the removal of livestock grazing.

Without Public Lands Grazing, Wouldn't there Be Leakage?

An argument for maintaining livestock grazing on public lands is that if cattle are not using these areas, they will be grazing somewhere else and hence there is no net loss of greenhouse gas emissions (the concept of leakage). But this argument ignores the carbon potentially gained via increased sequestration and storage on public landscapes if they are ungrazed by cattle. Such a change in public lands management would result in a net increase in carbon removals with little leakage.

Forage quality is a strong determinant of the amount of methane produced by ruminants. Sources of forage with a relatively low digestible energy content will produce relatively high quantities of methane. For example, crested wheatgrass and annual bromes are forages with notably low digestible energy contents, only 58 and 53%, respectively (USEPA 2018). Furthermore, late in the grazing season (e.g., August–October) these dried grasses will have digestible nutrient concentrations like that of straw (a digestible energy content of about 39%), suggesting that cattle on these diets would emit higher quantities of methane than on a diet of forages with high digestible energy. This is why methane emissions from feedlot cattle are only 35–43 kg CH_4 $year^{-1}$, compared to 89–95 kg CH_4 $year^{-1}$ for cattle on rangelands (USEPA 2018, Supplementary Information, Table S2). Thus, substituting the relatively poor quality of forages on rangelands, especially degraded rangelands, with higher quality feeds from other sources would represent a net reduction in greenhouse gas emissions (UNEP 2021). For this reason, the forage from public lands, especially when high in exotic grasses, is about the worst diet to feed cattle from a greenhouse gas perspective. Achieving very low emissions from the production of edible animal proteins may involve large-scale industrialized agriculture, which can have other social and environmental impacts beyond greenhouse gas emissions and hence such policies need to be considered with care (UNEP 2021). Dietary shifts away from beef would significantly contribute to reducing greenhouse gas emissions (Clark et al. 2019; Springmann et al. 2018).

The True Cost of Grazing Public Lands

The federal grazing fee for 2020 and 2021, set by a formula established by Congress in 1978, is $1.35 per AUM for public lands managed by the BLM and USFS (USDI-BLM 2021). In contrast, the estimated social cost of greenhouse gases arising from a cow-calf pair on public lands is nearly $36 (Table 2), or 26 times greater than the federal grazing fee. Furthermore, the administrative costs for managing livestock grazing on public lands have been estimated to range from approximately $8-$12 per AUM (GAO 2005; Glaser et al. 2015). Thus, the total costs to the US taxpayers and society for grazing a single AUM on public land may be at least $42–$48. Combining management costs with social costs of greenhouse gases from the more than 14 million AUMs of livestock that graze public lands in the western USA results in a total cost to taxpayers exceeding $608 million each year.

We limited our analyses to: (1) the greenhouse gas emissions from domestic livestock enteric fermentation and manure deposition while grazing public lands; (2) potential changes in carbon stocks due to grazing in the widespread sagebrush biome; and (3) the effects of grazing and livestock management on carbon sequestration and greenhouse gas emissions from these ecosystems on public lands. We did not examine in detail other important considerations that would be essential to calculate the true cost of grazing public lands. First, it is important to note that this is not a complete accounting of the greenhouse gas emissions associated with domestic cattle grazing on public lands (i.e., a life cycle analysis). For example, not included in this analysis are activities such as trucking livestock to and from private lands and to meat processing facilities, the costs of fencing, maintenance of water developments and hauling mineral supplements and water (which may increase with climate change), rangeland seeding and invasive species management, and many other ecological, economic and carbon costs associated with public lands grazing. In addition, the greenhouse gas emissions arising from the administration and monitoring of grazing permits were not included. Second, it is important to note this is not a complete accounting of the potential changes in carbon stocks due to grazing. For example, this analysis focuses on the loss of above ground carbon and does not quantify the potential significant loss of below ground biomass and biological soil crusts as a result of livestock grazing (Beschta et al. 2012; Bradley et al. 2006). Last, we did not ascertain social costs of desertification from overgrazing, losses in water quality and quantity, losses in biodiversity, losses in carbon sequestration capacity of the landscape, and the other ecosystem services negatively affected by livestock grazing. In short, the carbon sequestration losses and greenhouse gas emissions presented in this paper, while significant, nevertheless underestimate, perhaps substantially, the true costs of livestock grazing western public lands.

Conclusions

Improved stewardship of public lands in the western US is needed to achieve the international Paris Agreement on climate change and the USA's goals of reducing emissions and holding warming to below 2 °C. Nature-based or natural climate solutions include the conservation, restoration, and/or improved land management actions that increase carbon storage and/or avoid greenhouse gas emissions across global forests, wetlands, grasslands, and agricultural lands (Griscom et al. 2017). Given their vast area, significant carbon stocks, large extent of degradation, and high levels of greenhouse gas emissions associated with livestock grazing, the public lands in the western USA can play an important role in meeting government policy goals and addressing the climate crisis.

Land degradation, including loss of native vegetation, annual grass invasion, devastating fires, and losses of major carbon sinks is a heavy price to pay for the minimal economic gains from use of these intrinsically unproductive lands for livestock production (Meyer 2011). Grazing exclusion is an effective ecosystem restoration approach to sequester and store carbon in the living biomass and soil profiles, and hence, an important tool for climate change mitigation (Reda 2018). Removing livestock can increase soil carbon sequestration on lands that have been depleted in the past by poor management. Removing livestock is not only a viable, cost-effective natural climate solution; it also offers enhanced water quality, flood buffering, soil health, habitat diversity, and climate resilience (Beschta et al. 2012). Compensating holders of federally-issued grazing permits who wish to voluntarily relinquish their permits to graze public lands could accelerate the process and confer additional, complimentary economic, social and environmental benefits (Leshy and McUsic 2008; Salvo and Kerr 2006).

The United States has announced a target for achieving a 50–52% reduction from 2005 levels in economy-wide net greenhouse gas pollution by 2030, and a net-zero emissions economy by 2050. Attaining net-zero emissions requires transformative action across all sectors of society including the agricultural and natural resource sectors. To achieve these goals all federal and state agencies will need to contribute, and those entrusted to manage public lands are no exception. Outdated approaches to public land management are in conflict with stated current US climate goals, as these actions often increase greenhouse gas emissions, lower the carbon sequestration capacity, and increase the vulnerability of the public resources. Yet, changes in federal land management policy offer a significant opportunity for building climate resiliency where ungrazed landscapes are net carbon sinks of greenhouse gases within some of the most biologically diverse, expansive, and vulnerable ecosystems in North America.

Data Availability

Data on the aboveground biomass and carbon stocks of dominant semiarid ecosystems can be found in the Supplementary Information. Data on the numbers of livestock may be found at online databases provided by the USDA Forest Service (2021) and the USDI Bureau of Land Management (2021). Data on emissions from livestock in the USA may be found in US Environmental Protection Agency (2018). Global default values of methane emissions from enteric fermentation for beef cattle are from IPCC (2006).

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Compliance with ethical standards

Conflict of Interest The authors declare no competing interests.

Ethics Approval This article does not contain any studies with human or animal participants performed by any of the authors.

Consent to Participate All authors were active participants in the study and publication process and consented to participate.

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From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] Solar and tortoise murder
Date: Friday, December 2, 2022 4:06:24 PM

There is so much information about the repeated failures to translocate desert tortoises. Why doesn't someone listen? How can anyone think translocating desert tortoises is a smart environmentally sound course of action? How can the people responsible for all the deaths be allowed to continue this failed process of translocating desert tortoises? How can BLM continue to justify/tolerate/permit/participate in this deadly outcome for our desert tortoises and our public lands?

I know employees are just people trying to do their jobs. But when you do the same thing over and over and get the same results..... someone might think it was time to try another approach.

We are guardians of a 35 year old desert tortoise. We spend hours watching him wander around the neighborhood looking for burrows and girls and food. If you move him he has no idea how to get home, find girls, find food or shelter. By the time a translocated tortoise can find or build new burrows, find new food and water and figure out what has happened to him he will have used up all his food and water storage and that is a death sentence. Or he will be eaten by badgers and coyotes.

I continue to ask what you plan to do differently to protect these precious animals. We cannot sacrifice the desert tortoises for profit. Destroying our desert will not provide enough energy to make up for this devastating loss of environmental habitat and life. The desert tortoise belongs in the desert , not solar farms. Why not expand the farms near Boulder where the torts have all ready been damaged and not come to kill more tortoises? Why not make the industry be responsible for the long term survival of our desert tortoises.

And the dust control issue is being ignored totally. All this ground is being destroyed for an industry that cannot possibly grow fast enough to keep the lights on , let alone provide power for electric vehicles.

How does the relentless march of solar farms thru our public lands make sense to anyone?

We are ignoring the long term effects of this drought on our water resources and our environment. We are not solving any problems. We are supporting an industry that takes no responsibility for the death and destruction they are causing in the name of money with the growth of solar.

We are destroying everything in our path and there is no good end to this ridiculous situation.

I see how much government pressure is on

BLM etc to permit and approve the solar farms. The fact that they are practically giving away our public lands for free is ridiculous. please do the right thing and figure out how to save the desert tortoise from extinction.

Until there is some factual information about how to not murder the desert tortoise and push them into extinction, I oppose any further solar development in their undisturbed habitat.

The job is not to support the government and the desire for making money. The job is to protect our federal lands, the flora, the fauna and especially the desert tortoise.

[redacted]

From: [redacted]
To: BLM_NV_SND_EnergyProjects; info@earthjustice.org; info@earthshare.org
Subject: [EXTERNAL] Re: Scoping Period Extended for Copper Rays Solar Project EIS and RMP Amendment
Date: Saturday, December 3, 2022 3:39:27 AM

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

i do not believer wonderful desert should be turned into nothing but big solar projects. the desert has its own reason for being and this attack on nature is not justified. this comment is for the public record. plese receipt. [redacted] stp turning every bit of the national ownership of land into profit. leave it alone for the value of nature.

On Fri, Dec 2, 2022 at 6:32 PM BLM_NV_SND_EnergyProjects <BLM_NV_SND_EnergyProjects@blm.gov> wrote:

> Good Afternoon,
> The BLM Southern Nevada District Office has extended the scoping period for the Copper Rays Solar Project Environmental Impact Statement and Resource Management Plan Amendment. The scoping period will be extended to January 13, 2023, an additional 15-days from the previously scheduled end date of December 29, 2022. Additional information on the scoping period extension can be found in the published BLM News Release at the following link: https://www.blm.gov/press-release/blm-extends-public-scoping-period-copper-rays-solar-project-environmental-impact.
>
> The virtual scoping meetings are still scheduled for December 6 and December 7, 2022 from 6 p.m. to 8 p.m. Pacific Time. To register for the virtual scoping meetings, please utilize the below links:
>
> December 6, 2022 Virtual Scoping Meeting Registration:
> https://us02web.zoom.us/webinar/register/WN_SgKc-YJfT_eZemQbyycFVg
>
> December 7, 2022 Virtual Scoping Meeting Registration:
> https://us02web.zoom.us/webinar/register/WN_r2OKY8P3SX-BCnOvUYIZ9g
>
> More information on the Copper Rays Solar Project can be found at the project ePlanning website: https://eplanning.blm.gov/eplanning-ui/project/2019523/510.
>
> Comments must be received prior to the close of the scoping period or 15 days after the last public scoping meeting, whichever is later, to be included in the Draft EIS. Written scoping comments can be submitted by any of the following methods:
>
> - Email: BLM_NV_SND_EnergyProjects@blm.gov
> - ePlanning: Utilize the “Participate Now” function at the Project

webpage: https://eplanning.blm.gov/eplanning-ui/project/2019523/510

- Mail: BLM, Pahrump Field Office, Attn: Copper Rays Solar Project, 4701 North Torrey Pines Drive, Las Vegas, NV 89130-2301

If you have any questions, please contact Whitney Wirthlin, Project Manager, Energy and Infrastructure Team, by telephone at (725)-249-3318 or via email at BLM_NV_SND_EnergyProjects@blm.gov.

If you would like to be removed from this project's mailing list, please respond to this email.

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

Gmail

Fwd: Copper Rays Solar Project

Tue, Dec 6, 2022 at 10:57 AM

---------- Forwarded message ---------
From: [redacted] **via Invoicing** <vendor.invoicing@panoramaenv.com>
Date: Mon, Dec 5, 2022 at 6:37 PM
Subject: Copper Rays Solar Project
To: vendor.invoicing@panoramaenv.com <vendor.invoicing@panoramaenv.com>

Hello
What studies have been made on water use before construction of solar projects are approved?
It took 70,000,000 gallons of water in 6 weeks for a 2000 acre Solar project in Boulder City.
And what kind of survey was conducted with residents in Nye County who will be impacted by a solar project?
The majority of Pahrump residents do not want them closer than 50 miles radius of Nye County Towns.
Sincerely
[redacted]

Sent from Yahoo Mail on Android

From:	[redacted]
To:	BLM_NV_SND_EnergyProjects
Subject:	[EXTERNAL] Hello, & thanks for the first Copper Rays presentation. Looking fwds to daily new "utility scale solar vs microgrid" information for us, this evening.
Date:	Wednesday, December 7, 2022 12:52:16 AM

Thanking Mr Emmerich, as usual, for his expertise, last evening - Mr Hiatt and Mr vanWarmerdam, were great, too. Good Zoom, and info on other offices' meetings.
I will try to add my citizen 2 cents' for tortoise at the second Copper Rays discussion.

Solar industry "PV Magazine" articles to read online, say that Managers at US and transnational corporations (because of tech advances' market "Uncertainties"), are reporting profit declines and "underperformance" of planned development this year, in utility scale solar "large array infrastructure on 'free land'"-type projects. Unreasonably high expectations? were put on massive, already obsolete tech and materiel?

May I refer to these permit seekers' disappointed prospects and uncertain returns, as proof of an "unsound business" model? Just serially risking loss of the keystone tortoise, logically should be the most effective stop on the developers, but never is. The window of opportunity to profit from large array infrastructure timed out, but it's still being proposed as viable... What works, is making sure the public knows utility scale solar (1872/1976 business model) of the 1990s, - didn't - survive new tech and engineering innovations coming on since the last 5 years. A true decider - against - "developing" the irreplaceable Mojave Desert, is that developers see their own old solar large array infrastructure business model, (1872/1976) proving out to be "unacceptably" unprofitable and uncompetetive. - We - no longer have to tell them so. Yet, here they still are?

More work needed...Thank you for organizing the presentations.

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ePLANNING

Comment Submission

Project: DOI-BLM-NV-S030-2022-0009-EIS - Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS - Copper Rays Solar Project.pdf

Submission ID: SC-1-500323125

Comment

It is disappointing that BLM continues to be willing to sacrifice threatened Mojave desert tortoises and their habitats to satisfy solar developers.

But when this occurs, BLM should at least commit to providing robust compensation and mitigation.

In particular, BLM should stop remaining livestock grazing in tortoise habitats. This grazing is clearly not compatible with tortoise conservation. This grazing also provides nominal economic benefits while causing significant environmental impacts.

BLM needs to change its management to be more environmentally responsible and sustainable.

Submitter(s)

Submitter 1

Name:BLM should change its management
Address: Not Provided
Group or Organization Name: Not Provided

Disclaimer

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment - including your personal identifying information - may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Withhold my personally identifying information from future publications on this project) - ***NO***

From:	[redacted]
To:	BLM_NV_SND_EnergyProjects
Subject:	[EXTERNAL] Copper Rays Solar Project Zoom meetings
Date:	Wednesday, December 21, 2022 9:57:08 PM

Re: Comments, Zoom meetings, 6.-7. Dec. 2022, about participating in what seems like, protest - ceremony.

The DOI, DOE and DOD, all able to self-rearrange? - minimal - ESA environmental conservation requirements (ESA itself, with unexpected and famous approval in Congress) to - lower? or better yet - remove the cost of doing business for corporations, and then work alongside their developers, to expand, accommodate the applicants' preferred profit expectations?! Ensure there will be no "Uncertainties" about expenses for damaging of, say, tortoise-dependent environmental systems?

2014 "PSRM" idea was "landscape-scale". An "ecosystem" can also be far-reaching in its connections, but 2014 "PSRM" refers only? to consolidating a list of favorite business efficiencies, with one cost then covering all parts of (the business/the industry) "regions"... Projects go forwards, one at a time, for blocking public's specific choice to - not - threaten water, vegetation and wildlife. Then, DOI "PSRM" "improves" project contract processing "path", for blanket-"simplification", and "speed" in deciding mitigation - cost limits?! - as gifts to the corporations, to keep them coming in.... That - is as already described - The "Job". On its way to getting done - as already mentioned.

Previous Q&A speakers' observations were on target, polite, and inspiring. We know there are better ways for solar development already available, (microgrid; disrupted/built surfaces), which make building destructive utility scale "large array" infrastructure on arid wildlands' "biological refugia" unnecessary. We citizens - are at - these strange meetings, - but we are now seeing, that we are directed to the wrong place, if we are making an effort for conservation of natural wild desert: the exact place the Candela, Panorama, NextEra & 1872/1976's - culture, etc., skillfully constructed, and prefers for us to be in, while - They - are "in", at - Their work.

Looking to the "revised" RMPs with revised objectives. Thanks for the directions.

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

From: [redacted]
To: BLM_NV_SND_EnergyProjects
Subject: [EXTERNAL] Copper rays solar project application
Date: Thursday, December 22, 2022 6:14:58 PM

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

I am interested in applying or being pointed in the right direction to apply for copper rays solar project. If possible please point me in the right direction with maybe a link or address to apply.. Thank you so much and please have a very happy holiday.

[redacted]

Sent from the all new AOL app for Android

From:	[redacted]
To:	Ethics, DOI
Cc:	BLM_NV_SND_EnergyProjects
Subject:	[EXTERNAL] Dear Madam, Secretary Haaland, I am writing to ask your help in preventing US state governments, and the federal government, from (correctly) trying to grow solar energy development - but in an unfortunately misdirected, and consequently, ve...
Date:	Sunday, December 25, 2022 2:51:44 PM

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

https://www.upworthy.com/a-student-accidentally-created-a-rechargeable-battery-that-could-last-400-years-rp

I don't know if this is real, or if it is going to work, but it could be the start of how solar energy infrastructure for constant, heavy use (industry/city/residential needs), can be built close to where it is used: Panels only on "built surfaces", shopping complex and parking shelter roofs, and on other irreparably disrupted ground, for local Microgrids. Won't need hundreds of square miles of panels on wild desert - just 1000 square feet? for each Battery House ground location, - and in the town, more secure transmission and distribution lines would be far shorter, carry far more power safely, and far more efficiently.

If this is one of the now numerous "coming wave", of overnight evolutions for energy collection and storage, how can physics and investment - experts - like Nevada Energy & transnational financiering and developer corporation applicants, - still be applying to DOI for 30yr use permits? to build distant, last century, utility scale "large array" infrastructure onto authoritatively recognized "irreplaceable" "biological refugia" desert wildlands? - That utility scale tech and engineering, (so destructive to singular, natural, ancient living systems) - already - not having lower cost, not being more accessible or reliable, not being physically safer to run or upgrade than modular Microgrid, and never actually having been, even remotely, Green?

Please decide to - restrict - acceptable reasons for making laddered ROWs available to any and all industrial and Realty "development" -- rushes.

Please - reserve - the desert wildlands for the actually essential, irreproducible service, which only the uninterfered-with desert wildlands can provide.

We need solar energy "in time" - just not done, as in the past - "the only way that worked" for utility corporations.

I am wintering in Oregon, with time to try to contact leaders, before contracts are started for construction season in Nevada.
Volunteers' work, with County-contracted biologists' spring desert tortoise fence repair and roadkill surveys, also starts before the Heat sets in.

Thank you for your consideration on these questions.

[redacted]

NATIONAL SYSTEM OF PUBLIC LANDS

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ePLANNING

Comment Submission

Project: DOI BLM NV S030 2022 0009 EIS Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS Copper Rays Solar Project.pdf

Submission ID: SC-1-500323259

Comment

This project specifically seems to have very little public support from anyone in the area and it gets worse when combined in total with the other projects in process or already approved. As much as it has been published most citizens are not aware of the loss of public land for recreation, specifically OHV.

The Clark County projects went under the radar to most Nye County residents until recently. In the first one, the

Yellow Pine project, many OHV routes were cut off and there were no mitigation measures taken

OHV recreation and Solar are in direct competition for some of the last remaining lands with classifications that would allow either type of activity. So OHV recreation is losing out big time especially to participants who like dispersed and lesser used routes and who do not feel that riding through a corridor of black mirrors is an enjoyable experience.

My business has a current BLM Commercial Recreation permit for lands in the very near area. When applying for this permit I had asked about using routes in the proposed Copper Rays area and was told these routes would not be allowed due to it being a commercial activity and the RMP did not support this activity. Now it seems that the RMP can be modified for one type of activity but not another?

OHV activity is much less destructive to the land and in fact has been going on through this area for many years and it is still of the quality that even the environmental groups are impressed with the open space and visual quality values There have been historic Off Road Races that traversed these lands and the project throws a blanket of closure over the entire area.

As far as I know there is not a current Travel Management Plan in place for the area and no “official” map with the existing routes has appeared Myself and others have submitted, through the acting recreation planners at various times, route inventories with roads and trails in these areas. I would like to make sure these are considered Additionally I was never informed that I could go through a RMP revision to allow commercial use in this area as an option.

Open spaces in the desert are getting fewer and fewer. These lands in particular were never originally classified as a good place for solar farms, they were just closer to infrastructure which means only one thing The developer gets richer due to less costs. If solar was the answer it would be on all of our rooftops. These farms are just a quick get rich scam for the few people and companies that can slide through the regulations and pay off politicians to get them pushed through. They never produce what they claim and they are at best a horrible visual distraction Let alone the fact that they will displace endangered species In 30 years we will be wishing we never did this as there will be better and less destructive “ alternative” energy solutions. Don’t be part of this horrible mistake in this decision process

Submitter(s)

Submitter 1

Name: [redacted]
Address: [redacted]
Email Address: [redacted]
Phone Number: [redacted]
Group or Organization Name: [redacted]
Position: member
(Add me to the project mailing list) - ***YES***

Disclaimer

(Withhold my personally identifying information from future publications on this project) ***NO***

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ePLANNING

Comment Submission

Project: DOI-BLM-NV-S030-2022-0009-EIS - Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS - Copper Rays Solar Project.pdf

Submission ID: SC-1-500323328

Comment

I support solar development but it should be restricted to already disturbed or degraded lands. Pristine desert lands should be avoided.

Desert tortoises are declining and threatened with extinction in the wild. BLM has already allowed too much destruction of tortoise habitats on BLM lands. Remaining habitats should be protected.

If BLM allows further habitat destruction, there should at least be full mitigation. Tortoise habitat on state and private lands should be acquired and permanently become off limits to development. Grazing permits should not be renewed in these habitats and the allotments retired.

It is imperative that BLM do more to actually protect and restore natural habitats for tortoises and other native species.

I am grateful for this chance to submit my comments.

Submitter(s)

Submitter 1

Name:A supporter of tortoises and other native species
Address: Not Provided
Group or Organization Name: Not Provided

Disclaimer

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment - including your personal identifying information - may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

(Withhold my personally identifying information from future publications on this project) - ***NO***

NATIONAL SYSTEM OF PUBLIC LANDS

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BUREAU OF LAND MANAGEMENT

ePLANNING

Comment Submission

Project: DOI-BLM-NV-S030-2022-0009-EIS - Copper Rays Solar Project

Document: Notice of Intent to Prepare EIS - Copper Rays Solar Project.pdf

Submission ID: SC-1-500323407

Comment

BLM needs to be proactive instead of reactive. Stop processing ad hoc applications. Start with comprehensive planning like was done by BLM California in the Mojave desert. Identify those areas with less resource impacts and conflicts and zone them for solar development. This scoping is ass backwards, too narrow in spatial scale, and myopic. BLM should learn from landscape ecology and conservation biology science about the appropriate scale for this type of planning and NEPA analysis.

Submitter(s)

Submitter 1

Name: The proper planning scale is crucial
Address: Not Provided
Group or Organization Name: Not Provided

Disclaimer

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(Withhold my personally identifying information from future publications on this project) - ***NO***