5. WESTERN JOSHUA TREE

Today's Item **Information ☐** **Action ☒**

Consider the petition, the DFW's status review report, and comments received to determine whether listing western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act (CESA) is warranted.

Summary of Previous/Future Actions

• Received petition	Mar 15, 2019
• Transmitted petition to DFW	Mar 22, 2019
• Published notice of receipt of petition	Apr 19, 2019
• Received DFW's 90-day evaluation report	Apr 15-16, 2020; Teleconference
• FGC determined petitioned action may be warranted	Sep 22, 2020; Webinar/Teleconference
• Approved DFW's request for six-month extension	Jun 16-17, 2021; Webinar/Teleconference
• Public received DFW's one-year status review report	Apr 20-21, 2022; Monterey/Trinidad
• **Today potentially determine if listing is warranted**	**Jun 15-16, 2022; Los Angeles/Trinidad**

Background

In Oct 2019, FGC received a petition from the Center for Biological Diversity to list western Joshua tree (WJT) as threatened under CESA. At its Sep 2022 meeting, FGC determined that the petition provides sufficient information to indicate that listing may be warranted, and FGC subsequently provided notice regarding WJT's protected, candidate species status. The notice prompted DFW's status review of the species, as required by California Fish and Game Code Section 2074.6. At its Jun 2021 meeting, FGC approved DFW's request for a six-month extension of time to complete the status review report.

At FGC's Apr 2022 meeting, FGC formally received DFW's completed status review report (exhibits 1 and 2, with appendices included as exhibits 3 and 4). The report represents DFW's final written review of the status of WJT and delineates each of the categories of information required for a petition, evaluates the sufficiency of the available scientific information for each of the required components, and incorporates additional relevant information that DFW possessed or received during its review. Based on the information provided, possessed, or received, DFW concluded that the petitioned action to list WTJ as threatened under CESA is not warranted at this time.

At today's meeting, FGC may consider the petition, DFW's written petition evaluation and species status review reports, written and oral comments received, and the remainder of the administrative record, to determine if listing is warranted. The administrative record for this decision contains an exceptionally large volume of information, and much more is likely to be submitted at today's meeting. The administrative record contains substantial evidence that would tend to support listing, and substantial evidence that would tend to oppose listing. Reasonable minds may disagree on the appropriate interpretations of the information in the record and conclusions drawn therefrom.

Fish and Game Code Section 2075.5 allows FGC to (1) make a decision today on whether listing is warranted, (2) close the public hearing and continue the listing decision for the purpose of deliberation, or (3) continue the public hearing and deliberation on the listing decision to a subsequent date. Findings will be adopted at a meeting after the decision.

Significant Public Comments

Through the public comment deadline, FGC received over 1700 comments regarding the potential listing of WJT as a threatened species; most comments are in support of the petition, with just over 250 opposed. Approximately a dozen comment letters in opposition and a dozen in support are from associations or organizations representing many members.

Staff has reviewed the letters and provides a summary herein, with examples that are representative of the issues and concerns raised. While the large number of letters precludes including every comment in the meeting materials, all letters are available to commissioners for review.

1. State Senator Scott Wilk and Assembly Member Tom Lakey, representing areas of the state within the WJT range, oppose listing the tree, stating that DFW's status review report indicates that WJT is abundant and widespread, and that listing would jeopardize the state's ability to meet housing commitments. They also state that local governments have strict regulations in their planning codes that require direct preservation and relocation, along with stiff penalties for unpermitted removal and destruction of WJT, all designed to protect the tree (Exhibit 6).
2. The city of Hesperia, city of Victorville, town of Yucca Valley, Kern County, San Bernardino County, and the League of California Cities support DFW's findings and recommend against listing WJT. Yucca Valley notes that every residential lot in the town has multiple WJT of various ages; while it does not have a scientific census, it estimates there are hundreds of thousands of trees. San Bernardino states the county is a recognized leader in greenhouse gas emissions reduction, renewable energy and sustainable development, and is committed to comprehensive local protection of WJT. Hesperia notes it is actively working to protect the trees but, if WJT is listed, it would harm residents and employees in the Mojave Desert communities by limiting job opportunities and requiring residents to commute to more urban areas, exacerbating existing issues of traffic and pollution. (Exhibit 7)
3. Third-party analyses of the status review and petition were submitted by the County of San Bernardino and QuadState Local Governments Authority; 8Minute Solar Energy, Terra-Gen, EDF Renewables, and Longroad Energy; and the California Construction and Industrial Materials Association (CalCIMA), all opposed to listing (Exhibit 8).
4. A coalition of industry associations (including California Building Industry Association, California Farm Bureau, California Chamber of Commerce, and Rural County Representatives of California), CalCIMA, the California Council for Environmental and

Economic Balance (CCEEB), and Harrison Temblador Hungerford & Guernsey write in support of DFW's recommendation to not list WJT, stating that DFW used the best scientific information available and that WJT is not at risk of disappearing from a significant portion of its range. CalCIMA and CCEEB state they support broader nature-based solutions, such as the 30x30 conservation policy, and more comprehensive funding to support conservation and mitigate climate change, rather than listing under CESA. (Exhibit 9)

5. Hi-Desert Water District, Phelan Piñon Hills Community Services District, and Southern California Edison (SCE) support DFW's recommendation, stating that it is well-reasoned and that listing the tree would have severe impacts on already disadvantaged communities. SCE also states that critical electric utility work must occur in WJT habitat; to reduce wildfire risk and power shutoffs, SCE is occasionally required to make modifications to its more than 118,000 linear miles of existing electrical lines, and it states that listing WJT would significantly impact the work necessary to maintain the lines. (Exhibit 10)

6. Individual members of the public oppose the listing, citing similar concerns to those described in other opposition letters, and a lack of current imperilment; 246 form letters from realtors express the same (see Exhibit 11 for examples).

7. The petitioner, the Center for Biological Diversity (CBD), submits comments to highlight additional information that became available subsequent to submitting the petition and to address arguments made by various parties against protecting WJT, including those contained in DFW's status review. CBD states that FGC is required to construe CESA liberally to effectuate its purpose of protecting imperiled species and that DFW's status review ignores this directive and misinterprets the statutory definition of "threatened species." CBD also states that the status review ignores and misinterprets the requirement to use the "best available science" in such a way that it would all but preclude ever protecting any climate-threatened species or any currently widespread species no matter how great the threats. (Exhibit 12)

8. Dr. Jennifer Harrower of the University of California, Santa Cruz and Dr. Timothy Krantz of University of Redlands Center for Environmental Studies disagree with DFW's recommendation and the conclusion of the status review. Dr. Harrower offers insights from her research and states that the current data shows high tree mortality rates due to fire, invasive plants, and changes in soil are impacting the range of WJT. She also states that WJT would be the first species protected in California primarily due to climate change and it is important that California continues its legacy of climate leadership. Dr. Krantz provides comments and peer review of DFW's status review to evaluate the appropriateness of listing WJT as a threatened species. (Exhibit 13)

9. A coalition of conservation organizations (including Sierra Club California, Mojave Desert Land Trust, National Parks Conservation Association, et al.), the Antelope Valley Conservancy, Mohave Desert Land Trust, California Native Plant Society (CNPS), Advocates for Wildlife, and CactusToCloud Institute support listing WJT, citing different threats, including development, climate change, drought, wildfire, and non-native species; the tree's importance to the overall ecosystem; inadequate or unenforced current protections; and the tree's iconic beauty. Additionally, CNPS notes that four of the five peer reviews included in the DFW's status review report were

conducted by reviewers who have studied WJT, and all four disagreed with either DFW's recommendation or the rationale behind the recommendation (see Exhibit 14 for examples).

10. Multiple individuals share their concern that without CESA listing, large-scale destruction of the deserts and WJT will begin immediately and that local government protections are not enough to protect the trees and the habitat necessary for them to live. They also note that even with current protections, local governments are not providing adequate oversight or enforcement to protect the trees. One commenter provides pictures of WJT destruction. See Exhibit 15 for examples.
11. Numerous individuals support the petition and express concern that the tree is in danger due to climate change, construction, and fires. Many describe their personal experiences with the trees and the importance of WJT to the economy and environment. See Exhibit 16 for examples.
12. Over 1300 form letters were received in support of listing, for reasons previously stated. Additionally, the Center for Biological Diversity, Mohave Desert Land Trust, and Sierra Club submit letters signed by over 10,000 members of the public (collectively) in support of listing WJT as threatened (see Exhibit 17 for samples).

Recommendation

FGC staff: At the conclusion of today's public testimony, determine whether the hearing should be continued to obtain any additional analysis on the information in the administrative record and/or to continue deliberation. If the hearing is not continued, determine whether to list WJT as threatened under CESA.

DFW: Determine that listing WJT as threatened under CESA is not warranted.

Exhibits

1. DFW memo, received Apr 12, 2022
2. DFW status review report, dated Mar 2022
3. Appendix A, DFW status review report, public comment letters
4. Appendix B, DFW status review report, peer review
5. DFW presentation (to be provided separately)
6. Letters of opposition from elected officials
7. Letters from local and regional government agencies
8. Letters of opposition from organizations submitting third-party analyses of the status report and petition
9. Letters of opposition from industry associations and construction interests
10. Letters of opposition from utility organizations
11. Letters of opposition from the general public
12. Letter of support from Brendan Cummings, Center for Biological Diversity, received Jun 2, 2022
13. Letter of support from scientists
14. Letters of support from conservation organizations

15. Letters of support from those concerned with the adequacy of current protections
16. Letters of support from general public
17. Letters of support as form letters
18. Petitioner presentation (to be provided separately)

Motion

Moved by ___________ and seconded by __________ that the Commission, pursuant to Section 2075.5 of the California Fish and Game Code, finds the information contained in the petition to list western Joshua tree (*Yucca brevifolia*), and the other information in the record before the Commission, **does warrant** listing western Joshua tree as threatened under the California Endangered Species Act. Findings will be adopted at a future meeting.

OR

Moved by ___________ and seconded by __________ that the Commission, pursuant to Section 2075.5 of the California Fish and Game Code, finds the information contained in the petition to list western Joshua tree (*Yucca brevifolia*), and the other information in the record before the Commission, **does not warrant** listing western Joshua tree under the California Endangered Species Act, consistent with the Department recommendation. Findings will be adopted at a future meeting.

OR

Moved by ____________ and seconded by ___________ that the Commission, pursuant to Section 2075.5 of the California Fish and Game Code, closes the public hearing and administrative record for the Commission's decision and continues its deliberation and decision to a future meeting.

State of California
Department of Fish and Wildlife

Original on file,
received April 12, 2022

Memorandum

Date: April 12, 2022

To: Melissa Miller-Henson
Executive Director
Fish and Game Commission

From: Charlton H. Bonham
Director

Subject: **Status Review of Western Joshua Tree**

The California Department of Fish and Wildlife (Department) has prepared the attached Status Review for the Fish and Game Commission (Commission) regarding the petition from the Center for Biological Diversity to list western Joshua tree (*Yucca brevifolia*) as threatened pursuant to the California Endangered Species Act (CESA; Fish & G. Code, § 2050 et seq.). The Commission received the petition on October 21, 2019. The attached status review represents the Department's final written review of the status of western Joshua tree and is based on the best scientific information available to the Department.

The status review contains the Department's recommendation that listing western Joshua tree as threatened is not warranted at this time. The Department recognizes there will be a substantial reduction in areas with suitable climate conditions for western Joshua tree in the foreseeable future. This reduction in combination with other threats is expected to have negative effects on the abundance of western Joshua tree and is cause for substantial concern. Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall impact of these threats and lowers the threat of extinction within the foreseeable future. While the Department acknowledges the significant threats western Joshua tree faces, the Department ultimately concluded that the best available scientific evidence does not sufficiently demonstrate that populations of the species are negatively trending in a way that would show the species is likely to be in serious danger of becoming extinct throughout all of its range, or throughout the proposed northern or southern evolutionarily significant units the Petition identifies, due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease, in the foreseeable future in the absence of special protection and management efforts required by CESA.

If you have questions or need additional information, please contact Jeff Drongesen, Branch Chief, Habitat Conservation Planning Branch at (916) 207-2823, or by e-mail at nativeplants@wildlife.ca.gov, Attn: Western Joshua Tree.

Attachment

ec: California Department of Fish and Wildlife
Valerie Termini, Chief Deputy Director
Chad Dibble, Deputy Director, Wildlife and Fisheries Division
Jeff Drongesen, Branch Chief, Habitat Conservation Planning Branch
Isabel Baer, Environmental Program Manager, Timberland Conservation, Fire Resiliency and Native Plant Programs

State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION
STATUS REVIEW OF WESTERN JOSHUA TREE (*Yucca brevifolia*)

March 2022


Western Joshua tree, photo by Jeb McKay Bjerke

Charlton H. Bonham, Director
Department of Fish and Wildlife

TABLE OF CONTENTS

List of Figures v
List of Tables vi
Abbreviations, Acronyms, and Terms vi
Executive Summary 1
Introduction 3
  Species Being Reviewed 3
  Petition Evaluation Process 3
  Status Review Overview 4
Biology 5
  Species Description 5
  Taxonomy 7
  Range and Distribution 12
    Current Range 12
    Past Range 15
    Current Distribution 15
  Life History 19
    Flowering, Pollination, and Fruit Production 19
    Seed Dispersal 21
    Seed Germination 24
    Establishment and Early Survival 26
    Growth and Longevity 27
    Summary of Important Life History Needs 30
  Similar-looking Plants 30
Habitat That May Be Essential to the Continued Existence of the Species 31
  Natural Communities 31
  Geology and Soils 34
  Climate, Hydrology and Other Factors 35
    Precipitation 36
    High Temperatures 38
    Low Temperatures 39
Abundance and Trends in California 39

Abundance 39
Population Trends 42
Inferred Long-term Trends 42
Direct Population Monitoring 44
Demographic Information 46
Summary of Demographic Information 52
Factors Affecting the Ability to Survive and Reproduce 53
Large Population Size and Widespread Distribution 53
Climate Change 55
Regional Effects 55
Direct Effects 57
Species Distribution Models 61
Range-wide Models 63
Joshua Tree National Park Models 67
Limitations of Models 70
Summary of Species Distribution Models 73
Climate Change Vulnerability Assessments 73
Indirect and Cumulative Effects 74
Development and Other Human Activities 76
Wildfire 80
Summary of Wildfire Threat 88
Invasive Plants 88
Herbivory and Predation 90
Use and Vandalism 92
Existing Management 93
Regulatory Status and Legal Protections 93
Federal 94
Federal Endangered Species Act 94
National Environmental Policy Act 94
State 94
California Endangered Species Act 94
Native Plant Protection Act 95

California Desert Native Plants Act 96
California Environmental Quality Act 96
Local 97
Inyo County 97
City of Bishop 97
Kern County 98
California City 98
Ridgecrest 98
Tehachapi 98
Los Angeles County 98
City of Lancaster 99
City of Palmdale 99
County of Riverside 100
County of San Bernardino 100
City of Adelanto 101
Town of Apple Valley 101
City of Barstow 102
Hesperia 102
City of San Bernardino 102
Twentynine Palms 102
Victorville 103
Town of Yucca Valley 103
Nonregulatory Status 104
Natural Heritage Program Ranking and IUCN Red List 104
California Rare Plant Rank 105
Management Efforts 105
National Park Service 106
Joshua Tree National Park 106
Death Valley National Park 107
United States Department of Defense 107
Bureau of Land Management 108
United States Forest Service 108

State of California 109
Other 110
Summary of Listing Factors 111
Present or Threatened Modification or Destruction of Habitat 112
Overexploitation 116
Predation 116
Competition 116
Disease 116
Other Natural Occurrences or Human-related Activities 116
Summary of Key Findings 117
Protection Afforded by Listing 119
Recommendation for Petitioned Action 120
Management Recommendations and Recovery Measures 120
Public Response 122
Peer Review 122
Acknowledgements 123
Literature Cited 123
Literature 123
Personal Communication 149
Appendix A: Comments from Affected and Interested Parties on the Petitioned Action .. A
Appendix B: Comments from Peer Reviewers on the Western Joshua Tree Status Review Report .... B

LIST OF FIGURES

Figure 1: Western Joshua Tree Fruit with Seeds Consumed by Moth Larvae 8
Figure 2: Western Joshua Tree Range and California Ecoregions 13
Figure 3: Joshua Tree Range in California 14
Figure 4: Joshua Tree Absolute Cover 17
Figure 5: Average Deviation of Annual Precipitation in the Mojave Desert Region 37
Figure 6: Heights of western Joshua trees in 2021 at a development project site near Hesperia 49
Figure 7: Heights of western Joshua trees in 2013 from three sampling locations in California 50

Figure 8: Heights of western Joshua trees at six development project sites near the cities of Palmdale and Lancaster in 2021 50
Figure 9: Fires within the California Range of Western Joshua Tree, 1900–2020 84
Figure 10: Area Burned Within Western Joshua Tree Range, 1900–2020........ 85

LIST OF TABLES

Table 1: Vegetation alliances in California that may support Joshua tree 33
Table 2: Status Review Peer Reviewers 122

ABBREVIATIONS, ACRONYMS, AND TERMS

BLM – Bureau of Land Management
CCVI – Climate Change Vulnerability Index
CEQA – California Environmental Quality Act
CESA – California Endangered Species Act
CNDDB – California Natural Diversity Database
Commission – California Fish and Game Commission
Department – California Department of Fish and Wildlife
DNPA – California Desert Native Plants Act
ESA – Federal Endangered Species Act
et al. – “and others”
Ibid. – “in the same source”
Id. – “the same”
INRMP – Integrated natural resources management plan
IUCN – International Union for Conservation of Nature
NEPA – National Environmental Policy Act
NPPA – Native Plant Protection Act
ssp. – Subspecies
var. – Variety

EXECUTIVE SUMMARY

This Status Review is based on the best scientific information available to the California Department of Fish and Wildlife (Department) on western Joshua tree (*Yucca brevifolia* Engelm.) and serves as the basis for the California Department of Fish and Wildlife's (Department) recommendation to the California Fish and Game Commission (Commission) on whether to list the species as threatened under the California Endangered Species Act (CESA). On October 21, 2019, the Center for Biological Diversity submitted a petition to the Commission requesting that western Joshua tree be listed as a threatened species under CESA (Petition). At its scheduled public meeting on September 22, 2020, the Commission considered the Petition, and based in part on the Department's Petition evaluation and recommendation, found sufficient information exists to indicate the petitioned action may be warranted and accepted the Petition for consideration. Western Joshua tree was designated a candidate species on October 9, 2020, upon publication of the Commission's notice of its findings. This Status Review has also been independently reviewed by scientific peers.

Western Joshua tree is relatively widespread and abundant in California and is found in the Mojave Desert and Great Basin. Precipitation in these areas is low and oscillates between wetter and drier conditions over multi-year and multi-decade timescales. Sexual reproduction of western Joshua tree requires pollination by the moth species *Tegeticula synthetica,* and seed dispersal is facilitated by the scatter hoarding behavior of rodents. Several successive years of wet and/or cool conditions are then required to ensure seed germination and seedling survival. A western Joshua tree may require 30 to 50 or more years to reach reproductive maturity, and individual trees can survive for very long periods of time, perhaps over 150 years. The species is capable of asexual (clonal) reproduction which may allow individuals to survive indefinitely under appropriate conditions.

The population size and area occupied by western Joshua tree have declined since European settlement largely due to habitat modification and destruction, a trend that has continued to the present. Primary threats to the species are climate change, development and other human activities, and wildfire. Available species distribution models suggest that areas predicted to be suitable for western Joshua tree based on 20th century climate data will decline substantially through the end of the 21st century (2100) as a result of climate change, especially in the southern and lower elevational portions of its range. Predicted habitat for western Joshua tree based on 20th century climate conditions will likely remain in some areas at the end of the 21st century, and newly appear to the north and in higher elevation areas, although western Joshua tree is unlikely to colonize areas with newly suitable climate conditions quickly. The degree to which climate change will affect western Joshua tree populations will depend on both the magnitude of climate change and the species' resilience to a changing climate. Predicted loss of areas of 20th century suitable climate conditions for western Joshua tree could result in an overall reduction in the number of new individuals added to the population or an increase in adult tree mortality, but the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts on existing populations that are severe enough to threaten to eliminate the species from a significant portion of its range by the end of the 21st century. The effects of development and other human activities will cause western Joshua tree habitat and populations to be lost, particularly in the southern part of the species' range, but many populations within the range of the species are protected from development, suggesting that a significant portion of the species' range will not be lost by development alone. Wildfire can also kill over half of western Joshua trees in areas that burn, and wildfire impacted approximately 2.5% of the species' range in each of the last two decades, but wildfire does not appear to result in loss of range, only lowering of abundance within the species' range.

There will be a substantial reduction in areas with 20th century suitable climate conditions for western Joshua tree by the end of the 21st century (2100), which is considered to be the foreseeable future for the purposes of this Status Review. This reduction in areas with 20th century suitable climate conditions in combination with other threats to the species is expected to have negative effects on the abundance of western Joshua tree and is substantial cause for concern. Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species, and substantially lowers the threat of extinction within the foreseeable future. Furthermore, the Department does not have the data to determine the extent to which climate changes that are expected to occur in the foreseeable future are likely to affect western Joshua tree range within California within this timeframe. While the Department recognizes the threats faced by the species, and the evidence presented in favor of the petitioned action, the scientific evidence that is currently possessed by the Department does not demonstrate that populations of the species are negatively trending in a way that would lead the Department to believe that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future.

The Department recommends that the Commission find that the recommended action to list western Joshua tree as a threatened species is not warranted.

INTRODUCTION

Species Being Reviewed

This Status Review addresses the plant *Yucca brevifolia* Engelm. For the purposes of this Status Review the term "western Joshua tree" shall mean the species *Yucca brevifolia* and the term "eastern Joshua tree" shall mean the species *Yucca jaegeriana* (McKelvey) L.W. Lenz. The more general term "Joshua tree" shall be used to mean both western Joshua tree and eastern Joshua tree collectively, or it may be used when the information presented is not known to be specific to one of the two species. Information that is specific to eastern Joshua tree is sometimes presented in this Status Review because it may be applicable to western Joshua tree or may provide relevant context. Additional information on the distinction between western Joshua tree and eastern Joshua tree is presented in the Taxonomy section of this Status Review.

Petition Evaluation Process

A petition to list the western Joshua tree (*Yucca brevifolia* Engelm.) as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission) on October 21, 2019 by the Center for Biological Diversity. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on November 1, 2019 and published a formal notice of receipt of the petition on November 22, 2019 (Cal. Reg. Notice Register 2019, No. 47-Z, pp. 1592-1593). A petition to list or delist a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant" (Fish & G. Code, § 2072.3).

On March 11, 2020, the Department provided the Commission with its evaluation of the petition to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). By evaluating the information provided in the petition on its face and in relation to other relevant information the Department possessed or received relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.

At its scheduled public meeting on September 22, 2020 by webinar/teleconference, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, western Joshua tree was designated a candidate species on October 9, 2020 (Cal. Reg. Notice Register 2020, No. 41-Z, p. 1349).

Status Review Overview

Following the Commission's action to designate western Joshua tree a candidate species, the Department notified affected and interested parties and solicited data and comments on the petitioned action pursuant to Fish and Game Code section 2074.4 (see also Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). Comments received are included in Appendix A of this report. The Department promptly commenced its review of the status of the species as required by Fish and Game Code section 2074.6, which has now concluded with this Status Review.

The review process included independent peer review of the draft Status Review by persons in the scientific/academic community acknowledged to be experts on subjects relevant to this Status Review and possessing the knowledge and expertise to critique the scientific validity of the Status Review contents. Appendix B contains the specific input provided to the Department by the individual peer reviewers, the Department's written response to the input, and any amendments made to the Status Review (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). The Department does not have a duty or obligation to undertake independent studies or other assessments of western Joshua tree (Fish & G. Code, § 2074.8), and this Status Review is focused on presenting the relevant scientific information that was in the Department's possession during preparation of this Status Review.

The Commission's action designating western Joshua tree as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing the species is warranted. At its scheduled public meeting on June 16, 2021 by webinar/teleconference, the Commission granted the Department a six-month extension to complete this Status Review and facilitate external peer review.

This Status Review report is not intended to be an exhaustive review of all published scientific literature relevant to western Joshua tree; rather, it is intended to summarize the key points from the best scientific information available relevant to the status of the species. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to western Joshua tree. This review is intended to provide the Commission with the most current information on western Joshua tree and to serve as the basis for the Department's recommendation to the Commission on whether the petitioned action is warranted. The Status Review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

BIOLOGY

Species Description

Western Joshua tree is a visually distinctive plant found in California's Mojave Desert and adjacent areas. The unique silhouette and tall stature of western Joshua tree relative to typical surrounding vegetation make it one of the most recognizable native plants of California deserts. Joshua tree has been utilized by Native American cultures for food, fiber, and other uses (Coville 1892, Stoffle et al. 1990, Fowler 1995, Small 2013, Gaughen pers. comm. 2020). Joshua tree landscapes are frequently represented in western art and culture (U2 1987, Bruno and Bruno 2017, Harrower 2019) and have become increasingly popular tourist destinations (NPS 2021). Joshua trees may also have medicinal properties (Patel 2012).

A summary of western Joshua tree's appearance and physical attributes was compiled from a number of sources, including scientific papers (Simpson 1975, Lenz 2007), botanical manuals (McKelvey 1938, Little 1950, Webber 1953, Hess and Robbins 1993, 2002, Alexander et al. 2008, Hess 2012), and the U.S. Forest Service's Fire Effects Information System (Gucker 2006).

Western Joshua tree is a woody evergreen plant, that can mature to heights of approximately 5 to 20 m (16 to 66 ft), although trees exceeding 10 m (33 ft) are rare (Cornett 1997). Western Joshua trees often have one main trunk that branches approximately one to three m (3 to 10 ft) above the ground, and older trees can have extensive branching and a large, rounded tree-like canopy. Western Joshua trees have a monopodial branching pattern, which means that after branching, one stem remains dominant, even though the branches may appear to be approximately equal in size. Branching of western Joshua tree typically occurs after an inflorescence is produced at the end of a stem, or after the growing tissue at the end of a stem (called the apical meristem) is otherwise damaged, such as by the yucca-boring weevil (*Scyphophorus yuccae*) (Jaeger 1965). Western Joshua trees typically produce two or three branches at the end of the stem after the apical meristem is damaged, but can produce up to five branches (Simpson 1975).

The leaves of western Joshua tree are narrowly tapered, 15 to 35 cm (5.9 to 13.8 in) long and 0.7 to 1.5 cm (0.3 to 0.6 in) wide with spiny tips, parallel veins, and expanded bases where they attach to the stem of the tree. The edges of the leaves are lined with minute teeth. The outer surface of the leaf has a thick and waxy coating to help reduce water loss. Leaves near the ends of stems tend to be oriented more vertically, while leaves that are lower tend to be oriented more horizontally, which may be an adaptation to optimize light utilization (Smith et al. 1983). The evergreen leaves of Joshua trees are used by the plant for many years, reducing the need to produce new biomass. Dead leaves can remain attached for a number of years, and fold down, concealing the younger stems and bark, contributing to western Joshua tree's distinctive shaggy appearance when viewed from a distance. Western Joshua trees produce woody stems via tissue called monocot cambium, but unlike many woody plants, the stems of western Joshua trees do not produce discernable secondary growth rings that may be used to precisely age plants (Barkley 1924, Simpson 1975, Zinkgraf et al. 2017, Jura-Morawiec et al. 2021). The soft, cork-like bark of western Joshua tree is visible after dead leaves fall from the stems of older plants.

Few observations of Joshua tree root systems are available. The root system of *Yucca* species was described as "deep and rather massive" by Crosswhite and Crosswhite (1984), but also described as shallow-rooted with little or no developed taproot system by Rundel and Gibson (1996). Gucker (2006) reports that mature Joshua trees may take advantage of infrequent rains by storing near-surface water collected through their extensive network of fibrous roots. Underground roots of eastern Joshua tree were observed 11 m (36 ft) away from what appeared to be the aboveground portion of the plant by Bowns (1973). Communities of fungi occur in association with western Joshua tree roots, forming mycorrhizal associations which may benefit western Joshua tree (Harrower and Gilbert 2021).

Some western Joshua trees grow in close groupings that are the result of asexual growth from underground stems called rhizomes; this growth form is more common at higher elevations (Rowlands 1978). When present, rhizomes grow horizontally and often produce sprouts approximately 1 to 3 m (3 to 10 ft) away from the parent plant (Gucker 2006); however, at higher elevations in the San Bernardino Mountains, sprouts as far as 5 m (16 ft) from parent plants have been observed (Borchert pers. comm. 2021). In areas where western Joshua tree exhibits abundant asexual growth, clumps of plants may form ring shapes when viewed from above, similar to the ring-shaped clumps found in other clonal plant species (Bonanomi et al. 2014).

Western Joshua trees produce a dense group of flowers at the ends of branches. These groups of flowers are arranged in panicles, which means that each group of flowers is branched, and the flowers that are near the base or outside of the group open before the flowers at the tip or close to the center. These panicles are approximately 20 to 40 cm (8 to 20 in) long, and tend to bend or tilt towards the south (Warren et al. 2016). Western Joshua tree panicles are composed of spherical-shaped generally cream-colored to greenish flowers, described by Trelease (1893) as having an "odor which is so oppressive as to render the flowers intolerable in a room," and described by Simpson (1975) as having a "strong, sweet, mushroom-like fragrance." Western Joshua tree flowers produce little if any nectar (Trelease 1893). The flowers of western Joshua tree have six perianth segments all resembling petals. These perianth segments are strongly incurved and never fully expand. Western Joshua tree flowers are bisexual, and have six male sexual parts called stamens, and one female sexual part called a pistil that has three ovary chambers. The stylar canal is the portion of a pistil that is used to transport genetic material from pollen to the ovules via pollen tubes. The length of the stylar canal of western Joshua tree pistils matches with the length of the organ that western Joshua tree's obligate pollinating moth, *Tegeticula synthetica*, uses to deposit eggs into the ovaries of western Joshua tree pistils.

After pollination, Joshua tree panicles develop into groups of approximately 2 to 30 fruits that are approximately 6 to 10 cm (2 to 4 in) long and approximately 5 cm (2 in) in diameter. Western Joshua tree seeds are thinly disc-shaped, generally black, and approximately 10 mm (0.39 in) in diameter (Figure 1). There are approximately 80 seeds in mature western Joshua tree fruits, and they are arranged in stacks (Borchert 2021). The fruits are spongy or leathery when young but become dry when mature and do not open to release seeds on their own. Fruits become brittle when dry, making it easier for animals or environmental influence to break open fruits and release the seeds.

Taxonomy

Under CESA, threatened and endangered species definitions include the description "…a native species or subspecies…" (Fish & G. Code, § 2062 and § 2067). The Legislature left the interpretation of what constitutes a "species or subspecies" under CESA to the Department and the Commission, the organizations responsible for providing the best scientific information and for making listing decisions, respectively. (*Cal. Forestry Assn. v. Cal. Fish and G. Com*. (2007) 156 Cal.App.4th 1535, 1548-49). In 2018, a California court of appeals decision determined that courts should give a "great deal of deference" to Commission listing determinations supported by Department scientific expertise (*Central Coast Forest Assn. v. Fish & G. Com*. (2018)

Figure 1: Western Joshua Tree Fruit with Seeds Consumed by Moth Larvae, photo by Jeb McKay Bjerke

18 Cal. App. 5th 1191, 1198-99). The Commission's authority to list necessarily includes discretion to determine what constitutes a species or subspecies (*Id*. at p. 1237).

Western Joshua tree (scientific name *Yucca brevifolia*) belongs to the group of flowering plants called monocots, which are characterized by having one embryonic leaf in their seeds, and often having leaves with parallel veins and flower parts that are in multiples of three. Within the monocots, Joshua tree has been placed in various plant families over the years, including the lily family (Liliaceae) and the agave family (Agavaceae). More recently, *Yucca* has been placed within an agave subfamily (Agavoideae) within a larger treatment of the asparagus family (Asparagaceae) (Chase et al. 2009, APG 2016, ITIS 2019).

There may be extensive traditional ecological knowledge of Joshua tree, however, the earliest recorded accounts known to the Department include a written description from 1844 (Fremont 1845) and an illustration from 1853 (Williamson 1853) which are discussed in more detail by Lenz (2007). The first scientific description of Joshua tree was in 1871 (Engelmann 1871, McKelvey 1938). The taxonomy of Joshua tree has subsequently been the subject of some dispute, and this dispute has largely focused on whether intraspecific taxa (additional taxonomic divisions within the species) exist, and if so, at what taxonomic rank those taxa should be recognized (i.e., variety, subspecies, or species). The history of this uncertainty has been described in various sources (McKelvey 1938, Lenz 2007, Jones and Goldrick 2015, Wallace 2017, USFWS 2018, Cummings 2019), and a summary of this history from these sources is presented below.

Two intraspecific taxa have been validly described since Engelmann's 1871 publication of the name *Yucca brevifolia*. *Yucca brevifolia* var. *herbertii* was described by Webber (1953) and included in Munz (1959), but this form is now understood to be a result of asexual growth of western Joshua tree from underground rhizomes, and this growth form is more common at higher elevations. *Yucca brevifolia* var. *herbertii* is therefore no longer recognized as a distinct taxon and is not discussed further in this Status Review.

Yucca brevifolia var. *jaegeriana* was first described by McKelvey (1938) and a number of sources have recognized this name since that time (Clokey 1951, McMinn 1951, Webber 1953, Munz 1959, Kearney and Peebles 1960, Rowlands 1978, Thorne et al. 1981, Kartesz 1987). The taxonomic rank of the name was recognized as a subspecies by Hochstätter (2001, 2002). Other sources, however, did not recognize the *jaegeriana* taxon to be distinct from *Yucca brevifolia* (Reveal 1977, Hess and Robbins 1993, 2002, McKinney and Hickman 1993, 2002, Hess 2012). As described by Wallace (2017), timing or oversight may have been the reason that the *jaegeriana* taxon was not recognized as distinct from *Yucca brevifolia* in the Flora of North America (Hess and Robbins 2002) or the second edition of the Jepson Manual (Hess 2012).

Lenz (2007) provided evidence that the *jaegeriana* taxon is distinct from *Yucca brevifolia*, and described *Yucca jaegeriana* as a species, highlighting differences in overall shape and form, branching, leaves, flowers, fruits, and different species of obligate pollinating moth. The pollinating moth for western Joshua tree is *Tegeticula* *synthetica* and the pollinating moth for eastern Joshua tree is *Tegeticula antithetica* (Pellmyr and Segraves 2003).

Since Lenz's work in 2007, a substantial amount of scientific attention has been directed towards understanding the coevolution of western Joshua tree, eastern Joshua tree, and their obligate pollinating moths, with much of this attention focused on a small area in Tikaboo Valley, Nevada where the two species co-occur, and hybridization has been observed (Pellmyr 2003; Smith et al. 2008b, 2008a, 2009, 2011, 2021; Godsoe et al. 2008, 2009, 2010; Starr et al. 2013, Yoder et al. 2013, Royer et al. 2016, 2020; Cole et al. 2017). Some of this work has revealed that the length of the stylar canals of western Joshua tree and eastern Joshua tree match the length of the organs that each of their respective pollinating moths use to deposit eggs into flower ovaries. Some of this scientific work has also provided information on the divergent selection pressures on these taxa that may have contributed to their evolution and speciation. Several researchers have examined genetic relationships between western Joshua tree and eastern Joshua tree (Starr et al. 2013, Yoder et al. 2013, Royer et al. 2016, Smith et al. 2021). Based on an analysis of single nucleotide polymorphisms, Royer et al. (2016) found that western Joshua tree and eastern Joshua tree are genetically distinct, and that natural selection is maintaining the differences between them. Smith et al. (2021) also found strong support for the conclusion that western Joshua tree and eastern Joshua tree are genetically distinct taxa.

In 2015, the U.S. Fish and Wildlife Service (USFWS) received a petition to list Joshua tree under the federal Endangered Species Act (federal ESA) (Jones and Goldrick 2015). In their Species Status Assessment, the USFWS considered both *Yucca jaegeriana* (eastern Joshua tree) and *Y. brevifolia* (western Joshua tree) as species for purposes of the federal ESA during consideration of that petition (Wallace 2017; USFWS 2018, 2019). The Petition submitted to the Commission includes a discussion of Joshua tree taxonomy and specifically requests that the Commission list western Joshua tree as threatened under CESA, regardless of the taxonomic rank into which the Commission classifies western Joshua tree. Based on the available scientific information, the Department considers western Joshua tree and eastern Joshua tree to be separate species (not subspecies of the same species) for the purposes of CESA and this Status Review.

The Petition states that western Joshua tree warrants protection under CESA throughout its range in California; however, the Petition also requests that the Commission assess whether either of two population clusters, denoted as *Y. brevifolia* North [YUBR North] and *Y. brevifolia* South [YUBR South], warrant listing separately as "ecologically significant units." In the 2018 Joshua tree Species Status Assessment, the USFWS treated these northern and southern population clusters as two geographically separate “populations” of western Joshua tree, and these two populations are discussed separately in much of the document (USFWS 2018). The distinction between the northern and southern populations in the USFWS Species Status Assessment appears to be based primarily on the distinct vegetational and climatic “regions” of western Joshua tree that were described and distinguished by Rowlands (1978).

A population of organisms considered distinct for conservation purposes based on scientific analysis of the reproductive isolation and genetic differences between population groups is eligible for listing under CESA (see *Cal. Forestry Assn. v. Cal. Fish and G.*, *supra*, 156 Cal.App.4th at 1535 [upholding the Commission’s listing of two evolutionarily significant units of Coho Salmon]. The Department has recognized that similar populations of a species can be grouped for efficient protection of genetic diversity (Id. at p. 1546-47). Further, genetic structure in populations is important because it fosters enhanced long-term stability (Id. at p. 1547). Genetic diversity spreads risk and supports redundancy in the case of catastrophes, provides a range of raw genetic materials that allow adaptation and increase the likelihood of persistence in the face of long-term environmental change, and leads to greater abundance (Ibid.).

The Department recognizes that genetic divergence among populations and genetic diversity within those populations are critical to species protection. Genetic divergence indicates the amount of time that population lineages have been separated. Effective conservation strategies often identify the most divergent clades in a group of lineages as key management units. Further, quantifying genetic diversity provides information on population health and indicates the extent to which populations have the capacity to adapt to changing conditions. While it can be difficult to determine when populations within species have sufficiently differentiated to be considered separate species or subspecies, a population-genetics approach using the fixation index F_{ST} is the most widely used summary measure of population divergence.

Recent studies suggest that western Joshua tree and eastern Joshua tree have a moderate degree of genetic differentiation and diverged approximately 100,000 to 200,000 years ago, which is considered a relatively recent divergence (Smith et al. 2021). The work by Smith et al. (2021) supports the conclusion that Joshua trees fall into two distinct groups (K=2) that correspond with western Joshua tree and eastern Joshua tree. Smith et al. (2021) does indicate there is genetic diversity among populations of western Joshua tree, particularly among populations in the southern and western extent of its range, and the Department also recognizes the vegetational and climatic differences between the northern and southern populations identified by Rowlands (1978). The Department also recognizes that populations of western Joshua tree in the southern part of its range generally face more serious threats than populations in the northern part of its range, as described in the Factors Affecting the

Ability to Survive and Reproduce section of this Status Review. Nevertheless, the Department does not currently have enough evidence of a clear genetic subdivision within western Joshua tree, that would support the differentiation of northern and southern populations as separate and discrete evolutionary significant units that would qualify them as separate “species or subspecies” under CESA. The genetic structure of western Joshua tree from north to south may instead be representative of a genetic cline, which is a continuous gradient of change in the genetic composition of populations within the range of the species that is associated with geography. Populations that are near each other are more genetically similar than populations that are farther away, but none appear fully isolated so as to be an evolutionary significant unit (Smith et al. 2021). Therefore, for purposes of this Status Review, the Department does not consider populations of western Joshua tree in the northern part of its range or the southern part of its range to be distinct “species or subspecies” under CESA.

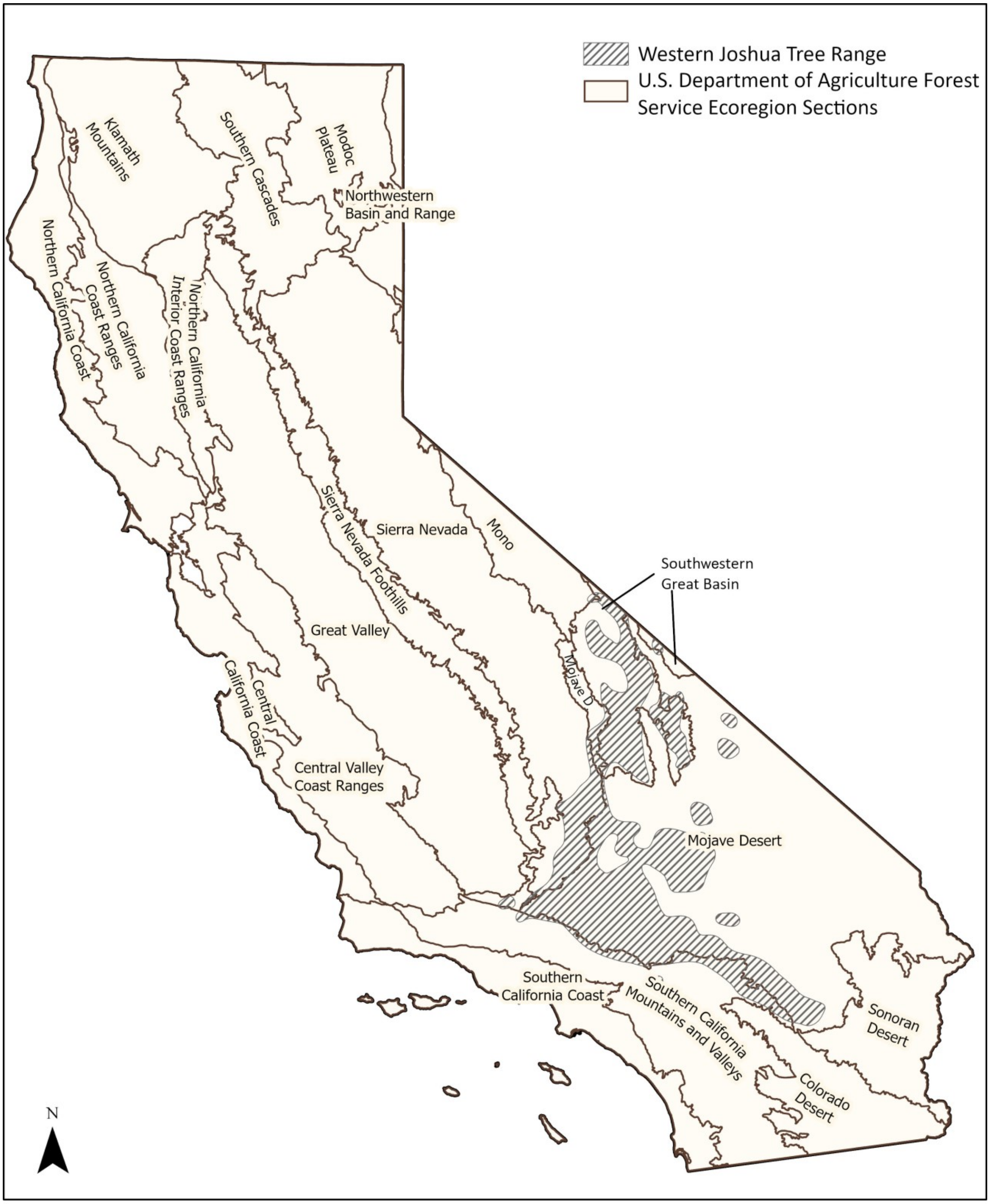
The scientific understanding of the genetic diversity of Joshua tree will continue to improve with the completion of an ongoing project to assemble a Joshua tree reference genome.

Range and Distribution

Range is the general geographical area in which an organism occurs. For purposes of CESA and this Status Review, the range is the species’ California range only (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551), even though western Joshua tree extends into southern Nevada, reaching north to Alkali and east to Tikaboo Valley (USFWS 2018). Range is largely independent of species abundance, because population declines within an area do not necessarily change the overall geographical area in which an organism occurs. Species distribution describes the actual sites where individuals and populations of the species occur within the species’ range.

Current Range

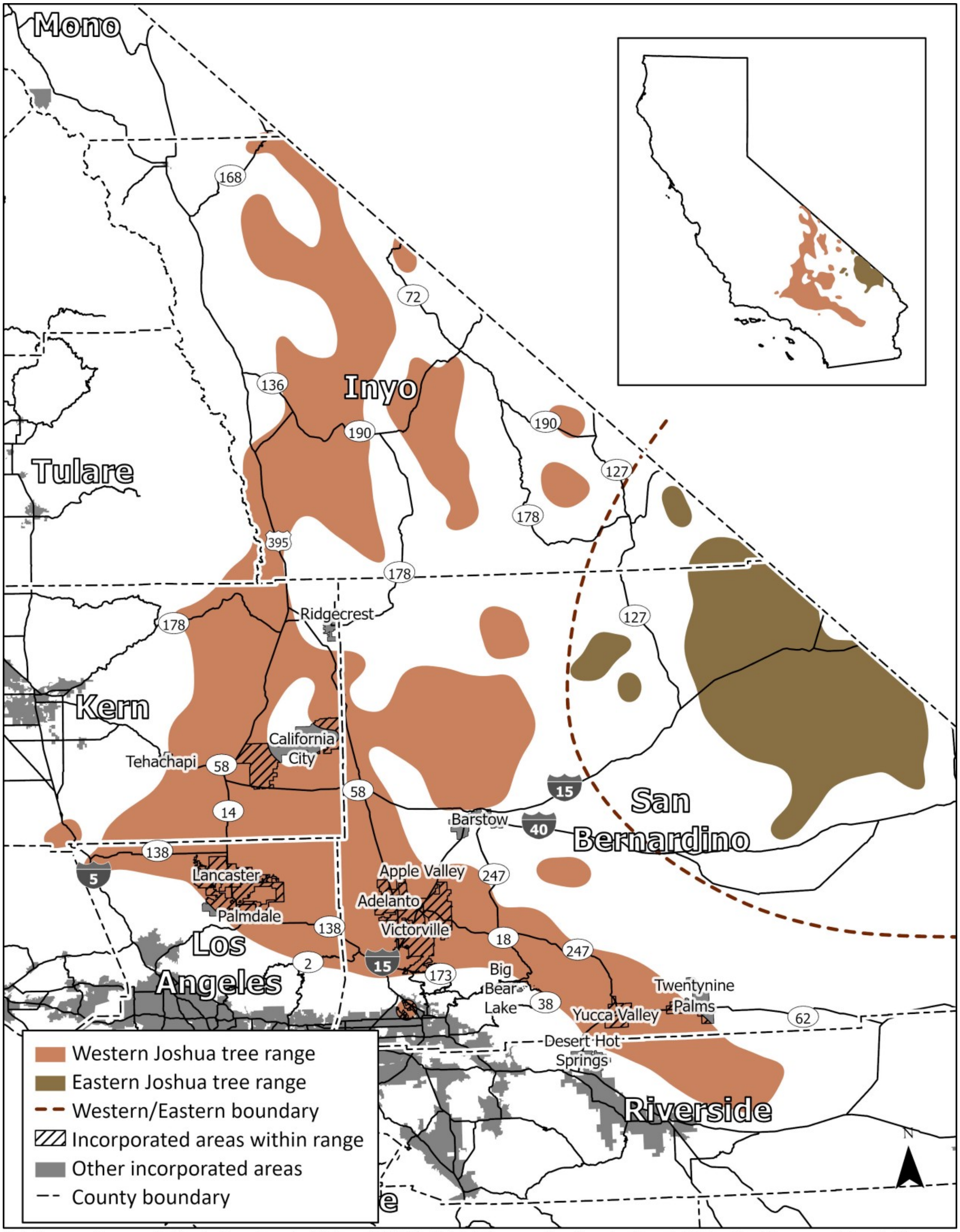
The California range of western Joshua tree is in southeastern California and covers much of the western half of the Mojave ecoregion (Figure 2) (USDA 2017). The southern and eastern extent of the species’ range is at Joshua Tree National Park in San Bernardino County and the western extent of the species’ range is near Gorman in Los Angeles County, where the species is found to the west of Interstate 5 (Figure 3). Within California, western Joshua trees extend to the north into Inyo County and occur within Death Valley National Park. The northernmost western Joshua trees are likely in the southeastern corner of Mono County near Fish Lake Valley, which is close to the California/Nevada border (Figure 3). Throughout California, substantial stands of



Data Source: Ecoregions -USDA Forest Service; Range - California Department of Fish and Wildlife, Habitat Conservation Planning Branch, Native Plant Program

0 25 50 100 Miles

Figure 2: Western Joshua Tree Range and California Ecoregions



Data Sources. Ranges - California Department of Fish and Wildlife. Habitat Conservation Planning Branch. Native Plant Program. Cities - Calfire.

0 15 30 60 Miles

Figure 3: Joshua Tree Range in California

western Joshua tree were reported as high as 2,100 m (6,900 ft) and as low as 750 m (2,500 ft) elevation by Rowlands (1978), and individual trees can likely be found at elevations that are slightly higher or lower than this range. The western Joshua tree range shown in Figures 2 and 3 was developed using distribution information in the Department's possession during preparation of this Status Review, as described in the Current Distribution section of this Status Review.

Past Range

Fossil evidence indicates that Joshua tree was more widespread during the late Pleistocene period (22,000 to 13,000 years before present) (Cole et al. 2011). Joshua tree's range during the late Pleistocene period extended south of its present range farther into southern California and into Arizona, and likely also into northwestern Mexico (Rowlands 1978, Cole et al. 2011). Joshua tree's range suddenly contracted from the south as climates rapidly warmed approximately 11,700 years ago at the beginning of the Holocene period, and now only the northernmost Joshua tree populations remain (Cole et al. 2011). While Joshua tree's range contracted from the south as climates warmed, Cole et al. (2011) states that it also may have expanded very slowly to the north, and attributed this to very limited dispersal capabilities, which are discussed in more detail in the Seed Dispersal section of this Status Review. Smith et al. (2011) modeled historical range using 20th century suitable climate conditions to reconstruct a potential range of Joshua tree approximately 21,000 years before present during the last glacial maximum. The results of this modeling also suggested that Joshua trees formerly occupied a larger range in the southern Mojave Desert. Smith et al. (2011) suggested that loss of range in the southern part of Joshua tree's range between 21,000 years ago and the present may have been offset by the addition of new habitat in the north.

Current Distribution

Western Joshua tree is distributed in discontinuous populations in the Mojave Desert and in a portion of Great Basin Desert (Figure 2). Western Joshua tree is often noted as being abundant near the borders of the Mojave Desert in transition zones. The general distribution of Joshua tree has been described in various sources, and over time the understanding of western Joshua tree distribution has improved, with newer and larger datasets of presence points contributing to more accurate distribution maps.

The USFWS described the distribution of both western Joshua tree and eastern Joshua tree as part of a Species Status Assessment for the two species in 2018 and produced a distribution map as part of the assessment. The USFWS distribution map was based on several sources including Rowlands (1978); Cole et al. (2003, 2011); Webb et al.

(2003); the LANDFIRE Reference Database (2007); Godsoe et al. (2009); and other available databases (USFWS 2018).

The Department possesses vegetation maps that cover a large portion of the California deserts where western Joshua tree generally occurs. The Department's Vegetation Classification and Mapping Program (VegCAMP) uses a combination of aerial imagery and fieldwork to delineate polygons with similar vegetation and to categorize the polygons into vegetation types. In 2013, an effort was made to create a vegetation map that covers a large portion of the California deserts (CDFW and AIS 2013, Menke et al. 2013). The vegetation data from this project includes percent absolute cover of Joshua tree and in some instances only Joshua tree presence and absence data. A rigorous accuracy assessment of the mapped Joshua tree woodland (*Yucca brevifolia* vegetation alliance) was performed using field collected data and it was determined to be mapped with approximately 95% accuracy. This means that approximately 95% of field-verified, polygons mapped as Joshua tree woodland alliance were mapped correctly. While Joshua tree woodland alliance requires even cover of Joshua tree at ≥1% to be categorized as this alliance, the vegetation dataset has polygons recorded with <1% cover of Joshua tree as well as simple presence and absence data. This information was used to visualize the distribution and cover of western Joshua tree within the survey area (Figure 4). While Figure 4 is not a comprehensive representation of the distribution of western Joshua tree in California, it reflects the best information available to the Department on the cover and distribution of western Joshua tree.

The Department used publicly available vegetation mapping information (polygons) (Thomas 2002; Agri Chemical and Supply, Inc. 2008; NPS 2012; CDFW and USGS 2014; CDFW and Chico State University 2015; CDFW et al. 2017; CDFW 2019 a, b, c, d) combined with data from other sources including herbarium records, Calflora, and iNaturalist (points) to create the western Joshua tree range shown in Figures 2 and 3. The Department reviewed publicly-available point observations from herbaria, Calflora, and iNaturalist that appeared to be geographic outliers to ensure that incorrectly mapped and erroneous observations did not substantially expand the presumed range of the species. The Department did not include point observations for range mapping if photos demonstrated that the species was identified incorrectly, the observation was for a horticultural planting, or if the geographic location of the point observation was mapped incorrectly or was too imprecise for accurate mapping. Creating a range map with incomplete presence data can sometimes be misleading because the absence of data does not necessarily mean the absence of the species. Some of the observations used to produce the range map may also be old, particularly if they are based on herbarium records, and trees may no longer be present in some locations. Additionally, different buffer distances around data points can yield wildly different results for occupied areas. To create the general western Joshua tree range shown in Figures 2

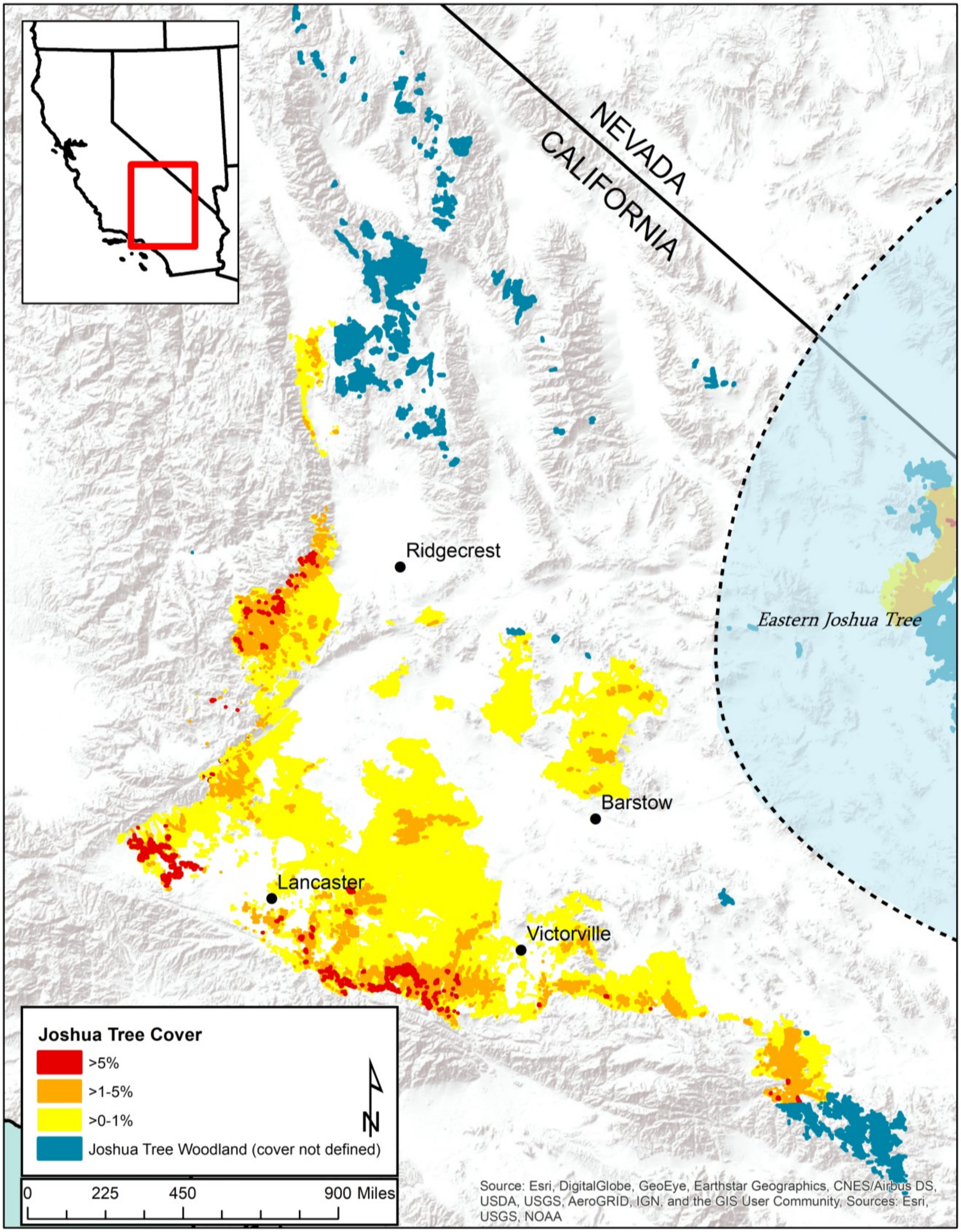


Figure 4: Joshua Tree Absolute Cover Classes (Data from Vegetation Maps)

and 3, the Department buffered presence locations, but did not use a specific buffer value, and instead used the data described above in a geographic information system exercise to extend the range polygons to closely follow known occurrence boundaries while eliminating small gaps between them.

The area occupied by the western Joshua tree range shown in Figures 2 and 3 is approximately 30,200 km^2 (11,660 mi^2); however, this is very likely an overestimation of the species distribution in California. If the point and polygon data used for the range are instead buffered by 0.2 km (0.12 mi) the distribution of the species in California would occupy 10,160 km^2 (3,920 mi^2) which is likely an underestimation of the actual distribution because populations represented only by points are likely larger than the buffered distance, and the Department does not have data for every location where western Joshua tree occurs. If each occupied area was reported as a point, with an average area of 0.59 km^2 (0.23 mi^2), and all point and polygon areas were additionally buffered by 0.2 km (0.12 mi), the distribution of western Joshua tree in California would be 13,880 km^2 (5,360 mi^2). To put these areas in perspective, the distribution of western Joshua tree is likely larger than the land area of the State of Connecticut, but smaller than the land area of the State of Hawaii. As part of its Species Status Assessment, the USFWS (2018) estimated that the distribution of western Joshua tree occupied an area of 22,823 km^2 (8,812 mi^2), but this estimate included areas outside of California. In an effort to estimate population size, WEST Inc. (2021a) used data from Cole et al. (2011) to report that western Joshua tree's distribution occupies 15,071 km^2 (5,819 mi^2), but WEST Inc. (2021b) later reported that this area was only for the southern part of the species' range, and the distribution in the northern and southern portions of the species' range together occupy an area of approximately 23,101 km^2 (8,919 mi^2), although this estimate likely includes areas outside of California.

The distributions of most plant species of conservation concern within California are documented in the Department's California Natural Diversity Database (CNDDB) (CDFW 2021a). The taxa that are tracked in the CNDDB are referred to as "elements." An "element occurrence" (occurrence) is a specific location where an element is known to occur. Occurrences are determined using a default separation distance of ¼ mi (0.4 km), meaning that if two populations of an element are separated by more than ¼ mi (0.4 km), the two populations will be considered separate occurrences (Bittman 2001, CDFW 2020). Prior to being designated a candidate species under CESA, western Joshua tree was not considered to be a plant species of conservation concern by the Department, and the species was therefore not tracked in the CNDDB. Although the Department has not begun tracking occurrences of western Joshua tree, initial estimates suggest that the number of western Joshua tree occurrences could total approximately 846 if it was tracked and mapped by the CNDDB using standard methodology. For comparison, the highest number of occurrences for a plant currently tracked by the Department in the CNDDB is 249 (CDFW 2021a). If western Joshua tree were tracked in the CNDDB, the number of occurrences would be much higher than any other plant element currently tracked in the database.

Scientific understanding of current western Joshua tree distribution is continuing to improve. Both remote sensing techniques using satellite imagery as described by Esque et al. (2020a) and citizen science applications such as iNaturalist are making it possible to develop a more detailed map of western Joshua tree distribution. These efforts nevertheless have limitations. Remote sensing techniques are most effective on western Joshua tree in lower-elevation areas where western Joshua trees are not surrounded by vegetation of similar height. Additionally, despite peer review of citizen science observations by other users, citizen science data frequently includes erroneous identification of species (including of western Joshua tree). Plants that may be confused with western Joshua tree are discussed in the Similar-looking Plants section of this Status Review.

Based on information available to the Department, western Joshua tree is relatively widespread across a large geographic area of southeastern California, western Joshua tree populations occupy relatively large areas within this geographic area, and the number of occurrences of western Joshua tree within California is very high compared with the number of occurrences for the approximately 1,700 plant species of conservation concern that are tracked and mapped by the Department's CNDDB.

Life History

Flowering, Pollination, and Fruit Production

Mature western Joshua trees do not produce flowers every year, and flowering is thought to be episodic, possibly only occurring in wetter years; however, the conditions that lead to flowering are not well known (Gucker 2006, St. Clair and Hoines 2018). Western Joshua tree flowers have been reported between January and May, but flowering as early as November has also been observed (Hess 2012, Waitman et al. 2012, Cornett 2018a, 2018c, Harrower and Gilbert 2018, Barve et al. 2020, Brenskelle et al. 2021). Cold and dry conditions have been implicated for flowering that occurs relatively early in the flowering season (Brenskelle et al. 2021). In some years, many western Joshua trees produce flowers synchronously, leading to the production of large quantities of fruits and seeds in that year, which is part of a reproductive strategy called masting (Kelly and Sork 2002, Borchert and DeFalco 2016, St. Clair and Hoines 2018). A mast seeding reproductive strategy is beneficial for species whose seeds are dispersed by seed predators, because when more seeds are produced than predators can eat, the surviving seeds have a higher likelihood of establishing and developing into a reproductive adult (Kelly and Sork 2002). Large flowering events are relatively infrequent, perhaps only occurring once or twice per decade, and the environmental or other conditions that lead to large flowering and mast seeding events are currently unknown (Esque et al. 2010, DeFalco and Esque 2014, Borchert and DeFalco 2016).

Esque et al. (2015) reported that flowering may occur in Joshua trees that are as short as one meter, but that 30-year-old trees at their study site had yet to flower (a discussion of the relationship between plant height and age is presented in the Growth and Longevity section of this Status Review). Rowlands (1978) investigated the average height to first branching, which is likely indicative of the height at first flowering. The information presented in Rowlands (1978) from ten populations of western Joshua tree showed that the average height to first branching was between 1 and 1.5 m at the three northernmost populations examined, and the average height to first branching was between 2 and 2.5 m at more southern populations. Larger western Joshua trees tend to produce more flower clusters than smaller trees (Harrower and Gilbert 2018).

Joshua tree flowers require pollination to produce fruits. Most species in the genus *Yucca* are pollinated by a different species of yucca moth. Mutually-beneficial relationships between organisms are called mutualisms. Within California, western Joshua tree forms an obligate pollination mutualism with its specialized nocturnal pollinating yucca moth *T. synthetica*, and eastern Joshua tree forms an obligate pollination mutualism with its specialized pollinating yucca moth *T. antithetica* (Trelease 1893, Pellmyr and Segraves 2003). The interactions between *Yucca* species and yucca moths have captivated the attention of biologists for over 150 years, beginning with observations by George Engelmann and Charles Riley in the 1800s, and these interactions continue to be the subject of research (Riley 1873, Sheppard and Oliver 2004, Royer et al. 2020). In a letter, Charles Darwin (1874) once described the *Yucca*-yucca moth interaction mutualism as “the most wonderful case of fertilisation ever published.”

Western Joshua tree flower panicles create large, light-colored landing pads for *T. synthetica* moths to use, and residual heat in the flower panicles that were warmed by the sun during the day may provide a thermal reward for its nocturnal pollinating moths (Warren et al. 2016). Female *T. synthetica* moths have special tentacle-like mouth parts for collecting, transporting, and transferring western Joshua tree pollen (Cole et al. 2017). Female moths first gather a ball of western Joshua tree pollen with their mouth parts, next they oviposit eggs into the western Joshua tree flower, and finally the moths actively transfer pollen to a portion of the female sexual part of the flower called the stigma, ensuring that the flower will be fertilized (Pellmyr 2003, Cole et al. 2017). When ovipositing her eggs, a female yucca moth cuts through the ovary wall of a western Joshua tree flower so she can insert her ovipositor down the stylar canal to lay eggs near ovules that can eventually become seeds after the flower is fertilized (Cole et al.

2017). The moth eggs hatch within a few days and feed on developing seeds (Pellmyr 2003). By actively pollinating western Joshua tree flowers, female yucca moths can ensure that there will be a food source for their developing moth larvae. Both western Joshua trees and *T. synthetica* moths benefit from this interaction because each species is dependent on the other for a critical aspect of its sexual reproduction. In the late summer, moth larvae that developed within Joshua tree fruits fall to the ground below the tree, burrow into the ground, create a cocoon, and enter a period of suspended development called diapause (Pellmyr 2003). Yucca moth larvae are likely able to remain in diapause for several years before pupating into moths; the environmental or other cues that trigger this pupation are currently unknown (Riley 1892, Pellmyr 2003). The Department has very little information on the range of *T. synthetica*, however, any instance of non-clonal western Joshua tree recruitment is an indication that *T. synthetica* was present at the time the flower that produced the seed was pollinated.

After pollination, western Joshua tree fruits develop and seeds are produced. Borchert and DeFalco (2016) found that fruits may reach full size around late May, although seeds did not become black and capable of germination until approximately 14 days after they are full size. Fruits turn from pale green to a whitish light brown as they dry and may fall to the ground or into the leaves of the tree or remain attached to the panicle of the tree. As would be expected in a masting species, the amount of western Joshua tree seeds and fruits produced can be highly variable from year to year (Borchert and DeFalco 2016). Viable seed production by western Joshua tree may be limited more by pollen than other resources, and more seeds tend to be produced in areas with more *T. synthetica* moths (Harrower and Gilbert 2018). Within the vicinity of Joshua Tree National Park, Harrower and Gilbert (2018) found *T. synthetica* moths at elevations ranging from 1,049 m (3,442 ft) to 2,076 m (6,811 ft), but not at the lowest elevation study site that had western Joshua trees at 1,004 m (3,294 ft) or the highest elevation study site with western Joshua trees at 2,212 m (7,257 ft), however this was a short-term study conducted within one continuous western Joshua tree population, and additional are needed to determine whether the moth is present at higher or lower elevations.

<u>*Seed Dispersal*</u>

The primary current method of western Joshua tree seed dispersal is from the scatter-hoarding behavior of rodents who actively collect seeds from fruits in the canopies of trees and fruits and seeds that have fallen on the ground, and bury seeds in the soil relatively short distances away (Vander Wall et al. 2006, Waitman et al. 2012, Borchert 2016). Other methods and agents of seed dispersal such as wind, other mammals, birds (e.g., California scrub jay (*Aphelacoma californica*)), and extinct megaherbivores (e.g., giant sloths and relatives of elephants) have also been suggested in the scientific literature (McKelvey 1938, Lenz 2001, Borchert 2016). Rare long-distance dispersal events are likely important for plant migrations over large geographic scales (Clark et al. 1998). Rare long-distance dispersal events may have occurred for Joshua tree in the past and could still occur.

Lenz (2001) provided observations of apparent dispersal distances in areas that had been previously cleared of vegetation and left fallow at a population of western Joshua tree in the western portion of the Antelope Valley (Los Angeles County), and at a population of eastern Joshua tree in Lanfair Valley, California (San Bernardino County). Lenz (2001) found young plants (cluster of leaves, no stem) or juvenile plants (with stem but unflowered) in limited numbers as far as 151 m (495 ft) from potential seed donors in the Antelope Valley, and 251 m (823 ft) from potential seed donors in Lanfair Valley. Lenz (2001) did not explicitly test seed dispersal mechanisms but hypothesized that these dispersal events were the result of wind dispersal. However, the role of rodents in Joshua tree seed dispersal was not well understood at that time.

Joshua trees produce fruits that do not open when seeds are ripe and produce seeds with an undersized wing structure relative to seed mass, which are morphological characteristics that can indicate seed dispersal via scatter-hoarding rodents. Borchert (2016) used camera traps and affixed line to 208 western Joshua tree fruits and placed them under trees at two sites in the San Bernardino Mountains to observe and measure fruit dispersal. White-tailed antelope squirrel (*Ammospermophilus leucurus*) and kangaroo rats (*Dipodomys merriami* and *D. agilis*) were observed carrying fruits away from trees before dismantling them. The maximum distance that a fruit was moved was 46.9 m (154 ft), and the average dispersal distance was 6.4 m (21 ft) (Borchert 2016). White-tailed antelope squirrels were responsible for carrying away the most western Joshua tree fruits. Kangaroo rats readily collected loose western Joshua tree seeds from dishes (Borchert 2016). Other species observed interacting with western Joshua tree seeds and fruits included pocket mice (*Chaetodipus fallax* and *Perognathus longimembris*), pinyon mice (*Peromyscus trueii*), and California scrub jays (Borchert 2016).

Vander Wall et al. (2006) placed a total of 1,000 radioactively marked eastern Joshua tree seeds at the base of five different eastern Joshua trees (200 seeds per tree). Rodents removed 995 of the 1,000 seeds within two days, and researchers were able to find 67.7%–97.5% of the seed originally placed below each tree in seed caches at distances between 0.5 and 56.6 m (1.6 and 186 ft) away from where the seeds were originally placed. The average maximum dispersal distance was 30.0 m (98.4 ft). On a subsequent visit, Vander Wall et al. (2006) found that many of the seeds discovered in the seed caches on the previous visit were re-cached in secondary caches located between 0.2 and 32.2 m (0.7 and 106 ft) away from the original cache. Assuming seeds are sometimes re-cached in the same direction away from the source tree, results of the Vander Wall et al. (2006) study suggest that rodents may be capable of moving eastern Joshua tree seeds as far as 88.8 m (291 ft) away from a source plant (56.6 meters plus 32.2 meters). If entire fruits are first carried away from source trees by rodents, dispersal distance could be farther (Borchert 2016). The Vander Wall et al. (2006) study examined dispersal from only five source trees, and therefore may not demonstrate the maximum possible dispersal distances that seed caching rodents are capable of moving eastern Joshua tree seeds. In a subsequent study by Waitman et al. (2012) using camera traps, white-tailed antelope squirrels cached eastern Joshua trees seeds a mean distance of 21.3 ± 2.8 m (69.9 ± 9.2 ft) from the source tree, but only three trials were conducted, because the primary purpose of this treatment was for comparison with treatments involving rodents kept within an enclosure.

Waitman et al. (2012) also examined factors related to seed dispersal of eastern Joshua trees and found evidence that rodents are a factor causing eastern Joshua tree fruits to drop from the tree canopy at two study sites. Waitman et al. (2012) also placed a total of 160 eastern Joshua tree fruits on the ground and found that approximately 90% of these fruits were removed by ground-foraging rodents within approximately 15 days. Eastern Joshua tree seeds placed on the ground were also removed, but less rapidly than whole fruits. Waitman et al. (2012) also conducted experiments that involved placing a white-tailed antelope squirrel or Merriam’s kangaroo rat into a 10 by 10 m enclosure with 200 radioactively marked eastern Joshua tree seeds to study the scatter-hoarding behavior of these rodents, including the depth of seed caches, distance of caches from source trees, and whether seeds were cached in the open or under shrubs. Seed caches created by rodents in this study were buried at a mean depth of 12 ± 3 mm. One study suggested that scatter-hoarding rodents may preferentially place Joshua tree seeds under shrubs which would likely be beneficial for seedling emergence (Swartz et al. 2010), but Vander Wall et al. (2006) and Waitman et al. (2012) found that rodents do not appear to disperse eastern Joshua tree seeds with regard to shrub cover.

Using a wind tunnel, Waitman et al. (2012) also measured the wind speeds necessary to move eastern Joshua tree fruits and seeds on a sandy and a rocky substrate. Wind speeds required to move fruits was lower than wind speeds required to move seeds (31.9 ± 2.6 km/h and 43.6 ± 2.6 km/h, respectively on the sandy substrate). Wind speeds sufficient to move fruits and seeds on the rocky substrate averaged and 73.6 ± 4.8 km/h and 87.6 ± 5.5 km/h, respectively. Waitman et al. (2012) suggested fruits and seeds that do fall are unlikely to be carried far by wind and are instead much more likely to be gathered by rodents; therefore, wind is unlikely to be a primary mode of dispersal where rodents are present.

Although scatter hoarding rodents and Joshua trees are capable of a mutualistic relationship where both organisms benefit each other, in non-masting years when Joshua trees only produce a small number of seeds, an overabundance of rodents may consume all the seeds, resulting in a shift from a mutualistic relationship to a predatory relationship, and Joshua tree may not benefit from the relationship in these years (Waitman et al. 2012).

Joshua tree has been found to be a chief component in fossilized dung of the now-extinct Shasta ground sloth (*Nothrotheriops shastensis* Sinclair) that was found in a cave in southern Nevada (Harrington 1933, Laudermilk and Munz 1935, Cole et al. 2011). Poorly masticated fragments of Joshua tree up to 2 cm long were found in the dung, including sharp leaf tips, parts of the flower stalk and fruits, and entire seeds, although all seeds observed were split. Researchers have speculated that Joshua tree's large fruits may have been an adaptation for consumption by large mammals that are now extinct (Simpson 1975, Lenz 2001). In addition to extinct ground sloths, extinct long-necked members of Camelinae (relatives of camels and llamas) and extinct relatives of elephants in the order Proboscidea were present within the range of Joshua tree in the past. Extinct members of the order Proboscidea may have been capable of feeding on Joshua tree fruits via an elephant-like trunk, and elephants are known seed dispersers because they consume large quantities of material that is passed relatively undigested within a relatively short period of time (Lenz 2001 and citations therein). Shasta ground sloth and other megaherbivores became extinct approximately 12,900 years before present, perhaps due to rising populations of humans (Steadman et al. 2005) and/or a meteorite impact (Firestone et al. 2007). Joshua tree's height may have been an evolutionary strategy to elevate leaves, flowers, and fruits so they could not be reached by large herbivores (Lybbert and St. Clair 2017). Assuming that even a small proportion of Joshua tree seeds were capable of remaining viable in the dung of Shasta ground sloth or another extinct herbivore, Joshua tree may have been capable of more frequent longer-distance seed dispersal in the past. However; using genetic data, Smith et al. (2011) found no evidence of a change in the rate of Joshua tree dispersal corresponding with the timing of the extinctions of such herbivores, which would be expected were they important Joshua tree seed dispersers.

Seed Germination

While western Joshua tree seeds germinate readily under optimal conditions, seedling establishment is exceptionally rare (Reynolds et al. 2012), and few Joshua tree seedlings are observed in the field, particularly at lower elevations (Webber 1953, Wallace and Romney 1972, Comanor and Clark 2000, Esque et al. 2010).

Twenty-year-old western Joshua tree seeds stored at California Botanic Garden had 100% germination with no pretreatment and grown on agar in a germination chamber (Birker pers. comm. 2021). Other studies have reported similarly high Joshua tree germination success under controlled conditions (Wallace and Romney 1972, McCleary 1973, Gucker 2006, Alexander et al. 2008, Waitman et al. 2012). Seeds used for germination studies likely had high seed viability (ability to germinate) because obviously damaged seeds (as seen in Figure 1) would have been avoided during collection in the field.

While seed germination appears to be high under controlled conditions, seed viability decreases dramatically after dispersal in the wild. Reynolds et al. (2012) found that after one year in an underground cache, only 50%–68% of recovered eastern Joshua tree seeds were able to germinate, and after three years and four months in an underground cache, approximately 3% of recovered eastern Joshua tree seeds were able to germinate. This suggests that Joshua tree has limited capacity to maintain viable seeds in the soil for long periods of time. In mast years when fruit production is high enough to provide ample food for larvae and rodents, Borchert and DeFalco (2016) speculated that uneaten fruits in the tree canopy may function as an aerial seed bank, because seeds may remain viable for a longer duration when protected within fruits than loose in the soil.

Once western Joshua tree seeds have dispersed, they appear to be able to germinate any time after rain (Went 1948, Reynolds et al. 2012). Reynolds et al. (2012) examined several cohorts of artificially placed eastern Joshua tree seeds, and found that seedling emergence was greatest during spring and summer, when increased soil moisture was accompanied by warm soil temperatures, but seedlings were also able to emerge at other times of the year, suggesting some potential for adaptation to shifting conditions. McCleary (1973) tested four different eastern Joshua tree germination temperatures and found seed germination was fastest at 25°C.

Waitman et al. (2012) found that seed caching by rodents increased the likelihood of seedling emergence and seeds were most likely to produce seedlings when buried 1–3 cm (0.4–1.2 in) deep, and that seeds placed on the soil surface seldom germinated. Between August 2007 and September 2008, Waitman et al. (2012) found that only 133 of 2,880 artificial caches (4.6%) placed in the field produced seedlings and only 183 of the 5,760 seeds (3.2%) placed in those caches produced seedlings. Significantly more Joshua tree seedlings emerge from under shrubs than in the open (Vander Wall et al. 2006, Waitman et al. 2012, Reynolds et al. 2012). One study suggested that scatter-hoarding rodents may preferentially place seeds under shrubs which would likely be beneficial for seedling emergence (Swartz et al. 2010), but Vander Wall et al. (2006)

and Waitman et al. (2012) found that rodents do not appear to disperse eastern Joshua tree seeds with regard to shrub cover.

Establishment and Early Survival

The process by which individuals are added to a population is called recruitment. Recruitment of plants may be limited by the availability of seed and/or by other constraints on seedling establishment (Grubb 1977, Clark et al. 1999, 2007). Few experiments involving the addition of seeds to Joshua tree habitat have been conducted (Waitman et al. 2012, Reynolds et al. 2012), but results suggest that constraints on seedling establishment may be a critical factor limiting western Joshua tree recruitment. Following germination, several successive years of sufficiently wet and/or cool conditions are likely required for establishment of Joshua tree seedlings (Wallace and Romney 1972, Cole et al. 2011). Joshua tree seedlings and very young plants appear to require sufficient soil moisture to survive, periods of cold temperatures for optimal growth, and must not be consumed by herbivores (Went 1957, Esque et al. 2015). Of seedling cohorts monitored by Reynolds et al. (2012), seedlings emerging in September survived the longest, although approximately 90% of them died within one year. Esque et al. (2015) identified the seedling height of 25 cm as an important size class threshold because seedlings that attained this height before the onset of drought conditions had a much greater likelihood of longer-term survival than the seedlings that did not attain this height, none of which survived the study’s 22 year monitoring period.

Nurse plants appear to be critical habitat components for Joshua tree establishment (Waitman et al. 2012, Reynolds et al. 2012, Esque et al. 2015), likely by providing a microclimate with less direct sun, higher soil moisture, lower soil temperature, a reduction in water loss to the atmosphere, increased soil nutrients, and/or a reduction in the drying effects from wind (Holmgren et al. 1997, Brittingham and Walker 2000, Legras et al. 2010). Many plants with which Joshua trees co-occur including blackbrush (*Coleogyne ramosissima*) and creosote bush (*Larrea tridentata*) can act as nurse plants for Joshua tree seedlings by providing favorable conditions for seedling growth and survival, and perhaps some protection from small mammal herbivory (Loik et al. 2000b).

Harrower and Gilbert (2021) found that the presence of arbuscular mycorrhizal fungi in association with the roots of western Joshua tree seedlings generally appeared to have positive benefits for nitrogen absorption and plant biomass. Some species of arbuscular mycorrhizal fungi from low elevation areas in Joshua Tree National Park were found to have an initial negative impact on one- to three-month old western Joshua tree seedlings, but these associations became beneficial when seedlings were six-months old.

McCleary (1973) tested four different light cycles on young eastern Joshua tree plants and found that 10 hours of light and 14 hours of dark produced the highest average number of leaves, and the longest average total length of leaves per plant. Western Joshua tree seedlings were observed by Wallace and Romney (1972) to grow best at root temperatures near 18°C and without calcium carbonate ($CaCO_3$) in the soil.

Germination and emergence of perennial desert plants have been associated with infrequent weather events such as those associated with the El Niño–Southern Oscillation (Bowers 1997, Holmgren et al. 2006). Such events bring winter and early spring precipitation after seed germination and may be the conditions that are most conducive to establishment of western Joshua tree.

Esque et al. (2015) monitored a cohort of 53 western Joshua tree plants that were 5 to 6 years old for a period of 22 years at Yucca Flat, Nevada. These western Joshua trees had an average height of 21.5 cm when monitoring began in 1989, and the surviving 10 plants had an average height of approximately 1 meter in 2011. Most of the mortality was attributed to the plants being consumed by black-tailed jackrabbit (*Lepus californicus*) during drought years. DeFalco et al. (2010) monitored burned and unburned western Joshua trees for a five year period after a wildfire in Joshua Tree National Park, and found that plants that were less than approximately one meter (3.3 feet) were more vulnerable to drought, herbivory, and fire than larger size classes, which had a greater likelihood of survival. Harrower and Gilbert (2018) found considerable western Joshua tree seedling recruitment within Joshua Tree National Park at elevations around 1,300 m (4,300 ft), where trees were generally the biggest, and they produced the most flowers, fruits, and seeds.

Growth and Longevity

Smith et al. (1983) investigated the photosynthetic characteristics and transpiration (water loss through leaves) of western Joshua tree, and despite early assumptions to the contrary, found that western Joshua tree survives solely on the C_3 carbon fixation pathway, despite growing in arid areas where other photosynthetic pathways (e.g., C_4 and CAM) are sometimes utilized by plants as an adaptation to hot environments. Western Joshua tree is capable of controlling the stomata (openings for transfer of gases to and from the environment) of its leaves throughout the day and the year, which is an adaptation allowing it to control water loss and maintain its leaves during the summer and fall dry seasons (Smith et al. 1983). Because western Joshua tree's evergreen leaves are maintained for many years, there is a reduced need to produce new biomass. Western Joshua tree's moderate photosynthetic rate, arrangement of leaves, and high leaf area nevertheless also allow it to exhibit substantial photosynthetic productivity during the winter-spring growth period (Smith et al. 1983). Wallace and

Romney (1972) estimated that western Joshua trees at one site in Nevada produced about three sets of six leaf blades per growing tip per year but noted that six to eight sets of six blades were developed in 1969 due to the large amount of rain in that year. Like many desert plants, Joshua trees can survive with limited water by utilizing moisture reserves of intermediate and deep soils and moisture that is stored in leaves, trunk, and roots (Crosswhite and Crosswhite 1984). Although Joshua tree trunk diameter is generally expected to increase with time, the diameter of Joshua tree trunks has also been reported to decrease, perhaps as a result of drought (Phillips et al. 1980, Gilliland et al. 2006).

Western Joshua tree grows in height very slowly, and growth rates can vary based on location and other factors, but may be somewhat uniform in localized areas. Esque et al. (2015) monitored one site in Nevada over 22 years and found an average western Joshua tree growth rate of 3.12 cm in height per year. Comanor and Clark (2000) monitored three plots over 20 years (two with western Joshua tree and one with eastern Joshua tree) and found an average growth rate of approximately 4 cm per year. Gilliland et al. (2006) observed a growth rate of 3.75 cm per year at a population of eastern Joshua trees in Utah over a period of 14 years. Wallace and Romney (1972) estimated average western Joshua tree growth rates of about 1.5 cm per year at one site in Nevada. A growth rate of over 8 cm per year through approximately 17 years was observed in one tree near Rose Mine in the San Bernardino Mountains, which Rowlands (1978) reported as supporting clonal trees that are the tallest and fastest growing Joshua trees recorded in the southwest. Rowlands attributed this high growth rate to relatively high water availability coupled with deep sandy loam soil. Western Joshua tree growth rates as high as 14.3 cm per year were reported by McKelvey (1938). In one monitoring plot at Cima Dome in Mojave National Preserve, Cornett (2018b) found that annual height increase of eastern Joshua tree was moderately correlated with summer precipitation ($r = 0.53$, $P = 0.009$). Because Joshua tree does not produce clearly identifiable secondary growth rings in its wood, tree height is often used to approximate the age of the plants (Gilliland et al. 2006). Estimates for the ages of western Joshua trees are therefore dependent on the assumptions used for annual growth rate, and these estimates include a high level of uncertainty. Despite uncertainty, information on tree height can provide information about the demographic structure of Joshua tree populations, as described in the Demographic Information section of this Status Review. Went (1957) published data demonstrating that after Joshua tree has reached an age of approximately three years the plant requires exposure to low temperatures for optimal growth.

In areas outside of the distribution of *T. synthetica* moths, asexual reproduction is the only viable reproductive strategy for western Joshua tree. Asexual reproduction occurs from underground stems called rhizomes that grow horizontally and produce sprouts near the parent plant, resulting in plants with more than one main stem and clumps of plants growing together. Asexual reproduction may allow western Joshua tree individuals to survive for indefinite periods of time, because new sprouts create genetically identical clones of parent plants that may replace the parent plants after they have died, and this process can continue for many generations. The extent of asexual reproduction in Joshua tree populations increases with elevation (Simpson 1975, Rowlands 1978), and asexual reproduction has also been reported at lower elevations where sexual reproduction is not occurring (Harrower and Gilbert 2018), which is consistent with observations that asexual reproduction tends to be more frequent at the edges of plant species ranges (Silvertown 2008). The use of asexual growth for reproduction and survival by western Joshua tree may be an adaptation to higher elevations, harsher environmental conditions, or may be an adaptation to lower availability of yucca moths for pollination at these locations (Webber 1953, Rowlands 1978, Harrower and Gilbert 2018). As is the case with some relict species, the ability to reproduce asexually may extend the ability of western Joshua tree to persist in marginal climate conditions for very long periods of time. Western Joshua tree often resprouts after fire (Vogl 1967, Loik et al. 2000b, Gucker 2006, DeFalco et al. 2010), and like Joshua tree asexual growth, fire is also more frequent at higher elevation areas of the Mojave Desert (Brooks et al. 2018). DeFalco et al. (2010) found that resprouting of burned but still living western Joshua trees in Joshua Tree National Park generally prolonged the survival of burned plants five years after fire, compared with plants that did not resprout, but only at wetter, high-elevation sites. Abella et al. (2020) found resprouting to aid in eastern Joshua tree population persistence in areas that had previously burned, and therefore sprouting may be an important adaptation of Joshua tree to fire (Brooks et al. 2018). DeFalco et al. (2010) found that while sprouting may have increased survival of burned trees, sprouting in unburned trees may have negatively affected survival, suggesting that there is also a cost to sprouting, particularly during periods of low precipitation.

Assuming an average height of first flowering for western Joshua tree is approximately 2 m (6.6 ft), and an average growth rate for western Joshua tree is 4 cm (1.6 in) per year, the average time required for a germinated seed to reach reproductive maturity may be approximately 50 years, which appears to be consistent with the 50 to 70 years estimated by Esque et al. (2015). Western Joshua tree individuals that have reached reproductive maturity have high survivorship and are therefore likely to maintain reproductive potential for decades. Esque et al. (2020b) used an estimate of annual survival rate of 0.992 for eastern Joshua tree from one 14-year study (Gilliland et al. 2006) to calculate a generation length for western Joshua tree of approximately 185 years. Despite speculation that western Joshua tree may live for hundreds of years or even more than a thousand years, the maximum lifespan of western Joshua tree is unknown (Cornett 2006, Gilliland et al. 2006). If the average western Joshua tree lifespan becomes shorter than the generation length, populations will decline.

<u>Summary of Important Life History Needs</u>

Sexual recruitment of western Joshua trees requires a number of conditions to occur in succession; however, western Joshua trees are also capable of asexual growth for indeterminate periods of time, particularly at higher elevations, if the environmental conditions for survival and growth are maintained. Available information suggests that seed germination is most likely after large mast seeding events, which perhaps only occur once or twice per decade. The environmental or other conditions that lead to large simultaneous flowering events that result in mast seeding events are not currently known. Sexual reproduction requires the presence of western Joshua tree's obligate pollinating moth *T. synthetica*. The conditions that lead to the emergence and survival of *T. synthetica* moths are not currently known. After a mast seeding event, seed dispersal is facilitated by the scatter hoarding behavior of rodents, which results in burial of some western Joshua tree seeds at a soil depth suitable for germination and sometimes under a nurse plant that may aid in seedling survival. After burial of seeds, several successive years of sufficiently wet and/or cool conditions are likely required to ensure that seeds germinate, and that seedlings reach a sufficiently large size (perhaps at least 25 cm) before the arrival of a period of hotter and/or drier conditions. This period of several successive years of sufficiently wet and/or cool conditions must occur relatively soon after a mast seeding event, because western Joshua tree seeds do not remain viable in the soil for long periods of time. After a seedling has become established, it must survive a long period of time (perhaps 30-50+ years) to reach reproductive maturity. The minimum recruitment rate needed to keep populations of western Joshua tree from declining is not known (Wiegand et al. 2004).

Similar-looking Plants

Although Joshua tree is a distinctive plant, differentiating between western Joshua tree and eastern Joshua tree may be difficult, and there are several plant species known to occur within the range of western Joshua tree that look superficially similar to the species. In California, western Joshua tree and eastern Joshua tree do not co-occur.

Lenz (2007) described the differences between western Joshua tree and eastern Joshua tree, and highlighted differences in the overall shape and form, branching, leaves, flowers, fruits, and different species of obligate pollinating moth. Lenz provided photos showing visual differences between flowers, fruits, and entire trees, and provided the following key to differentiate between the two species:

Plants ca. 6–9 (–16) m tall, arborescent with distinct trunk and monopodial branching, branches stout; leaves 15–35 cm long; corollas cream-colored, globular to depressed globular, never opening fully; perianth segments broadly ovate, tightly incurved; fruits ovoid to broadly ovoid, rounded at tips; pollinator *Tegeticula synthetica*. CALIFORNIA, NEVADA: *Yucca brevifolia*

Plants ca. 3–6 (–9) m tall, stemless or with trunks, usually branching less than 1 m above ground, the branching dichotomous until flowering, irregular thereafter; branches relatively numerous, somewhat slender; leaves 10–20 cm long; corollas greenish to cream-colored, narrowly campanulate, conspicuously expanded at bases; perianth segments narrowly oblong, tips recurving; fruits ellipsoid, tapering at tips; pollinated by *Tegeticula antithetica*. ARIZONA, CALIFORNIA, NEVADA, UTAH: *Yucca jaegeriana*

There are two other species in the *Yucca* genus that occur in California: banana yucca (*Yucca baccata* var. *baccata*) and Mojave yucca (*Yucca schidigera*) (Hess 2012). Both of these species can look superficially similar to western Joshua tree but can be easily distinguished from Joshua tree by examining the edges of leaves: banana yucca and Mojave yucca have "fibrous-shredding" leave edges that peel off, while Joshua tree's leaf edges do not peel off, and are slightly serrated when viewed up close.

HABITAT THAT MAY BE ESSENTIAL TO THE CONTINUED EXISTENCE OF THE SPECIES

Habitat for plants can often be described in terms of the other species they are found in association with (natural communities), the geology and soils in the area they grow, and the climate, hydrology, and other factors that support the species' survival and reproduction. The Department's preliminary identification of the habitat that may be essential to the continued existence of western Joshua tree includes habitat that fits the general descriptions provided below and that supports a relatively high density of western Joshua trees, supports relatively high recruitment of western Joshua trees from seed, and/or is predicted to remain suitable for the species in the future despite the effects of climate change.

Natural Communities

The Department uses *A Manual of California Vegetation*, Second Edition (Sawyer et al. 2009) to classify natural communities within California. Within this classification system Joshua tree is the defining species for the *Yucca brevifolia* vegetation alliance (Joshua tree woodland), which is within the Mojavean–Sonoran Desert Scrub vegetation macrogroup. Joshua tree woodland is classified as having Joshua trees evenly distributed at greater than or equal to one percent absolute cover, and with other trees such as California juniper (*Juniperus californica*), Utah juniper (*Juniperus osteosperma*), or single leaf pinyon (*Pinus monophyla*) with less than one percent absolute cover in the tree canopy (Thomas et al. 2004). Joshua tree woodlands have Joshua trees as emergent small trees over a shrub or grass layer with white bur-sage (*Ambrosia dumosa*), cheesebush (*Ambrosia salsola*), common sagebrush (*Artemisia tridentata*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), blackbrush (*Coleogyne ramosissima*), buckhorn cholla (*Cylindropuntia acanthocarpa* var. *acanthocarpa*), Nevada ephedra (*Ephedra nevadensis*), California buckwheat (*Eriogonum fasciculatum*), sticky snakeweed (*Gutierrezia microcephala*), winterfat (*Krascheninnikovia lanata*), creosote bush (*Larrea tridentata*), Anderson thornbush (*Lycium andersonii*), banana yucca, and Mojave yucca (CNPS 2021a).

While Joshua trees are the defining feature of Joshua tree woodland, Joshua trees may also be components of many other vegetation alliances within California (Table 1) (Rowlands 1978, Turner 1982, CNPS 2021a). Figure 4 shows the areas in California where vegetation has been mapped and where western Joshua tree has been recorded as present within one of three cover classes (>0%–1%, >1%–5%, and >5%). The darkest red areas in Figure 4 provide a rough approximation of the areas in California where the species is most abundant.

Rowlands (1978) found the largest Joshua trees in communities dominated by blackbrush, creosote bush, and big galleta grass (*Hilaria rigida*). Some researchers suggest that while Joshua tree may be the most obvious plant in an area visually due to its height and dramatic silhouette, understory species are often more dominant cover components of the natural communities where Joshua trees occur (Rowlands 1978, Turner 1982). Due to the variety of natural communities that western Joshua trees can be found in, they do not appear to require specific plant species assemblages to meet their critical life history needs.

Joshua tree seedlings are often found growing under the canopy of other woody shrubs and perennial plants which act as nurse plants for the seedlings and aid in their survival. Loik et al. (2000b) reports that blackbrush appears to be an important nurse plant for western Joshua tree in the Covington Flats area of Joshua Tree National Park. Brittingham and Walker (2000) found that a large majority of eastern Joshua tree seedlings in southern Nevada were found growing under the canopy of 16 different woody shrubs, with blackbrush appearing to be the most common nurse plant in the study area. Advantages of germination under the canopy of another plant likely include higher soil moisture, reduced exposure to direct sun, reduced surface temperatures, reduced evapotranspirational (water) demand, increased nutrients, reduced herbivory, and/or reduced wind desiccation. Brittingham and Walker (2000) found that eastern

Table 1: Vegetation alliances in California in which Joshua trees occur or may occur (CNPS 2021a). Table organized by primary lifeform followed by alliance scientific name.

Primary lifeform	Alliance scientific name	Alliance common name
Tree	*Chilopsis linearis - Psorothamnus spinosus*	Desert-willow - smoketree wash woodland
Tree	*Juniperus californica*	California juniper woodland
Tree	*Juniperus osteosperma*	Utah juniper woodland and forest
Tree	*Pinus sabiniana*	Foothill pine woodland
Tree	*Quercus lobata*	Valley oak woodland and forest
Tree	*Yucca brevifolia*	Joshua tree woodland
Shrub	*Ambrosia salsola - Bebbia juncea*	Cheesebush - sweetbush scrub
Shrub	*Coleogyne ramosissima*	Blackbrush scrub
Shrub	*Ephedra nevadensis - Lycium andersonii - Grayia spinosa*	Nevada joint fir – Anderson's boxthorn - spiny hop sage scrub
Shrub	*Ericameria nauseosa*	Rubber rabbitbrush scrub
Shrub	*Eriogonum fasciculatum - Bahiopsis parishii*	California buckwheat – Parish's goldeneye scrub
Shrub	*Gutierrezia sarothrae - Gutierrezia microcephala*	Snakeweed scrub
Shrub	*Larrea tridentata*	Creosote bush scrub
Shrub	*Larrea tridentata - Ambrosia dumosa*	Creosote bush - white bursage scrub
Shrub	*Menodora spinescens*	Spiny menodora scrub
Shrub	*Prunus fasciculata - Scutellaria mexicana*	Desert almond - Mexican bladdersage scrub
Shrub	*Purshia tridentata - Artemisia tridentata*	Bitter brush scrub
Shrub	*Yucca schidigera*	Mojave yucca scrub
Herb	*Hilaria jamesii*	James' galleta shrub-steppe
Herb	*Hilaria rigida*	Big galleta shrub-steppe
Herb	*Stipa speciosa*	Desert needlegrass grassland

Joshua tree recruitment occurred predominantly on the east and west sides of nurse shrubs and suggested that microclimates are important for seedling establishment.

Communities of fungi occur in soils and can sometimes form mutualisms with plants. Mycorrhizal fungi grow into plant roots and provide nutrients to the plant. Western Joshua tree has been shown to sometimes form mycorrhizal associations that may benefit western Joshua tree (Harrower and Gilbert 2021), but it is not known whether mycorrhizal associations are required for western Joshua recruitment. In a study of western Joshua tree across an elevational gradient in Joshua Tree National Park, Harrower and Gilbert (2021) found that mycorrhizal fungal communities change with elevation, and that mycorrhizal colonization of western Joshua tree roots decreased significantly at higher elevations. Natural communities that support the presence of western Joshua tree's obligate pollinating moth *T. synthetica* and that support populations of scatter-hoarding rodents for seed dispersal are likely important components of Joshua tree habitat, yet the specific characteristics of the natural communities that support these species that are important for the reproduction and dispersal of western Joshua tree are not currently known.

Geology and Soils

The origin and properties of bedrock materials and the tectonic history of the Mojave Desert and Great Basin regions are important components of the geology of these areas; however, most of the current desert landforms in the region are likely due to climatic changes during the last million years, erosion, and other processes within the past several thousand years (Stoffer 2004). Within the Mojave Desert and Great Basin regions, western Joshua trees occur on various landforms including gentle alluvial fans, bajadas, ridges, flats, mesas, and gentle to moderate slopes, often near the bases of mountains (Huning and Petersen 1973, Thomas et al. 2004, Gucker 2006). The highest densities of Joshua trees may be found on well-drained sandy to gravelly alluvial fans within and adjacent to mountains. In some areas where western Joshua trees are less common, such as Edwards Air Force Base, they may be restricted to areas that store sufficient groundwater, such as large sand dunes or along groundwater drainages (Charlton and Rundel 2017).

Water availability likely limits survival and reproduction of western Joshua trees, and therefore the water-retention capacity of the soil in a given area may be an important component of habitat for the species. Soil textures in Joshua tree habitat have been described as silts, loams, and/or sands, and variously described as fine, loose, well drained, and/or gravelly. Huning and Petersen (1973) collected a number of soil samples along transects within and outside of western Joshua tree habitat in California in an investigation of soil water potential. Huning and Petersen (1973) found western Joshua tree to occur more frequently in areas with bimodal soil textures (with both larger sand particles and smaller silty clay particles) that facilitate soil moisture retention than in areas with well-sorted soil (with soil particles tending to all be of similar size). Huning and Petersen (1973) reasoned that soil moisture is the limiting factor governing the distribution of western Joshua tree, and therefore when the amount of precipitation is a limiting factor for western Joshua tree survival, soil textures that retain moisture become an important habitat characteristic. Similarly, Huning and Petersen reported that western Joshua tree tends to not occur where the depth to bedrock is less than one meter because there is insufficient groundwater to support the Joshua trees in these locations. Western Joshua tree also appears to be unable to grow well in soils with a high clay content or other "extremes of composition" such as high volumes of coarse fragments (Huning and Petersen 1973, Borchert 2021). Wallace and Romney (1972) reported that western Joshua tree grows best at root temperatures near 18°C (64°F) and without calcium carbonate in the soil. Huning and Petersen (1973) found that soil pH, soil nutrients, and the age of soils (more modern soils versus soils from the Tertiary period) did not seem to be significant factors determining western Joshua tree distribution within their study area near Riverside, California.

Areas that collect water due to topography, subsurface bedrock, and/or soil structure could allow western Joshua tree to grow in some areas that may otherwise be too hot or too dry, and such areas could provide important refugia for the species in the future.

Climate, Hydrology and Other Factors

Climate in the Mojave Desert and southwestern Great Basin where western Joshua tree occurs consists of long, hot summers, mild winters, and low overall precipitation. The local climate in these regions varies primarily due to elevation and topography. Precipitation across the Mojave Desert region is highly variable from year to year and oscillates between wetter and drier conditions within multi-year and multi-decade timescales. While average climate may be associated with the physical condition, distribution, or population dynamics of many species, extreme climate may be equally if not more relevant for explaining these factors (Zimmermann et al. 2009, Siegmund et al. 2016, Germain and Lutz 2020, Stewart et al. 2021). Acclimation can affect the tolerances of many organisms, including plants, to extreme environmental conditions (Gerken et al. 2015, Nievola et al. 2017). Little information about the climate tolerances of western Joshua tree is known; however, some inferences and assumptions have been made by examining available information about average climatic conditions during all or a portion of the 20th century within the species' range. These assumptions have primarily been used for species distribution models, which are described in more detail in the Climate Change section of this Status Review. While examining 20th century suitable climate conditions within the known range of the species undoubtedly provides insight into the species' climate tolerances, average climate conditions from a single century (or portion thereof) are not entirely representative of the climate conditions and climate variability that western Joshua tree has endured in the past or can endure in the future.

Precipitation

As in many desert regions, the magnitude and seasonality of precipitation is a principal driver of ecosystem processes (Holmgren et al. 2006), and precipitation is likely a critical factor for understanding what constitutes western Joshua tree habitat. Precipitation provides water for plants to absorb immediately and may also replenish underground moisture that plants may utilize later in the season via roots. With extensive root systems and moisture stored in tissues, adult Joshua trees are somewhat resilient to periods with little precipitation. Juvenile Joshua trees and seedlings, on the other hand, cannot access deep groundwater and cannot store as much water in their tissues, and are therefore more dependent on regular precipitation for their establishment and survival. The intensity and duration of droughts and periods of relatively high precipitation are likely important factors in determining where western Joshua trees can survive and reproduce. Recent drought in the Mojave Desert, and the predicted effects of climate change in the region are discussed further in the Climate Change Regional Effects section of this Status Review.

In areas where western Joshua trees occur, precipitation is received in the form of rain and less frequently snow. Most precipitation occurs between October and April, and May and June are consistently dry, accounting for less than five percent of average annual precipitation (Hereford et al. 2004). Isolated thunderstorms are possible in summer (typically July-September), and more of these summer thunderstorms occur in the eastern part of the Mojave Desert than in the western part (Hereford et al. 2004). Precipitation across the Mojave Desert region is highly variable from year to year and oscillates between wetter and drier conditions within multi-year and multi-decade timescales. During the period of 1893 to 2001 annual precipitation averaged across the Mojave Desert region ranged from as low as 34 mm (1.3 in) in one year to as high as 310 mm (12.2 in) in another year, with an average annual precipitation across all 108 years of 137 mm (5.4 in) (Hereford et al. 2004, 2006). During the 108-year period studied, Hereford et al. (2006) and Tagestad et al. (2016) identified multi-year or multi-decade periods of drought or otherwise predominantly dry conditions with contrasting multi-year or multi-decade periods that had above average precipitation (Figure 5). Although the dataset presented by Hereford et al. (2004) (and shown in Figure 5 of this Status Review) ends in 2001, the early 21st century has been a period of predominately dry conditions in the Mojave Desert (Khatri-Chhetri et al. 2021). This interannual variation and longer-term oscillation of relatively wet and relatively dry conditions are likely the result of global-scale climate fluctuations including the El Niño-Southern

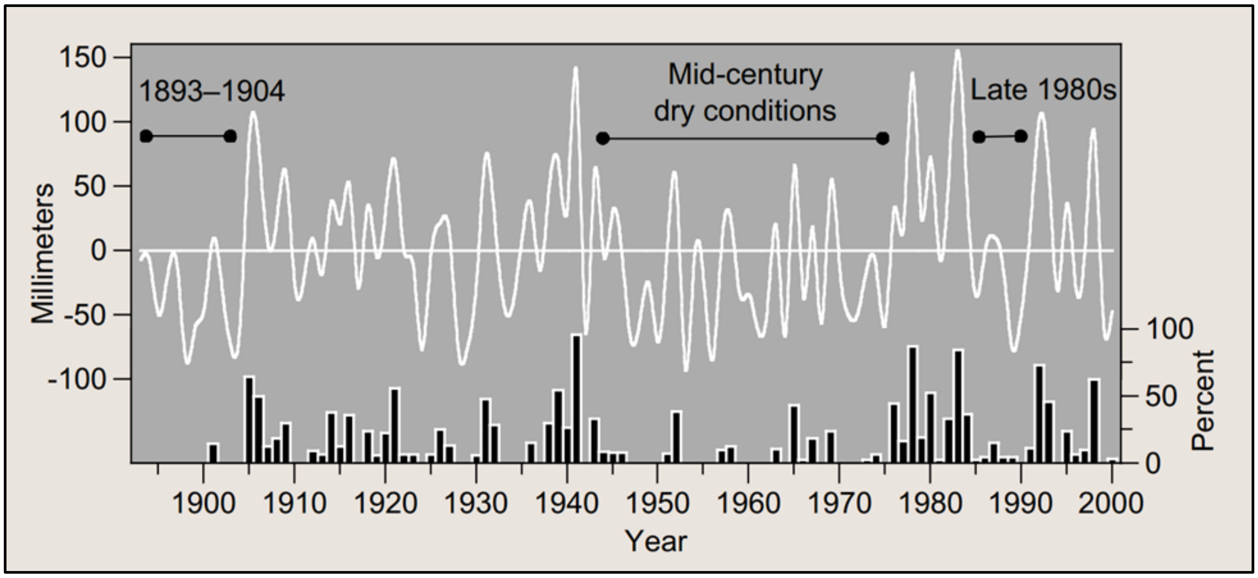


Figure 5: Average Deviation of Annual Precipitation in the Mojave Desert Region, 1893 to 2001 (Source: United States Geological Survey, Hereford et al. 2004).

Oscillation and the Pacific Decadal Oscillation (Cayan et al. 1998, McCabe and Dettinger 1999, Mantua and Hare 2002). The El Niño-Southern Oscillation may result in sea surface temperatures that may or may not result in anomalously wet or dry conditions across the Mojave. El Niño sea surface temperatures can often result in relatively wet winters, La Niña sea surface temperatures can often result in relatively dry winters, or there may be years that are considered neither El Niño nor La Niña. Analysis by Hereford et al. (2006) suggests that Mojave Desert precipitation oscillates between wetter and drier conditions irregularly, but with each successive wet winter event occurring an average of 4.8 years after the previous wet winter event. The Pacific Decadal Oscillation may also result in sea surface temperatures that result in decades-long periods of relatively wet or relatively dry conditions in the Mojave Desert, with each condition lasting for periods of two to three decades.

The timing and minimum amount of precipitation necessary for adult western Joshua tree survival, or for the germination and establishment of western Joshua tree seedlings is not currently known, but the available life history information suggests that seedlings require periods with regular precipitation to establish, and therefore it is likely that wet winter El Niño conditions, combined with longer-duration wet periods of the Pacific Decadal Oscillation provide the best chance for germination and establishment of western Joshua tree seedlings. In one monitoring plot at Cima Dome in Mojave National Preserve, Cornett (2018b) found that survivability (percentage of trees that survived since previous year) of eastern Joshua tree plants was moderately correlated with annual precipitation ($r = 0.51$, $P = 0.01$). Western Joshua tree is somewhat more abundant in the western Mojave Desert, where summer thunderstorms and precipitation are less common, and therefore western Joshua trees in the western Mojave Desert receive a greater proportion of their annual precipitation in the winter (Hereford et al. 2006). The amount of precipitation required for western Joshua tree likely varies depending on life history stage, and is also likely dependent upon a multitude of contributing factors including soil texture, ambient temperatures, local topography, elevation, and the presence and cover of other plants.

Climatic water deficit is a metric that has been correlated with vegetation distribution across many spatial scales, can be used to quantify the drought stress on plants in an area, and is generally considered to be a much more biologically meaningful metric than precipitation alone (Stephenson 1998). Climatic water deficit is defined as the amount of water that could have evaporated or been utilized by plants in an area (this is called potential evapotranspiration), minus the water that actually evaporated or was utilized by plants in an area (actual evapotranspiration). These metrics are less intuitive to understand than precipitation and temperature on their own, but they are affected by several abiotic factors that are important for plants, including soils, and the slopes and aspects of terrain, in addition to the timing and durations of precipitation, temperature, and solar radiation. Low elevation warm desert areas tend to have high climatic water deficits, and these deficits often decrease with increasing elevation.

Precise information on the climatic water deficits that western Joshua trees are able to tolerate, and the timing and amount of precipitation necessary for western Joshua trees to establish and survive are not directly known and are likely dependent on a number of factors. Nevertheless, some inferences may be made by examining available information on previous climatic conditions within the known range of the species. Much of the species distribution modeling work for western Joshua tree discussed in the Species Distribution Models section of this Status Report utilizes information on 20th century suitable climate conditions to make assumptions regarding the conditions necessary for western Joshua tree survival and establishment in the future.

High Temperatures

Smith et al. (1983) tested the thermal tolerances of western Joshua tree by subjecting leaves to temperature treatments, with results suggesting that the high temperature limit is 57°C (135°F), at which point photosynthetic functions are impacted. Although such high air temperatures are not expected to occur in areas with western Joshua tree in the foreseeable future, thermal tolerances in laboratory settings are different than thermal tolerances in the natural environment, which are confounded by a number of factors including but not limited to duration of exposure, water availability, and exposure to wind. High temperature alone may not be a direct physiological limit on western Joshua tree survival, but extreme high temperatures may nevertheless limit the distribution of the species, perhaps by contributing to climatic water deficit of an area, and other physiological stresses, particularly water stress, and therefore high temperatures likely limit the distribution of western Joshua tree indirectly.

St. Clair and Hoines (2018) found positive correlations between temperature and Joshua tree flower and seed production, suggesting that warming may positively affect Joshua tree reproduction. However, increased seed production would also depend on adequate pollination by *T. synthetica* under warmer climatic conditions. St. Clair and Hoines (2018) also found negative relationships between temperature and Joshua tree stand density, and suggested that there may be potential constraints of warmer temperatures on establishment success. Reynolds et al. (2012) found greatest seedling emergence occurred during spring and summer when warm soil temperatures were accompanied by increased soil moisture.

Low Temperatures

Smith et al. (1983) found the low temperature thermal tolerance of western Joshua tree to be approximately -6°C (21°F), which is a temperature that is reached in some areas of western Joshua tree's range, and may therefore be a limit on the distribution of the species in colder and higher elevation areas. Went (1957) published data demonstrating that after a Joshua tree has reached a certain age the plant requires exposure to low temperatures for optimal growth. This suggests that while extreme cold may be a limit on distribution, cold winter periods may be an important component for Joshua tree growth (Turner 1982).

Loik et al. (2000a) examined the effects of approximately doubled carbon dioxide (CO_2) levels (similar to what is expected globally at the end of the 21st century) and low temperatures on Joshua tree seedlings, and found that low-temperature tolerance was enhanced for Joshua tree seedlings maintained in the elevated CO_2 environment. Loik et al. (2000a) found that western Joshua tree seedlings that were acclimatized to low temperatures were better able to survive extreme low temperature events. Dole et al. (2003) utilized the work of Loik et al. (2000a) by incorporating the effects of elevated CO_2 levels on low temperature tolerance into a species distribution model for Joshua tree, which is discussed under the Species Distribution Models section of this Status Review.

ABUNDANCE AND TRENDS IN CALIFORNIA

Abundance

For the purposes of this Status Review abundance is defined as the number of individuals that are present overall, and density is the number of individuals that are present per unit of area. Western Joshua tree is currently relatively abundant in

California. Plant abundance can be quantified via a complete census of plants or estimated via statistical sampling. It is challenging to accurately estimate the size of plant populations that are patchy, occur at varying densities, or that occur over large geographical areas, and the western Joshua tree population has all of these characteristics. Estimates of the abundance of western Joshua tree therefore have a high amount of uncertainty associated with them.

As shown in Figures 2 and 3, western Joshua tree is widespread in the western Mojave Desert, and its range extends north into the southwestern Great Basin. Based on vegetation mapping data possessed by the Department, and as described in the Current Distribution section of this Status Review, western Joshua tree woodland could occupy an area within California of approximately 10,160 km^2 (3,920 mi^2) to 13,880 km^2 (5,360 mi^2), and additional areas that are not currently mapped could have lower densities of western Joshua trees, increasing the area occupied by the species. The USFWS (2018) estimated that the area occupied by western Joshua tree was 22,823 km^2 (8,812 mi^2), but this estimate included areas outside of California. WEST Inc. (2021a) used data from Cole et al. (2011) to report the area occupied by western Joshua tree as 15,071 km^2 (5,819 mi^2), but WEST Inc. (2021b) later reported that this estimate was only for the southern part of the species' range, and the northern and southern portions of the species' range together occupy an area of approximately 23,101 km^2 (8,919 mi^2), although this combined area likely includes areas outside of California. Within the areas occupied by western Joshua tree, the density of individuals varies widely. Some areas of the Mojave Desert have scattered Joshua trees at very low densities, while other areas have dense stands of trees.

WEST Inc. (2021a) used an analysis of aerial imagery to estimate the density of western Joshua trees within the species' southern range, and corrected for undercounting using density data from areas that were censused for western Joshua tree as part of renewable energy projects. WEST Inc. (2021a) used similar methods to separately estimate the density of western Joshua trees near the edges (± 5 km) of the area evaluated. This was done in an effort to make a more accurate estimate since the perimeter of the species' range was expected to have a generally lower density of plants than other portions of the range. WEST Inc. (2021a) estimated an overall western Joshua tree density of 4.27 to 7.04 trees per ha (95% confidence) within its southern range. Although the estimate from WEST Inc. (2021a) is only for the southern range of the species, it is likely the most accurate estimate of overall western Joshua tree density available. WEST Inc. (2021b) later revised their estimation methods to account for the effects of historical wildfire, but WEST Inc. did not provide the revised density estimates.

More localized estimates of western Joshua tree population density have also been made, ranging from 3.2 to 280 western Joshua trees per hectare. Esque et al. (2010)

examined 50 random plots containing at least one Joshua tree in Joshua Tree National Park and 50 random plots containing at least one Joshua tree in Death Valley National Park and found high variability in western Joshua tree density. Esque et al. (2010) reported an average density of 95.2 western Joshua trees per ha in Joshua Tree National Park and an average density of 62 Joshua trees per ha in Death Valley National Park. St. Clair and Hoines (2018) collected demographic information from ten different Joshua tree sites distributed across the Mojave Desert. Five of the sites were within the range of western Joshua tree, and three of those were within California. Western Joshua tree population density varied by more than an order of magnitude from 20 trees per ha in the eastern portion of Joshua Tree National Park to 280 trees per ha at Walker Pass, California. The average density of the five western Joshua tree sites studied by St. Clair and Hoines (2018) was 140 trees per ha. Rowlands (1978) recorded densities of Joshua trees at 21 stands throughout the range of eastern and western Joshua tree. Eight of these sites were within the range of western Joshua tree, and these had an average density of 81 trees per ha. It is unlikely that the density data from St. Clair and Hoines (2018) and Rowlands (1978) were intended to be representative of the entire California range of western Joshua tree, particularly areas with very low densities of trees. Sweet et al. (2019) reported densities of western Joshua tree at 14 nine-hectare macroplots within and near Joshua Tree National Park in 2016 and 2017, which were highly variable and ranged from 5.3 to 62.4 trees per ha. Densities of 3.2 and 33.9 western Joshua trees per ha have been reported to the Department at a preserve near Red Rock Canyon State Park and a preserve east of the North Haiwee Reservoir, respectively (Natural Resources Group, Inc. 2021). Despite the limitations of the estimates described above, they do provide information on possible densities of western Joshua tree.

Estimates indicate that the abundance of western Joshua tree is currently relatively high, but there is high uncertainty in estimates of population size due to both the uncertainty of density estimates, and uncertainty regarding how much area is occupied by the species. Assuming that the average density of western Joshua trees in all age classes in California is between 4.27 and 7.04 trees per ha (427 to 704 trees per km^2) (WEST Inc. 2021a), and the area occupied by western Joshua tree in California is between 10,160 km^2 and 13,880 km^2 (see Current Distribution section of this Status Review), there could be between 4.3 million and 9.8 million western Joshua trees in California (all age classes). An analysis by WEST Inc. (2021a) concluded that there are between 6.5 million and 10.6 million western Joshua trees, but this estimate appears to have only been for the southern part of the species' range and did not take into account population reductions due to wildfires within the previous 100 years (WEST Inc. 2021b).

The Department also made a separate estimate of the number of adult western Joshua trees within California via stratified random sampling of aerial imagery. The resolution of the aerial imagery used (Google 2021) varied and we were unable to accurately recognize and count short and unbranched trees via aerial imagery, and no ground-truthing was conducted. The Department's estimates are therefore representative of taller adult trees, and not representative of all western Joshua trees like the density estimates previously described in this section of the Status Review. We randomly placed 150 circular 4-ha sampling plots entirely within mapped vegetation polygons containing western Joshua tree in California. We stratified these 150 sampling plots (50 per strata) within vegetation polygons with three different cover classes of western Joshua tree (>0%-1%, >1%-5%, and >5%) as identified on vegetation maps possessed by the Department. Cover class information was not available for 8% of the mapped area containing western Joshua tree and we had difficulty discerning individual trees in areas with abundant clonal growth. Based on the Department's stratified random sampling estimates, the average sample density across all areas and cover classes was approximately 3.1 to 3.5 adult western Joshua trees per ha (95% statistical confidence based on the methods in Elzinga et al. (1998)). Applying this estimate of adult western Joshua tree density to an estimated range of area that could be occupied by western Joshua tree within California (10,160 km^2 to 13,880 km^2) suggests that there could be between 3.1 million and 4.9 million adult western Joshua trees in California that are discernable via aerial imagery.

Population Trends

This section of the Status Review provides information on population trends of western Joshua tree from the past to the present. Discussion of western Joshua tree population trends that may occur in the future is provided in the Factors Affecting the Ability to Survive and Reproduce section of this Status Review. Population trends may be measured directly, inferred from demographic information, or indirectly inferred from fossil evidence or environmental impacts that have occurred in the past. Population trends can be an important predictor for extinction risk (O'Grady et al. 2004). Based on the available information, the Department concludes that development and other human activities which began with European settlement during and before the 19th century have resulted in the greatest decline in the number of western Joshua trees in California. Available information on Joshua tree population trends prior to European settlement is provided in the following section.

Inferred Long-term Trends

Genetic signatures suggest that western Joshua tree had a large population growth and range expansion into the Sonoran and Great Basin deserts from the Mojave Desert beginning about 200,000 years before present (Smith et al. 2011). Studies have made contradictory conclusions about Joshua tree's population trend over the past 20,000 years. Fossil evidence indicates that Joshua tree was more widespread during the late Pleistocene period (22,000 to 13,000 years before present) than it is today, with its range at that time extending south of its present range farther into southern California and Arizona, and likely also into northwestern Mexico, however a larger range does not necessarily mean that abundance was also higher (Rowlands 1978, Holmgren et al. 2010, Cole et al. 2011, Smith et al. 2011). Cole et al. (2011) noted that after a rapid warming of approximately 4°C in winter minimum temperatures in the Grand Canyon and 4°C increase in mean annual sea surface temperature off the coast of Northern California over an approximately 50-year period at the beginning of the Holocene period (approximately 11,700 years ago), available fossil records suggest that the range of Joshua tree contracted from the south over the following 3,700 years until the current southern range extent was reached. The apparent reduction in Joshua tree range from the late Pleistocene period to modern times suggests the population trend of Joshua tree across its entire range has been in decline. However, Smith et al. (2011) found no indication of dramatic Joshua tree population declines since the last glacial maximum approximately 21,000 years before present and suggested that habitat loss in the southern part of the Joshua tree's range may have been offset by the addition of new habitat in the north.

More recently, populations of western Joshua tree within California have declined following European settlement of the Mojave Desert region, primarily due to habitat loss and degradation related to agricultural conversion and development. It is difficult to quantify the magnitude of this population decline because there has been no long-term range-wide population monitoring, and the distribution of western Joshua tree prior to European settlement is not completely known. Nevertheless, western Joshua trees were removed from the Mojave Desert region as a result of human activities and continue to be removed to this day. Prior to 1920 and ending in the 1980s, much of the western portion of the Antelope Valley was utilized for alfalfa production (Borge 2018; Historic Aerials 2021), likely resulting in a widespread decline of western Joshua tree individuals as the desert was cleared for agricultural use. Figure 4 shows conspicuous areas where western Joshua tree is absent from western Antelope Valley and near the metropolitan areas of Palmdale and Lancaster, and these areas approximately overlap the same locations as current and historical agricultural activity and developed land use. These areas likely supported substantially more western Joshua trees in the past, as did other population centers and agricultural areas in western Joshua tree's range, such as Victorville, Hesperia, and Yucca Valley. Based on historic aerial imagery from the mid-20th century (Historic Aerials 2021) and presumed general distribution of western Joshua trees prior to European settlement, the Department estimates that approximately 30% of the habitat occupied by western Joshua tree in California may have been modified between European settlement and the present. While the historical densities of western Joshua tree in the areas of agricultural conversion and development are not known, the loss in number of individuals may have been somewhat proportional to the area of habitat lost. Information from aerial photography and the United States Geological Survey National Land Cover Database also show continuing land development within western Joshua tree habitat in the cities of Palmdale, Lancaster, Yucca Valley, Joshua Tree, Twentynine Palms, Victorville, Hesperia, and Apple Valley from 1984 to 2021, with many fragmented and isolated blocks of open space likely containing western Joshua tree (Krantz pers. comm. 2021, Appendix B). Despite the loss of a substantial number of western Joshua tree individuals from habitat loss since European settlement, the range (general geographical area in which the species occurs) in California appears to have remained more or less unchanged, with fragmented populations remaining in Antelope Valley and near the metropolitan areas of Palmdale and Lancaster, and dense stands remaining to the west of the areas presumed to have suffered the most serious historical habitat loss (see Figure 4). Habitat fragmentation is discussed further in the Development and Other Human Activities section of this Status Review.

Photographic evidence has shown various changes to western Joshua tree populations that are unrelated to direct tree removal and habitat loss. Historical photographs have been used to compare current and past conditions of western Joshua trees in some areas of California and Nevada (Cornett 1998), and a number of photographic monitoring plots were also established in Nevada in 1964 (Webb et al. 2003). Photo monitoring provides a view into the past that can be used to make direct comparisons, and photos have shown a range of changes to western Joshua tree populations including mortality of individuals, increases in individual plant size and number of branches, changes in vegetation composition, and migration into areas that appeared to be previously unoccupied (Wallace and Romney 1972, Webb et al. 2003). While localized observations from repeat photo monitoring can provide insights, they are not necessarily representative of landscape-wide trends.

Direct Population Monitoring

Recruitment is rare for many perennial plants in the Mojave Desert (Cody 2000), which provides a challenge for direct population monitoring. In addition to rare recruitment, western Joshua tree has a long generation time (see the Growth and Longevity section of this Status Review), and plants are long-lived. As a result, the population dynamics for western Joshua tree take place over long timescales and monitoring them directly requires planning and a long-term perspective. Very little long-term monitoring data for western Joshua tree is currently available. The quantitative monitoring data that are available span less than one full generation of the long-lived species (few monitoring efforts have reported data spanning a period greater than 30 years), and provide only a narrow view of population dynamics. Furthermore, the available long-term monitoring efforts for western Joshua tree lack replication and typically consist of only one small (typically 1 ha) plot per location without any replicates that would allow the results to be extrapolated to larger areas. Population trends from available direct population monitoring of western Joshua tree are not uniform, but several plots have shown declines in abundance, and little recruitment in plots has been observed. Trends in recruitment are discussed in more detail in the Demographic Information section of this Status Review.

Early monitoring plots were established, and data were collected from several locations within Joshua Tree National Park in the 1970s; however, attempts by Joshua Tree National Park staff to revisit and recollect data from these plots has not been possible because staff have been unable to replicate the original methods to collect comparable data (Frakes 2017b, Frakes pers. comm. 2021).

Comanor and Clark (2000) collected monitoring data from 1975 to 1995 from three circular 0.1-ha plots containing Joshua trees, but only two of these three plots had western Joshua tree and only one of those plots was in California. That plot was near Victorville at a relatively low elevation of 875 m (2,870 ft). Over the monitoring period from 1975 to 1995, the number of western Joshua trees in the Victorville plot remained the same (21 plants), and no recruitment was evident (Comanor and Clark 2000). Similarly, the number of Joshua trees in the other two plots examined by Comanor and Clark (2000) remained largely unchanged over the 20-year monitoring period.

Cornett (2009, 2012, 2013, 2014, 2016, 2020) established 1 ha monitoring plots in the late 1980s and mid-1990s at different western Joshua tree populations in the Mojave Desert and began collecting periodic data on western Joshua trees within those plots, with monitoring results spanning between 18 and 23 years. Western Joshua tree population declines were observed at the monitoring plot in Saddleback Butte State Park (Cornett 2016), Red Rocks Canyon State Park (Cornett 2020), and in the three monitoring plots within Joshua Tree National Park (Cornett 2009, 2012, 2014). The western Joshua tree population increased at the monitoring plot at Lee Flat in Death Valley National Park (Cornett 2013).

DeFalco et al. (2010) monitored western Joshua tree at five pairs of burned and unburned sites in Joshua Tree National Park from 1999 to 2004, to study post-fire effects. DeFalco et al. (2010) found that plants in burned plots declined by 80% at the end of the study, and plants in unburned plots declined by 26%, with drought likely increasing the decline in both burned and unburned plots during the monitoring period.

Barrios and Watts (2017) conducted a geographic information system (GIS) analysis of western Joshua tree population trends on Edwards Air Force Base from 1992 to 2015, focusing on area occupied by western Joshua trees as a proxy for the number of trees.

The report identified 18,673 ha (46,142 ac) as containing Joshua trees in 1992, 28,408 ha (70,198 ac) containing Joshua trees in 2008, and 32,508 ha (80,329 ac) as containing Joshua trees in 2015; however, the resolution of methods used for quantifying the number of trees improved greatly over time; 1992 (photogrammetry) methods were substantially different than the methods used in 2008 (LIDAR with 1.0-meter spot spacing) and in 2015 (LIDAR with 0.33-meter spot spacing). The different methodologies used, the known life history characteristics of the species, and a number of other factors identified by Barrios and Watts (2017) cast significant doubt on the validity of the reported 74% expansion of area occupied by western Joshua tree at Edwards Air Force Base between 1992 and 2015. This increase in area occupied may instead be better explained by technological advances that substantially increased the ability to detect western Joshua trees.

Gilliland et al. (2006) monitored a group of eastern Joshua trees by collecting demographic data from 77 trees at two-year intervals from 1987 through 2001. During the 14 years of the study, 8 of the 77 trees died, and Gilliland et al. (2006) did not report the establishment of any new eastern Joshua trees.

Several additional efforts to monitor Joshua tree populations have been initiated more recently and are discussed in the Management Efforts section of this Status Review. These monitoring efforts will likely provide additional direct population monitoring data in the future.

Demographic Information

The demographics of western Joshua tree are closely tied to the life history requirements of the species which are described in the Life History section of the Status Review. Important components in the life history of western Joshua tree include seed production, dispersal, and germination, seedling establishment, plant growth, sexual reproduction, asexual reproduction, long-term survival, and mortality of individuals. If comprehensive demographic data are available, it may be possible to use those data to provide insight into both the past and possible future demographic structure and size of populations (Brook et al. 2000). Demographic data can also be used to conduct population viability analyses to assess risk of extinction for populations or species (Chaudhary and Oli 2020), however no population viability analyses have been published for western Joshua tree. Demographic data that are not comprehensive nor collected in a systematic randomized sample should not be used to make statistical inferences about western Joshua tree populations on a larger population or species-wide scale. The Department does not currently have data on mortality levels of western Joshua tree across its range and similarly does not have data on the amount of recruitment that may be needed to maintain populations of western Joshua tree. Mortality and recruitment likely vary with the location and density of populations.

Because the Department does not have demographic data on current levels of mortality and recruitment and does not have data on the minimum amount of recruitment needed to maintain populations, many of the conclusions presented below on future population trends are somewhat speculative. Nevertheless, demographic information from the studies and other sources described in this Status Review provides the best available evaluation of western Joshua tree population trends in the late-20th century and may provide insight into possible future demographic structure and size of western Joshua tree populations.

Given the relatively long lifespan of western Joshua tree, the window for western Joshua tree reproduction is many decades long, and with the high abundance of existing populations the species may also be able to recruit a high number of individuals during favorable conditions, such as during multi-year or multi-decade periods of above-average precipitation described in the Precipitation section of this Status Review. On the other hand, multi-year or multi-decade periods of below-average precipitation in the future could also lead to periods of low recruitment and high mortality of adults. If recruitment does not keep pace with mortality, population sizes will decline.

Tree height is the most practical character to use for estimating Joshua tree age, and data from tree height surveys at a single point in time can provide insight into the current demographic structure of an area, an estimate of when trees were recruited into the population, and the trend of the population based on the relative numbers of plants in different Joshua tree age cohorts. Populations of Joshua trees that are increasing or sustainable at current population levels would be expected to have high numbers of young plants, decreasing numbers of older plants, and relatively few very old plants.

Although tree height is the best proxy to use for tree age, there are some limitations. The smallest size class is often underestimated because seedlings that are obscured beneath the canopies of other plants are very difficult to see, and researchers often note the difficulty in finding Joshua tree seedlings (Webber 1953, Wallace and Romney 1972, Comanor and Clark 2000, Esque et al. 2010, Reynolds et al. 2012). This limitation makes it problematic to utilize tree height data to identify relatively recent trends involving seedling establishment and early growth. It is therefore difficult in the short term to detect both periods of high seedling establishment and periods where little or no seedling establishment is taking place. Furthermore, the abundance of the youngest class of long-lived plants such as western Joshua tree are expected to fluctuate because seedling establishment is episodic. Nevertheless, seedlings that may initially be difficult to detect eventually become tall enough to be easily seen, with Cornett (2013) suggesting that it may take a minimum of three years for seedlings to become readily detectable. As trees get older, growth rates are affected by microhabitat and other factors, and distinct cohorts of trees that germinated near the same time may become less well-defined by height.

The Department does not possess a comprehensive random field sample of western Joshua tree heights across the species' range in California, and therefore the overall demographic trend of western Joshua tree in California is not currently known. The Department has, however, received western Joshua tree height information that is related to recently proposed development projects, and information that has been published or summarized in various scientific papers and reports. Demographic information based on western Joshua tree height from various locations is discussed in the following paragraphs and summarized at the end of this section.

In 2007, the National Park Service and U.S. Geological Survey established 50 randomly-placed 0.25 ha monitoring plots within the range of western Joshua tree in both Joshua Tree National Park and Death Valley National Park to collect initial demographic data and eventually monitor long-term trends of the species (Esque et al. 2010). The National Park Service and U.S. Geological Survey also established plots on National Park Service land within the range of eastern Joshua tree. The size distribution of Joshua trees reported in Esque et al. (2010) was aggregated among sampling locations within the range of both western Joshua tree and eastern Joshua tree and is typical of what would be expected for sustainable or increasing populations of long-lived plant species, e.g., generally large numbers of plants in the smaller size classes, moderate numbers of middle-sized plants, and greatly reduced numbers of the largest and oldest plants. Based on the information presented by Esque et al. (2010), which does not isolate height data on western Joshua tree by National Park Service Unit, Joshua tree populations on National Park Service lands appear to be sustainable, with large numbers of trees in younger age classes that may be able to replace the number of trees in the larger height classes, even if many of these smaller plants die.(see data specific to Joshua Tree National Park from St. Clair and Hoines (2018)). For a development project near the city of Hesperia, the Department also received western Joshua tree height data (Figure 6) showing a size distribution that is similar to the results presented by Esque et al. (2010), typical of what would be expected for a sustainable or increasing population of a long-lived plant species. The smallest 0-0.5 m height category of Figure 6 may represent a recent decline in seedling establishment, and/or it may be partially the result of underestimating seedlings, as discussed earlier in this section; however, the large numbers of trees in the younger age classes may still be able to replace the number of trees in the larger height classes, even if many of these smaller plants die.

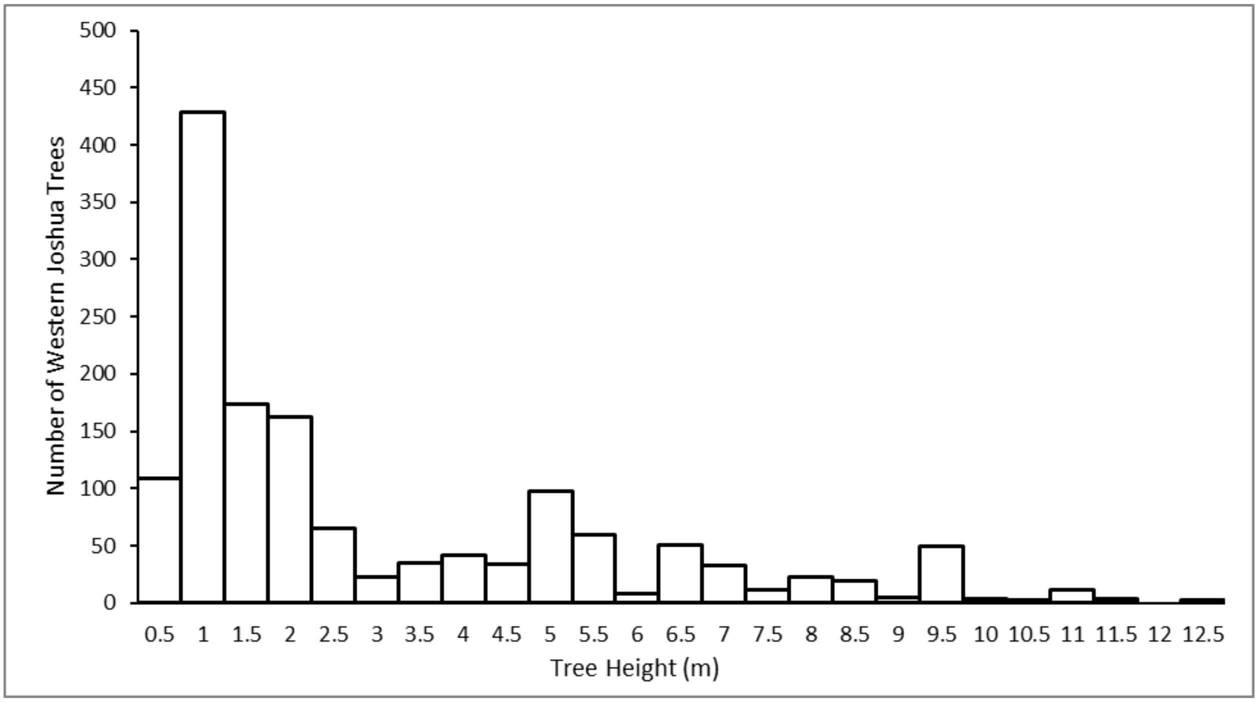


Figure 6: Heights of western Joshua trees in 2021 at a development project site near Hesperia (unpublished data from incidental take permit application to the Department)

The Department also aggregated western Joshua trees size class data reported for 11 recent solar energy development project sites in Kern County. Three broad size classes were reported for 222,073 western Joshua trees. Forty-four percent of trees were less than 1 m tall, 55% of trees were between 1 and 5 m tall, and 1% of trees were 5 m or greater in height. While these data are not as detailed as the height data presented in Figures 6, 7, and 8, the aggregated demographic structure in the form of tree height from these 11 project sites appears to be representative of relatively sustainable populations of western Joshua tree, with nearly half of the trees measuring under one meter tall, suggesting that they established in the early 1990s. The Department also received size class information for western Joshua trees at a preserve near Red Rock Canyon State Park which appears to be representative of a relatively sustainable population of western Joshua trees, with 83 percent of the trees measuring under one meter tall, suggesting that they established in the early 1990s (Natural Resources Group, Inc. 2021). The Department also received size class information for western Joshua trees at a development project site west of Adelanto and a mining project south of Lucerne Valley that appear to be representative of relatively sustainable populations of western Joshua tree. The demographic structure reported by Gilliland et al. (2006) for eastern Joshua tree was also broadly similar to that reported by Esque et al. (2010), with more trees in younger, smaller size classes than in older and larger size classes.

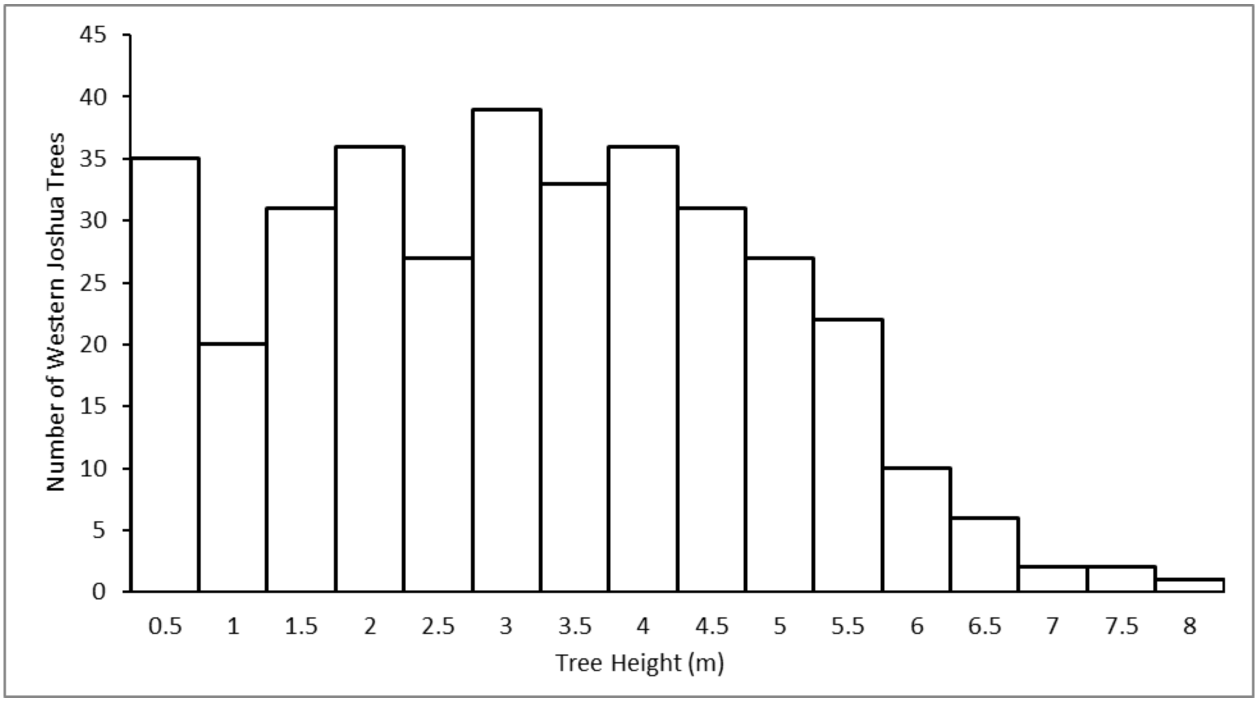


Figure 7: Heights of western Joshua trees in 2013 from three sampling locations in California (data from St. Clair and Hoines (2018))

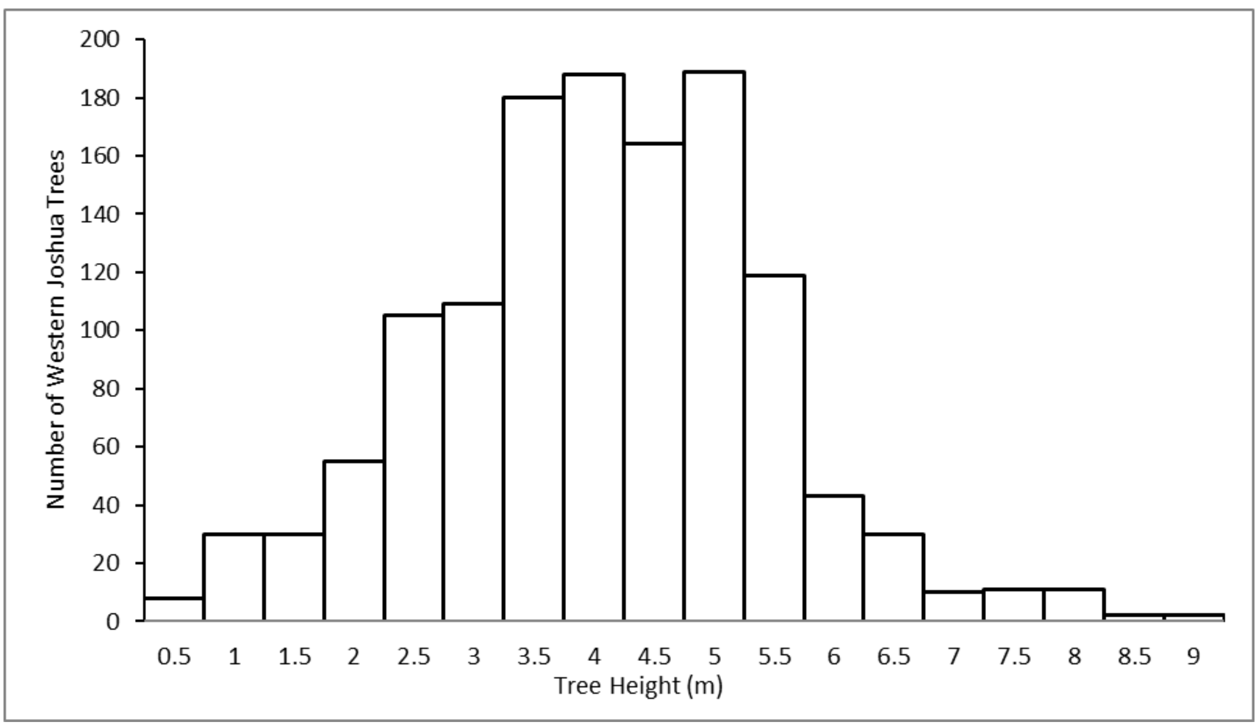


Figure 8: Heights of western Joshua trees at six development project sites near the cities of Palmdale and Lancaster in 2021 (unpublished data from incidental take permit applications sent to the Department)

A Joshua tree height dataset was made available by St. Clair and Hoines (2018) that consists of demographic information randomly collected from ten different Joshua tree sites distributed across the Mojave Desert. At each site, data were collected from 20 trees at each of six transects that were placed at one km intervals, so that 120 trees were sampled at each site. Five of the sites were within the range of western Joshua tree, and three of those were within California (Walker Pass, western Joshua Tree National Park, and eastern Joshua Tree National Park). While these three sites are not representative of the entire California range of western Joshua tree, they do provide a small sample of demographic data. The height of western Joshua tree at the three sites within the California range of western Joshua tree is presented in Figure 7. Unlike the tree height data shown in Figure 6 and the tree height data reported by Esque et al. (2010), St. Clair and Hoines (2018) found relatively fewer western Joshua trees in the younger (i.e., shorter tree height) categories, meaning there would need to be less mortality among the younger trees for them to be able to replace the older trees (there are fewer trees in the 0-0.5 m height class than the 2.5-3 m height class, which has the highest number of trees in Figure 7). Of the three western Joshua tree sites evaluated by St. Clair and Hoines (2018) in California, the eastern Joshua Tree National Park site had the lowest recruitment and the Walker Pass site had the highest recruitment. Assuming an average growth rate of 3-4 cm per year (Comanor and Clark 2000, Gilliland et al. 2006, Esque et al. 2015), these data from Clair and Hoines (2018) suggest a decline in western Joshua tree establishment since perhaps the 1950s. This decline may have been due, in part, to the mid-20th century dry conditions illustrated in Figure 5 and other factors discussed in this Status Review. The demographic structure of Joshua tree populations sampled by St. Clair and Hoines (2018) does not appear to be as sustainable as that reported for lands managed by the National Park Service; nevertheless, western Joshua trees have continued to establish within California in recent decades. The Department also received size class information for western Joshua trees at a preserve in southwestern Inyo County that is somewhat similar to the size class information shown in Figure 7, suggesting a decline in western Joshua tree establishment at that preserve since perhaps the 1950s (Natural Resources Group, Inc. 2021).

WEST Inc. (2021a) used an analysis of aerial imagery from the National Agriculture Imagery Program combined with and corrected by field data from solar energy development project sites to estimate the number of western Joshua trees in the southern portion of the species' range in three broad size classes. The estimate by WEST Inc. (2021a) indicated that 21% of western Joshua trees were less than 1 m tall, 58% of trees were between 1 and 5 m tall, and 21% of trees were 5 m or greater in height. These estimates of tree height include uncertainty because they are statistically estimated and not direct counts of plants in the field. The estimate of trees in the smallest, less than 1 m tall size class has the highest amount of uncertainty due, in part, to the difficulty in discerning them via aerial imagery, and therefore the number of plants in the smallest size class may have been underestimated. Furthermore, the size classes reported by WEST Inc. (2021a) are not as detailed as the height data presented in Figures 6, 7, and 8. Unlike the tree height data shown in Figure 6, reported by Esque et al. (2010), and reported for 11 recent solar energy development project sites in Kern County, the estimates provided by WEST Inc. (2021a) had fewer western Joshua trees in the youngest size class of less than 1 m tall. Fewer western Joshua trees in the youngest size classes suggests that an overall decline in western Joshua tree establishment may have taken place in the southern portion of the species' range since at least the early 1990s and perhaps earlier, but western Joshua trees have nevertheless continued to establish.

Contrasting further with the information presented in Figure 6 and presented by Esque et al. (2010), western Joshua tree height data from six development project sites near urban areas of Palmdale and Lancaster in Los Angeles County were reported to the Department in 2021 and are presented in Figure 8. Again, assuming an average growth rate of 3-4 cm per year, these data suggest that relatively few western Joshua trees have established at these sites since perhaps the 1950s, and establishment has continued to decrease since that time. While this decrease may have been due, in part, to mid-20th century dry conditions illustrated in Figure 5, environmental degradation related to urban and agricultural development may have disrupted an important aspect of western Joshua tree life history (see the Summary of Important Life History Needs section of this Status Review) which contributed to the reduced ability of western Joshua tree populations to establish new plants at these project sites in recent decades.

With an increasing number of monitoring plots being established for Joshua tree and other desert vegetation (see the Management Efforts section of this Status Review), the understanding of western Joshua tree recruitment, mortality, population trends, and demographic structure is expected to improve substantially in the coming decades, improving understanding of the status of the species.

Summary of Demographic Information

Based on the information available to the Department, local populations of western Joshua tree are currently exhibiting short-term demographic trends ranging from apparent increase or stability to apparent decline, but there does not appear to be a uniform range-wide trend. Data from WEST Inc. (2021a) suggests that there may be an overall declining trend in western Joshua tree establishment in the southern portion of the species' range in recent decades; however, this interpretation of the data may not be accurate due to the methods used for the study and the high uncertainty in estimating the abundance of the youngest size class. Populations of western Joshua tree are showing signs of drastic short-term decline in recruitment at six development project sites near the cities of Palmdale and Lancaster in the southwestern part of the species' range. More gradual decline in recruitment can be seen at the three locations in California sampled by St. Clair and Hoines (2018), which includes two locations in Joshua Tree National Park in the southern part of the species' range, and at a preserve in southwestern Inyo County. Populations appear to be experiencing stable short-term recruitment levels at various locations throughout the species' range, including at a development project site near Hesperia (Figure 6), another development project site west of Adelanto, a mining project site south of Lucerne Valley, several solar energy development project sites in Kern County, a preserve near Red Rocks Canyon State Park, and lands managed by the National Park Service as reported by Esque et al. (2010). The recent demographic trend information available to the Department suggests that density or extent of some populations may decline by the end of the 21st century (2100), but due to continuing recruitment, high abundance, widespread distribution, and the longevity of the species, the available demographic data does not currently suggest that western Joshua tree is likely to be at risk of disappearing from a significant portion of its range during this timeframe.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Large Population Size and Widespread Distribution

As described in the Range and Distribution and Abundance Sections of this Status Review, western Joshua tree is widespread and abundant in California. The abundance and widespread distribution of western Joshua tree within California are significant factors affecting the ability of the species to survive and reproduce. The smaller a species' range, the higher the probability that disturbances and environmental changes will affect a large enough portion of the species' range to jeopardize its persistence. Species with large ranges therefore tend to be less vulnerable to extinction from disturbances, environmental changes, random events, and other threats than species with more limited ranges (Purvis et al. 2000, Harris and Pimm 2007, Gaston and Fuller 2009, Pimm et al. 2014, Leão et al. 2014, Newbold et al. 2018, Silva et al. 2019, Enquist et al. 2019, Staude et al. 2020).

Population size and trends are also important predictors for extinction risk (Shaffer 1981, Pimm et al. 1988, O'Grady et al. 2004). Populations with high abundance can suffer substantial losses and still remain viable. Species with large populations that occupy large environmentally variable regions also generally have higher genetic diversity than species restricted to smaller areas and, therefore, avoid many problems of smaller populations (Ellstrand and Elam 1993, Reed 2005, Hobohm 2014). Populations with high levels of genetic diversity are less likely to require rapid evolutionary adaptation or migration to more suitable locations in order to persist in the face of climate change. Populations containing more genetic variability are more likely to contain traits that are beneficial under changing conditions, increasing the likelihood of persistence in their current range (Hoffmann et al. 2005, Hoffmann and Sgro 2011, Stotz et al. 2021). Western Joshua tree's current range, distribution, and abundance are all evidence that the species has been able to adapt to or endure the range of climate conditions and climate variability that has occurred within the species' range since the late Pleistocene period (22,000 to 13,000 years before present), although the species' range shifted during this time, as described in the Inferred Long-term Trends section of this Status Review.

In assessing whether western Joshua tree should be listed under the federal ESA (16 U.S.C. §§ 1531-1544), the USFWS (2018, 2019) concluded that western Joshua tree has a relatively large population and distribution that covers a range of elevations with differing climatic conditions and soil types, and concluded that western Joshua tree had: (1) a high capacity to withstand or recover from stochastic disturbance events (resilience); (2) the ability to recover from catastrophic events (redundancy); and (3) ability to adapt to changing conditions (representation) as those terms are defined by Smith et al. (2018), however the USFWS findings for Joshua tree were set aside and remanded to the USFWS for reconsideration in 2021 as described in the Federal Endangered Species Act section of this Status Review.

The concept that widespread and abundant species are less vulnerable to extinction is also reflected in the methodologies used by international nonprofit organizations to objectively rank the vulnerability to extinction of species throughout the world. The two most widely used approaches for assessing the conservation status of species in North America are NatureServe's assessments which prioritize rarity in assessing extinction risk and the International Union for Conservation of Nature (IUCN) Red List which places a higher emphasis on trends (Frances et al. 2018). NatureServe considers the abundance and distribution of species, or rarity, to be more than twice as important as threats in assessing the conservation status of a species (Faber-Langendoen et al. 2012). The IUCN uses any of several criteria to assess and rank the status of species under their Red List, including: (A) significant population size reduction, (B) significant reduction in geographic range, (C) small population size and decline, (D) very small or restricted population, or (E) a quantitative analysis demonstrating probability of extinction (Mace et al. 2008, IUCN 2012). The abundance and distribution of many widespread species excludes them from consideration under many of the IUCN Red List criteria listed above unless significant declines have been observed or quantitative analysis demonstrates a probability of extinction within 100 years or less.

Climate Change

It is unequivocal that human influence has warmed the atmosphere, ocean, and land, and widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred (IPCC 2014, 2021). Global surface temperature will continue to increase until at least the mid-21st century under all emissions scenarios considered by the Intergovernmental Panel on Climate Change, and global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in emissions occur in the coming decades (Schwalm et al. 2020, IPCC 2021). While projected changes in climate may benefit some species, experimental and empirical evidence indicates that climate change is negatively impacting species and natural systems across the globe (Parmesan and Yohe 2003, Parmesan 2006, Scheffers et al. 2016), is increasing extinction risk (Warren et al. 2011, Nic Lughadha et al. 2020), and has already caused local extinction of some species (Wiens 2016). California's physical and biological systems have already been affected by climate change (Office of Environmental Health Hazard Assessment 2018, Iknayan and Beissinger 2018, Riddell et al. 2019). According to the California Global Warming Solutions Act of 2006, climate change is now considered one of the greatest threats to California's ecosystems, and over the 21st century, climate change will alter the fundamental character, production, and distribution of the ecosystems in California and elsewhere (Snyder et al. 2002, Snyder and Sloan 2005, California Energy Commission 2009, Shaw et al. 2011, Notaro et al. 2012, Garfin et al. 2013, Bedsworth et al. 2018). Climate change is a major challenge to the conservation of California's biological resources, and it will amplify existing threats and create new threats to natural systems.

Species distribution modeling efforts that have been conducted for Joshua tree so far and much of the climate change science available to the Department focus their predictions on conditions at the end of the 21st century (2100). Due to the high uncertainty in projecting the pace and magnitude of climate change and other threats in the 22nd century (after 2100), and the lack of available scientific information that contemplates such timeframes for the species, the Department cannot yet consider the range of the species in the 22nd century to be foreseeable. For the purposes of this Status Review, the Department considers the foreseeable future to be through the end of the 21st century (2100).

Regional Effects

Studies indicate that by the end of the 21st century California's climate will be considerably warmer than it is today, precipitation will become more variable, droughts will become more frequent, heavy precipitation events will become more intense, more winter precipitation will fall as rain instead of snow, snowpack will melt earlier in the year, and snowpack will be diminished (Leung et al. 2004, Hayhoe et al. 2004, Mote et al. 2005, Knowles et al. 2006, Garfin et al. 2013, Bedsworth et al. 2018, He et al. 2018). California is also vulnerable to climate fluctuations because it derives a large percentage of its water supply from a small number of large winter storms. These storms arise from "atmospheric rivers" which are long and narrow corridors of enhanced water vapor that are often associated with a low-level jet stream of an extratropical cyclone (Dettinger 2011, Dettinger et al. 2011).

The Mojave Desert and other regions of California where western Joshua trees grow are expected to become significantly hotter by the end of the 21st century, with daily average high temperatures in the Inland Deserts Region (all of Imperial County and the desert portions of Riverside and San Bernardino Counties) projected to increase by up to 4.5°C to 8°C (8°F to 14°F) at the end of the 21st century depending on future greenhouse gas emissions (Hopkins 2018), an increase that is greater than most other areas of California (He et al. 2018). Higher temperatures will exacerbate water stress on a region that is already limited by water availability. In areas supporting western Joshua tree the number of days with freezing temperatures is expected to go down (Sun et al. 2015).

Precipitation in areas with western Joshua tree is low, and highly variable from year to year, and this variability is projected to increase in the coming decades, with extreme droughts and extreme precipitation events both becoming more common (Hopkins 2018). The effects that climate change will have on overall average annual precipitation within the range of western Joshua tree is still uncertain, and projections suggest that there may be only slight changes, even under different emission scenarios (Allen and Luptowitz 2017, Hopkins 2018, He et al. 2018), or an overall drying pattern (Seager and Vecchi 2010), however water availability may nevertheless decrease as a result of increased temperatures and more precipitation falling as rain instead of snow. An analysis by Gonzalez (2019) found that approximately half of climate models evaluated project increased precipitation in Joshua Tree National Park at the end of the 21st century, and approximately half of the models project decreased precipitation, although higher predicted temperatures would tend to increase aridity. The Mojave Desert receives most of its average annual precipitation between October and April; however, a substantial amount of summer precipitation is also possible in the form of thunderstorms, with more summer precipitation falling in the eastern part of the Mojave Desert than in the western part (Hereford et al. 2004). According to some climate models, average winter precipitation (falling mainly in December, January, and February) may increase in the region (Allen and Luptowitz 2017), however, average precipitation from summer thunderstorms may decrease (Pascale et al. 2017). A 2021 study by Khatri-Chhetri et al. (2021) found that the Mojave Desert region is experiencing more frequent and severe drought conditions in recent years. In this study, both precipitation and temperature data were used in calculating the Standardized Precipitation Evapotranspiration Index (SPEI) which served as a proxy for drought. SPEI values from 1950 to 1999 were compared to SPEI values from 2000 to 2015 and it was shown that plant communities in the Mojave Desert experienced more drought stress during the 2000 to 2015 time period than the 1950-1999 time period. Based on this data, the authors concluded that the frequency and severity of dry periods are increasing in the 21st century. There may also be a slight reduction in wildfire ignitions due to lightning as a result of the reduced number of thunderstorms, although whether this will have any effect on wildfire risk is not known. Effects of climate change on oscillations between wetter and drier conditions within multi-year and multi-decade timescales are uncertain.

Direct Effects

The climatic conditions across western Joshua tree's range have already changed and will continue to change as a result of ongoing global greenhouse gas emissions. The Department expects that some of the effects of climate change described in the Regional Effects section of this Status Review (e.g., increased temperatures and decreased total water availability locally) will likely contribute to a decline in populations of western Joshua tree within California through the end of the 21st century; however, the extent to which the negative effects of climate change will impact the species' range, distribution, density, abundance, life history, and demographics as described in this Status Review in this timeframe is less clear. The primary reasons for the expected decline of populations of western Joshua tree within California may be the incremental contribution of climate change to high intensity and longer duration droughts, coupled with extreme high temperatures during the summer months, which may have direct physiological effects on western Joshua tree plants. These effects of climate change will likely reduce western Joshua tree seedling recruitment, and to a lesser extent also increase adult western Joshua tree mortality, leading to population declines as recruitment does not keep pace with mortality. Climate change may also contribute to the decline of populations of western Joshua tree via other more indirect mechanisms, including increased impacts from small mammals during drought, reduced growth due to lack of low winter temperatures, increases in fire activity, or effects on pollinating moths, which are discussed in more detail in the Indirect and Cumulative Effects, Wildfire, and Herbivory and Predation sections of this Status Review.

While the available evidence predicts that areas with suitable climate conditions based on 20th century climate data for western Joshua tree within California will decline substantially through the end of the 21st century (2100) due to climate change (exposure to climate change is high), the Department does not have data on the extent to which these changes to the climate conditions are likely to affect the demographics (e.g., recruitment and mortality) of the species throughout its range in the foreseeable future. Without data on the extent to which climate change is likely to affect western Joshua tree demographics through the end of the 21st century (2100), the Department does not have the data to conclude that climate change will likely result in a significant reduction of the species' range during this timeframe. The most direct evidence of climate change affecting the range of Joshua tree comes from Cole et al. (2011). Cole et al. (2011) noted that after a rapid warming of approximately 4°C in winter minimum temperatures in the Grand Canyon and 4°C increase in mean annual sea surface temperature off the coast of Northern California over an approximately 50-year period at the beginning of the Holocene period (approximately 11,700 years ago), available fossil records suggest that the range of Joshua tree contracted from the south over the following 3,700 years until the current southern range extent was reached. For this reason, the Department expects that any declines in abundance or changes in range of western Joshua tree that are caused by climate change may occur very slowly.

Western Joshua tree currently occupies a highly variable environment and some areas of climate refugia are expected to remain throughout the species' range in the foreseeable future, even at its southern trailing edge (Barrows and Murphy-Mariscal 2012, Sweet et al. 2019, Barrows et al. 2020). Because western Joshua tree evolved in a highly variable environment, the species may also have some resilience to a changing climate, particularly at the warmer and drier extents of its range. Species responses to increased climate variability are likely to be complex, and may be difficult to predict (Vázquez et al. 2017).

Based upon the information in the Life History and Climate, Hydrology and Other Factors sections of this Status Review, recruitment of western Joshua tree seedlings requires a number of conditions to occur in succession, notably the conditions leading to large mast seeding events, followed by several successive years of sufficiently wet and/or cool conditions so that seeds can germinate, and seedlings can reach a sufficiently large size before the arrival of a period of hotter and/or drier conditions. This suggests that western Joshua tree seedlings and juveniles may be particularly vulnerable to warming and droughts from climate change. Increasing summer temperatures and related water stress that are expected to occur by the end of the 21st century likely mean that recruitment of western Joshua tree seedlings will occur less frequently in many areas, and as a result, populations of western Joshua trees in these areas will decline in size over time. Declines due to reduced seedling recruitment will likely be most severe in areas of western Joshua tree's range that are already near the thermal and water stress tolerance limits for recruitment, such as at hotter, low-elevation areas. St. Clair and Hoines (2018) found significant positive relationships between temperature and Joshua tree flower and seed production, suggesting that Joshua trees have higher reproduction when temperatures are warmer; however, St. Clair and

Hoines (2018) also found negative relationships between temperature and Joshua tree stand density, and suggested that there may be potential constraints of warmer temperatures on establishment success. Despite concerns of lack of western Joshua tree seedling recruitment at low elevation areas within Joshua Tree National Park, Frakes (2017a) reported the presence of Joshua trees that were less than 50 cm (20 in) tall in 500 x 500 m (1,640 x 1,640 ft) monitoring plots across the entire elevation gradient in which the species occurs in the park, including the three lowest elevation plots. Due to the relatively long lifespan of western Joshua tree, and the species' ability to reproduce asexually, adult western Joshua trees may be able to persist on the landscape for long periods of time, even if they are not able to recruit new individuals into the population through sexual reproduction. As described in the Demographic Information section of this Status Review, it may be possible to use demographic information on western Joshua tree to identify areas where seedling recruitment in recent decades does not appear to be sufficient to maintain current population levels. A random field sample of western Joshua tree demographic information across the species' range could perhaps be used to correlate declines in recruitment with areas most severely affected by climate warming that has already occurred, however, such work has not been completed (discussions of work by Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are in the Species Distribution Models section of this Status Review).

As described in the Precipitation section of this Status Review the timing and minimum amount of precipitation necessary for adult western Joshua tree survival is not currently known, but increasing summer temperatures and related water stress may negatively affect adult western Joshua trees in some areas, or even cause them to die, particularly during periods of extended drought. In instances where increasing summer temperatures and related water stress are not severe enough to result in direct mortality of established adult Joshua trees, this water stress may nevertheless reduce the ability of the adult trees to grow or reproduce asexually or limit the resources available to produce flowers and mature fruits for sexual reproduction. In 2016 and 2017, Frakes (2017b) collected data in Joshua Tree National Park on the health of live western Joshua trees and the number of trees that appeared to have died within the previous five years (i.e., recent mortality rate). Frakes (2017b) acknowledged there was likely some error in their ability to visually assess when a western Joshua tree had died, and some may have died more than five years earlier. Frakes (2017b) reported that across the 12 500 x 500 m (1,640 x 1,640 ft) plots, most live Joshua trees appeared robust or moderately healthy, but the estimated recent mortality rates ranged from 4% to 57% over five years, and the mortality rates across all 12 plots averaged together was 20% over five years. Drought from 2012 to 2016 was hypothesized to have contributed to the recent mortality. Harrower and Gilbert (2018) collected western Joshua tree demographic data at 11 sampling sites along a 1,200 m (3,900 ft) elevational gradient in

Joshua Tree National Park in 2016 and 2017, and found that the number of dead western Joshua trees was greatest at the highest elevation sampling site at 2,212 m (7,257 ft) and at the lowest elevation sampling site at 1,004 m (3,294 ft). Harrower and Gilbert (2018) suggested that this observation at the lowest elevation sampling site was consistent with expectations from species distribution models (Cole et al. 2011, Barrows and Murphy-Mariscal 2012), which are discussed in more detail in the Species Distribution Models section of this Status Review. Changes in CO_2 concentrations can affect the rate of chemical reactions in plants, and Huxman et al. (1998) found evidence that elevated CO_2 conditions may help offset high-temperature stress in a coastal *Yucca* species, but not Joshua tree.

There may be a time delay between the time when an area becomes no longer suitable for a species (crossing an extinction threshold) and when that species is no longer present, (Tilman et al. 1994, Kuussaari et al. 2009, van Mantgem et al. 2009, Svenning and Sandel 2013, Figueiredo et al. 2019). Extinction processes often occur with a time delay and populations living close to their extinction threshold might survive for long periods of time despite local extinction being inevitable (Hanski and Ovaskainen 2002, Lindborg and Eriksson 2004, Helm et al. 2006, Vellend et al. 2006, Malanson 2008, Cronk 2016). Because western Joshua tree is a long-lived species, adults could persist for decades or longer in areas that are no longer suitable for recruitment, or recruitment may continue, but at rates that are ultimately insufficient to maintain the species. Although these areas may be occupied, the presence of western Joshua tree may merely represent a delayed local extinction. The ability of western Joshua tree to reproduce asexually may extend the ability of the species to persist within its range for very long periods of time, and delay local extinction for centuries or millennia, or perhaps preserve it as a relict species from an earlier climate. The ability of western Joshua tree to reproduce asexually and the episodic nature of western Joshua tree recruitment may also mask the ability to determine whether populations have passed a local extinction threshold. Due to the lack of basic demographic information for western Joshua tree, such as mortality rates, sexual and asexual recruitment rates, and fluctuations of those rates over long timescales, and the lack of information on how these factors affect abundance, the Department does not currently have a way to determine if populations are likely subject to a delayed local extinction or not. The Department therefore does not currently have any information showing that western Joshua tree populations are experiencing delayed local extinction.

Migration may help some species respond to climate change (Neilson et al. 2005); however, western Joshua tree may not be able to naturally colonize areas of newly suitable climate quickly or at all due to species traits (e.g., slow growth and limited dispersal ability) and other factors such as geology, soils, land use, and existing natural communities in newly suitable climates. Nevertheless, while the direct effects of climate change are likely to result in the decline of populations at hotter, lower-elevation areas due to adult mortality and reduced recruitment of seedlings, climate change could also allow for the expansion of western Joshua tree into areas that were previously too cold or perhaps too wet to support the species. Smith et al. (1983) found the low temperature thermal tolerance of western Joshua tree to be approximately -6°C (21°F). As the climate warms, areas at higher elevations and higher latitudes that were sometimes below this low temperature thermal tolerance, but that were otherwise suitable for western Joshua tree, may become suitable for the species. Loik et al. (2000a) further examined the effects of low temperatures and elevated CO_2 levels on Joshua tree seedlings, and found that low-temperature tolerance was enhanced for Joshua tree seedlings maintained in an elevated CO_2 environment, which suggests that western Joshua tree populations that experience extreme low temperature events may receive a survival benefit from elevated CO_2 conditions that are expected in the future, further expanding the ability of the species to occupy colder areas. Newly suitable climates could therefore become populated by western Joshua tree, assuming that western Joshua tree is able to disperse into those areas. Trends since the beginning of the Holocene period approximately 11,700 years ago (Cole et al. 2011) suggest that natural colonization of areas that become suitable for western Joshua tree in the future would take place very slowly, however, dispersal facilitated by humans (assisted migration) could accelerate colonization.

Species Distribution Models

Efforts to predict effects of global climate change on the future range and distribution of species can be conducted using species distribution models (Elith and Leathwick 2009), which may also identify important areas of climate change refugia where species may persist (Barrows et al. 2020). These efforts usually involve inputting relevant geographic data into computer software, identifying variables that appear to influence the distribution of a species at one time period, and then using the climate variables expected in the future under climate change scenarios to generate a prediction of where climate conditions that supported the species during the historical period could be expected to persist in the future. Spatial data layers used for species distribution models ideally include a large set of biotic and abiotic variables hypothesized to have a major effect on the distribution of the species, and temporally matched data on climate and species distribution (e.g., abundance, presence-absence, presence only). The species distribution models for Joshua tree discussed below model suitable climate conditions using climate data from 30- to 100-year timespans from the 20th century, combined with past or current species distributions and sometimes other biotic or abiotic variables to project potential future species distributions.

Species distribution models have substantial inherent limitations (described near the end of this section), but despite their limitations, species distribution models are useful ways to anticipate how climate change may affect species distributions in the future, and can provide a useful first approximation of the direction and magnitude of potential impacts of climate change on species range (Ackerly et al. 2010). Furthermore, species distribution models gain power if they incorporate large sets of validated observations, and because western Joshua tree is so visually distinctive and well-observed, it is a good species for species distribution modeling applications. While species distribution models can help identify areas where climate conditions will likely depart from historical climate conditions (i.e. exposure), they cannot predict how and when a species will respond to that change in climate (i.e., sensitivity, or whether the climate change will cause the species to disappear from affected areas, and when that may occur) (Dawson et al. 2011). Uncertainty in species distribution modeling results could mean that a species' exposure to climate change is either higher or lower than models predict.

Seven Joshua tree species distribution modeling efforts that assess possible future distributions have been published, and five of them consider western Joshua tree and eastern Joshua tree collectively as one species across their entire range (Thompson et al. 1998, Shafer et al. 2001, Dole et al. 2003, Cole et al. 2011, Thomas et al. 2012). Two of the species distribution modeling efforts are specific to western Joshua tree, but only examine climate changes within Joshua Tree National Park and the surrounding vicinity (Barrows and Murphy-Mariscal 2012, Sweet et al. 2019). The Department is not aware of any species distribution modeling efforts that are specifically focused on the California range of western Joshua tree. The Department did not independently produce a species distribution model to predict the effects of global climate change on the future range and distribution of western Joshua tree within California as a part of this Status Review, but did assess the vulnerability of western Joshua tree to climate change using the NatureServe Climate Change Vulnerability Index (CCVI) Version 3.02 (NatureServe 2016, CDFW 2021b).

The species distribution modeling efforts that have been conducted for Joshua tree suggest that climate change could cause substantial reductions in areas with 20th century suitable climate conditions for the species at the southern parts of western Joshua tree's range, including within Joshua Tree National Park. These species distribution modeling efforts also suggest that substantial additional areas of 20th century suitable climate conditions may become available for western Joshua tree to the north, particularly in Nevada (outside of the scope of CESA) but also in some parts of eastern California, although the species is unlikely to naturally colonize these areas in the foreseeable future. There is also evidence that areas of 20th century suitable climate will remain within the species' range at the end of the 21st century, including within Joshua Tree National Park. While species distribution models are useful in suggesting that a shift in the potential range of the species will take place sometime in the future, the effects of climate change on the population dynamics or current populations of western Joshua tree in the foreseeable future are unknown. The negative effects of western Joshua tree exposure to climate change within the foreseeable future could perhaps be very severe, resulting in a loss of significant range, or perhaps they will be less severe, resulting in lowered abundance without significant range loss. Due in large part to the lack of information on western Joshua tree's sensitivity to climate change (see the Direct Effects section of this Status Review), in combination with resiliency of the species due to its high abundance and widespread distribution (as discussed in the Large Population Size and Widespread Distribution section of this Status Review), the Department does not currently have enough information to conclude that climate change is likely to cause western Joshua tree to become in serious danger of disappearing from a significant portion of its range in the foreseeable future (prior to 2100). While the Department does not currently foresee that the species is likely become in serious danger of reductions in a significant portion of its range in the foreseeable future, western Joshua tree populations within the areas that will be most severely impacted by climate change may nevertheless experience declines in density and distribution. Species distribution modeling efforts for western Joshua tree are discussed in more detail in the following sections.

<u>Range-wide Models</u>

The most useful range-wide species distribution modeling effort for this Status Review is Cole et al. (2011), which analyzes the entire range of western Joshua tree (lumped with eastern Joshua tree), uses climate variables at a relatively fine scale (1-km and 4-km grids), considers some climate variables at a monthly scale rather than annually, utilizes baseline climate conditions that may be somewhat more representative of what the species experienced during its evolution than other models produced for the species (the entire 20th century record and 1930-1969), and involved six different species distribution models and compared their results. The models developed by Cole et al. (2011) that most accurately describe how climate is correlated with Joshua tree's present distribution included variables such as average precipitation, extreme high and low temperatures, and average high and low temperatures in certain months. Based on these species distribution models, Cole et al. (2011) suggested that the northern portion of Joshua tree's range is spatially limited by extreme winter cold, but at lower elevations it is limited by extreme high temperature in summer or winter. The species distribution models also suggest that average precipitation patterns limit the range of Joshua trees on the east and west edges of its distribution, as well as above and below its elevational range during portions of the year. Cole et al. (2011) explains that low precipitation in April and May seems to prevent Joshua tree from growing at lower elevations, and high winter rainfall or snow limit it from the higher elevations in some ranges of Nevada. Cole et al. (2011) also suggested that the June drought period and summer thunderstorm season may be important in limiting the distribution of Joshua tree to the east and to the west.

Cole et al. (2011) provides a map product showing how one of their suitable climate models for Joshua tree compares with current distribution presence points. While there is rough concordance between many of the Joshua tree presence points and the model results, the Cole et al. (2011) model of baseline conditions also shows many areas that were predicted to be highly suitable but that do not support the species, along with many areas that were predicted to have low suitability but that nevertheless do support the species. This demonstrates that while species distribution models have utility for providing a useful first approximation of the direction and magnitude of potential impacts of climate change on species range, no model is perfect, and all models should be used with caution until tested with independent validation (Lee-Yaw et al. 2021). Even under baseline conditions, current species distribution models can only partially explain observed species distribution patterns and range. When species distribution models can only partially explain observed species distribution patterns and range, and are not strengthened with demographic data that agrees with model predictions, predictions of species distributions in the future become very speculative.

Based on the variety of models and scenarios analyzed, Cole et al. (2011) concludes that as much as 90% of the area with 20th century suitable climate conditions within Joshua tree's range is predicted to disappear by 2070-2099. Areas of 20th century suitable climate conditions are predicted to be lost throughout most of the southern portions of Joshua tree's current range (Cole et al. 2011).

Cole et al. (2011) also compared the projected loss of suitable Joshua tree climate with a climate-related contraction of Joshua tree's range from the south that occurred as the climate rapidly warmed approximately 11,700 years ago, at the beginning of the Holocene period. Joshua tree now only occurs at the northern periphery of its late-Pleistocene range, and this contraction may have occurred over a period of approximately 3,700 years. Cole et al. (2011) points out that while suitable climate may shift with warming, Joshua tree is a poor long-distance disperser, and based on historical migration rates, and current information on dispersal distances via seed-caching small rodents (Vander Wall et al. 2006, Waitman et al. 2012, Reynolds et al. 2012), Joshua tree may only be capable of migrating at a rate of perhaps two meters per year. This suggests that the species may have a difficult time naturally keeping pace with projected shifts in suitable climate conditions.

Thompson et al. (1998) modeled the range-wide response of Joshua tree to climate as forced by doubled CO_2 concentrations, along with the responses of 15 other common trees and shrubs of the western United States. Thompson et al. (1998) used a somewhat coarse 15-km grid, a range map from 1976, and climate data from a 30-year period as the baseline (dates of the 30-year period were not reported), with average January and July temperature and precipitation data for the analysis. The model of Joshua tree distribution prepared by Thompson et al. (1998) projects a reduction of historically suitable Joshua tree climate conditions at the western edge of its range, near Antelope Valley and to the north, but also projects a significant expansion of suitable climate conditions for Joshua tree in many directions into Mexico, Texas, and Washington. The model prepared by Thompson et al. (1998), poorly matches the current observed distribution of Joshua tree, which calls into question the modeling methodology and/or the assumptions used.

Shafer et al. (2001) modeled range-wide shifts in mid-20th century climate conditions within the range of Joshua tree and 76 other North American tree and shrub species in response to climate change by 2090–2099, assuming a one percent per year compound increase in greenhouse gases and using three different future climate change scenarios. Shafer et al. (2001) used a somewhat coarse 25-km grid, a range map from 1976, and climate data from a 30 year period (1951–1980) as the baseline, with (1) the average temperature of the coldest month, (2) a sum of the number of °C that was over 5°C on days that were warmer than 5°C, and (3) a moisture index similar to climatic water deficit for the analyses (climatic water deficit is discussed in the Precipitation section of this Status Review). All three future climate change scenarios used by Shafer et al. (2001) produced what appears to be near complete elimination of 1951–1980 suitable climate conditions from the southern portion of western Joshua tree's range by the year 2099, and also substantial expansion of 1951–1980 suitable climate conditions to the north and to the east into Nevada, Arizona and Utah, but also as far away as New Mexico, Wyoming, and Washington (outside of the scope of CESA). Unlike some of the other species distribution modeling efforts discussed, Shafer et al. (2001) did not perform checks of their model parameters by using 1951–1980 suitable climate conditions to assess how well their model accurately predicts the current distribution of Joshua tree, which calls into question the modeling methods used and therefore the accuracy of model predictions.

Dole et al. (2003) modeled the range-wide response of areas predicted to be suitable for Joshua tree based on late-20th century climate conditions under doubled CO_2 conditions, while also taking into account increased tolerance of extreme cold temperatures that could be expected to occur with increased CO_2 conditions (Loik et al. 2000a). Dole et al. (2003) used a relatively coarse grid-based distribution map for the current range of the species. Dole et al. (2003) used temperature data from a 30-year period (1961–1990) as the baseline for the species distribution model, and the climate variables used were January precipitation, July precipitation, annual precipitation, January average daily minimum temperature, July average daily maximum temperature, and July average temperature. All data layers used for the analysis were resampled to a 10-km grid. The results of the Dole et al. (2003) species distribution model under doubled CO_2 conditions show an overall 9% decrease in the number of grid cells with predicted late-20th century suitable climate conditions across the entire range, with 29% of grid cells retaining suitable climate conditions, and the remaining grid cells representing either loss or expansion of suitable climate conditions (percentages of loss and expansion were not reported). While the Dole et al. (2003) model predicted that some areas of late-20th century suitable climate conditions could become unsuitable in the future, grid cells of suitable climate conditions remained in substantial portions of the species' range, including in the southern portion. The model also projected new areas with late-20th century suitable climate conditions in the Mojave Desert, north of the current distribution limit in Nevada (outside of the scope of CESA), in the Owens Valley, in the Panamint and Inyo Mountains of California, and also in the southern San Joaquin Valley which is currently under intensive agricultural land use. The Dole et al. (2003) species distribution model broadly overestimates the ability of Joshua tree to disperse into new areas, but nevertheless identifies several areas where late-20th century suitable climate conditions for western Joshua tree would persist in California under doubled CO_2 conditions.

Thomas et al. (2012) used a Maxent-based approach to model range-wide response of Joshua tree and 165 other southwestern United States plant species to climate change using Intergovernmental Panel on Climate Change emission scenarios B1, A1B, and A2 for two time periods: 2040 to 2069 and 2070 to 2100. Maxent is a species distribution modeling package that uses a set of environmental (e.g., climatic) grids and georeferenced occurrence localities to express a probability distribution where each grid cell has a predicted suitability of conditions for the species (Phillips et al. 2021). Thomas et al. (2012) used species presence data from 30 different field studies, with occurrence records translated to the center of 843.5 m^2 grid cells. Monthly and annual average precipitation and temperature (minimum and maximum) from the years 1971–2000 were used as the baseline climate conditions. The areas modeled to be suitable for species using late-20th century suitable climate conditions were compared with the areas modeled to be suitable for species under the different emissions scenarios to assess climate vulnerability. Thomas et al. (2012) found that all 166 species evaluated were predicted to lose areas with 20th century suitable climate conditions under the scenarios evaluated, with substantial reductions in areas with 20th century suitable climate conditions for Joshua tree at the southern parts of its range, and substantial additional areas of 20th century suitable climate conditions becoming available to the north, particularly in Nevada.

Species distribution models for eastern Joshua tree have also predicted shifts in historically suitable climate. In an analysis of potential impacts of climate change on vegetation in Arizona, New Mexico, Utah, and Colorado, Notaro et al. (2012) used Maxent to produce species distribution models for 170 tree and shrub species, including eastern Joshua tree. Similar to the results from other Joshua tree species distribution modeling efforts, Notaro et al. (2012) projected a reduction in areas with historically suitable eastern Joshua tree climate conditions in the southern part of its range, and a substantial expansion of areas with historically suitable climate conditions to the north.

Joshua Tree National Park Models

Barrows and Murphy-Mariscal (2012) used a finer-scale species distribution modeling approach, focusing only on western Joshua tree within and near Joshua Tree National Park under scenarios of 1°C, 2°C and 3°C increases in maximum July temperatures, and precipitation scenarios of 25 mm less precipitation per 1°C of warming, no change in precipitation, and a model that does not use precipitation. All three warming scenarios are less severe than the warming that is generally expected to occur in the Mojave Desert by the end of the 21st century (Hopkins 2018). Using western Joshua tree location data from the National Park Service augmented with additional location data from researchers and citizen scientists, Barrows and Murphy-Mariscal (2012) utilized 30 years of July temperature data and average annual precipitation data from 1971-2000 and abiotic variables related to topography and soil to develop several species distribution models. The model that performed the best in predicting current western Joshua tree location data was selected and used to project the distribution of adult western Joshua tree in the future under different precipitation and warming scenarios. Rather than predicting the complete elimination of areas with late-20th century suitable climate conditions for western Joshua tree in Joshua Tree National Park, the model developed and selected by Barrows and Murphy-Mariscal (2012) predicted that approximately 10% of the current distribution of western Joshua tree within Joshua Tree National Park would retain late 20th century suitable climate conditions for adult trees under a +3°C warming with little change in average annual precipitation. Although climate models do not agree on whether there will be a decrease in precipitation, Barrows and Murphy-Mariscal (2012) predicted that approximately 2% of the current distribution of western Joshua tree within Joshua Tree National Park would retain late-20th century suitable climate conditions for adult trees under a +3°C warming scenario with a 75 mm decrease in annual precipitation. Barrows and Murphy-Mariscal (2012) also found that with a temperature increase of 1°C to 3°C, the areas with late-20th century suitable climate conditions for western Joshua tree are expected to shift upward in elevation in Joshua Tree National Park, but because western Joshua tree already occupies the highest elevation areas within Joshua Tree National Park, there will be a net loss of areas with late-20th century suitable climate conditions within Joshua Tree National Park.

Barrows and Murphy-Mariscal (2012) also developed a species distribution model for juvenile western Joshua trees less than 30 cm in height, representing the most recent cohort of juvenile western Joshua trees within Joshua Tree National Park. When areas suitable for juvenile western Joshua trees were modeled using late-20th century climate conditions, the area predicted to be suitable was 51% of the size of the area currently observed to be occupied by adult western Joshua trees. Barrows and Murphy-Mariscal (2012) also compared the area modeled for juvenile western Joshua trees under late-20th century suitable climate conditions to the distribution modeled for adult trees under the +1°C warming scenario and suggested that warming that has already taken place may be related to the apparent reduction in area that appears to be suitable for western Joshua tree recruitment. Barrows and Murphy-Mariscal (2012) did not observe any evidence of mortality of western Joshua trees that was not related to fire within Joshua Tree National Park. Barrows and Murphy-Mariscal (2012) did not model suitable climate for juvenile western Joshua trees under future warming scenarios, nor did they report on how well their distribution model for juvenile western Joshua trees accurately predicted actual observations of the distribution of juvenile western Joshua trees in Joshua Tree National Park.

The most recent effort to model how the distribution of western Joshua tree may respond to changes in 20th century suitable climate was conducted by Sweet et al. (2019). Similar to Barrows and Murphy-Mariscal (2012), Sweet et al. (2019) used a finer-scale species distribution modeling approach, focusing only on western Joshua tree within and near Joshua Tree National Park. Sweet et al. (2019) expanded on the western Joshua tree data used by Barrows and Murphy-Mariscal (2012) to generate a Maxent species distribution model. The model developed by Sweet et al. (2019) was developed using climate variables from 1951–1980 and physical environmental variables including soil sand content, slope, and terrain ruggedness. Sweet et al. 2019 identified annual precipitation as being the most important variable for the model, but slope, and annual maximum hot season temperature, minimum cold season temperature, and climatic water deficit were also important predictors of western Joshua tree presence.

Based on the results of this Maxent model, Sweet et al. (2019) projected how much of the area with mid-20th century suitable climate conditions for western Joshua tree would remain within Joshua Tree National Park under the observed climate conditions from 1981–2010 and the climate conditions projected between 2070–2099 under three climate change emissions scenarios: CMIP5 MIROC RCP 4.5, 6.0, and 8.5 (Taylor et al. 2012), representing CO_2 emissions under highly mitigated, moderately mitigated, and unmitigated scenarios, respectively. The model predicted that 13.4% of the area with predicted suitable climate for the species based on climate conditions between 1951 and 1980 remained during the subsequent period between 1981 and 2010. Also compared with the area of 1951–1980 predicted suitable climate conditions, the model predicted that 18.6% of the area would remain at the end of the 21st century under the highly mitigated emissions scenario, 13.9% under the moderately mitigated emissions scenario, and only 0.02% would remain by under the unmitigated emissions scenario. Although the Sweet et al. (2019) model projected substantial loss of the area with mid-20th century suitable climate conditions during the 1981–2010 climate period, western Joshua trees continued to recruit in these climate conditions throughout Joshua Tree National Park during this time period (Frakes 2017a). Continuation of western Joshua tree recruitment in areas of Joshua Tree National Park that Sweet et al. (2019) modeled as no longer containing suitable climate during the 1981–2010 climate period demonstrates that a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species, at least in the short term.

To examine whether recent recruitment of western Joshua trees in Joshua Tree National Park was occurring in areas predicted to be suitable for western Joshua tree between 2070–2099, Sweet et al. (2019) examined demographic information collected from 14 nine-ha macroplots in Joshua Tree National Park in 2016 and 2017. Sweet et al. (2019) considered macroplots that had fewer than 247 western Joshua trees under 60 cm as “low recruiting” and macroplots that had more than 247 western Joshua trees under 60 cm as “high recruiting,” but did not report the number of trees in each macroplot, or use the number of adult trees in these macroplots to put the number of juvenile trees in the macroplots into relative context (areas with low densities of adult western Joshua trees would naturally be expected to have low densities of juvenile western Joshua trees regardless of climate change effects). Sweet et al. (2019) found that “high recruiting” macroplots tended to be geographically closer to areas predicted to be more suitable for western Joshua tree between 2070–2099 under the species distribution model developed for the study, which suggests that climate change could be affecting the demography of populations within Joshua Tree National Park, but there could also be other explanations, which are not contemplated by Sweet et al. (2019).

The Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) studies provide evidence for the predicted effects of climate change at the southern (trailing) edge of western Joshua tree’s range, and these studies are the first to associate western Joshua tree demographic data with predictions from species distribution models. The climatic conditions and projections for the small geographic area used in these studies (Joshua Tree National Park) does not present a comprehensive representation of future conditions across western Joshua tree’s range. Nevertheless, studies that suggest recruitment of western Joshua tree is decreasing in marginal habitats that have already been subject to the warming effects of climate change can provide field evidence that overall, climatic warming is correlated with lower recruitment (Barrows and Murphy-

Mariscal 2012, Sweet et al. 2019). Species distribution models for western Joshua tree that are validated with random field samples of western Joshua tree demographic data from across the species' range in California would substantially improve the ability to evaluate the predictive capacity of the work initiated by Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019).

Limitations of Models

Species distribution models have substantial inherent limitations and should be credible, transparent, reproducible, and evaluated carefully to be used effectively for decision-making (Sofaer et al. 2019, Lee-Yaw et al. 2021). Natural systems are highly complex, as are the effects of climate change (Pimm 2009), and by necessity predictive species distribution modeling must reduce many complex factors to relatively simple geographic variables that can be used by the relevant software. Limitations in the accuracy and precision of predictive species distribution models arise from the availability of spatially continuous data on biotic and abiotic variables of interest, by the capacity of the scientific community to make accurate measurements or projections of certain variables (e.g., projections of temperature generally are more feasible than projections of wind speed), and by the feasibility and reliability of downscaling or aggregating data to a common spatial and temporal resolution (Pearson and Dawson 2003, Keith et al. 2008). Uncertainty of species distribution model outputs also increases when projected values of predictor variables are outside the range used to build the model and models generally do not account for climate heterogeneity in complex terrain, such as mountains. Species distribution models also often rely on just a few available climate change scenarios that are often selected arbitrarily (Casajus et al. 2016). In addition, species distributions are often dynamic, and not necessarily static on the landscape, and therefore data on the current distribution of species used for models may not accurately represent where species can occur. There are also uncertainties regarding whether species may occupy environments that are not yet present on the landscape, but that are expected to arise in the future (Fitzpatrick and Hargrove 2009). A species may also be adapted to a narrow niche in some areas, and species distribution models that use coarse, homogenized environmental data will not identify small areas of climate change refugia that match the species' niche requirements. Although species distribution models are fundamentally designed to account for variation in the habitat in which a species occurs, they cannot entirely account for resilience to a changing climate that an abundant and widespread species (such as western Joshua tree) may already possess. Species distribution models also do not account for the adaptive potential of a species in the face of a changing climate, but long-lived species and species with limitations to dispersal (such as western Joshua tree) may be unlikely to undergo rapid evolutionary change on the timescale that the climate is projected to change.

A methodology for evaluating the reliability and usefulness of species distribution models is provided by Sofaer et al. (2019), and the Department identified a number of concerns related to the species distribution models that have been prepared for Joshua tree. These include the lack of range-wide validation of results with demographic data, the non-iterative approach of all models evaluated, the relatively short time periods used for describing historically suitable climate data (Roubicek et al. 2010), use of map products with binary instead of continuous data, little discussion of suitability thresholds used, little discussion of data/model assumptions, little discussion of model performance, homogenization of the climate variability that is important for western Joshua tree recruitment, the relatively coarse scale of climate data used, the lumping of western Joshua tree and eastern Joshua tree as one species for modeling despite their differences, and the poor performance of species distribution models to accurately and precisely explain current species distribution patterns using historical climate conditions.

All species distribution models evaluated by the Department used historical climate data from a 30-year period, or in the case of the Cole et al. (2011) study a 40- or 100-year period to define what constitutes suitable climate conditions for the species, and the climate data was averaged over these periods. These time periods are shorter than the maximum lifespan of a western Joshua tree, which can likely live for 150 years or more. As described in the Precipitation and Life History sections of this Status Review, precipitation in western Joshua tree's range oscillates between wetter and drier conditions over multi-year and multi-decade timescales with wet or dry conditions of the Pacific Decadal Oscillation often persisting for two to three decades. These oscillations are likely important for recruitment of western Joshua trees because periods of above average precipitation are important for the episodic recruitment of western Joshua trees and therefore may be more important for characterizing the climate conditions necessary for western Joshua tree to survive and reproduce than averaged climate conditions. There were substantial differences in modeled suitable climate between the base historical 1951–1980 suitable climate conditions and more recent (1981–2010) climate conditions reported by Sweet et al. (2019), demonstrating how sensitive all species distribution models are to the climate data used to construct them. For these reasons, it may not be appropriate to use averages of narrow (30 to 40 year) timeframes to represent the climate conditions and climate variability that western Joshua tree experienced and perhaps developed resiliency to during its evolution in the Mojave Desert and other regions over thousands of years. Climate variability such as the oscillations between wetter and drier conditions over multi-year and multi-decade timescales is excluded from species distribution models that average precipitation data over 30- to 100-year time periods. For this reason, the species distribution models that have been produced so far have, to some extent, mischaracterized the precipitation patterns that western Joshua tree depends on for recruitment. Species distribution models that use average climate conditions over relatively short time periods to characterize the climate tolerances of western Joshua tree produce results that contain substantial uncertainty.

There are substantial limitations in the current understanding of the climate tolerances that the range of western Joshua tree is limited by. The species distribution models that have attempted to model the current distribution of Joshua trees have only produced rough approximations of the current range and distribution of the species. While some of the species distribution modeling efforts for Joshua tree evaluated by the Department provided corresponding information on how well the model predictions matched the current distribution of western Joshua tree (i.e., performance), generally only one performance metric was used, and there was limited discussion of the ecological plausibility of results (Cole et al. 2011, Thomas et al. 2012, Sweet et al. 2019). Because of our limited understanding of the true climate tolerances that the range of western Joshua tree is limited by, the magnitude and timing of effects of the loss of areas with 20th century suitable climate conditions (i.e., sensitivity of the species) is not known. The loss of substantial areas of 20th century suitable climate conditions (i.e., exposure to climate change) that is projected by species distribution models in some areas is expected to have negative effects on populations in the affected areas, but the Department does not have information indicating whether western Joshua trees in the affected areas are likely to die, whether populations are likely to cease reproducing, whether populations will be sustainable, and/or how climate change exposure may affect seedling, juvenile, and adult trees (i.e. the sensitivity of the species to climate change). Loss of areas with 20th century suitable climate conditions may instead result in reductions in population density and distribution that are not likely to result in a serious risk of reduction in a significant portion of the species' range in the foreseeable future.

Due to the inherent limitations in predictions from species distribution models, limitations in the current understanding of the climate conditions that limit western Joshua tree's range (as described in the Climate, Hydrology and Other Factors section of this Status Review), and limited information that relates western Joshua tree demographic and population trends with the predicted effects of climate change (as described in the Population Trends section of this Status Review), the Department does not consider the available data on the potential timing and magnitude of negative effects of climate change on western Joshua tree's range as sufficient to support a conclusion that the species is likely to become endangered in the foreseeable future. The Department does not currently possess information that suggests the effects of climate change on the species in the foreseeable future are likely to place the western Joshua tree in serious danger of becoming extinct throughout all or a significant portion of its range.

Summary of Species Distribution Models

All of the studies assessed by the Department come to similar conclusions that the areas with climate conditions that supported western Joshua tree during the 20th century are expected to contract substantially by the end of the 21st century (2100), especially in the southern and lower elevation portions of the species' range. The information available to the Department indicates that western Joshua tree will have high exposure to the effects of climate change. Areas with historical 20th century suitable climate conditions for the species will also expand to the north and into higher elevation areas in some parts of eastern California, but most substantially in Nevada (outside of the scope of CESA). Western Joshua tree is only likely to colonize areas with newly suitable climate conditions very slowly. Studies assessed by the Department also suggest that areas of 20th century suitable climate conditions for western Joshua tree will remain in some limited areas at the southern and lower elevation portions of its range at the end of the 21st century under some climate scenarios. The results of the species distribution models assessed by the Department provide a useful first approximation of the direction and magnitude of potential impacts of climate change on the species. If western Joshua tree populations are exposed to a severe enough change in climate, a significant loss of range could occur, however, the Department does not have information on how severe this change in climate would need to be to result in a serious risk of significant range loss. The Department has very little information to suggest that loss of 20th century suitable climate conditions for western Joshua tree will result in serious risk of significant range loss. Loss of 20th century suitable climate conditions are nevertheless expected to have negative effects on individuals and populations of western Joshua tree in the affected areas, and those negative effects may result in population declines. But due to the lack of information that correlates climate change with demographic trends over significant portions of the species' range, the Department does not have information indicating that modeled exposure to climate change will mean that there will be a serious risk that western Joshua trees will likely die, or that populations are likely to cease reproducing and no longer be sustainable at the end of the 21st century. Loss of areas with 20th century suitable climate conditions may instead result in reductions in population density and distribution that are not likely to result in a serious risk of reduction in a significant portion of the species' range in the foreseeable future.

Climate Change Vulnerability Assessments

In addition to reviewing the species distribution modeling efforts described above, Department staff assessed the vulnerability of western Joshua tree to climate change using the NatureServe Climate Change Vulnerability Index (CCVI) Version 3.02 (NatureServe 2016, CDFW 2021b). The CCVI is a rapid means of estimating a plant or animal species' relative vulnerability to climate change. The CCVI analyzes exposure to local climate change within a species' range and assesses indirect climate change effects and the species sensitivity and adaptive capacity to provide a qualitative assessment of how the abundance and/or range extent of the species may change due to climate change. The results of the CCVI indicated that western Joshua tree has a climate change vulnerability index value of moderately vulnerable (MV), indicating that "abundance and/or range extent within geographical area assessed likely to decrease by 2050;" however, the confidence in this vulnerability index score is low, indicating that a higher vulnerability score is also a possible result. Factors contributing to these vulnerability assessments include barriers to western Joshua tree dispersal and limited dispersal capability, the species physiological thermal niche, the historical hydrological niche of the species, increasing wildfire activity, dependence on an obligate pollinating moth, and existing documented or modeled response to climate change (i.e., the species distribution models described above).

In 2016, Thorne et al. conducted a CCVI assessment that evaluated the sensitivity and adaptive capacity of five major plant species of the Mojavean–Sonoran Desert Scrub vegetation macrogroup, including Joshua tree (Thorne et al. 2016). Joshua tree was assessed individually as highly vulnerable to climate change. Thorne et al. (2016) ranked the adaptive capacity of Joshua tree to be low due to its low adaptivity to fire and its slow and limited recruitment abilities. Thorne et al. (2016) also identified fire sensitivity, requirements for germination, and limited dispersal capacity as primary reasons for the high sensitivity of Joshua tree to climate change. Thorne et al. (2016) concluded that the Mojavean–Sonoran Desert Scrub vegetation macrogroup was moderately vulnerable to climate change in California.

Indirect and Cumulative Effects

Changes to precipitation due to climate change could have cascading effects on western Joshua tree. Climate change within the range of western Joshua tree will affect the abundance and distribution of plant species, sometimes with unexpected results (Kimball et al. 2010), and may increase suitability for presence and high abundance of some invasive plant species (Curtis and Bradley 2015). Climate variability could result in more extreme wet periods that result in extensive growth and spread of invasive annual plant species, which would have implications for wildfire frequency and intensity that would affect western Joshua tree. These negative effects on western Joshua tree are discussed in more detail in the Wildfire section of this Status Review. Climate change could also contribute to more severe drought events, which would reduce the amount of resources available for animals, potentially increasing herbivory and damage to western Joshua tree as described in more detail in the Herbivory and Predation section of this Status Review.

Climate change may also indirectly impact western Joshua tree habitat via an increase in renewable energy development in areas occupied by the species. Impacts of development are discussed in the Development and Other Human Activities section of this Status Review.

Climate change could also indirectly impact western Joshua tree through effects on western Joshua tree's specialized obligate pollinator, the yucca moth *T. synthetica*, because the two species are dependent upon one another for sexual reproduction. In general, species of butterflies and moths are predicted to experience changes in abundance, distribution, and timing of life history events as a result of climate change, and examples of such changes have been observed in different parts of the world (Kocsis 2011). The extent to which climate change may affect *T. synthetica* is not currently known, but climate change could affect the mutualism with western Joshua tree in various ways that either increase the number of viable seeds produced (benefitting western Joshua tree), increase the number of seeds eaten by moth larvae (benefitting *T. synthetica*), or disrupting the mutualism in a way that harms both western Joshua tree and *T. synthetica*. Harrower and Gilbert (2018) examined various aspects of the mutualism between western Joshua tree and *T. synthetica* along an elevation gradient within Joshua Tree National Park, which provides some context for how climate change may affect this mutualistic relationship. Harrower and Gilbert (2018) collected western Joshua tree demographic data and data on the abundance of *T. synthetica* and bogus yucca moths (*Prodoxus* sp.) at 11 sampling sites along a 1,200 m (3,900 ft) elevational gradient from 1,004 to 2,212 m (3,294 to 7,257 ft). *Prodoxus* sp. moths parasitize western Joshua trees and do not pollinate them. Harrower and Gilbert (2018) found that near 1,250 m (4,100 ft) in elevation western Joshua trees were numerous and large and produced many flowers, pods, seeds, fertile seeds, and seedlings that grew from seeds; this site also had a high abundance of both *T. synthetica* and *Prodoxus* sp. moths. *T. synthetica* was not observed, and sexual reproduction was not found to occur at the highest elevation sampling site at 2,212 m (7,257 ft) or at the lowest elevation sampling site at 1,004 m (3,294 ft). Harrower and Gilbert (2018) found that at an elevation of approximately 1,500 to 1,600 m (4,900 to 5,250 ft) where western Joshua trees were at their highest density, *T. synthetica* abundance was relatively low, and there were fewer viable seeds produced at that sampling site. Harrower and Gilbert (2018) speculated that the range of environmental conditions that support *T. synthetica* may be narrower than those for western Joshua tree. The Department has very little information on the range of *T. synthetica*, but it is possible that climate change may make some low-elevation areas unsuitable for the species. In areas outside of the distribution of *T. synthetica*, sexual reproduction is not possible and asexual reproduction is the only viable reproductive strategy for western Joshua tree. Sexual reproduction promotes genetically diverse offspring through recombination, mutation, and gene flow from immigrants thereby allowing for evolutionary adaptation (Hoffmann and Sgro 2011, Yang and Kim 2016). Sexual reproduction also allows for increased dispersal ability (Winkler and Fischer 2002). Therefore, if *T. synthetica* were lost from western Joshua tree populations the loss of sexual reproduction would present serious additional challenges for the long-term persistence of affected populations.

Considered collectively, the direct and indirect effects of climate change, the direct and indirect effects of development and other human activities, and the direct and indirect effects of wildfire are interconnected and will affect different portions of western Joshua tree's range in different ways, sometimes cumulatively. Climate change may reduce recruitment and abundance in southern and lower elevation portions of western Joshua tree's range, with higher elevation areas perhaps remaining more suitable for the species. These higher elevation areas are also at higher risk of wildfire, as described in the Wildfire section of this Status Review, and fire is expected to kill a proportion of trees in burned areas and temporarily reduce recruitment in those areas. Sweet et al. (2019) calculated the area where the refugia for western Joshua tree modeled within Joshua Tree National Park at the end of the 21st century under climate change emissions scenario CMIP5 MIROC RCP 4.5 (representing CO_2 emissions under a highly mitigated scenario) (Taylor et al. 2012) would overlap with the approximate area of historic fires, circa 1890s to 2018. The area of overlap of the refugia under CMIP5 MIROC RCP 4.5 and historic fires was over 6000 ha or approximately 49.9%, demonstrating that wildfire may disproportionately affect areas most likely to support western Joshua tree in the future. If the amount of habitat for western Joshua tree does become severely limited in the future, wildfire has a greater potential to result in impacts that will affect the species' range.

Development and Other Human Activities

Habitat loss is considered the primary cause for species extinctions at all scales: local, regional, and global (Dirzo and Raven 2003). Habitat loss is caused by a variety of human activities including cultivation of land for agriculture; development of land for residential, commercial, or industrial use; development of utilities, roads, and other infrastructure; resource harvest and extraction; use of land for livestock; and recreational use of land including off-highway vehicle use. These activities often involve removing native vegetation, disturbing soil and the biological communities therein, and installing structures, impermeable surfaces, and other features that render areas incapable of supporting native species assemblages (habitat destruction). Even if human activities do not result in the complete elimination of habitat in an area, the indirect effects from such activities can cause substantial changes to the environment (habitat modification), which can affect the abundance of native species. Indirect effects from development and other human activities include soil disturbance and compaction; introduction and spread of exotic species and pathogens; increased dust, pollution, runoff, and trash; artificial noise, light, and vibration; and use of herbicides, pesticides, and other chemicals. The contribution of development and other human activities to the introduction and spread of invasive plants is discussed in the Wildfire and Invasive Plants sections of the Status Review. While development and other human activities often result in habitat loss and largely negative impacts to native species, some native species could benefit from certain human activities, for example irrigation near populated areas could increase survival of perennial plants during drought.

Development and other human activities reduce the amount of contiguous habitat, resulting in habitat fragmentation. Habitat fragmentation may have several repercussions for individual species or entire ecosystems, including increased edge effects, reduced ability of species to migrate or colonize, and reductions in species richness (i.e., number of total species), although fragmentation, in and of itself, may not necessarily be bad for biodiversity (Haddad et al. 2015, Evans et al. 2017, Fletcher et al. 2018, Fahrig et al. 2019). The Department does not have information on the effects of habitat fragmentation on western Joshua tree or on the yucca moth *T. synthetica* specifically, however western Joshua tree is a poor disperser and habitat fragmentation could disrupt plant and pollinator population dynamics by altering pollinator densities and behavior (Xiao et al. 2016).

Western Joshua tree habitat has been subject to a history of habitat modification and destruction in California (see the Inferred Long-term Trends section of this Status Review), and this habitat modification and destruction is expected to continue. Much of the recent western Joshua tree habitat modification and destruction has been the result of ongoing urban development, typically on private property within the general vicinity of existing developed areas. The USFWS (2019) reported that approximately 50% of the southern part of western Joshua tree's range is on private property, 2% of the northern part of western Joshua tree's range is on private property, with the remainder predominately on federal land. WEST Inc. (2021b) found a higher percentage of western Joshua tree's range on private property than the USFWS did, with approximately 65% of the southern range on private property, and approximately 13% of the northern range on private property. Due to very limited regulation prior to CESA candidacy, as described in the Regulatory Status and Legal Protections section of this Status Review, western Joshua trees and habitats on private property have been very vulnerable to habitat modification and destruction. Local land use planning and state legal protections such as the 1970 California Environmental Quality Act may have led to the avoidance of some impacts to western Joshua tree. However, development has continued, and cities within the range of the species have expanded substantially into previously undeveloped areas contributing to the loss of many western Joshua trees and habitat. During the candidacy period for western Joshua tree, the Department received numerous reports of the unpermitted killing of western Joshua trees on private property and related habitat modification and destruction.

Renewable energy development has been increasing rapidly in recent decades with development primarily occurring on private lands and lands managed by the U.S. Bureau of Land Management (BLM) in less-developed portions of the Mojave Desert. Under the Desert Renewable Energy Conservation Plan which was finalized in 2016, 157,000 ha (388,000 ac) of BLM lands in the plan area were identified for solar, wind, and geothermal development, with more than 162,000 additional ha (400,000 ac) that could be considered for renewable energy development in the future (BLM 2016). Under the Desert Renewable Energy Conservation Plan, substantial areas of habitat were also identified for conservation. During the candidacy period for western Joshua tree, land with western Joshua trees has been approved to be cleared for renewable energy development following a Special Order approved by the Commission pursuant to Fish and Game Code section 2084. Authorizations under this Special Order required that take of western Joshua tree is mitigated.

Private property that has not been protected from development is at a high risk of habitat modification and destruction in the foreseeable future, and this threat is highest in the southern and western part of western Joshua tree's range, where most of the western Joshua trees on private property occur. Private property within incorporated city limits of Palmdale, Lancaster, Yucca Valley, Joshua Tree, Twentynine Palms, Victorville, Hesperia, and Apple Valley may be at greatest risk of habitat modification and destruction in the foreseeable future, although expansive development of rural "ranchettes" and related infrastructure are likely to continue in unincorporated communities (Figure in Krantz comments, Appendix B). To a lesser extent, western Joshua tree habitat modification and destruction is likely to occur on federal lands due to renewable energy development, off-highway vehicle use, resource extraction activities, livestock grazing activities on BLM lands, and military activities on U.S. Department of Defense lands. While habitat is likely to be modified or destroyed on BLM lands and U.S. Department of Defense lands in the foreseeable future from ongoing activities or facility expansions, habitat destruction from activities on these lands may be limited, as much of these areas are expected to be maintained in an undeveloped state. Lands close to existing base infrastructure may be developed and used for military purposes, however, U.S. Department of Defense has historically maintained large buffers of natural habitat around many of its military bases, including lands maintained to "enable realistic, mission essential testing, training, and operations" (Department of Defense 2021).

Habitat modification from development and other human activities may also impact the ability of western Joshua tree to recruit new individuals from seed in ways that are not fully understood. As described in the Demographic Information section of this Status Review, information submitted to the Department suggests that relatively few western Joshua trees established from seed in recent decades at six proposed development project sites near the cities of Palmdale and Lancaster. This decreasing recruitment may have been due, in part, to mid-20th century dry conditions illustrated in Figure 5, combined with environmental degradation related to urban and agricultural use and development. Habitat modification and destruction from development and other human activities in these areas may have impacted the ability of western Joshua tree to sexually recruit new individuals by disrupting the fulfillment of one or more of western Joshua tree's critical life history needs. Western Joshua tree's obligate pollinating moth *T. synthetica* could be disrupted while dormant in the soil or as adults. The seed dispersal behavior of rodents could be disrupted, which is the primary way that western Joshua tree seeds are buried at a soil depth suitable for germination. Nurse plants that are critical for western Joshua tree seedling survival could also be eliminated. Any one or a combination of these disturbances may have contributed to the observed population declines.

There is much uncertainty in predicting the extent of future development within the range of western Joshua tree. The magnitude of this habitat modification and destruction will be related to the economic values of development and other human activities in the Mojave Desert and surrounding areas, and the effectiveness of local, state, and federal regulatory and legal mechanisms for protecting western Joshua tree individuals and habitat. During the candidacy period for western Joshua tree, the Department received at least 36 applications for incidental take permits to remove western Joshua trees for development projects. Regional general plans, landscape planning efforts, and specific development plans may influence where development of private property occurs in the future, but the Department considers any private property that is not protected to be at substantial ongoing risk of habitat modification and destruction from development and other human activities.

The economic value of western Joshua tree habitat for energy generation may also continue to increase. According to an analysis done by the USFWS using U.S. Environmental Protection Agency Integrated Climate and Land Use Scenarios projections, between 22% and 42% of the habitat within the southern part of western Joshua tree's range may be lost by the year 2095 due to urban growth and renewable energy development; however, less than one percent of the habitat within the northern part of western Joshua tree's range is expected to be lost during this time period (EPA 2009, 2016, USFWS 2018). Irrespective of the ultimate amount of habitat that will be lost, habitat modification and destruction of western Joshua tree habitat from development and other human activities is certain to continue.

Some areas within western Joshua tree habitat were subject to temporary disturbances or land clearing in the past but have since been left fallow. Joshua tree reestablishment in areas after disturbance from plowing and other land use such as homestead sites appears to occur very slowly if at all (Carpenter et al. 1986, Abella 2010). As described in the Establishment and Early Survival section of this Status Review, nurse plants appear to be critical habitat components for Joshua tree establishment. Regeneration of western Joshua tree to pre-disturbance levels may require the reestablishment of nurse plants before western Joshua tree seedlings are able to reestablish. The rate that Mojave Desert vegetation recovers from human-related degradation depends on the nature and severity of impacts, but recovery generally happens very slowly (Lovich 1999). Based on a review of 47 studies, Abella (2010) reported that cover of perennial vegetation in the Mojave Desert generally rebounds faster after fire compared with other disturbances such as land clearing, and this is likely due to the roots and seeds that survive wildfire. In this way modification or destruction of habitat from land clearing and other human activities is more destructive to western Joshua tree habitat than the impacts from wildfire. Development and other human activities are also a source of ignition that likely contributes to wildfire risk, as discussed in the Wildfire section of this Status Review.

As described under the Climate Change section of this Status Review, there may be a time delay between when an area becomes no longer suitable for sustaining a species, and when that species becomes locally extinct. Delayed local extinction could be occurring in areas where western Joshua tree adults remain relatively abundant, but juvenile western Joshua trees are rare, such as at the six development project sites near the cities of Palmdale and Lancaster for which the Department received western Joshua tree height data in 2021 (see Figure 8).

Present or threatened modification or destruction of habitat is a substantial threat to western Joshua tree in California, particularly at renewable energy development sites, on private property, and within the vicinity of existing urban areas in the southern part of western Joshua tree's range.

Wildfire

Fire is a defining component in many of California's ecosystems, as it is in most of the world's Mediterranean-climate regions (Keeley et al. 2011, Sugihara et al. 2018); however, the frequency and severity of fire is generally lower in California deserts than it is in other California ecosystems. Fire occurrence in the southeastern deserts of California is primarily limited by the availability of fuels, and fire return intervals in California deserts tend to be relatively long (Brooks et al. 2018, CNPS 2021a). Fire is unevenly distributed in the Mojave Desert, and fire occurrence tends to align with distinct precipitation regime boundaries, with most large and recurring fires occurring in areas that have a relatively high amount of precipitation in summer (Tagestad et al. 2016). Fuels tend to be more available, and fires tend to be more frequent at higher-elevation areas of the Mojave Desert, and the availability of fuels and frequency of fires is somewhat lower at middle elevation areas, and still lower at the low elevation areas of the Mojave Desert (Brooks et al. 2018). The abundance and distribution of invasive grasses in California deserts fluctuates with precipitation patterns. Periods of relatively high and low fire activity have been associated with periods of relatively wet and dry conditions in the Mojave Desert Region, respectively, and can be influenced by global-scale climate fluctuations including the El Ninõ-Southern Oscillation and the Pacific Decadal Oscillation, as described in the Precipitation section of this Status Review (see Figure 5). During multi-decadal periods of relatively wet conditions, cover of perennial vegetation may expand, increasing the amount of fuel on the landscape. High precipitation in one or more years may also result in a high biomass of annual plant species in those years, particularly in the spaces between perennial and woody vegetation (Brooks and Matchett 2006, Van Linn et al. 2013, Gray et al. 2014, Hegeman et al. 2014, Rao et al. 2015, Tagestad et al. 2016). Fire potential may, then, be greatest when one or more high precipitation years occurs near the end of a multi-decadal period of relatively wet conditions (Brooks et al. 2018).

Wildfire ignitions in the southeastern deserts of California were prehistorically caused by lightning, which occurs at a higher frequency in the southeastern deserts region of California than in other parts of the state (van Wagtendonk and Cayan 2008). Native Americans also ignited fires in the southeastern deserts when they arrived in California approximately 12,000 years ago (Anderson 2018). Fire regimes and related ecosystem processes were profoundly altered by land use practices associated with Euro-American settlement beginning in the mid-1800s, and these changes have in turn led to major modifications in vegetation distribution, structure, and composition (Skinner and Chang 1996, Barbour et al. 2007, Safford and Van de Water 2014, van Wagtendonk et al. 2018). When Euro-Americans began occupying lands in the Mojave Deserts region in the mid-1800s, ignitions from traditional Native American practices were curtailed, invasive plant species were widely introduced and spread, and livestock grazing became a widely implemented land use practice (Brooks et al. 2018). Livestock grazing and use of off-road vehicles, which can be extensive in the Mojave Desert, are generally associated with expansion of non-native invasive grasses. As the human population and associated electrical and transportation infrastructure rapidly increased from the early 1900s to present, sources of human-caused wildfire ignitions in the Mojave Desert also increased.

Syphard et al. (2017) examined the variety of factors contributing to wildfire in the Mojave Desert and nearby areas for a 40-year timespan. While the variables contributing to wildfires in the region are complex, Syphard et al. (2017) found that the spatial and temporal distribution of most fires (including many small fires) in the Mojave Desert from 1970 to 2010 was correlated with human disturbance, with ignitions concentrated near roads and areas of nitrogen deposition. The relationship between nitrogen deposition and fire is discussed in the Invasive Plants section of this Status Review. Syphard et al. (2017) also looked at the variables contributing to the spatial and temporal distribution of large (> 20 ha) fires, which can affect much larger areas of western Joshua tree habitat during one event. Most large fires in the Mojave Desert from 1970 to 2010 were correlated with a number of variables, but the most important variables identified were measures of the current year's and the previous year's vegetation cover, followed by nitrogen deposition and elevation. The human-caused variables contributing most to the spatial and temporal distribution of large fires was the location of power lines, oil and gas wells, wind turbines, and power plants.

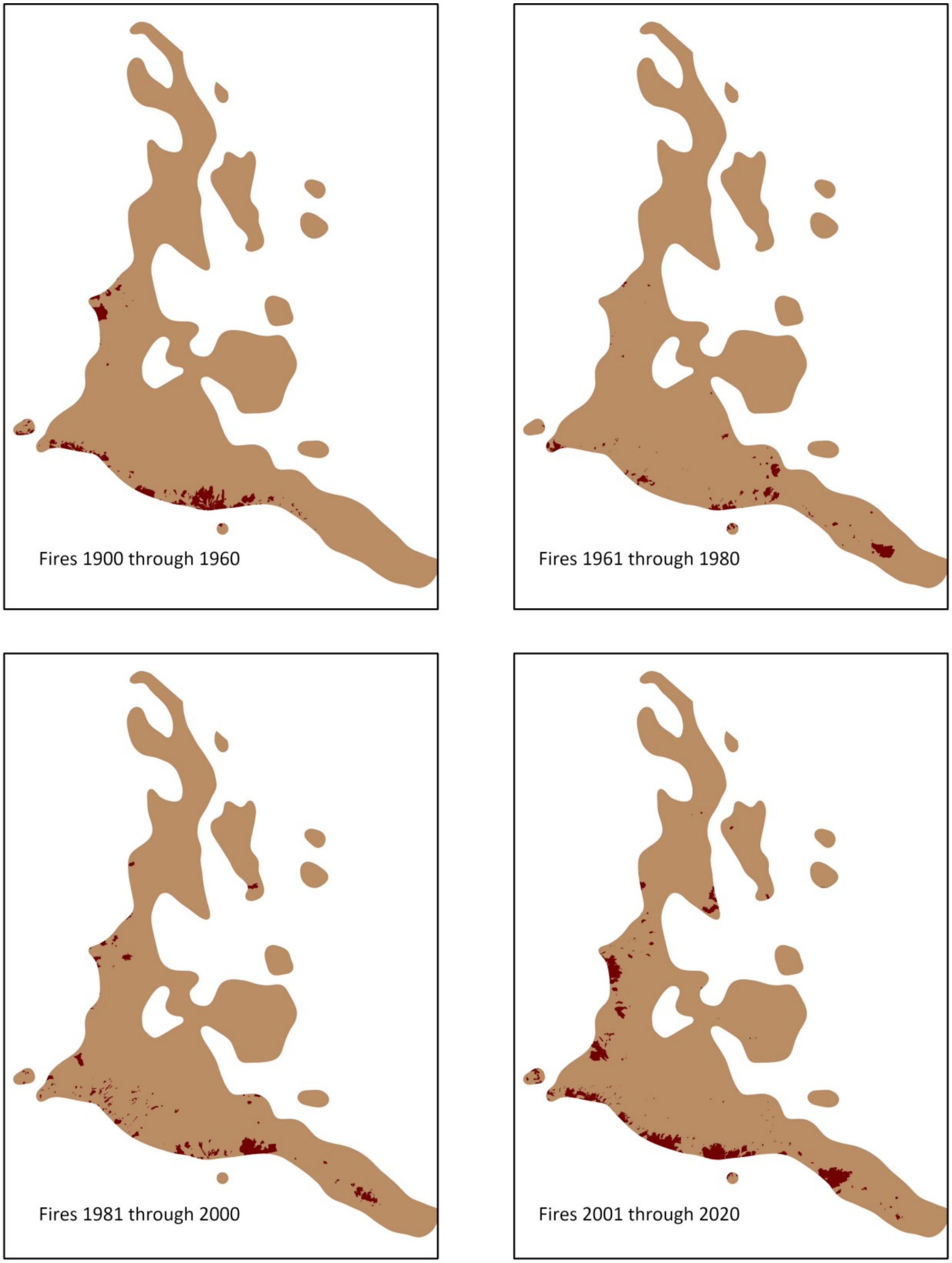
There was less summer precipitation and fewer fires during the mid-20th century period of dry conditions in the Mojave Desert that took place from approximately 1947–1975 (Tagestad et al. 2016), but since that time, particularly since the beginning of the 2000s, desert ecosystems in California have become increasingly susceptible to wildfire (Syphard et al. 2017, Brooks et al. 2018). One reason for this increasing susceptibility to wildfire is the presence of exotic annual plant species (D'Antonio and Vitousek 1992, Brooks et al. 2004, Brooks and Matchett 2006, Brooks and Chambers 2011, Fuentes-Ramirez et al. 2015, 2016). Invasive plant species were likely first introduced to the Mojave Desert by the Spanish during the late 1500s, and current human activities, such as livestock grazing, water diversion, mineral and gas extraction, military training, and recreational activities have likely continued the introduction and spread of invasive plants species in the region (Brooks 1999, Brooks and Pyke 2001). Annual plants in the spaces between shrubs provide a more continuous fuel source that allows fire to spread more easily, increasing wildfire risk (Brooks et al. 2016, Klinger et al. 2018). While native annual plants contribute to wildfire risk in the Mojave Desert, exotic annual plant species have a greater impact on wildfire risk as these species are more likely to occur in areas between shrubs and other vegetation, helping perpetuate the wildfire (Moloney et al. 2019).

There is some evidence that invasive plant species in the Mojave Desert are contributing to a grass/fire cycle (D'Antonio and Vitousek 1992), particularly in the middle-elevation areas, which is where western Joshua tree is most frequently found (Brooks and Matchett 2006, Brooks et al. 2018). The grass/fire cycle occurs when an invasive annual grass colonizes an area and provides the fine fuel necessary for the initiation and propagation of fire, leading to an increase in frequency, area, and perhaps intensity of wildfires. Following these grass-fueled fires, invasive species can increase more rapidly than native species, creating a positive feedback loop that further increases susceptibility to wildfire, and areas that previously burned may burn again

(Zouhar et al. 2008, Klinger and Brooks 2017). Red brome (*Bromus madritensis* ssp. *rubens*) can dominate middle-elevations of the Mojave Desert where western Joshua tree is frequently found, and contributes to the grass/fire cycle in these areas. Cheatgrass (*Bromus tectorum*) has dramatically shortened fire return intervals in the Great Basin, which is a cold desert province (Whisenant 1992, Balch et al. 2013), and the grass/fire cycle has caused substantial ecological impacts in the region (Brooks and Pyke 2001, Brooks et al. 2018). Cheatgrass also occurs in higher elevation areas of the Mojave Desert, a warm desert province, which receives less consistent precipitation from year to year than the Great Basin. The wildfire behavior in the middle elevation areas of the Mojave Desert is influenced by the grass/fire cycle after years of high precipitation, but less so during relatively dry periods (Brooks et al. 2016). Over the short-term, fire may have a positive effect on soil nutrients in the immediate vicinity of burned shrubs, but this effect fades in the long term (Fuentes-Ramirez et al. 2015). Wildfires can increase nitrogen availability, making soils more suitable for invasive annual species like cheatgrass, which in turn can create a feedback loop by increasing the area affected by fire (Kerns and Day 2017). There is also evidence that cheatgrass itself can increase soil nitrogen availability (Stark and Norton 2015).

Western Joshua trees tend to be found at highest densities in the middle-elevation areas of the Mojave Desert. Brooks et al. (2018) reported that the middle elevation areas of the Mojave Desert had a fire return interval of approximately 687 years based on data from 1984–2013, which is equivalent to approximately 3.0% of these middle elevation areas burning every 20 years. Brooks et al. (2018) also reported an increase in annual fire area in middle elevation areas during this 1984–2013 period (Brooks et al. 2018). Fire probability is also related to elevation, as the proportion of area burned was largest at higher elevations and lowest at lower elevations (Brooks and Matchett 2006, Brooks et al. 2018). As discussed in the Species Distribution Models section of the Status Review, high-elevation areas of the Mojave Desert likely have the highest probability of retaining 20th century suitable climate conditions for western Joshua tree, however, these areas also have a high probability of wildfire, which means that wildfire may disproportionately affect areas of climate refugia for the species.

The Department evaluated California Department of Forestry and Fire Protection (CALFIRE 2021) records of areas burned by wildfire from 1900 to present within western Joshua tree's California range, as shown on Figure 9. Wildfire primarily affects the southern and western edges of western Joshua tree's range. Based on California Department of Forestry and Fire Protection records, the area burned within western Joshua tree's California range has increased over the period of 1900–2020 (Figure 10).



California Department of Fish and Wildlife. Habitat Conservation Planning Branch. D.Mastalir. 20210813

Figure 9: Fires within the California Range of Western Joshua Tree, 1900–2020 (CALFIRE 2021)

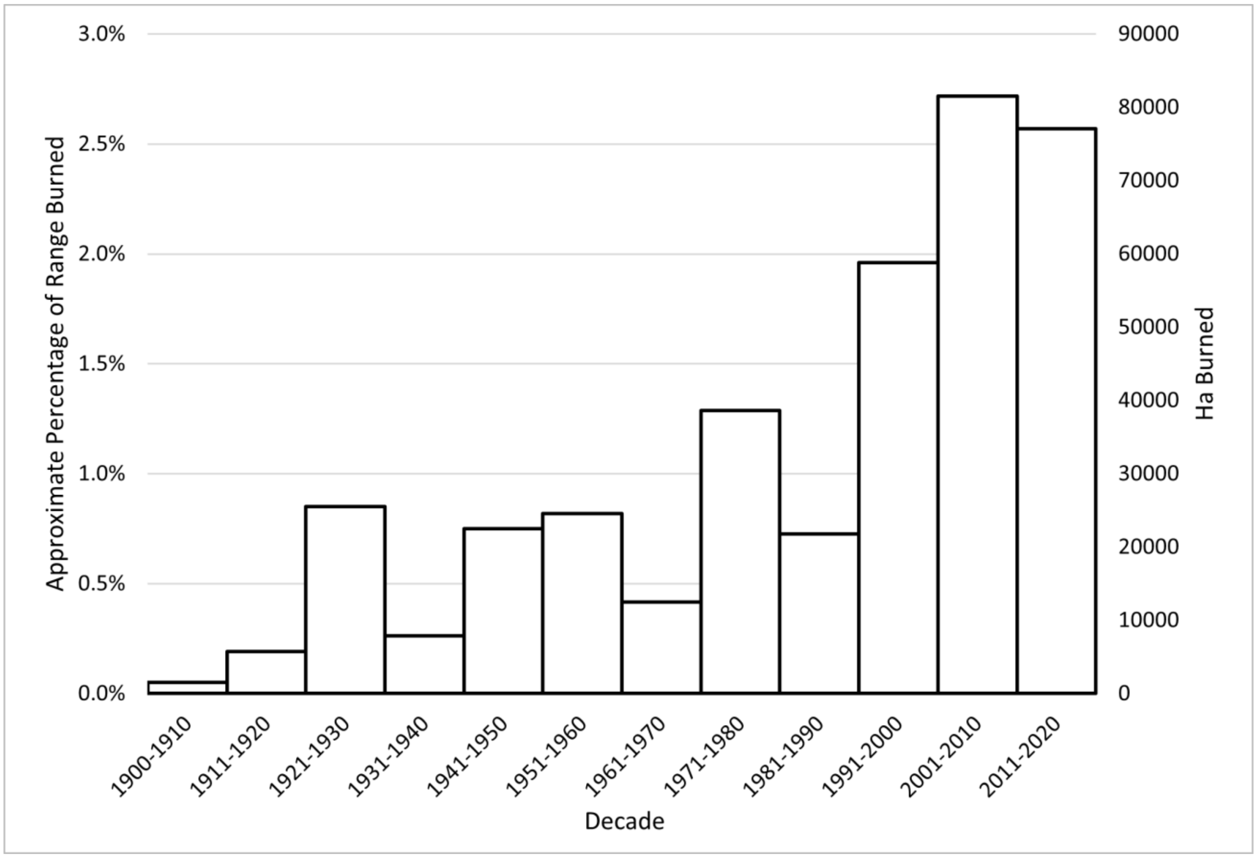


Figure 10: Area Burned Within Western Joshua Tree Range, 1900–2020 (CALFIRE 2021)

Wildfire has increased from burning less than 0.5% of western Joshua tree's California range each decade in the early 1900s, to burning approximately 2.5% of the species' range per decade between 2001–2020, though some of the increase in burned area shown in Figure 10 may be attributable to increasingly accurate and complete records in the second half of the 20th century and into the 2000s. Some areas of western Joshua tree habitat may have burned more than once over short time periods, so the areas burned within western Joshua tree's range are not necessarily cumulative. Many of the fire areas shown in Figure 9 roughly overlap with areas that have higher cover of western Joshua tree, as shown in Figure 4. In a separate analysis of California Department of Forestry and Fire Protection (CALFIRE 2021) records, Thompson (2021) calculated that 6.62% of the southern portion of western Joshua tree's range was affected by one or more wildfires between 1980–2019, however, Krantz (Appendix B) later reported that approximately 8% of total western Joshua range, and as much as 12.9% of the southern portion of western Joshua tree's range, was affected by one or more wildfires during this time period. There have been many fires in Joshua tree habitat, and the recent 2020 Dome Fire burned over 17,000 hectares (43,000 acres), and was estimated by the National Park Service (2020) to have killed 1.3 million eastern

Joshua trees, demonstrating how rapidly a wildfire can impact a dense Joshua tree population.

Fire has been recognized as a threat to Joshua tree for many decades (Webber 1953), and Joshua trees are negatively impacted or killed by wildfire and slow to recover from impacts (Minnich 1995, Loik et al. 2000b, DeFalco et al. 2010, Vamstad and Rotenberry 2010, Cornett 2012, Abella et al. 2020). Taller western Joshua trees may escape mortality from fire and heat due to their tall stature (Minnich 1995); however shorter trees are more severely affected by surface fires, with DeFalco et al. (2010) finding only approximately 20 percent of trees less than 1 m (3.2 ft) in height surviving five years after fire. The severe effect of wildfire on shorter trees causes long-lasting negative effects on the demographic health of affected populations. Persistent dead leaves along western Joshua tree trunks sometimes carry fire to the canopies of taller trees (Minnich 1995). As discussed in the Growth and Longevity section of this Status Review, post-fire recruitment from seeds appears to be rare (Borchert 2021), so Joshua tree may primarily recover from wildfire via resprouting. The new sprouts are prone to herbivory, and herbivory of western Joshua tree rhizome sprouts has been observed to be very high in the first year after a fire; however, sprouts continue to be produced in the second year after fire (Borchert pers. Comm. 2021). Western Joshua tree populations are very slow to recover from fire. Minnich (1995) found that 64% to 95% of western Joshua tree stems were fatally damaged by wildfire in all but one of 13 study sites in Joshua Tree National Park, and western Joshua tree cover and density remained low in burned sites compared with unburned sites, even 47 years after burning. DeFalco et al. (2010) found that plants in burned plots declined by 80% between 1999–2004 in Joshua Tree National Park, and plants in unburned plots declined by 26%, with drought likely contributing to the decline in both burned and unburned plots during the monitoring period. Barrios et al. (2017) compared aerial photography from 1992 with field survey results from 2017 to examine western Joshua tree survivorship and regeneration in two areas affected by a fire on Edwards Air Force Base in 1999. Barrios et al. (2017) found that the number of western Joshua trees in study areas increased from 108 in 1992 to 127 in 2017, but acknowledged that smaller western Joshua trees may not have been discernable via aerial imagery in 1992, and therefore may have been underreported. Barrios et al. (2017) reported that 73 of the 127 trees present in 2017 (57%) had been burned by the 1999 fire but resprouted and were alive.

Heat from wildfire may also kill western Joshua tree seeds on or in the soil. Keeley and Meyers (1985) found that Joshua tree seeds could not germinate after heat treatments of two hours at 90°C (194°F) or five minutes at 120°C (248°F). Peak fire temperatures reported by Brooks (2002) under and near shrubs in the Mojave Desert suggests that temperatures hot enough to kill Joshua tree seeds sometimes occur during wildfire, particularly if Joshua tree seeds are near burning shrubs and are not buried under soil.

Negative effects of wildfire on western Joshua tree could also affect *T. synthetica* populations because of the mutualistic relationship between the species, and these effects could therefore create a negative feedback loop. Lybbert and St. Clair (2016) examined the possible extended effects of wildfire on flower production, fruit production, yucca moth visitation, and cattle herbivory of eastern Joshua tree approximately eight to nine years after fire but did not find significant differences between burned and unburned populations of eastern Joshua tree. The study only examined areas where some eastern Joshua trees survived, because areas without surviving trees could not be assessed. These results suggest that the fire did not present a significant long-term impact to the population of its specialized pollinating yucca moth, or a long-term disruption to sexual reproduction, but Lybbert and St. Clair (2016) did note that the selection of eastern Joshua tree study locations in burned areas was limited due to low post-fire survival of the species.

In addition to directly killing adult and juvenile western Joshua trees, wildfire may eliminate important nurse plants (Loik et al. 2000b, Abella 2010, Brooks et al. 2018, Abella et al. 2020), increase herbivory and predation due to lowered resource availability (see Herbivory and Predation section of this Status Review), and create conditions that are more favorable for the establishment and spread of invasive species. Vamstad and Rotenberry (2010) examined how vegetation in a western Joshua tree woodland recovers after fire by examining a chronological sequence of historic burns in Joshua Tree National Park. Vamstad and Rotenberry (2010) found that while plant cover values returned to pre-fire levels between 19 and 65 years after wildfire, the reestablished vegetation assemblages in burned areas did not converge to the assumed pre-burn composition, even after 65 years. The authors suggest that the slow recovery is likely due to slow rates of reestablishment for some species. There is evidence that native annual plants in the Mojave Desert may reestablish more quickly than the Mojave Desert invasive plant species *Bromus madritensis* ssp. *rubens* (red brome) in the years immediately after fire, but red brome populations can reestablish to pre-fire conditions within two to nine years (Abella et al. 2009, Vamstad and Rotenberry 2010, Jurand and Abella 2013). Blackbrush vegetation communities appear to be particularly affected by wildfire in the Mojave Desert, and are very slow to recover from wildfire (Tagestad et al. 2016).

The amount and seasonality of precipitation in the Mojave Desert will affect fire potential in the future, but climate change effects on precipitation patterns in the Mojave Desert are still uncertain. Although many factors could be contributing to increasing wildfire risk and the spread of the invasive species that contribute to this risk in the western U.S., climate change could add to these effects via increases in the length of the growing seasons of invasive species and decreases in episodic cold mortality events, changes in the frequency of extreme precipitation events, and increases in the frequency of conditions that are conducive to increased fire potential (Abatzoglou and Kolden 2011, Hopkins 2018). Smith et al. (2000) found that elevated CO_2 increased the productivity and success of invasive species in an arid ecosystem, which suggests that climate change might enhance the long-term success of invasive species in the Mojave Desert, further increasing wildfire risk. Regardless of the extent to which climate change is contributing to wildfire risk in the Mojave Desert, if the wildfire trends reported by Brooks et al. (2018) and shown in Figure 10 continue, the threat of wildfire to western Joshua tree will increase.

Summary of Wildfire Threat

Wildfire is a substantial threat to western Joshua tree and invasive plants contribute to that threat, but wildfire does not affect the entire range of the species evenly, does not necessarily burn through areas in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. For these reasons, wildfire is likely to reduce the abundance of the species, and may negatively impact the species distribution, however, it is unlikely to result in a serious danger of elimination of the species throughout a significant portion of its range. Nevertheless, because western Joshua tree recruitment from seed is rare, and because the species takes a long time to reestablish in burned areas, wildfire causes long-lasting negative effects in burned areas. The Department expects that the impacts from continuing and increasing wildfire activity in the Mojave Desert and surrounding areas will cause ongoing gradual reductions in the size of at-risk populations of western Joshua tree within California, but the range of the species is unlikely to be affected by wildfire in the foreseeable future, because western Joshua tree is unlikely to be completely eliminated from affected areas due to its high abundance and widespread distribution.

Invasive Plants

Non-native species are those that did not naturally occur in an area but that have become established and continue to reproduce in the wild. Invasive species are non-native species that have been determined to cause negative impacts to the environment or economy. Invasive species are often cited as the second greatest threat to biodiversity behind habitat loss (Wilcove et al. 1998, Mack et al. 2000, Levine et al. 2003, Pimentel et al. 2004) and North America has accumulated the largest number of naturalized, non-native plants in the world (van Kleunen et al. 2015). Many studies hypothesize or suggest that competition is the process responsible for observed invasive species impacts to biodiversity; however, invasive species may impact native species in a variety of ways (Levine et al. 2003). Invasive species may threaten native populations through competition for light, water, or nutrients; deposition of harmful biochemicals to soil; alteration of soil chemistry (e.g., pH, salinity); thatch accumulation that inhibits seed germination and seedling recruitment; changes in fire frequency; disruptions to pollination or seed-dispersal mutualisms; changes in soil microorganisms; diseases; or other mechanisms. The magnitude of invasive species impacts depends on the characteristics of the invading species and the characteristics of the location being invaded (Gaertner et al. 2009, Fried et al. 2014). Invasive species may also influence native species' colonization rates, leading to declines in local diversity over longer timescales (Yurkonis and Meiners 2004).

Invasive plant species are widespread in the Mojave Desert and throughout California, and in many cases, they compose large proportions of overall plant biomass (Brooks and Berry 2006). Invasive plant species that have reached "infested" to "spreading" status by the California Invasive Plant Council and that are causing severe ecological impacts within the Mojave Desert region of California include Saharan mustard (*Brassica tournefortii*), red brome, and cheatgrass (California Invasive Plant Council 2021). Russian-thistle (*Salsola tragus*), Arabian schismus (*Schismus arabicus*), and common Mediterranean grass (*Schismus barbatus*) are also reported by the California Invasive Plant Council to have reached "infested" to "spreading" status within the Mojave Desert region of California, but are not currently causing as severe of ecological impacts as Saharan mustard, red brome, and cheatgrass (California Invasive Plant Council 2021). There are many other species of plants that are not native to the Mojave Desert region of California but that have become established, and are continuing to reproduce and persist in the region (Weatherwax et al. 2002). The best predictors for the abundance and diversity of non-native and invasive plant species in the Mojave Desert may be proximity to human disturbance and development, including roads, off-highway vehicle use, livestock grazing and agriculture (Brooks and Berry 2006). Even within the protected lands of Joshua Tree National Park, there are few, if any, areas that have not been invaded by non-native and invasive grasses (Frakes pers. comm. 2021).

Increased nutrient availability through anthropogenic nitrogen deposition from air pollution has been shown to be a contributor to the abundance and spread of invasive plant species, including within the Mojave Desert (Allen et al. 2009, Allen and Geiser 2011, Pardo et al. 2011, Bytnerowicz et al. 2015, Rao et al. 2015). While precipitation is the primary driver influencing the biomass of invasive species in the Mojave Desert, nitrogen deposition has a smaller contributing effect (Rao et al. 2015), and this nitrogen deposition is already making an indirect, but substantial contribution to the spatial and temporal patterns of wildfire in the Mojave Desert (Syphard et al. 2017). Nitrogen deposition from anthropogenic sources is expected to increase in some parts of the world with increasing global emissions in the coming decades, particularly in areas that are still developing, but the depositions may show decreases in the 2100s even under different emissions scenarios (Zhang et al. 2019).

The primary way in which non-native and invasive plant species currently affect western Joshua tree is indirectly by fueling wildfire, as discussed in the Wildfire section of this Status Review. The contribution of invasive plant species to wildfire is expected to continue in the future, as human activities continue to promote the spread of non-native and invasive species within the range of western Joshua tree.

The Department is not aware of any studies examining the competitive effects of other plant species on western Joshua tree specifically, but invasive plant species, especially annual grasses, can rapidly invade Mojave Desert habitats and can compete with other plants for light, water, space, and nutrients (Brooks 2000, DeFalco et al. 2003, 2007, Blank 2010, Perkins and Hatfield 2014). Western Joshua tree is likely the most vulnerable to competitive effects from invasive plant species in the years immediately following germination, and plants likely become less vulnerable as they get larger. The Department currently considers competition with invasive plant species to be a minor threat to western Joshua tree.

Herbivory and Predation

Consumption of western Joshua tree seeds by both *T. synthetica* larvae, and seed-caching rodents is a natural component of the western Joshua tree life cycle. While there is a cost of these ecological relationships for western Joshua tree, the species also receives benefits in the form of sexual reproduction and seed dispersal. Physical damage to ovules of another species, Adam's needle (*Yucca filamentosa*), can trigger affected flowers to selectively abort and drop (Pellmyr and Huth 1994, Huth and Pellmyr 2000, Marr and Pellmyr 2003), which suggests that western Joshua tree may also be able to limit excessive negative effects from moth larvae eating seeds by dropping flowers that may have too many moth eggs. The relative costs and benefits of the ecological relationships between western Joshua tree, *T. synthetica*, and seed-caching rodents likely fluctuates based on environmental conditions and other factors, and the costs might outweigh the benefits when other stressors are acting upon the system, such as the factors that are discussed in this Status Review.

Other moth species may also oviposit on Joshua tree flowers so that their larvae may hatch inside and feed on seeds, but this relationship is strictly parasitic, because these moth species do not also pollinate western Joshua tree (Althoff et al. 2004). Along an elevational gradient within Joshua Tree National Park, Harrower and Gilbert (2018) found bogus yucca moth (*Prodoxus* sp.) that parasitizes western Joshua tree to be the most abundant in areas with the highest density of western Joshua tree, except at the highest elevation sampling site at 2,212 m (7,257 ft) where no sexual reproduction of western Joshua tree was observed, and asexual reproduction was abundant. Western Joshua tree may be able to limit impacts of seed predation from these moth larvae by dropping fruit before maturity, and infertile seeds could also help limit predation because moth larvae sometimes exit the fruit after encountering infertile seeds (Ziv and Bronstein 1996). There has been some investigation into how strongly the bogus yucca moths negatively impact the reproductive success of *Yucca* spp., but a strong effect has not been found (Althoff et al. 2004).

Other insect species feed on western Joshua tree as well. Yucca weevil (*Scyphophorus yuccae*) is a native insect species that feeds on *Yucca* spp. and related plants in the southwestern region of the United States, and has been found on Joshua tree (Vaurie 1971, Huxman et al. 1997). Yucca weevil larvae build protective cases near the ends of Joshua tree branches, and resulting damage to the meristem has been noted to cause branching in affected plants (Jaeger 1965). The Navaho yucca borer butterfly (*Megathymus yuccae navaho*) is reported to ignore young Joshua tree plants growing from seeds, and instead lays eggs only in Joshua trees that arise from asexual growth, with the resulting larvae boring into the underground rhizomes, where they feed and later pupate (Jaeger 1965). Lastly, a small contained outbreak of the yucca plant bug (*Halticoma valida*) was reported as impacting several planted Joshua trees at a demonstration garden in the town of Joshua Tree (JTNP 2017).

Domestic grazing animals can modify and degrade western Joshua tree habitat, and cattle may also eat portions of western Joshua tree plants. Cattle have been reported to graze on Joshua tree flowers when they can be reached (Wallace and Romney 1972, Lybbert and St. Clair 2017), and seeds and fruits are reported to be “fairly good feed materials” (Webber 1953). Cornett (2013) observed conspicuous cattle browsing on shrubs and other plants at one monitoring plot in Death Valley National Park but did not observe any evidence that cattle browsed western Joshua trees within the plot. Lybbert and St. Clair (2017) found that cattle removed 40% of eastern Joshua tree flower inflorescences that were lower than 2 m (6.6 ft) in one study area in Nevada but found that flower inflorescences above this height were not removed. Conversely, Cornett (1995) speculated that grazing by cattle can benefit Joshua tree by reducing bunch grass, favoring the presence of shrubs (nurse plants) that aid in Joshua tree seedling survival.

Small mammals, including antelope ground squirrels (*Ammospermophilus leucurus*), Botta’s pocket gophers (*Thomomys bottae*), black-tailed jackrabbits (*Lepus californicus*), and woodrat (*Neotoma* spp.) sometimes strip the periderm (bark) from Joshua trees, exposing large light-colored patches of underlying tissue and hollowing out stems, and this occurs more frequently during periods of drought (Esque et al. 2003, 2015, DeFalco et al. 2010). Following observations of damage to the trunks of western Joshua trees within Joshua Tree National Park in October of 2001, Esque et al. (2003) measured the survivorship of damaged trees in the summers of 2002 and 2003 and found that 95% of undamaged trees survived, but only 42% of trees with bark damage survived. The more damaged the western Joshua trees were, the less likely they were to be alive in 2003. No trees with more than 25% of their bark removed survived, but 60% of the trees with <5% of their bark removed survived. Five years after a wildfire and after a period of drought in Joshua Tree National Park, DeFalco et al. (2010) found that 14% of western Joshua trees in unburned areas and 28% of western Joshua trees in burned areas had bark damage from small mammals and this bark damage was correlated with reduced survival of plants, particularly at lower elevation areas where the most bark damage occurred.

Mammals can also eat other parts of western Joshua tree. Black-tailed jackrabbits can consume young western Joshua tree rhizome sprouts (Cornett 1995) and seedlings. Over half of a cohort of 53 five to seven year-old western Joshua tree plants were killed from black-tailed jackrabbit herbivory during a drought in 1989 and 1990 (Esque et al. 2015). Herbivory on basal sprouts may also be particularly high in the first year after a fire (Borchert pers. comm. 2021). Sanford and Huntly (2009) found that desert woodrats (*Neotoma lepida*) primarily fed on the tips of eastern Joshua tree leaves, tending to leave the leaf bases intact, and that they prefer leaves with higher nitrogen content, which tends to occur on the south side of plants.

Herbivory and predation result in relatively minor negative impacts overall to western Joshua tree. Impacts from small mammals are likely highest in non-masting years, when they consume nearly all of the western Joshua tree seeds that are produced, and during periods of drought, when they can damage the bark of trees, potentially causing mortality in affected trees. Cattle may also consume quantities of flowers in grazed areas. Herbivory during early seedling stages may negatively impact recruitment because the species may be particularly vulnerable at this life stage. Herbivory of western Joshua tree may also increase if droughts become more frequent and longer due to climate change (Esque et al. 2015). Nevertheless, because western Joshua tree is currently abundant and widespread, the Department considers the overall threat to the species from herbivory and predation to be relatively small.

Use and Vandalism

Western Joshua tree has long been available and used in the horticultural trade, with seeds and plants collected from the wild, and individuals planted within and outside of the species' native range. Joshua tree was briefly but unsuccessfully used for paper pulp and surgical splints in the late 1800s and early 1900s (McKelvey 1938). Concern about impacts from commercial collecting and overutilization of Joshua trees and other desert plants was raised as early as 1930 (Carr 1930, Griffin 1930, Runyon 1930), and shortly afterwards some areas of the Mojave Desert were protected. Desert vegetation also received protection from commercial collection with the passage of the California

Desert Native Plants Act (DNPA) in the early 1980s. Collection of western Joshua tree seeds and plants from the wild for horticultural reasons likely continues to occur to some extent near roads, but the impact to the species from these activities is considered relatively minor. Western Joshua tree may also continue to be used traditionally by Native Americans (Coville 1892, Stoffle et al. 1990, Fowler 1995, Small 2013, Gaughen pers. comm. 2020), but impact to the species from these activities is also considered relatively minor. Vandalism of western Joshua trees occasionally occurs in some areas (Airhart 2019), and one of the largest known western Joshua trees was maliciously burned to the ground (McKelvey 1938, Cummings 2019). Western Joshua tree is currently abundant and widespread, and the threat to the species from use and vandalism is currently considered relatively minor.

EXISTING MANAGEMENT

Regulatory Status and Legal Protections

Some local, state, and federal laws apply to activities undertaken in California that may provide western Joshua tree and its habitat some level of protection from development and other human activities. A discussion of some of the local, state, and federal laws that are applicable to western Joshua tree is provided below; however, the following is not an exhaustive list.

In general, the highest level of regulatory protection that western Joshua tree has received so far has been the result of the species being designated a candidate under CESA on October 9, 2020, which prohibits take of the species during the candidacy period and typically requires take to be minimized and fully mitigated to Department standards. Absent the protections of CESA, other federal, state, and local laws and regulations may provide limited avoidance, minimization, and mitigation of impacts for the species, with protection or mitigation of impacts often only required when a controlling agency or project proponent determines it is feasible to do so. In many cases, removal of western Joshua trees and related habitat destruction may proceed with a permit from a local agency that does not require mitigation for habitat loss. Permits may also be issued that only require moving individual western Joshua trees out of the habitat that is to be destroyed, but the habitat destruction is not mitigated. Absent the protections of CESA, trends of western Joshua tree habitat loss and degradation from development and other human activities will likely continue.

During the candidacy period for western Joshua tree, the Department has also received numerous reports of the unpermitted killing of western Joshua trees on private property, and related habitat modification and destruction. Impacts from unpermitted or illegal activities do take place, and laws and regulatory mechanisms are only effective if they are followed and enforced.

Federal

Federal Endangered Species Act

Western Joshua tree has no regulatory protection under the federal ESA. Both western Joshua tree and eastern Joshua tree were petitioned to be listed as threatened under the federal ESA (16 U.S.C. §§ 1531-1544) in 2015 (Jones and Goldrick 2015). After conducting an assessment of the two species, the USFWS issued a decision (12 Month Finding) that listing Joshua tree as an endangered or threatened species was not warranted (USFWS 2018, 2019). In *WildEarth Guardians v. Haaland*, 2021 U.S. Dist. LEXIS 179024, the United States District Court for the Central District of Columbia set aside the USFWS' 12 Month Finding as arbitrary, capricious, and contrary to the federal ESA and remanded the 12 Month Finding to the USFWS for reconsideration consistent with the court's findings.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to assess the environmental effects of their proposed actions prior to making certain decisions. Using the NEPA process, agencies evaluate the environmental and related social and economic effects of their proposed actions. Agencies also provide opportunities for public review and comment on those evaluations. Title I of NEPA contains a Declaration of National Environmental Policy. This policy requires the federal government to use all practicable means to create and maintain conditions under which man and nature can exist in productive harmony. Section 102 in Title I of the Act requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach. Specifically, all federal agencies are to prepare detailed statements assessing the environmental impact of and alternatives to major federal actions significantly affecting the environment. These statements are commonly referred to as Environmental Impact Statements and Environmental Assessments.

State

California Endangered Species Act

Western Joshua tree was designated a candidate species under CESA on October 9, 2020. During candidacy, CESA prohibits the import, export, take, possession, purchase, or sale of western Joshua tree, or any part or product of western Joshua tree, except as otherwise provided by the Native Plant Protection Act (NPPA), the DNPA, or Fish and Game Code, such as through a permit or agreement issued by the Department under the authority of the Fish and Game Code (Fish & G. Code, § 2080 et seq.). For example, the Department may issue permits that allow the incidental take of listed and candidate species if the take is minimized and fully mitigated, the activity will not jeopardize the continued existence of the species, and other conditions are met (*Id*. at § 2081, subd. (b)). The Department may also authorize the take and possession of listed and candidate species for scientific, educational, or management purposes (*Id*. at § 2081, subd. (a)). Furthermore, the Department may issue a Safe Harbor Agreement to authorize incidental take of listed or candidate species if a landowner provides a net conservation benefit to the species, implements practices to avoid or minimize incidental take, establishes a monitoring program, and meets other program conditions (*Id*. at § 2089.2 et seq.). Finally, the Department may authorize take associated with routine and ongoing agricultural activities through Voluntary Local Programs if management practices avoid and minimize take to the maximum extent practicable, as supported by the best scientific information for both agricultural and conservation practices, among other conditions (*Id*. at § 2086).

<u>Native Plant Protection Act</u>

The NPPA (Fish and G. Code, §§ 1900-1913) was enacted to preserve, protect, and enhance endangered or rare native plants in the state. (*Id*. at § 1900). The NPPA allows the Fish and Game Commission (Commission) to designate plants as rare or endangered. (*Id*. at § 1904). Section 1908 of the NPPA prohibits the take, possession, or sale of any endangered or rare native plant or part or product thereof except as otherwise provided by the NPPA. Provisions in the NPPA allow for the take of rare and endangered plants under limited circumstances, including clearing of land for agricultural practices or fire control measures as authorized by a public agency; timber operations conducted in accordance with a timber harvesting plan submitted pursuant to the Z'berg-Nejedly Forest Practice Act of 1973; required mining assessment work pursuant to federal or state mining laws; removal of endangered or rare native plants from a canal, lateral ditch, building site, or road, or other right-of-way by the landowner or his agent; or performance by a public agency or public utility of its obligation to provide service to the public (*Id*. at § 1913, subd. (a) and (b)). A landowner who has been notified by the Department pursuant to NPPA section 1903.5 that a rare or endangered native plant is growing on their land must notify the Department at least 10 days before changing the land use to allow for salvage of such plants (*Id*. at § 1913, subd. (c)). If the Department fails to salvage plants within 10 days of notification, the landowner shall be entitled to proceed without regard to the NPAA. (*Id*.) The NPPA does not apply to western Joshua tree because it is a candidate for listing as a threatened species, and the NPPA only applies to endangered and rare species.

California Desert Native Plants Act

The DNPA (Food and Ag. Code, § 80001 et seq.) generally allows for take of specified desert native plants (including yuccas, such as western Joshua tree) upon issuance of a permit from the county commissioner or sheriff. The DNPA allows for harvest or possession of five or fewer plants without a permit (*Id.* at § 80118). The DNPA also provides exemptions from permitting for a variety of activities, including land clearing for agricultural purposes, fire control, and required mining assessment work pursuant to federal or state mining laws; recreational events sanctioned by BLM; clearing or removal of native plants from a canal, lateral ditch, survey line, building site, or road, or other right-of-way by a landowner or his agent; and actions taken by a public agency or public utility in the performance of its obligation to provide service to the public (*Id*. at § 80117). The DNPA states that rare, endangered, and threatened native plants are exempt from its requirements (*Id*. at § 80075). Pursuant to this provision, the DNPA does not apply to western Joshua tree because it is a candidate for listing as a threatened species.

California Environmental Quality Act

State and local agencies must conduct environmental review under the California Environmental Quality Act (CEQA) for discretionary projects proposed to be carried out or approved by the public agency unless the agency properly determines the project is exempt from CEQA (Pub. Resources Code, § 21080). If a project has the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species, the lead agency must make a finding that the project will have a significant effect on the environment and prepare an environmental impact report (EIR) or mitigated negative declaration as appropriate before proceeding with or approving the project (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15070, and 15380). An agency cannot approve or carry out any project for which the EIR identifies one or more significant effects on the environment unless it makes one or more of the following findings: (1) changes have been required in or incorporated into the project that avoid the significant environmental effects or mitigate them to a less than significant level; (2) those changes are in the responsibility and jurisdiction of another agency and have been, or can and should be, adopted by that other agency; or (3) specific economic, legal, social, technological, or other considerations make infeasible the mitigation measures or alternatives identified in the environmental impact report (Pub. Resources Code, § 21081; Cal. Code Regs., tit. 14, §§ 15091 and 15093). For (3), the agency must make a statement of overriding considerations finding that the overriding benefits of the project outweigh the significant effects on the environment. CEQA establishes a duty for public agencies to avoid or minimize such significant negative effects where feasible (Cal. Code regs., tit. 14, § 15021). Impacts to western Joshua tree, as a CESA-candidate species, should be identified, evaluated, disclosed, and mitigated or justified under the Biological Resources section of an environmental document prepared pursuant to CEQA.

Local

Many local city and county ordinances regulate tree removal, some with specific regulations potentially applicable to western Joshua trees. As applied to western Joshua tree, most of these local ordinances are currently preempted by CESA given the species' candidacy status and will continue to be preempted if the species is listed. The only two exceptions are the newer ordinances adopted by the City of Palmdale and Town of Yucca Valley to implement the Fish and Game Code section 2084 regulation adopted by the Commission. However, the City of Palmdale and Town of Yucca Valley ordinances will only be valid during western Joshua tree's candidacy since section 2084 regulations cannot apply to western Joshua tree after candidacy. If western Joshua tree is not listed as a threatened or endangered species under CESA or the federal ESA after candidacy, certain local ordinances would allow for removal of western Joshua tree without required mitigation under specified circumstances. Therefore, these local regulations may not adequately protect western Joshua trees from direct removal or loss of habitat, and the species may remain threatened by human development absent protections under CESA.

Inyo County

Property owners are responsible for maintenance of trees on private property and no permit is required for private property owners to trim or remove trees in the streetside apron or on private property (Inyo County Code, tit. 12, §§ 12.20.030, 12.20.040). In districts zoned for wireless communications or solar facilities, the planning commission may consider the nature, type, and extent of tree coverage when reviewing and issuing a conditional use permit (*Id*. at tit. 18, §§ 18.76.080, 18.79.080). Grading, filling, or stripping vegetation during subdivision development must be performed concurrently with the final map or parcel map improvement and required bonds, or must be authorized pursuant to a grading permit issued by the advisory agency with appropriate erosion control conditions to protect adjoining properties and the general welfare (*Id*. at tit. 16, § 16.040.030).

City of Bishop

The location and type of all trees greater than four inches in diameter must be shown on final maps and parcel maps, including parcels proposed for subdivision (City of Bishop Code, tit. 16, §§ 16.20.320, 16.16.100). The city may require removal of trees on right-of-way easements (*Id*. at § 16.28.170). Grading restrictions defer to the subdivision map or parcel map improvement and bonds requirements, or to authority given by the planning commission (*Id*. at § 16.28.170). Applications for conditional use permits for conversion of residential units to condominiums must include development plans specifying the location of and provisions for any unique natural and/or vegetative site features (*Id*. at tit. 17, § 17.84.030).

<u>Kern County</u>

The Kern County Code of Ordinances does not provide any protection for western Joshua trees. In general, tree removal is not prohibited. Development permits may require a landscaping plan or assessment of native vegetation to be removed but do not restrict removal nor encourage retention.

<u>California City</u>

The California City code of ordinances provides regulations for maintenance and removal of trees in public places and prohibits persons operating off-road vehicles from malicious or unnecessary damage to vegetative resources (California City Code, tit. 4, § 4-2.606 and tit. 7, § 7-8.104). No regulations for trees on private property are included in this code of ordinances.

<u>Ridgecrest</u>

The Ridgecrest City Planning Commission may require development plan standards related to planting and maintenance of trees (City of Ridgecrest Code, § 106-347). Development projects and rezoning proposals must undergo site review; applications must describe the location of existing and proposed trees (*Id*. at § 106-172). Grading permits are reviewed by the city engineer and applicants must present detailed written plans for the site (*Id*. at § 104-4).

<u>Tehachapi</u>

In public spaces in Tehachapi, the removal, maintenance, and replacement of trees is overseen by the street superintendent (Tehachapi Code, tit. 12, § 12.08.080). In the area zoned for the airport, regulations limit tree height and provide for removal of nonconforming or deteriorated/decaying trees (*Id*. at tit. 11, § 11.12.150). Removal of trees on utility easements may be required by the city (*Id*. at tit. 17, § 17.28.140).

<u>Los Angeles County</u>

Within Significant Ecological Areas designated in the Los Angeles General Plan, protections for western Joshua tree are thorough and detailed (Los Angeles County Code of Ordinances, tit.22, § 22.102). In these areas, Los Angeles County issues

Protected Tree Permits and Conditional Use Permits requiring mitigation for removal of any single heritage tree, removal of two or more non-heritage trees, or encroachment into more than 10% of the buffer zone around any western Joshua tree. Exceptions include removal related to construction or improvement of single-family residences, accessory structures, and animal keeping facilities, fuel reduction around existing buildings (no buffer limit stated), and maintenance related to public utility lines.

<u>City of Lancaster</u>

The City of Lancaster incentivizes the retention of Joshua trees by allowing commercial and industrial zoning parcel adjustments by up to 10% if the changes will result in the retention or preservation of Joshua trees (City of Lancaster Code of Ordinances, tit. 17, §§ 17.12.100, 17.12.780, and 17.16.090).

<u>City of Palmdale</u>

Pursuant to the Special Order approved by the Commission on December 10, 2020, pursuant to Fish and Game Code section 2084, the City of Palmdale amended Chapter 14.04 of the Palmdale Municipal Code to authorize removal of western Joshua trees only as consistent and compliant with the Special Order. With limited exceptions, Chapter 14.04 generally prohibits the removal of western Joshua trees and other specified native desert vegetation without approval by permit from the City's Landscape Architect, or in lieu thereof, the Director of Public Works' designee (Palmdale Municipal Code, § 14.04.040). All development proposals for sites containing native desert vegetation must contain a written report and site plan with specified information on each western Joshua tree located on-site, a site landscaping plan, and a long-term maintenance program for any western Joshua trees preserved on-site (*Id*. at § 14.04.050). These development proposals must also meet minimum preservation criteria, including preservation of at least two western Joshua trees per gross ac on average unless specified conditions are met that allow for use of a different standard determined by a desert native plant specialist (*Id*. at § 14.04.060). In specified circumstances, western Joshua trees may be transplanted (*Id*.). If western Joshua trees will be removed and not replanted on-site, they can be made available to the City of Palmdale or the public to plant elsewhere (*Id*.) If none of those options are feasible, the proponent may pay an in-lieu fee to the City of Palmdale (*Id*.). After construction of the development proposal and final inspection, project proponents must meet ongoing maintenance requirements, including maintaining western Joshua trees and other native desert vegetation in healthy condition for at least two growing seasons (*Id*. at § 14.04.070). Except in limited circumstances, a violation of Chapter 14.04 is a misdemeanor punishable by a fine of up to $1,000, imprisonment for up to six months, or both such fine and imprisonment (*Id*. at §§ 14.04.110, 1.12.010, and 1.12.020). In addition to these penalties, Chapter 14.04 requires the responsible party to replace any damaged, illegally cut, destroyed, killed, removed, mutilated or harvested western Joshua trees pursuant to the recommendation of an authorized desert native plant specialist retained at the responsible party's expense (*Id*. at § 14.04.100).

County of Riverside

A permit is required for the removal of living native trees located above 5,000 ft in elevation in the unincorporated areas of the county, unless an exemption for timber operations, federal or state government actions, or public utility actions applies; unless the removal is authorized under an approved conditional use or public use permit; or unless the tree constitutes an immediate threat to public health, safety, or general welfare. Trees can also be removed if they are located within 20 ft of an existing permitted structure; the tree is diseased, dead, or dying and removal is recommended by the California Department of Forestry and Fire Protection to protect forest health; or the fire protection agency with jurisdiction requires removal pursuant to a fire hazard reduction program. (Riverside County Code of Ordinances, tit. 12, § 12.24). Trees located below 5,000 ft in elevation receive no protection. All known western Joshua trees within Riverside County that are above 5,000 ft are within Joshua Tree National Park.

County of San Bernardino

Preconstruction inspections shall be required before approval of development permits to determine the presence of regulated trees and plants (County of San Bernardino Code, tit. 8, § 83.10.050). All Joshua trees are designated as Regulated Desert Native Plants; thus, a Tree or Plant Removal Permit is required for removal of any western Joshua tree or any part thereof (*Id*. at tit. 8, § 83.10.060). These permits may be issued by the County Director of Land Use Services in conjunction with or not in conjunction with a land use application or development permit. The permit review authority may require certification from an appropriate arborist, registered professional forester, or desert native plant expert that the proposed removal activities are appropriate, supportive of a healthy environment, and in compliance with both the County of San Bernardino Municipal Code and the California Department of Fish and Wildlife's procedures. The permit conditions of approval may specify criteria, methods, and persons authorized to conduct the tree removal and may require the trees to be transplanted and/or stockpiled for future transplanting.

In order to authorize the removal of a western Joshua tree, the applicable review authority must find that removal is justified for one of the following reasons: the location of the tree or its dripline interferes with an allowed structure, street, or other planned improvement and there is no other feasible location for the improvement; the tree is hazardous to pedestrian or vehicular travel or safety, or is causing extensive damage to public structures, or the tree is in such close proximity to an existing or proposed structure that the tree will sustain significant damage. If the tree is located in the desert region of San Bernardino County, additional findings must be made including that western Joshua trees will be transplanted or stockpiled for future transplanting wherever possible and that for removal of specimen-sized western Joshua trees (circumference equal to or greater than 50 in, total height of 15 ft or greater, possessing a bark-like trunk, or in a cluster of ten or more individual tress of any size), no other reasonable alternative exists for the development of the land.

For each removal of a separate tree, penalties for illegal removal can include misdemeanor charges, fines of $500-$1000 and/or six months in jail, and other requirements to correct the conditions resulting from the violation.

The 2020 San Bernardino Countywide Plan includes the County Policy Plan, which encourages retention of western Joshua trees but does not provide regulations nor clarify a permit review process. Community plans nested within this plan describe values and characteristics of planned communities but do not regulate removal or retention of western Joshua trees. While much of San Bernardino County is federal property, these community plans cover most of the remaining private land within county boundaries.

<u>City of Adelanto</u>

Any application for a new development or for proposal to increase existing land use or outdoor recreational or other use by 25% must provide a biological resources report including mitigating measures to reduce or eliminate impacts to biological resources (City of Adelanto Code, tit. 17, § 17.57.030). Development projects must abide by County of San Bernardino requirements for relocation of Joshua trees (*Id*. at tit. 17, § 17.57.040). Only the City Engineer may be authorized to trim, prune, cut, or deface trees on City property, roads, or streets (*Id*. at tit. 13, § 13.50.050).

<u>Town of Apple Valley</u>

Town of Apple Valley must review and approve any removal of a Joshua tree on any property within any zoning district (Apple Valley Code of Ordinances, tit. 9, § 9.76.040). The code includes detailed requirements for documented removal justification, provides guidance for relocation/transplanting, and establishes a Joshua Tree Preservation and Adoption program. Development permits must find that all Joshua trees are adequately protected and preserved where feasible (*Id*. at tit. 9, § 9.17.080).

City of Barstow

City of Barstow Code of Ordinances suggests retention of native vegetation where possible but does not prohibit removal or require a survey or review process (Barstow Code of Ordinances, tit. 19, § 19.08.050). The code does not specifically reference western Joshua trees.

Hesperia

Removal of any western Joshua tree requires a permit issued by the agricultural commissioner or other applicable review authority (Hesperia Code of Ordinances, tit. 16, §16.24.150). However, the Hesperia Code does not provide specific information about the review process. Penalties for violation of the code include revocation of the permit, prohibition on issuance of new permits for one year (first offence) or life (second offense), and requirements to turn over any unused tags and seals or wood receipts (*Id*. at tit. 16, § 16.24.170). Lot design standards encourage retention of dense stands of Joshua trees to the maximum extent possible (*Id*. at tit. 17, § 17.48.070).

City of San Bernardino

There is a small population of western Joshua trees in Cajon Wash in the City of San Bernardino. A permit is required for removal of more than five trees within any 36-month period from a development site or parcel of property (City of San Bernardino Code of Ordinances, tit. 15, § 15.34.020). Permits are issued by the Development Services Department of the City of San Bernardino, wherein the Planning Official determines whether the trees can be removed without detriment to the environment and welfare of the community and thereby issues or denies the permit (*Id*. at tit. 15, § 15.34.040). Penalties for noncompliance include infraction or misdemeanor, fine, and restitution to the City of San Bernardino for the amount not to exceed the replacement value (*Id*. at tit. 15, § 15.34.060). Development standards encourage retention of natural vegetation where possible and Conditional Use Permits require a landscaping plan showing disposition of existing trees (*Id*. at tit. 19, §§ 19.17.070, 19.17.080).

Twentynine Palms

To reduce disturbances to fragile desert soils and reduce the amount of fugitive dust, removal of natural vegetation on parcels one ac or greater in size for construction of building pads, driveways, landscaping, agriculture, or other allowed uses in the underlying zone requires a Building Permit or Grading Permit issued by the City's Building Official (Twentynine Palms Code of Ordinances, tit. 19, § 19.64.030). In areas zoned for scenic vistas or scenic highways and geologic hazards, retention of native vegetation is encouraged but not required (*Id*. at tit. 19, §§ 19.26.030, 19.26.040). The code does not specifically reference western Joshua trees.

Victorville

Written approval from the director of parks and recreation or his designee is required to cut, damage, destroy, dig up, or harvest a western Joshua tree (Victorville Code of Ordinances, tit. 13, §13.33.040). The code does not include details about the approval process. Penalties include misdemeanor charge and up to six months in jail and/or $500 fine (*Id*. at tit. 13, §13.33.040).

Town of Yucca Valley

Pursuant to the Special Order approved by the Commission on December 10, 2020, pursuant to Fish and Game Code section 2084, the Town of Yucca Valley adopted Chapter 9.56 of its Code of Ordinances authorizing removal of western Joshua trees only as consistent and compliant with the Special Order. The Town of Yucca Valley Planning Commission may authorize the take of western Joshua tree associated with developing single-family residences, accessory structures, and public works projects concurrent with its approval of the project subject to specified census, application, and submittal conditions (Yucca Valley Code of Ordinances, § 9.56.060). No project will be eligible to receive take authorization pursuant to Chapter 9.56 if it will result in the take of more than 10 western Joshua trees from the project site (*Id*. at § 9.56.060(A)(1)). Projects authorized under Chapter 9.56 must avoid take of western Joshua trees to the extent practicable and avoid ground-disturbing activities within 10 ft of any western Joshua tree except under limited specified circumstances (*Id*. at §§ 9.56.070 and 9.56.080). To the maximum extent feasible, the project proponent must relocate all western Joshua trees that cannot be avoided to another location to the project site in accordance with specified conditions (*Id*. at § 9.56.090). Western Joshua trees may only be removed subject to Chapter 9.56 requirements if they cannot feasibly be avoided or relocated pursuant to Chapter 9.56 (*Id*. at § 9.56.100). Before presenting an application to the Planning Commission, project proponents must pay specified mitigation fees to the Town of Yucca Valley's Western Joshua Tree Mitigation fund (*Id*. at § 9.56.110). The Planning Commission may issue permits to authorize the removal of a dead western Joshua tree or the trimming of a western Joshua tree (*Id*. at § 9.56.120). Permits for removal of a dead western Joshua tree or the trimming of a western Joshua tree may be issued without payment of mitigation fees if the tree or limb has fallen over and is within 30 ft of a structure, is leaning against an existing structure, or creates an imminent threat to health or safety (*Id*. at § 9.56.120). Any violation of Chapter 9.56 shall constitute a misdemeanor and may be punishable by an administrative citation of $1,000 per western Joshua tree taken or trimmed without a permit (*Id*. at § 9.56.130). In addition, any person or entity that takes or trims a western Joshua tree without a permit required under Chapter 9.56 must subsequently obtain a permit under this Chapter (*Id*. at § 9.56.130). Failure to submit a permit application within 30 days of service of a notice of violation of Chapter 9.56 shall constitute a separate violation of Chapter 9.56 for which a separate administrative citation, fine, or other penalty may be imposed (*Id*. at § 9.56.130).

Nonregulatory Status

Species that are not listed under CESA or the federal ESA may nevertheless be rare or at risk of extinction and nonprofit organizations often assign such species a nonregulatory status, sometimes in collaboration with a government agency. Impacts to species that have a nonregulatory status may sometimes be analyzed and mitigated under CEQA and NEPA, even if the species are not listed under CESA or the federal ESA.

Natural Heritage Program Ranking and IUCN Red List

All natural heritage programs, such as the CNDDB, use the same ranking methodology originally developed by The Nature Conservancy and now maintained by NatureServe. This ranking methodology consists of a global rank describing the rank for a given taxon over its entire distribution, and a state rank describing the rank for the taxon over its state distribution. Both global and state ranks reflect a combination of rarity, threat, and trend factors. The ranking methodology uses a standardized calculator that uses available information to assign a numeric score or range of scores to the taxon, with lower scores indicating that a taxon is more vulnerable to extinction, and higher scores indicating that a taxon is more stable (Faber-Langendoen et al. 2012). The rank calculation process begins with an initial rank score based on rarity and threats, with rarity (multiplied by 0.7) factored more heavily into the calculator than threats (multiplied by 0.3). The combined rarity and threat rank is then either raised or lowered based on trends. When there is a negative trend, the rank score is lowered, and when there is a positive trend the rank score is raised. Short-term trends are factored more heavily into the calculator than long-term trends.

Western Joshua tree has been assigned a global rank of G3G4 indicating that there is uncertainty regarding the rank of the species, and it is either “G3 vulnerable and at moderate risk of extinction or collapse due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors” or “G4 apparently secure and at fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.” The factors cited for this rank include fire, drought, climate change, and numerous threats related to habitat loss including off road vehicle use (Master et al. 2012, NatureServe 2021). Western Joshua tree's conservation status in California under this ranking system has not yet been assessed. Natural heritage ranking does not provide any regulatory protections but is often considered during the CEQA process (Hammerson et al. 2008).

The International Union for Conservation of Nature (IUCN) Red List provided a global scope assessment of western Joshua tree in October 2020 (Esque et al. 2020b) resulting in a designation of Least Concern, which is the Red List category representing the lowest risk of extinction, and is assigned when a taxon has been evaluated against the ranking criteria and does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened (IUCN 2012). In the IUCN assessment of western Joshua tree, the reviewers noted a decreasing population trend due to the severely fragmented population as well as the reduced number of and continuing decline of mature individuals (Esque et al. 2020b). Noted threats include renewable energy development, gathering terrestrial plants, fire and fire suppression, invasive non-native species and diseases, and drought. IUCN's assessment also states that no international legislation, management, or trade controls exist for western Joshua tree.

IUCN and NatureServe assess extinction risk for species using a time period of 10 years or 3 generations, whichever is longer, up to a maximum of 100 years (Faber-Langendoen et al. 2012, IUCN 2012).

California Rare Plant Rank

The Department works in collaboration with the California Native Plant Society and botanical experts throughout the state to assign rare and endangered plants a California Rare Plant Rank reflective of their status. Joshua tree was considered for a California Rare Plant Rank in 2011 but a rank was not assigned due to the species being too common (CNPS 2021b).

Management Efforts

There are currently no federal or state range-wide management efforts or recovery plans for western Joshua tree; however, because most of the known range of the species is under federal jurisdiction the species receives some special protection and management by federal agencies. Natural resources within designated wilderness areas receive a very high level of protection from human impacts. There are also various ongoing efforts to study Joshua tree biology, ecology, threats, conservation, genetics, and other topics related to the species.

National Park Service

Lands administered by the National Park Service within California that have western Joshua tree include Death Valley National Park, Joshua Tree National Park, and Manzanar National Historic Site (horticultural plantings). Natural resources on lands managed by the National Park Service generally receive a high level of protection, including some active management for the benefit of natural resources, although they may also be subject to impacts from recreational use and development and maintenance of related infrastructure.

Western Joshua tree does not occur in the Mojave National Preserve, but the preserve does support a large population of eastern Joshua tree. Mojave National Preserve is currently undergoing a large restoration effort in response to the 2020 Dome Fire with a primary focus on returning Joshua trees to an area that was predicted to be a climate refugium for the species (Kaiser 2021).

Joshua Tree National Park

The Joshua Tree Wilderness was designated in 1976 and includes 1,890 km^2 (730 mi^2) protected by The Wilderness Act (Public Law 94-567 [H.R. 13160]). The Superintendent's Compendium applies to all persons within the boundaries of federally owned or designated public use lands within Joshua Tree National Park and prohibits possessing, destroying, injuring, defacing, removing, digging, or disturbing Joshua trees, including climbing, sitting, or standing on live Joshua trees or using them as anchors for hammocks or slacklines (36 CFR § 2.1 (a)(1)(ii)).

Joshua Tree National Park established a Foundation Statement which states that adult populations of Joshua trees are stable, but knowledge of community structure and distribution is incomplete, and trends are unknown (Rogers pers. comm. 2021). It further designates Joshua trees as a fundamental resource and value, warranting primary consideration during park planning and management activities. In addition, Joshua Tree National Park is actively engaged in conservation efforts to protect areas identified as potential climate change refugia for Joshua trees. This includes fuel breaks, defensible space, removing nonnative grasses around mature reproductive trees (Frakes 2017b), and extensive long term demographic monitoring across the population. In the early 2000's, Joshua Tree National Park shifted fire management philosophies from considering the use of fire on the landscape (controlled burns and allowing fires to burn) to full suppression, acknowledging the unacceptable risks to Joshua tree woodlands, and Joshua Tree National Park continues to manage fires aggressively to protect native vegetation (Frakes 2017a).

Joshua Tree National Park has also implemented restoration activities involving western Joshua trees and other native plants within Joshua Tree National Park, typically for revegetation purposes associated with road realignment projects, social trails restoration, and burned area rehabilitation (Frakes 2017a). Joshua trees have also been salvaged and subsequently transplanted by Joshua Tree National Park following planned disturbances such as road realignments. These activities are labor intensive and expensive, and generally require prolonged follow-up care in the form of protective caging and two years of bi-weekly irrigation. (Frakes 2017a)

A number of monitoring efforts by Joshua Tree National Park are underway (Frakes pers. comm. 2021). Joshua Tree National Park established three 500 x 500 m (1,640 x 1,640 ft) "range edge plots" in 2016 and 2017 at lower elevation areas of Joshua Tree National Park that support western Joshua trees. In-depth tree-by-tree demographic data were collected within these plots, and these plots will likely be very important in the future for direct observations of possible western Joshua tree range reductions. Joshua Tree National Park also established 100 50 x 50 m (164 x 164 ft) plots that were randomly placed within vegetation communities in Joshua Tree National Park where western Joshua tree is currently relatively abundant to monitor changes that take place in these areas. Joshua Tree National Park staff also revisited and collected data from 55 western Joshua tree monitoring plots in 2021 that were established by Todd Esque in 2008.

Death Valley National Park

The Death Valley Wilderness was designated in 1994 and includes 12,911 km^2 (4,985 mi^2) protected by The Wilderness Act (Public Law 94-567 [H.R. 13160]), making it the largest wilderness in the U.S. The Superintendent's Compendium applies to all persons within the boundaries of federally owned or designated public use lands within Death Valley National Park and prohibits taking biological specimens (plants, fish, and wildlife) rocks or minerals except in accordance with other regulations or pursuant to the terms and conditions of a specimen collection permit (36 CFR § 2.5 (a)). Death Valley National Park contains roughly 209 km^2 (81 mi^2) of western Joshua tree habitat and supports scientific research through a permitting system (Reynolds pers. comm. 2021).

United States Department of Defense

The Department of Defense manages natural resources on military lands via development and implementation of integrated natural resources management plans (INRMPs). INRMPs use an ecosystem based approach, and balance conservation and mission activities to provide "no net loss" to testing, training, and operational activities (Department of Defense 2021). Military installations coordinate their INRMPs with the USFWS and the appropriate state fish and wildlife agency pursuant to the Sikes Act.

The INRMP for Edwards Air Force Base incorporates avoidance and minimization measures that could reduce individual fatalities of western Joshua tree and disturbance of its habitat. (U.S. Air Force 2020). The INRMP for National Training Center and Fort Irwin requires that if removal is necessary, trees must be re-located to sites with the same orientation and similar characteristics as their original sites to reduce the risk of tree mortality (U.S. Army 2006). The INRMP for Naval Air Weapons Station China Lake does not list western Joshua tree as a sensitive species, but discusses the sensitivity of the species to fire, and mentions transplantation of western Joshua tree as a component of revegetation or landscaping (U.S. Navy n.d.).

Bureau of Land Management

Several wilderness areas managed by the BLM in California support populations of western Joshua tree. Wilderness areas managed by the BLM in California that may support populations of western Joshua tree and provide them with a high level of protection from human impacts include Black Mountain Wilderness, Bright Star Wilderness, Chimney Peak Wilderness, Coso Range Wilderness, Darwin Falls Wilderness, Domeland Wilderness, El Paso Mountains Wilderness, Grass Valley Wilderness, Inyo Mountains Wilderness, Kiavah Wilderness, Owens Peak Wilderness, Piper Mountain Wilderness, Rodman Mountains Wilderness, Sacatar Trail Wilderness, Surprise Canyon Wilderness, and White Mountains Wilderness.

Outside of wilderness areas, populations of western Joshua tree on BLM lands may receive various levels of protection from human impacts, but lands supporting western Joshua tree may also be utilized for destructive non-conservation purposes. A number of plans have been adopted regarding management of BLM lands within the range of western Joshua tree including the California Desert Conservation Area Plan, Desert Renewable Energy Conservation Plan, West Mojave Plan, and West Mojave Route Network Project Land Use Plan Amendment (BLM 1980, 2005, 2016, 2019). The Desert Renewable Energy Conservation Plan identified large areas of western Joshua tree habitat for conservation.

United States Forest Service

There are several wilderness areas managed by the United States Forest Service in California that may support populations of western Joshua tree and provide them with a high level of protection from human impacts, including Bighorn Mountain Wilderness, Golden Trout Wilderness, Kiavah Wilderness, Pleasant View Ridge Wilderness, and Sheep Mountain Wilderness. Western Joshua tree may occur to some extent within Angeles National Forest, Inyo National Forest, San Bernardino National Forest, and Sequoia National Forest. Forest Service lands are generally at a low risk of habitat destruction due to forest management policies, but habitat modification from land use may still occur.

State of California

Some areas of western Joshua tree habitat occur on lands managed by the California Department of Parks and Recreation. Natural resources on lands managed by the California Department of Parks and Recreation generally receive a high level of protection, including some active management for the benefit of natural resources, although they may also be subject to impacts from recreational use and development and maintenance of related infrastructure. Natural resources on vehicular recreation areas are subject to many impacts from off highway vehicle use. The following lands managed by the California Department of Parks and Recreation may support western Joshua tree: Antelope Valley California Poppy Preserve State Natural Reserve, Antelope Valley Indian Museum State Historic Park, Arthur B. Ripley Desert Woodland State Park, Eastern Kern County Onyx Ranch State Vehicular Recreation Area, Hungry Valley State Vehicular Recreation Area, Red Rock Canyon State Park, and Saddleback Butte State Park. California Department of Parks and Recreation is planning to gather baseline information on western Joshua trees within the Great Basin District (Tejada pers. comm. 2020).

Some western Joshua tree habitat is within lands managed by the Department. Natural resources on lands managed by the Department generally receive a high level of protection, including some active management for the benefit of natural resources, although they may also be subject to impacts from recreational use and development and maintenance of related infrastructure. The following lands managed by the Department may support western Joshua tree: Canebrake Ecological Reserve, Fremont Valley Ecological Reserve, King Clone Ecological Reserve, Mojave River Public Access, West Mojave Desert Ecological Reserve, and several undesignated lands.

The California Desert Conservation Act (Fish & G. Code, § 1450 et seq.) became effective on January 1, 2022, and establishes a California Desert Conservation Program within the Wildlife Conservation Board with the goals of protecting habitat in California's Mojave and Colorado deserts by planning and implementing land acquisition and restoration projects. The California Desert Conservation Program could result in conservation or restoration of western Joshua tree habitat in California.

Western Joshua tree may benefit from land use planning and conservation planning efforts in the Mojave Desert. The Natural Community Conservation Planning Program is a program by the State of California to promote collaborative planning efforts designed to provide for region-wide conservation of plants, animals, and their habitats, while allowing for compatible and appropriate economic activity. There is currently a Natural

Community Conservation Plan in development for the Town of Apple Valley that intends to include Joshua tree as a covered species. However, it is not yet known when this plan will be finalized, or the extent to which this plan may help conserve western Joshua tree habitat. Regional Conservation Investment Strategies is a program by the State of California to encourage voluntary, non-regulatory regional planning intended to result in high-quality conservation outcomes. There is currently one Regional Conservation Investment Strategy in development for the Antelope Valley area that is near completion, and another for western San Bernardino County that is still in development. Both Regional Conservation Investment Strategies include Joshua tree as a focal species, but it is not yet known the extent to which these strategies will help conserve western Joshua tree habitat.

Other

Some nonprofit organizations work to acquire, restore, and protect areas supporting western Joshua tree within the Mojave Desert for conservation and preservation purposes (MDLT 2021).

Desert revegetation may be an important component of western Joshua tree management in the future and there have been some scientific investigations into the effectiveness of desert revegetation activities. Abella and Newton (2009) reviewed 15 planting and 8 seeding studies conducted in the Mojave Desert and found that treatments of irrigation (3 studies), caging (3 studies), and shelter (2 studies) generally resulted in increases in plant survival. Only two of the studies reviewed by Abella and Newton (2009) included Joshua tree. Hunter et al. (1980) examined how fencing affected survival of 14 species of desert plants in Nevada and found that wire fencing generally marginally improved survival of plants, including western Joshua tree and *Yucca schidigera*, but only six western Joshua trees were used in the study. Krantz (Appendix B) reports that western Joshua trees as tall as 3-3.7 m (10-12 ft) with moderate branching can be transplanted using a 36-inch hydraulic tree spade, and that after transplanting larger trees must be tethered to stabilize the weight of the tree and receive additional irrigation. Wallace et al. (1980) reported the results of a study in Nevada where 16 western Joshua trees were transplanted in 1971 and watered as needed for the first six months, with seven of them surrounded by wire cages and nine of them left uncaged. Five years later in 1976, two of the seven caged western Joshua trees had survived (28%) and four of the nine uncaged western Joshua trees had survived (44%). Franson (1995) reported the health and survival of 1,447 eastern Joshua trees that were salvaged and transplanted in rows to two different nurseries. Two years after transplanting 36% of the eastern Joshua trees were rated as being in excellent health, 56% of the trees were rated as being in poor health, and 8% of the trees had died.

The Joshua Tree Genome Project (2020) is an ongoing effort to assemble a Joshua tree reference genome and conduct other investigations such as a large common garden experiment. The Department is also aware of various ongoing western Joshua tree research and monitoring efforts that will continue to improve the scientific understanding of the status of western Joshua tree in California.

SUMMARY OF LISTING FACTORS

CESA directs the Department to prepare this report regarding the status of western Joshua tree based upon the best scientific information available to the Department (Fish & G. Code, § 2074.6). CESA's implementing regulations identify key factors that are relevant to the Department's analyses. Specifically, a "species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors: 1. Present or threatened modification or destruction of its habitat; 2. Overexploitation; 3. Predation; 4. Competition; 5. Disease; or 6. Other natural occurrences or human-related activities" (Cal. Code Regs., tit. 14, § 670.1, subd. (i)(1)(A)).

The definitions of endangered and threatened species in the Fish and Game Code provide key guidance to the Department's scientific analyses. An endangered species under CESA is one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species under CESA is one "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]" (*Id.*, § 2067). A species' range for CESA purposes is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com*. (2007) 156 Cal.App.4th 1535, 1551).

The preceding sections of this Status Review describe the best scientific information available to the Department, with respect to the key factors identified in the regulations. The section below considers the significance of any threat to the continued existence of western Joshua tree for each or a combination of the factors. The best available science focuses on projecting conditions near the end of the 21st century. There is much uncertainty in predicting future outcomes in complicated systems, and there is an even greater uncertainty in projecting outcomes further into the future. Therefore, the Department's determinations for this Status Review focus only on end of the 21st century projected conditions.

The physical and biological systems and relationships that affect the future of western Joshua tree are complicated, and despite the body of scientific information that is currently available, uncertainty remains. Additionally, the future of western Joshua tree not only depends on predictions that are based on the physical and biological sciences, but factors related to national and international laws, politics, and economics; the value that humanity places on conserving biodiversity; and the global human responses to climate change.

The Department is required to make a recommendation on whether the petitioned action is warranted. The Department acknowledges that the combined and cumulative effects of the listing factors discussed in this Status Review can be interpreted in different ways (see independent peer review in Appendix B). The Department also acknowledges the possibility that the combined and cumulative effects of the factors discussed in this Status Review could be severe enough to result in a serious risk of loss of a significant portion of western Joshua tree's range in the foreseeable future. However, given the uncertainties and limitations of the information currently available to the Department, this Status Review presents the outcome that the Department considers to be the most likely.

Present or Threatened Modification or Destruction of Habitat

Western Joshua tree habitat could be modified in a negative way or destroyed by several factors discussed under the Factors Affecting the Ability to Survive and Reproduce section of this Status Review. These factors include the direct and indirect effects of climate change; the direct and indirect effects of development and other human activities; and the direct and indirect effects of wildfire. Some of these factors are interconnected and cumulative, and the southern portion of the species' range faces greater threats than the northern portion of the species' range.

Based on the best available science, available information suggests that the direct and indirect effects of climate change will cause a reduction in the areas with 20th century suitable climate conditions for western Joshua tree by the end of the 21st century (2100), especially in the southern and lower elevation portions of its range. Areas with 20th century suitable climate conditions for the species will also expand to the north and into higher elevation areas, though the species is unlikely to naturally colonize these areas in the foreseeable future. While 20th century suitable climate conditions for the species are predicted to expand into areas of eastern California, it will primarily expand into Nevada where it is not considered under CESA. Studies assessed by the Department suggest that at the end of the 21st century, some areas of climate refugia for western Joshua tree will remain at the southern and lower elevation portions of its range.

While the available evidence suggests that the area with 20th century suitable climate conditions for western Joshua tree within California will decline substantially through the end of the 21st century (2100) due to climate change, the Department does not have any data on the extent to which these climate changes will likely affect the demographics of the species (such as recruitment and mortality) in the foreseeable future. Based on fossil records following climate changes approximately 11,700 years ago, the Department expects that any changes in the range of western Joshua tree that are ultimately caused by climate change will likely occur very slowly, perhaps over thousands of years. Because adult western Joshua trees are relatively resilient to harsh climate conditions, the Department expects that the effects of the reduction of areas with 20th century suitable climate conditions within the species' range in the foreseeable future will likely have a greater negative effect on seedling recruitment than on adult tree mortality, although both may occur. Additionally, because western Joshua tree is currently abundant and widespread, it likely has a high capacity to withstand or recover from stochastic (random) disturbance events. Therefore, it may already have capacity to withstand changing conditions, and the species may be able to withstand changes to 20th century suitable climate conditions in the foreseeable future without becoming in serious danger of extinction throughout all or a significant portion of its range within California.

Due to western Joshua tree's ability to survive harsh conditions and reproduce asexually, there may be a long time delay between when an area becomes no longer suitable for sustaining western Joshua tree populations and when the species is no longer present in that area, and it may not be possible to easily recognize whether populations in an area are ultimately sustainable. Based on the current best available science, the Department expects that the effects of climate change will cause the abundance of western Joshua tree to decline in the southern part of its range by the end of the 21st century, but because the Department does not have demographic data showing that departures from 20th century suitable climate conditions will mean that the species will not be able to persist in significant portions of its range, the Department does not foresee that western Joshua tree is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range by the end of the 21st century (2100) due to climate change. The Department does not expect that the special protection and management efforts required by CESA would ameliorate the direct and indirect effects of climate change on western Joshua tree.

Based on the best available science, the Department expects that the direct and indirect effects of development and other human activities will cause negative modification and destruction of habitat for western Joshua tree in some areas by the end of the 21st century, particularly in the southern part of the species' range. The Department expects that habitat modification and destruction will primarily be limited to private property, lands within the vicinity of roads and existing development, and lands chosen for renewable energy development. The magnitude of this habitat modification and destruction will likely be related to the economic values of development and other human activities in the Mojave Desert and surrounding areas, and the effectiveness of state and federal regulatory and legal protections that are enforced through the end of the 21st century.

The USFWS predicted that between 22% and 42% of the habitat within the southern part of western Joshua tree's range may be lost by the year 2095 due to urban growth and renewable energy development. The extent to which development and other human activities will cause habitat for western Joshua tree to be negatively modified and destroyed by the end of the 21st century is uncertain. The Department does expect that habitat modification and destruction will continue on lands that remain unprotected from development, but that undeveloped, protected lands supporting western Joshua tree habitat will also remain throughout the range of the species, though they may be fragmented. Additionally, because western Joshua tree is currently abundant and widespread, scattered habitat loss is unlikely to result in a change in the overall range of the species, particularly when lost habitat continues to be surrounded by occupied habitat on protected lands and on occupied undeveloped lands that may be protected in the future. While habitat loss continues to be a substantial, ongoing threat, it does not necessarily mean that the species is likely to be at serious risk of extinction throughout all or a significant portion of its range. The Department does not foresee that western Joshua tree will be in serious danger of becoming extinct in a significant portion of its range by the end of the 21st century due to habitat modification and destruction caused by development and other human activities. The Department does expect that the special protection and management efforts required by CESA would ameliorate some of the direct and indirect effects of development and other human activities on western Joshua tree in the southern portion of its range, because a large proportion of western Joshua tree's habitat in this area occurs on private land that is vulnerable to continuing modification and destruction.

Based on the best available science, available information suggests that when a wildfire burns through an area, the immediate and delayed effects of wildfire may kill a majority (greater than 50%) of western Joshua trees in burned areas. Some western Joshua trees and their seeds are likely to survive burning, providing the opportunity for the species to repopulate burned areas, which may take one or more centuries. The direct and indirect effects of wildfire are also likely to temporarily modify western Joshua tree habitat by eliminating important nurse plants and by potentially increasing the suitability of burned areas for further invasion by invasive plant species. The average area burned by wildfire each decade since the early 1900s appears to have generally increased, and approximately 2.5% of western Joshua tree's range burned each decade from 2001–2010 and from 2011–2020, and some areas may have burned more than once. The wildfire activity in western Joshua tree habitat has likely increased in recent decades due to the effects of invasive species with nitrogen deposition contributing to invasive species abundance. Large fires can be triggered after one or more years of relatively high precipitation, favoring vegetation growth leading to higher fuel loads. Invasive plant species are expected to continue their spread across the Mojave Desert, and nitrogen deposition is not expected to cease in the near future. It is unknown if wildfire activity will continue to increase at the same rate observed in recent decades. Based on the current best available science, the Department expects that wildfire will continue to cause reductions in the population of western Joshua trees and will cause temporary modifications to habitat in burned areas that will reduce the ability of the species to recruit new individuals. However, because western Joshua tree is currently abundant and widespread, it is inherently less vulnerable to extinction from the effects of stochastic and localized events such as wildfire. Furthermore, losses in abundance due to wildfire are not expected to change the species' range in the foreseeable future because some trees within burned areas survive, and occupied habitat remains outside of burned areas. The Department does not foresee that western Joshua tree is in serious danger of becoming extinct in a significant portion of its range by the end of the 21st century due to wildfire. The Department does not expect that the special protection and management efforts required by CESA would ameliorate the direct and indirect effects of wildfire on western Joshua tree.

Considered collectively, the direct and indirect effects of climate change, the direct and indirect effects of development and other human activities, and the direct and indirect effects of wildfire are interconnected and will affect different portions of western Joshua tree's range in different ways, sometimes cumulatively. Climate change may reduce recruitment and abundance in southern and lower elevation portions of western Joshua tree's range, development and other human activities are expected to destroy and modify habitat on unprotected private property, and fire is expected to kill a proportion of trees in burned areas and temporarily reduce recruitment in those areas. Climate change and wildfire will have interconnected and cumulative negative effects on western Joshua tree populations in some areas, and the effects of climate change and the direct and indirect effects of development and other human activities will also have interconnected and cumulative negative effects on western Joshua tree populations in some areas. Development and other human activities may also contribute to wildfire risk. The cumulative impacts of climate change, wildfire, and development and other human activities may also affect populations of *T. synthetica*, reducing western Joshua tree's ability to sexually reproduce.

In summary, the Department expects that western Joshua tree will be subject to ongoing habit modification and destruction through the end of the 21st century due to substantial threats from climate change, wildfire, development and other human activities, and the interconnected cumulative effects of some of these threats, particularly in the southern portion of its range, but western Joshua tree is also currently abundant and widespread, which lessens the overall relative impact of these threats to the species.

Overexploitation

Based on the best available science, the Department does not believe that overexploitation is a threat to western Joshua tree, primarily because western Joshua tree is currently abundant and widespread, and the impacts to the species from overexploitation are relatively small.

Predation

Based on the best available science, the Department believes that predation and herbivory is a minor threat to western Joshua tree, and the threat should be considered in the context of the threats from climate change and wildfire. Impacts from small mammals are likely most severe in non-masting years, when they consume nearly all of the western Joshua tree seeds that are produced, and during periods of drought, when they can damage the bark of trees, potentially causing mortality in affected trees. Cattle may also consume quantities of flowers in grazed areas. Nevertheless, because western Joshua tree is currently abundant and widespread, the Department considers the threat to the species from herbivory and predation to be relatively small.

Competition

Based on the best available science, the Department believes that competition is a minor threat to western Joshua tree. Although invasive plant species are prevalent throughout the range of the species, the primary way in which invasive plant species currently affect western Joshua tree is indirectly by fueling wildfires. Invasive plant species may also directly compete with western Joshua tree seedlings for light, water, space, or nutrients, but the Department does not currently have enough information to consider this interaction a major threat to the species.

Disease

The Department does not have any information on diseases or parasites affecting western Joshua tree. The Department does not consider disease or parasites to be a significant threat to the continued existence of western Joshua tree.

Other Natural Occurrences or Human-related Activities

The primary threats to western Joshua tree are from climate change, wildfire, and development and other human activities, and are discussed in the Present or

Threatened Modification or Destruction of Habitat section above. While these primary threats may most often manifest themselves in the form of habitat modification and destruction, they could result in direct mortality of western Joshua trees or have other direct or indirect effects to western Joshua trees that are not necessarily related to a modification or destruction of habitat. It could therefore be appropriate to also categorize them here under Other Natural Occurrences and Human-related Activities. The Department's determinations under the Present or Threatened Modification or Destruction of Habitat section above take into account all of the effects of climate change, wildfire, and development and other human activities on western Joshua tree based on a broad interpretation of what constitutes habitat modification and destruction under the appropriate regulation (Cal. Code Regs., tit. 14, § 670.1, subd. (i)(1)(A)). Under this interpretation, there are no other natural occurrences or human-related activities that the Department considers to be significant threats to the continued existence of western Joshua tree.

Summary of Key Findings

Western Joshua tree is a widespread and abundant species that is found in the Mojave Desert and Great Basin. Climate in the desert regions where western Joshua tree occurs consists of long, hot summers, mild winters, and low overall precipitation. Precipitation across the Mojave Desert region is highly variable from year to year and oscillates between periods of wetter and drier conditions over multi-year and multi-decade timescales.

Joshua tree has received a large amount of attention from the scientific community, and its life history has been studied for over 150 years. Sexual reproduction requires the presence of western Joshua tree's obligate pollinating moth *T. synthetica*. After a mast seeding event, seed dispersal is facilitated by the scatter hoarding behavior of rodents, which results in burial of some western Joshua tree seeds at a soil depth suitable for germination. Western Joshua tree seedlings most successfully establish after large mast seeding events, which perhaps only occur once or twice per decade. Seedlings that emerge from under nurse plants are more likely to survive. Several successive years of sufficiently wet and/or cool conditions are likely required to ensure that seeds germinate and that seedlings can reach a sufficiently large size before the arrival of a period of drier and/or hotter conditions. A western Joshua tree may require 30 to 50 or more years to reach reproductive maturity and begin producing seeds. Individual western Joshua trees can survive for very long periods of time, perhaps over 150 years, and the species is also capable of asexual growth which may allow individuals to survive indefinitely under appropriate conditions.

The population size and area occupied by western Joshua tree has declined since European settlement of the Mojave Desert due to habitat modification and destruction, a trend that has continued to the present. Despite the declines since European settlement, the range of the species has remained largely unchanged, with the species continuing to occupy the same general geographical area within California. The primary threats to the species are the direct and indirect effects of climate change, development and other human activities, and wildfire. Available species distribution models suggest that areas with 20th century suitable climate conditions for western Joshua tree will be reduced substantially through the end of the 21st century (2100) as a result of climate change, especially in southern and lower elevation portions of its range. Areas with 20th century suitable climate conditions for western Joshua tree may also expand to the north and into higher elevation areas, though the species is unlikely to colonize these areas quickly, and climate refugia for western Joshua tree will likely remain at the southern and lower elevation portions of its range at the end of the 21st century.

Species distribution models of future conditions have substantial limitations, and there is much uncertainty of what the predicted effects of climate change will be on western Joshua tree individuals, populations, distribution, abundance, and ultimately range. The Department does not have scientific information on how changes from the 20th century suitable climate conditions within Joshua tree's range will affect the demographics of western Joshua tree populations in California, which limits the extent to which the effects of climate change on populations of western Joshua tree in the foreseeable future can be reasonably predicted. The future of the species will largely depend on its existing ability to withstand change and the magnitude of the global human response to climate change. The effects of development and other human activities will also cause habitat for western Joshua tree to decline and become more fragmented by the end of the 21st century, particularly in the southern part of the species' range, however, western Joshua tree populations on protected and undeveloped lands are expected to remain, and therefore the continuing habitat loss will not necessarily result in an overall change in the range of the species. Western Joshua trees on private property, on lands within the vicinity of roads and existing development, and lands chosen for renewable energy development may be at the highest risk of being lost. Wildfire poses a substantial threat and may kill over half of western Joshua trees in burned areas. In each of the last two decades, approximately 2.5% of western Joshua tree's range burned. Additionally, western Joshua tree is susceptible to herbivory by large and small mammals, especially during periods of drought, although this is considered a minor threat to the species. Competition from invasive plant species is a minor threat to western Joshua tree, and some of the threats to western Joshua tree are interconnected and may affect the species cumulatively.

The combined threats to western Joshua tree are cause for substantial concern. Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species. The Department anticipates that the threats acting upon western Joshua tree will result in a reduction in the abundance of the species by the end of the 21st century, and that the abundance may continue to decline after that time. However, due to the high uncertainty in projecting the pace and magnitude of climate change and other threats into the 22nd century (after 2100), and the lack of scientific information in the Department's possession that contemplates such timeframes for the species, the Department does not yet consider the range of the species in the 22nd century to be foreseeable. The Department anticipates that the scientific information on the status of western Joshua tree will continue to improve in the coming years and decades, with demographic data and species distribution modeling eventually allowing for an analysis of the viability of western Joshua tree populations across their entire California range.

PROTECTION AFFORDED BY LISTING

It is the policy of the state to conserve, protect, restore and enhance any endangered or any threatened species and its habitat (Fish & G. Code, § 2052). If western Joshua tree is listed under CESA, unauthorized "take" of western Joshua tree would be prohibited, and the conservation, protection, and enhancement of the species and its habitat would be an issue of statewide concern. Under CESA, "take" is defined as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (*Id.*, § 86). Any person violating the take prohibition would be punishable under state law. The Fish and Game Code provides the Department with related authority to authorize "take" under certain circumstances (*Id.*, §§ 2081, 2081.1, 2086, 2087, 2089.6, 2089.10 and 2835). As authorized through an incidental take permit, however, impacts of the take of an endangered or threatened species caused by the activity must be minimized and fully mitigated according to state standards.

Protection of western Joshua tree could also occur with required public agency environmental review under CEQA, and its federal counterpart NEPA. CEQA and NEPA both require affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on endangered, threatened, and rare special status species. Under CEQA's "substantive mandate," for example, state and local agencies in California must avoid or substantially lessen significant environmental effects to the extent feasible. Impacts to species that are of conservation concern may be analyzed and mitigated under CEQA and NEPA even if the species are not listed; however, in common practice, potential impacts to listed species are examined more closely in CEQA and NEPA documents than potential impacts to unlisted species. State listing, in this respect, and required consultation with the Department during state and local agency environmental review under CEQA, may benefit western Joshua tree.

If western Joshua tree is listed under CESA, it may also increase the likelihood that state and federal land and resource management agencies will allocate funds towards protection and recovery actions. CESA listing of western Joshua tree could also increase public awareness of the conservation needs of the species and California desert ecosystems, and could lead to an increased interest in scientific research on the species.

RECOMMENDATION FOR PETITIONED ACTION

CESA directs the Department to prepare this report regarding the status of western Joshua tree in California based upon the best scientific information available to the Department (Fish & G. Code, § 2074.6). CESA also directs the Department to indicate in this Status Review whether the petitioned action is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). Based on the criteria described above, the best scientific information available to the Department at this time indicates that western Joshua tree is not in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease, and is not likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by CESA.

The Department recommends that the Commission find the petitioned action to list western Joshua tree as a threatened species to be not warranted.

MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES

CESA directs the Department to include in its Status Review recommended management activities and other recommendations for recovery of western Joshua tree (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). Department staff generated the following list of recommended management actions and recovery measures based on considerations from federal agencies, researchers, non-profit organizations, and other interested parties. The following list is not a detailed conservation strategy for western Joshua tree; however, it outlines possible components of a preliminary strategy to conserve the species. Although the Department's recommendation in this Status Review is to find the petitioned action to be not warranted, the Department does recognize that the combined threats to western Joshua tree are a substantial cause for concern. Western Joshua tree faces serious challenges, and long-term conservation of the species is likely beyond the scope of any one government, agency, or organization, and could require new funding and legislation. The Department therefore recommends that the following actions be conducted in coordination with a broad group of stakeholders including private citizens, scientists, and other local, state, and federal governments and organizations, consistent with California's goals of conserving biodiversity and preventing the extinction of rare, threatened, and endangered species.

- Continue efforts to drastically reduce greenhouse gas emissions.
- Complete a western Joshua tree conservation plan in partnership with a broad group of stakeholders.
- Identify, preserve, and manage western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia.
- Minimize wildfire risk to western Joshua tree woodlands via vegetation management or other means, particularly following one or more years of high precipitation, and particularly in areas with high recruitment and areas projected to be climate refugia.
- Manage active fires aggressively to protect Joshua tree woodlands, particularly in areas with high recruitment and areas projected to be climate refugia.
- Implement disincentives to destruction of western Joshua tree habitat and individuals via legislation, regulatory change, or other means, particularly in areas with high recruitment and areas projected to be climate refugia.
- Implement and ensure proper enforcement of state and/or local laws and regulations that limit unmitigated impacts to high quality western Joshua tree habitat.
- Develop standards and protocols for environmental assessment and mitigation of impacts to western Joshua tree habitat and individuals.
- Continue scientific investigations into the biology, ecology and genetics of western Joshua tree and the species and habitats upon which it depends, and integrate results of scientific research into management and conservation actions:
    - Collect and analyze range-wide demographic information to detect baseline population trends and identify populations that do not appear to be recruiting new individuals at sustainable levels.
    - Implement long-term range-wide direct population monitoring and vegetation monitoring with emphasis on leading and trailing edges and highest and lowest elevations of the species' range.
    - Produce and improve upon range-wide species distribution models for western Joshua tree.
    - Investigate the significance of multi-year and multi-decade climate variability patterns for western Joshua tree recruitment.

- Investigate the life history, environmental tolerances, and distribution of western Joshua tree's obligate pollinating moth *T. synthetica*.
- Produce range-wide species distribution models for *T. synthetica*.
- Investigate ways to control the spread and abundance of invasive plant species to reduce wildfire risk.
- Investigate the feasibility, practicality, and risks of implementing assisted migration and translocation.

PUBLIC RESPONSE

Comments on the petitioned action were invited via a general notification dated October 21, 2020, and a tribal notification dated November 12, 2020. These notifications were distributed to tribes; industry organizations; nonprofit organizations; media outlets; scientists familiar with western Joshua tree and related topics; universities; federal, state, and local agencies; and other interested individuals and organizations. Responses to the notifications are included in Appendix A.

PEER REVIEW

Independent experts familiar with western Joshua tree and the subjects discussed in this Status Review were invited to review the Status Review report before submission to the Commission. All comments received are included in Appendix B. The Department's response to the independent peer review is included in Appendix B. Independent experts that reviewed the Status Review are listed in Table 2, below.

Table 2: Status Review Peer Reviewers

Name	Affiliation
Dr. Cameron Barrows	University of California Riverside
Dr. Erica Fleishman	Oregon Climate Change Research Institute
Dr. Timothy Krantz	University of Redlands
Dr. Lynn Sweet	University of California, Riverside
Dr. Jeremy B. Yoder	California State University Northridge

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Jeb McKay Bjerke in the Department's Habitat Conservation Planning Branch, Native Plant Program prepared this Status Review. Dr. Christina Sloop in the Department's Science Institute coordinated scientific peer review of this Status Review. Department staff Katrina Smith, Kristi Lazar, Diane Mastalir, Dr. Melanie Gogol-Prokurat, Rachelle Boul, Rosie Yacoub, and Ashley Kammet contributed important content for this Status Review. Department staff Dr. Raffica La Rosa, Cherilyn Burton, Dr. Benjamin Waitman, Brandy Wood, Reagen O'Leary, Kelly Schmoker-Stanphill, Julie Vance, and Carrie Swanberg provided valuable scientific review.

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LITERATURE CITED

The following sources were used during the preparation of this Status Review report.

Literature

ABATZOGLOU, J. T., and C. A. KOLDEN. 2011. Climate change in western US deserts: potential for increased wildfire and invasive annual grasses. Rangeland Ecology & Management 64:471–478.

ABELLA, S. R. 2010. Disturbance and plant succession in the Mojave and Sonoran Deserts of the American southwest. International Journal of Environmental Research and Public Health 7:1248–1284.

ABELLA, S. R., E. C. ENGEL, C. L. LUND, and J. E. SPENCER. 2009. Early post-fire plant establishment on a Mojave Desert burn. Madroño 56:137–148.

ABELLA, S. R., D. M. GENTILCORE, and L. P. CHIQUOINE. 2020. Resilience and alternative stable states after desert wildfires. Ecological Monographs 91. Available at: https://onlinelibrary.wiley.com/doi/10.1002/ecm.1432 (accessed February 12, 2021).

ABELLA, S. R., and A. C. NEWTON. 2009. A systematic review of species performance and treatment effectiveness for revegetation in the Mojave Desert, USA. p. 30 Arid Environments and Wind Erosion. Nova Science Publishers, Inc.

ACKERLY, D. D., S. R. LOARIE, W. K. CORNWELL, S. B. WEISS, H. HAMILTON, R. BRANCIFORTE, and N. J. B. KRAFT. 2010. The geography of climate change: implications for conservation biogeography: geography of climate change. Diversity and Distributions 16:476–487.

AGRI CHEMICAL AND SUPPLY INC. 2008. Vegetation of Twentynine Palms, CA. Received from California Department of Fish and Wildlife (VegCAMP).

AIRHART, E. 2019. Miley Cyrus versus the Joshua tree. Podcast. Available at: https://plantcrimes.podbean.com/e/episode-two-miley-cyrus-versus-the-joshua-tree/ (accessed October 23, 2021).

ALEXANDER, R. R., F. W. POND, RODGERS, J.E., F. T. BONNER, and KARRFALT, R.P. 2008. The woody plant seed manual. U.S. Department of Agriculture, Forest Service, Washington D.C.

ALLEN, E. B., and L. H. GEISER. 2011. North American deserts, chapter 12. pp. 133–142 Assessment of nitrogen deposition effects and empirical critical loads of nitrogen for ecoregions of the United States. General Technical Report NRS-80.

ALLEN, E. B., L. E. RAO, R. J. STEERS, A. BYTNEROWICZ, and M. E. FENN. 2009. Impacts of atmospheric nitrogen deposition on vegetation and soils at Joshua Tree National Park. The Mojave Desert: Ecosystem Processes and Sustainability, University of Nevada Press:78–100.

ALLEN, R. J., and R. LUPTOWITZ. 2017. El Niño-like teleconnection increases California precipitation in response to warming. Nature Communications 8:16055.

ALTHOFF, D. M., K. A. SEGRAVES, and J. P. SPARKS. 2004. Characterizing the interaction between the bogus yucca moth and yuccas: do bogus yucca moths impact yucca reproductive success? Oecologia 140:321–327.

ANDERSON, M. K. 2018. The use of fire by Native Americans in California, Chapter 19. pp. 381–397 Fire in California's Ecosystems. Second Edition. University of California Press, Berkeley, California.

[APG] ANGIOSPERM PHYLOGENY GROUP. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181:1–20.

BALCH, J. K., B. A. BRADLEY, C. M. D'ANTONIO, and J. GÓMEZ-DANS. 2013. Introduced annual grass increases regional fire activity across the arid western USA (1980–2009). Global Change Biology 19:173–183.

BARBOUR, M., T. KEELER-WOLF, and A. A. SCHOENHERR, editors. 2007. Terrestrial vegetation of California. University of California Press, Berkeley, California.

BARKLEY, G. 1924. Secondary Stelar Structures of *Yucca*. Botanical Gazette 78:433–439.

BARRIOS, J., M. HAILSTONE, J. PAPIN, and L. ZIMMERMAN. 2017. Joshua tree survivorship and/or regeneration in fire area on Edwards Air Force Base. p. 10. Final Report, U.S. Air Force, 412 CEG/CEVA.

BARRIOS, J., and S. WATTS. 2017. Joshua tree historical status on Edwards AFB. p. 12. Edwards Air Force Base, 412th Civil Engineering Group. Environmental Management Division.

BARROWS, C. W., and M. L. MURPHY-MARISCAL. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: how scale impacts predictions. Biological Conservation 152:29–36.

BARROWS, C. W., A. R. RAMIREZ, L. C. SWEET, T. L. MORELLI, C. I. MILLAR, N. FRAKES, J. RODGERS, and M. F. MAHALOVICH. 2020. Validating climate-change refugia: empirical bottom-up approaches to support management actions. Frontiers in Ecology and the Environment 18:298–306.

BARVE, V. V., L. BRENSKELLE, D. LI, B. J. STUCKY, N. V. BARVE, M. M. HANTAK, B. S. MCLEAN, D. J. PALUH, J. A. OSWALD, M. W. BELITZ, R. A. FOLK, and R. P.

GURALNICK. 2020. Methods for broad-scale plant phenology assessments using citizen scientists' photographs. Applications in Plant Sciences 8. Available at: https://onlinelibrary.wiley.com/doi/10.1002/aps3.11315 (accessed August 31, 2021).

BEDSWORTH, L., D. CAYAN, G. FRANCO, L. FISHER, and S. ZIAJA. 2018. Statewide summary report. California's fourth climate change assessment. p. 133. California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission.

BITTMAN, R. 2001. The California Natural Diversity Database: A natural heritage program for rare species and vegetation. Fremontia 29:3–4.

BLANK, R. R. 2010. Intraspecific and interspecific pair-wise seedling competition between exotic annual grasses and native perennials: plant–soil relationships. Plant and Soil 326:331–343.

[BLM] BUREAU OF LAND MANAGEMENT. 1980. California desert conservation area plan.

[BLM] BUREAU OF LAND MANAGEMENT. 2005. West Mojave plan, a habitat conservation plan and California desert conservation area plan amendment. Final environmental impact report and statement, Moreno Valley, California. (accessed August 20, 2021).

[BLM] BUREAU OF LAND MANAGEMENT. 2016. Desert renewable energy conservation plan. Available at: https://eplanning.blm.gov/eplanning-ui/project/66459/570 (accessed August 20, 2021).

[BLM] BUREAU OF LAND MANAGEMENT. 2019. West Mojave route network project : draft California desert conservation plan amendment and supplemental environmental impact statement for the California Desert District. Available at: https://archive.org/details/westmojaverouten00unse (accessed August 20, 2021).

BONANOMI, G., G. INCERTI, A. STINCA, F. CARTENÌ, F. GIANNINO, and S. MAZZOLENI. 2014. Ring formation in clonal plants. Community Ecology 15:77–86.

BORCHERT, M. 2016. Rodent removal of fallen Joshua tree (*Yucca brevifolia*) fruits. Bulletin, Southern California Academy of Sciences 115:146–155.

BORCHERT, M. I. 2021. Post-fire seedling establishment of *Prunus fasciculat*a and *Yucca brevifolia* from simulated seed caches in the Mojave Desert.

BORCHERT, M. I., and L. A. DEFALCO. 2016. *Yucca brevifolia* fruit production, predispersal seed predation, and fruit removal by rodents during two years of contrasting reproduction. American Journal of Botany 103:830–836.

BORGE, A. 2018. Alfalfa industry. Available at: https://www.lancastermoah.org/single-post/alfalfa-industry (accessed June 28, 2021).

BOWERS, J. E. 1997. Demographic patterns of *Ferocactus cylindraceus* in relation to substrate age and grazing history. Plant Ecology 133:37–48.

BOWNS, J. E. 1973. An Autecological Study of Blackbrush (*Coleogyne ramosissima* torr.) in Southwestern Utah. Dissertation, Utah State University.

BRENSKELLE, L., V. BARVE, L. MAJURE, R. P. GURALNICK, and D. LI. 2021. Predicting phenological anomaly: a case study of *Yucca* in the southwestern United States. preprint in review. Available at: https://www.researchsquare.com/article/rs-548860/v1 (accessed August 31, 2021).

BRITTINGHAM, S., and L. R. WALKER. 2000. Facilitation of *Yucca brevifolia* recruitment by Mojave Desert shrubs. Western North American Naturalist 60:374–383.

BROOK, B. W., J. J. O'GRADY, A. P. CHAPMAN, M. A. BURGMAN, H. R. AKÇAKAYA, and R. FRANKHAM. 2000. Predictive accuracy of population viability analysis in conservation biology. Nature 404:385–387.

BROOKS, M. L. 1999. Alien annual grasses and fire in the Mojave Desert. Madroño 46:13–19.

BROOKS, M. L. 2000. Competition Between Alien Annual Grasses and Native Annual Plants in the Mojave Desert. The American Midland Naturalist 144:92–108.

BROOKS, M. L. 2002. Peak fire temperatures and effects on annual plants in the Mojave Desert. Ecological Applications 12:1088–1102.

BROOKS, M. L., and K. H. BERRY. 2006. Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA. Journal of Arid Environments 67:100–124.

BROOKS, M. L., C. S. BROWN, J. C. CHAMBERS, C. M. D'ANTONIO, J. E. KEELEY, and J. BELNAP. 2016. Exotic annual *Bromus* invasions: comparisons among species and ecoregions in the western United States. pp. 11–60 *in* M. J. Germino, J. C. Chambers, and C. S. Brown, editors. Exotic brome-grasses in arid and semiarid ecosystems of the western US. Springer International Publishing. Available at: http://link.springer.com/10.1007/978-3-319-24930-8_2 (accessed August 17, 2021).

BROOKS, M. L., and J. C. CHAMBERS. 2011. Resistance to invasion and resilience to fire in desert shrublands of North America. Rangeland Ecology & Management 64:431–438.

BROOKS, M. L., C. M. D'ANTONIO, D. M. RICHARDSON, J. B. GRACE, J. E. KEELEY, J. M. DITOMASO, R. J. HOBBS, M. PELLANT, and D. PYKE. 2004. Effects of invasive alien plants on fire regimes. BioScience 54:677.

BROOKS, M. L., and J. R. MATCHETT. 2006. Spatial and temporal patterns of wildfires in the Mojave Desert, 1980–2004. Journal of Arid Environments 67:148–164.

BROOKS, M. L., R. A. MINNICH, and J. R. MATCHETT. 2018. Southeastern deserts bioregion, chapter 18. pp. 353–378 Fire in California's ecosystems. Second Edition. University of California Press, Berkeley, California.

BROOKS, M. L., and D. A. PYKE. 2001. Invasive plants and fire in the deserts of North America. pp. 1–14 Proceedings of the invasive species workshop: the role of fire in the spread and control of invasive species. Tall Timbers Research Station, Tallahassee, FL.

BRUNO, D., and G. BRUNO. 2017. Religion, spiritual meaning and traditions associated with succulents 35:203–208.

BYTNEROWICZ, A., FENN, MARK, ALLEN, EDITH B., and CISNEROS, RICARDO. 2015. Atmospheric chemistry, chapter 7. pp. 107–128 Ecologically relevant atmospheric chemistry. E. Zavaleta and H.A. Mooney. Edited by the University of California Press, Berkeley, California.

[CALFIRE] CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION. 2021. California fire perimeters (all). CALFIRE wildfire perimeters and prescribed burn. Available at: https://gis.data.ca.gov/datasets/CALFIRE-Forestry::california-fire-perimeters-all/about (accessed August 1, 2021).

CALIFORNIA ENERGY COMMISSION. 2009. The impact of climate change on California's ecosystem services. California Energy Commission, Sacramento, California.

CALIFORNIA INVASIVE PLANT COUNCIL. 2021. Invasive species management opportiunities in Mojave Desert USDA ecoregion. California Invasive Plant Council. Available at: https://weedmap.cal-ipc.org/weedmapper/ (accessed August 19, 2021).

CARPENTER, D. E., M. G. BARBOUR, and C. J. BAHRE. 1986. Old field succession in Mojave Desert scrub. Madroño 33:111–122.

CARR, H. 1930. The Lancer. Desert Magazine.

CASAJUS, N., C. PÉRIÉ, T. LOGAN, M.-C. LAMBERT, S. DE BLOIS, and D. BERTEAUX. 2016. An objective approach to select climate scenarios when projecting species distribution under climate change. PLoS ONE 11:e0152495.

CAYAN, D. R., M. D. DETTINGER, H. F. DIAZ, and N. E. GRAHAM. 1998. Decadal variability of precipitation over western North America. Journal of Climate 11:19.

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE. 2019a. Vegetation survey points [ds1020]. California Department of Fish and Wildlife (VegCAMP), Received from California Department of Fish and Wildlife (VegCAMP). Available at: https://wildlife.ca.gov/Data/BIOS (accessed December 5, 2019).

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE. 2019b. Jawbone north for AA. unpublished data. [AIS] Aerial Information Systems, California Department of Fish and Wildlife (VegCAMP). Available at: https://wildlife.ca.gov/Data/BIOS.

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE. 2019c. Owens Valley for AA. unpublished data. [AIS] Aerial Information Systems, California Department of Fish and Wildlife (VegCAMP).

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE. 2019d. Jawbone south for AA. unpublished data. [AIS] Aerial Information Systems, California Department of Fish and Wildlife (VegCAMP). Available at: https://wildlife.ca.gov/Data/BIOS.

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE. 2020. California Natural Diversity Database Management Framework. p. 31. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=181808&inline (accessed February 14, 2022).

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE. 2021. Climate change vulnerability assessment for western Joshua tree. The NatureServe climate change vulnerability index. release 3.02, Sacramento, CA.

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, VEGETATION CLASSIFICATION AND MAPPING PROGRAM and [AIS] AERIAL INFORMATION SYSTEMS. 2013. 2013 California Desert Vegetation Map and Accuracy Assessment in Support of the Desert Renewable Energy Conservation Plan. California Department of Fish and Wildlife Vegetation Classification and Mapping Program. Available at: https://gis.data.ca.gov/datasets/CDFW::vegetation-mojave-desert-for-drecp-final-ds735-1/about.

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, AERIAL INFORMATION SYSTEMS, INC., and UNIVERSITY OF CALIFORNIA RIVERSIDE CENTER FOR CONSERVATION BIOLOGY. 2017. Vegetation - Mojave Desert for DRECP [ds735]. Available at: https://wildlife.ca.gov/Data/BIOS (accessed December 12, 2019).

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, VEGETATION CLASSIFICATION AND MAPPING PROGRAM and CHICO STATE UNIVERSITY, GEOGRAPHIC INFORMATION

CENTER. 2015. Vegetation - proposed Tehachapi Pass high speed rail corridor [ds1328]. Available at: https://wildlife.ca.gov/Data/BIOS (accessed November 25, 2019).

[CDFW] CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, VEGETATION CLASSIFICATION AND MAPPING PROGRAM, and [USGS] U.S. GEOLOGICAL SURVEY. 2014. Vegetation map - Johnson Valley [ds1019]. Available at: https://wildlife.ca.gov/Data/BIOS (accessed November 25, 2019).

CHARLTON, D., and P. RUNDEL. 2017. The vegetation and flora of Edwards Air Force Base, western Mojave Desert, California. Aliso 35:51–68.

CHASE, M. W., J. L. REVEAL, and M. F. FAY. 2009. A subfamilial classification for the expanded asparagalean families Amaryllidaceae, Asparagaceae and Xanthorrhoeaceae: Asparagales subfamilial classification. Botanical Journal of the Linnean Society 161:132–136.

CHAUDHARY, V., and M. K. OLI. 2020. A critical appraisal of population viability analysis. Conservation Biology 34:26–40.

CLARK, C. J., J. R. POULSEN, D. J. LEVEY, and C. W. OSENBERG. 2007. Are Plant Populations Seed Limited? A Critique and Meta-Analysis of Seed Addition Experiments. The American Naturalist 170:128–142.

CLARK, J. S., B. BECKAGE, P. CAMILL, B. CLEVELAND, J. HILLERISLAMBERS, J. LICHTER, J. MCLACHLAN, J. MOHAN, and P. WYCKOFF. 1999. Interpreting recruitment limitation in forests. American Journal of Botany 86:1–16.

CLARK, J. S., C. FASTIE, G. HURTT, S. T. JACKSON, C. JOHNSON, G. A. KING, M. LEWIS, J. LYNCH, S. PACALA, C. PRENTICE, E. W. SCHUPP, T. WEBB, and P. WYCKOFF. 1998. Reid’s paradox of rapid plant migration. BioScience 48:13–24.

CLOKEY, I. W. 1951. Flora of the Charleston Mountains, Clark County, Nevada. University of California Publications in Botany 24:1–274.

CNDDB, (CALIFORNIA NATURAL DIVERSITY DATABASE). 2021. RareFind 5 [internet]. Government Version -- Dated, October 31, 2021. Available at: https://apps.wildlife.ca.gov/rarefind/view/RareFind.aspx (accessed November 12, 2021).

[CNPS] CALIFORNIA NATIVE PLANT SOCIETY. 2021a. A manual of California vegetation, online edition. Available at: https://vegetation.cnps.org/ (accessed August 3, 2021).

[CNPS] CALIFORNIA NATIVE PLANT SOCIETY. 2021b. Inventory of rare and endangered plants of California. Online Database. Available at: https://rareplants.cnps.org/Home/ (accessed August 24, 2021).

CODY, M. L. 2000. Slow-motion population dynamics in Mojave Desert perennial plants. Journal of Vegetation Science 11:351–358.

COLE, K. L., K. IRONSIDE, J. EISCHEID, G. GARFIN, P. B. DUFFY, and C. TONEY. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications 21:137–149.

COLE, K. L., K. PUHS, and J. A. CANNELLA. 2003. Range map of Joshua tree (*Yucca brevifolia*). Layer Package, U.S. Geological Survey. Available at: https://databasin.org/datasets/b74f96cc008d4c7398ea0ef0bb6b4078/ (accessed April 26, 2021).

COLE, W. S., A. S. JAMES, and C. I. SMITH. 2017. First recorded observations of pollination and oviposition behavior in *Tegeticula antithetica* (Lepidoptera: Prodoxidae) suggest a functional basis for coevolution with Joshua tree (*Yucca*) hosts. Annals of the Entomological Society of America 110:390–397.

COMANOR, P. L., and W. H. CLARK. 2000. Preliminary growth rates and a proposed age-form classification for the Joshua tree, *Yucca brevifolia* (Agavaceae). Haseltonia 7:10.

CORNETT, J. 1997. Giant Joshua trees. pp. 30–31 Abstracts from proceedings on the 1997 desert research symposium. San Bernardino County Museum Association Quarterly.

CORNETT, J. W. 1995. The Joshua tree in ancient surfaces of the east Mojave Desert. San Bernardino County Museum Association Quarterly 42.

CORNETT, J. W. 1998. The California deserts: today and yesterday. Palm Springs Desert Museum, Palm Springs, CA.

CORNETT, J. W. 2006. Rapid demise of giant Joshua trees. pp. 72–73 Making Tracks Across the Southwest.

CORNETT, J. W. 2009. Population dynamics of the Joshua tree (*Yucca brevifolia*): twenty-one year analysis, Upper Covington Flat, Joshua Tree National Park. p. 2009 Desert Symposium.

CORNETT, J. W. 2012. Population dynamics of the Joshua tree (*Yucca brevifolia*): twenty-three-year analysis, Queen Valley, Joshua Tree National Park. p. 146.

CORNETT, J. W. 2013. Population dynamics of the Joshua tree (*Yucca brevifolia*), Lee Flat, Death Valley National Park. p. Death Valley Natural History Conference Proceedings. Death Valley Natural History Association.

CORNETT, J. W. 2014. Population dynamics of the Joshua tree (*Yucca brevifolia*): twenty-three-year analysis, Lost Horse Valley, Joshua Tree National Park. pp. 71–73. Desert Studies Consortium, California State University Desert Studies Center.

CORNETT, J. W. 2016. Long-term population dynamics of the Joshua tree (*Yucca brevifolia*) at Saddleback Butte State Park, Los Angeles County, California. pp. 211–217 Going LOCO: Investigations along the Lower Colorado River. California State University Desert Studies Center.

CORNETT, J. W. 2018a. The Joshua tree. Second Edition. Nature Trails Press, Palm Springs, CA.

CORNETT, J. W. 2018b. Eastern Joshua tree (*Yucca jaegeriana*) growth rates and survivability on Cima Dome, Mojave National Preserve. pp. 84–87 The 2018 Desert Symposium Field Guide and Proceedings.

CORNETT, J. W. 2018c. Joshua trees are blooming early in the desert. It's not a good thing — you can thank climate change. Desert Magazine. Available at: https://www.desertsun.com/story/desert-magazine/2019/01/30/early-bloom-of-joshua-trees-could-be-dire-for-mojave-desert-ecosystem/2706708002/.

CORNETT, J. W. 2020. Dynamics of a western Joshua tree (*Yucca brevifolia*) population, Red Rock Canyon State Park, California. p. The 2020 Desert Symposium Field Guide and Proceedings. Desert Symposium, Inc.

COVILLE, F. 1892. The Panamint Indians of California. American Anthropologist 5:351–361.

CRONK, Q. 2016. Plant extinctions take time. Science 353:446–447.
CROSSWHITE, F. S., and C. D. CROSSWHITE. 1984. A Classification of life forms of the Sonoran Desert, with emphasis on the seed plants and their survival strategies. Desert Plants:131–136.
CUMMINGS, B. 2019. A petition to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act (CESA). Center for Biological Diversity.
CURTIS, C. A., and B. A. BRADLEY. 2015. Climate Change May Alter Both Establishment and High Abundance of Red Brome (*Bromus rubens*) and African Mustard (*Brassica tournefortii*) in the Semiarid Southwest United States. Invasive Plant Science and Management 8:341–352.
D'ANTONIO, C. M., and P. M. VITOUSEK. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63–87.
DARWIN, C. 1874. Letter from Charles Darwin to J.D. Hooker.
DAWSON, T. P., S. T. JACKSON, J. I. HOUSE, I. C. PRENTICE, and G. M. MACE. 2011. Beyond Predictions: Biodiversity Conservation in a Changing Climate. Science 332:53–58.
DEFALCO, L. A., D. R. BRYLA, V. SMITH-LONGOZO, and R. S. NOWAK. 2003. Are Mojave Desert annual species equal? Resource acquisition and allocation for the invasive grass *Bromus madritensis* subsp. *rubens* (Poaceae) and two native species. American Journal of Botany 90:1045–1053.
DEFALCO, L. A., and T. C. ESQUE. 2014. Soil seed banks: preserving native biodiversity and repairing damaged desert shrublands. Fremontia 42:5.
DEFALCO, L. A., T. C. ESQUE, S. J. SCOLES-SCIULLA, and J. RODGERS. 2010. Desert wildfire and severe drought diminish survivorship of the long-lived Joshua tree (*Yucca brevifolia*; Agavaceae). American Journal of Botany 97:243–250.
DEFALCO, L. A., G. C. J. FERNANDEZ, and R. S. NOWAK. 2007. Variation in the establishment of a non-native annual grass influences competitive interactions with Mojave Desert perennials. Biological Invasions 9:293–307.
DEPARTMENT OF DEFENSE. 2021. DoD Natural Resources Program fact sheet. Available at: https://www.denix.osd.mil/nr/ (accessed August 26, 2021).
DETTINGER, M. 2011. Climate change, atmospheric rivers, and floods in California - a multimodel analysis of storm frequency and magnitude changes. Journal of the American Water Resources Association 47:514–523.
DETTINGER, M. D., F. M. RALPH, T. DAS, P. J. NEIMAN, and D. R. CAYAN. 2011. Atmospheric rivers, floods and the water resources of California. Water 3:445–478.
DIRZO, R., and P. H. RAVEN. 2003. Global state of biodiversity and Loss. Annual Review of Environment and Resources 28:137–167.
DOLE, K. P., M. E. LOIK, and L. C. SLOAN. 2003. The relative importance of climate change and the physiological effects of CO_2 on freezing tolerance for the future distribution of *Yucca brevifolia*. Global and Planetary Change 36:137–146.
ELITH, J., and J. R. LEATHWICK. 2009. Species distribution models: ecological explanation and prediction across space and time. Annual Review of Ecology, Evolution, and Systematics 40:677–697.

ELLSTRAND, N. C., and D. R. ELAM. 1993. Population genetic consequences of small population size: implications for plant conservation. Annual Review of Ecology and Systematics 24:217–242.

ELZINGA, C. L., D. W. SALZER, and J. W. WILLOUGHBY. 1998. Measuring and monitoring plant populations. Bureau of Land Management.

ENGELMANN, G. 1871. *Yucca brevifolia* in C. King, report no. 5, geological exploration of the fortieth parallel. p. 496. Government Printing Office, Washington D.C.

ENQUIST, B. J., X. FENG, B. BOYLE, B. MAITNER, E. A. NEWMAN, P. M. JØRGENSEN, P. R. ROEHRDANZ, B. M. THIERS, J. R. BURGER, R. T. CORLETT, T. L. P. COUVREUR, G. DAUBY, J. C. DONOGHUE, W. FODEN, J. C. LOVETT, P. A. MARQUET, C. MEROW, G. MIDGLEY, N. MORUETA-HOLME, D. M. NEVES, A. T. OLIVEIRA-FILHO, N. J. B. KRAFT, D. S. PARK, R. K. PEET, M. PILLET, J. M. SERRA-DIAZ, B. SANDEL, M. SCHILDHAUER, I. ŠÍMOVÁ, C. VIOLLE, J. J. WIERINGA, S. K. WISER, L. HANNAH, J.-C. SVENNING, and B. J. MCGILL. 2019. The commonness of rarity: global and future distribution of rarity across land plants. Science Advances 5:1–13.

ESQUE, T. C., P. E. BAIRD, F. C. CHEN, D. C. HOUSMAN, and J. T. HOLTON. 2020a. Using remotely sensed data to map Joshua tree distributions at Naval Air Weapons Station China Lake, California, 2018. Scientific Investigations Report, U.S. Department of the Interior U.S. Geological Survey.

ESQUE, T. C., L. A. DEFALCO, W. HODGSON, A. SALYWON, R. PUENTE, and K. CLARY. 2020b. *Yucca brevifolia*. The IUCN Red List of Threatened Species. Available at: https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T117423077A117469962.en (accessed June 21, 2021).

ESQUE, T. C., D. F. HAINES, L. A. DEFALCO, J. E. RODGERS, K. A. GOODWIN, and S. J. SCOLES. 2003. Mortality of adult Joshua trees (*Yucca brevifolia*) due to small mammal herbivory at Joshua Tree National Park, California. p. 10. United States Geological Survey, Western Ecological Research Center.

ESQUE, T. C., P. A. MEDICA, D. F. SHRYOCK, L. A. DEFALCO, R. H. WEBB, and R. B. HUNTER. 2015. Direct and indirect effects of environmental variability on growth and survivorship of pre-reproductive Joshua trees, *Yucca brevifolia* Engelm. (Agavaceae). American Journal of Botany 102:85–91.

ESQUE, T. C., B. REYNOLDS, L. A. DEFALCO, and B. A. WAITMAN. 2010. Demographic studies of Joshua trees in Mojave Desert national parks: demography with emphasis on germination and recruitment. Mojave National Preserve Science Newsletter:9–12.

EVANS, M. J., S. C. BANKS, D. A. DRISCOLL, A. J. HICKS, B. A. MELBOURNE, and K. F. DAVIES. 2017. Short- and long-term effects of habitat fragmentation differ but are predicted by response to the matrix. Ecology 98:807–819.

FABER-LANGENDOEN, D., J. NICHOL, L. MASTER, K. SNOW, A. TOMAINO, R. BITTMAN, G. HAMMERSON, B. HEIDEL, L. RAMSAY, A. TEUCHER, and B. YOUNG. 2012. NatureServe conservation status assessments: methodology for assigning ranks. p. 52. NatureServe, Arlington, VA.

FAHRIG, L., V. ARROYO-RODRÍGUEZ, J. R. BENNETT, V. BOUCHER-LALONDE, E. CAZETTA, D. J. CURRIE, F. EIGENBROD, A. T. FORD, S. P. HARRISON, J. A. G. JAEGER, N. KOPER, A. E. MARTIN, J.-L. MARTIN, J. P. METZGER, P. MORRISON, J. R. RHODES, D. A. SAUNDERS, D. SIMBERLOFF, A. C. SMITH, L. TISCHENDORF, M. VELLEND, and J. I.

WATLING. 2019. Is habitat fragmentation bad for biodiversity? Biological Conservation 230:179–186.
FIGUEIREDO, L., J. KRAUSS, I. STEFFAN-DEWENTER, and J. SARMENTO CABRAL. 2019. Understanding extinction debts: spatio–temporal scales, mechanisms and a roadmap for future research. Ecography 42:1973–1990.
FIRESTONE, R. B., A. WEST, J. P. KENNETT, L. BECKER, T. E. BUNCH, Z. S. REVAY, P. H. SCHULTZ, T. BELGYA, D. J. KENNETT, J. M. ERLANDSON, O. J. DICKENSON, A. C. GOODYEAR, R. S. HARRIS, G. A. HOWARD, J. B. KLOOSTERMAN, P. LECHLER, P. A. MAYEWSKI, J. MONTGOMERY, R. POREDA, T. DARRAH, S. S. Q. HEE, A. R. SMITH, A. STICH, W. TOPPING, J. H. WITTKE, and W. S. WOLBACH. 2007. Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. Proceedings of the National Academy of Sciences 104:16016–16021.
FITZPATRICK, M. C., and W. W. HARGROVE. 2009. The projection of species distribution models and the problem of non-analog climate. Biodiversity and Conservation 18:2255–2261.
FLETCHER, R. J., R. K. DIDHAM, C. BANKS-LEITE, J. BARLOW, R. M. EWERS, J. ROSINDELL, R. D. HOLT, A. GONZALEZ, R. PARDINI, E. I. DAMSCHEN, F. P. L. MELO, L. RIES, J. A. PREVEDELLO, T. TSCHARNTKE, W. F. LAURANCE, T. LOVEJOY, and N. M. HADDAD. 2018. Is habitat fragmentation good for biodiversity? Biological Conservation 226:9–15.
FOWLER, C. S. 1995. Some notes on ethnographic subsistence systems in mojavean environments in the Great Basin. Journal of Ethnobotany 15:99–117.
FRAKES, N. 2017a. Interim report on the distribution, abundance, and health of *Yucca brevifolia* in Joshua Tree National Park report to U.S. Fish and Wildlife Service. p. 15. Joshua Tree National Park.
FRAKES, N. 2017b. Invasive plant management at Joshua Tree National Park. PowerPoint presentaion, California Invasive Plant Council Symposium.
FRANCES, A. L., A. B. SMITH, and C. K. KHOURY. 2018. Conservation status and threat assessments for North American crop wild relatives: chapter 7. p. *in* S. L. Green, S. A. Williams, C. K. Khoury, M. B. Kantar, and L. F. Marek, editors. North American Crop Wild Relatives, Volume 1: Conservation Strategies. Springer, Switzerland.
FRANSON, R. L. 1995. Health of plants salvaged for revegetation at a Mojave Desert gold mine: year two. p. INT-GTR-315 *in* B. A. Roundy, E. D. McArthur, J. S. Haley, and D. K. Mann, editors. Proceedings: Wildland Shrub and Arid Land Restoration Symposium. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT. Available at: https://www.fs.usda.gov/treesearch/pubs/34717 (accessed December 18, 2020).
FREMONT, J. C. 1845. The exploring expedition to the Rocky Mountains in the year 1842; and to Oregon and Northern California, in the years 1843–1844. Gales and Seaton, Printers, Washington.
FRIED, G., B. LAITUNG, C. PIERRE, N. CHAGUE, and F. D. PANETTA. 2014. Impact of invasive plants in Mediterranean habitats: disentangling the effects of characteristics of invaders and recipient communities. Biological Invasions 16:1639–1658.

FUENTES-RAMIREZ, A., J. L. SCHAFER, E. L. MUDRAK, M. SCHAT, H. A. PARAG, C. HOLZAPFEL, and K. A. MOLONEY. 2015. Spatio-temporal impacts of fire on soil nutrient availability in *Larrea tridentata* shrublands of the Mojave Desert, USA. Geoderma 259–260:126–133.

FUENTES-RAMIREZ, A., J. W. VELDMAN, C. HOLZAPFEL, and K. A. MOLONEY. 2016. Spreaders, igniters, and burning shrubs: plant flammability explains novel fire dynamics in grass-invaded deserts. Ecological Applications 26:2311–2322.

GAERTNER, M., A. D. BREEYEN, C. HUI, and D. M. RICHARDSON. 2009. Impacts of alien plant invasions on species richness in Mediterranean-type ecosystems: a meta-analysis. Progress in Physical Geography 33:319–338.

GARFIN, G., A. JARDINE, R. MERIDETH, M. BLACK, and S. LEROY, editors. 2013. Assessment of climate change in the southwest United States: a report prepared for the national climate assessment. Island Press/Center for Resource Economics, Washington, DC. Available at: http://link.springer.com/10.5822/978-1-61091-484-0 (accessed June 24, 2021).

GASTON, K. J., and R. A. FULLER. 2009. The sizes of species' geographic ranges. Journal of Applied Ecology 46:1–9.

GERKEN, A. R., O. C. ELLER, D. A. HAHN, and T. J. MORGAN. 2015. Constraints, independence, and evolution of thermal plasticity: Probing genetic architecture of long- and short-term thermal acclimation. Proceedings of the National Academy of Sciences 112:4399–4404.

GERMAIN, S. J., and J. A. LUTZ. 2020. Climate extremes may be more important than climate means when predicting species range shifts. Climatic Change 163:579–598.

GILLILAND, K. D., N. J. HUNTLY, and J. E. ANDERSON. 2006. Age and population structure of Joshua trees (*Yucca brevifolia*) in the northwestern Mojave Desert. Western North American Naturalist 66:202–208.

GODSOE, W., E. STRAND, C. I. SMITH, J. B. YODER, T. C. ESQUE, and O. PELLMYR. 2009. Divergence in an obligate mutualism is not explained by divergent climatic factors. New Phytologist 183:589–599.

GODSOE, W., J. B. YODER, C. I. SMITH, C. S. DRUMMOND, and O. PELLMYR. 2010. Absence of population-level phenotype matching in an obligate pollination mutualism: absence of phenotype matching. Journal of Evolutionary Biology 23:2739–2746.

GODSOE, W., J. B. YODER, C. I. SMITH, and O. PELLMYR. 2008. Coevolution and divergence in the Joshua tree/yucca moth mutualism. The American Naturalist 171:816–823.

GONZALEZ, P. 2019. Anthropogenic climate change in Joshua Tree National Park, California, USA. p. 48. National Park Service, U.S. Department of the Interior. Available at: http://www.patrickgonzalez.net/images/Gonzalez_climate_change_Joshua_Tree_NP.pdf.

GOOGLE. 2021. Google Earth Pro 7.3.4.8248 (64-bit). Aerial imagery in the Mojave Desert. (accessed August 16, 2021).

GRAY, M. E., B. G. DICKSON, and L. J. ZACHMANN. 2014. Modelling and mapping dynamic variability in large fire probability in the lower Sonoran Desert of south-western Arizona. International Journal of Wildland Fire 23:1108.

GRIFFIN, H. E. 1930. Preserving California desert scenery. Desert Magazine:118.

GRUBB, P. J. 1977. The maintenance of species-richness in plant communities: the importance of the regeneration niche. Biological Reviews 52:107–145.

GUCKER, C. L. 2006. *Yucca brevifolia*. In: fire effects information system. Available at: https://www.fs.fed.us/database/feis/plants/tree/yucbre/all.html (accessed December 18, 2019).

HADDAD, N. M., L. A. BRUDVIG, J. CLOBERT, K. F. DAVIES, A. GONZALEZ, R. D. HOLT, T. E. LOVEJOY, J. O. SEXTON, M. P. AUSTIN, C. D. COLLINS, W. M. COOK, E. I. DAMSCHEN, R. M. EWERS, B. L. FOSTER, C. N. JENKINS, A. J. KING, W. F. LAURANCE, D. J. LEVEY, C. R. MARGULES, B. A. MELBOURNE, A. O. NICHOLLS, J. L. ORROCK, D.-X. SONG, and J. R. TOWNSHEND. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Science Advances 1:e1500052.

HAMMERSON, G. A., D. SCHWEITZER, L. MASTER, J. CORDEIRO, A. TOMAINO, L. OLIVER, and J. NICHOLS. 2008. Ranking species occurrences: a generic approach and decision key. p. 17. NatureServe.

HANSKI, I., and O. OVASKAINEN. 2002. Extinction debt at extinction threshold. Conservation Biology 16:666–673.

HARRINGTON, M. R. 1933. Gypsum cave, Nevada. Report of the second Sessions expedition. Southwest Museum:197.

HARRIS, G., and S. L. PIMM. 2007. Range size and extinction risk in forest birds. Conservation Biology 22:163–171.

HARROWER, J., and G. S. GILBERT. 2018. Context-dependent mutualisms in the Joshua tree-yucca moth system shift along a climate gradient. Ecosphere 9:e02439.

HARROWER, J. T. 2019. Species interactions and climate change in the loss of Joshua trees and the role of eco-art for understanding multispecies connections. PhD dissertation, University of California Santa Cruz, Santa Cruz, California.

HARROWER, J. T., and G. S. GILBERT. 2021. Parasitism to mutualism continuum for Joshua trees inoculated with different communities of arbuscular mycorrhizal fungi from a desert elevation gradient. PLOS ONE 16:e0256068.

HAYHOE, K., D. CAYAN, C. B. FIELD, P. C. FRUMHOFF, E. P. MAURER, N. L. MILLER, S. C. MOSER, S. H. SCHNEIDER, K. N. CAHILL, E. E. CLELAND, L. DALE, R. DRAPEK, R. M. HANEMANN, L. S. KALKSTEIN, J. LENIHAN, C. K. LUNCH, R. P. NEILSON, S. C. SHERIDAN, and J. H. VERVILLE. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences 101:12422–12427.

HE, M., A. SCHWARZ, E. LYNN, and M. ANDERSON. 2018. Projected changes in precipitation, temperature, and drought across California's hydrologic regions in the 21st century. Climate 6:31.

HEGEMAN, E. E., B. G. DICKSON, and L. J. ZACHMANN. 2014. Probabilistic models of fire occurrence across National Park Service units within the Mojave Desert network, USA. Landscape Ecology 29:1587–1600.

HELM, A., I. HANSKI, and M. PARTEL. 2006. Slow response of plant species richness to habitat loss and fragmentation. Ecology Letters 0:051109031307003.

HEREFORD, R., R. H. WEBB, and C. I. LONGPRE. 2004. Precipitation history of the Mojave Desert region, 1893–2001. p. 4. U.S. Geological Survey.
HEREFORD, R., R. H. WEBB, and C. I. LONGPRÉ. 2006. Precipitation history and ecosystem response to multidecadal precipitation variability in the Mojave Desert region, 1893–2001. Journal of Arid Environments 67:13–34.
HESS, W. J. 2012. *Yucca brevifolia* In Jepson flora project (eds.) Jepson eFlora. Available at: http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=48766 (accessed December 18, 2019).
HESS, W. J., and R. L. ROBBINS. 1993. *Yucca brevifolia*. Available at: http://floranorthamerica.org/Yucca_brevifolia (accessed March 5, 2021).
HESS, W. J., and R. L. ROBBINS. 2002. *Yucca*. pp. 423–439 *in* editorial Committee, editor. Flora of North America, north of Mexico. Oxford University Press, New York.
HISTORIC AERIALS. 2021. Historical aerial photographs of the Antelope Valley of California from various years, 1948–1974. Available at: https://www.historicaerials.com/ (accessed June 28, 2021).
HOBOHM, C., editor. 2014. Endemism in vascular plants. Springer, Netherlands.
HOCHSTÄTTER, F. 2001. Geslacht *Yucca*. Agavaceae. 9. *Yucca brevifolia*. Succulenta (Netherlands) 80:262–268.
HOCHSTÄTTER, F. 2002. *Yucca* II (Agavaceae). English Translation by C. Holland, Privately printed, Germany.
HOFFMANN, A. A., and C. M. SGRO. 2011. Climate change and evolutionary adaptation. Nature 470:479–485.
HOFFMANN, A. A., J. SHIRRIFFS, and M. SCOTT. 2005. Relative importance of plastic vs genetic factors in adaptive differentiation: geographical variation for stress resistance in *Drosophila melanogaster* from eastern Australia. Functional Ecology 19:222–227.
HOLMGREN, C. A., J. L. BETANCOURT, and K. A. RYLANDER. 2010. A long-term vegetation history of the Mojave-Colorado desert ecotone at Joshua Tree National Park. Journal of Quaternary Science 25:222–236.
HOLMGREN, M., M. SCHEFFER, and M. A. HUSTON. 1997. The interplay of facilitation and competition in plant communities. Ecology 78:1966–1975.
HOLMGREN, M., P. STAPP, C. R. DICKMAN, C. GRACIA, S. GRAHAM, J. R. GUTIÉRREZ, C. HICE, F. JAKSIC, D. A. KELT, M. LETNIC, M. LIMA, B. C. LÓPEZ, P. L. MESERVE, W. B. MILSTEAD, G. A. POLIS, M. A. PREVITALI, M. RICHTER, S. SABATÉ, and F. A. SQUEO. 2006. Extreme climatic events shape arid and semiarid ecosystems. Frontiers in Ecology and the Environment 4:87–95.
HOPKINS, F. 2018. Inland deserts summary report. California's fourth climate change assessment. p. 67. University of California, Riverside.
HUNING, J. R., and R. M. PETERSEN. 1973. Use of *Yucca brevifolia* as a surrogate for detection of near-surface moisture retention. p. 35.
HUNTER, R. B., A. WALLACE, and E. M. ROMNEY. 1980. Fencing enhances shrub survival and growth for Mojave Desert revegetation. Great Basin Naturalist Memoir 4:212–215.
HUTH, C. J., and O. PELLMYR. 2000. Pollen-mediated selective abortion in yuccas and its consequences for the plant-pollinator mutualism. Ecology 81:1100–1107.

HUXMAN, T. E., E. P. HAMERLYNCK, M. E. LOIK, and S. D. SMITH. 1998. Gas exchange and chlorophyll fluorescence responses of three south-western *Yucca* species to elevated CO_2 and high temperature. Plant, Cell and Environment 21:1275–1283.

HUXMAN, T. E., K. A. HUXMAN, and M. R. STAMER. 1997. Dispersal characteristics of the yucca weevil (*Sctphophorus yuccae*) in a flowering field of *Yucca whipplei*. Great Basin Naturalist 57:38–43.

IKNAYAN, K. J., and S. R. BEISSINGER. 2018. Collapse of a desert bird community over the past century driven by climate change. Proceedings of the National Academy of Sciences 115:8597–8602.

[IPCC] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. 2014. Climate change 2014: synthesis report. contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland. 151 pp.

[IPCC] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. 2021. Summary for policymakers. in: climate change 2021: the physical science basis. contribution of working group I to the sixth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

[ITIS] INTEGRATED TAXONOMIC INFORMATION SYSTEM. 2019. ITIS Database. Available at: http://www.itis.gov/index.html (accessed December 18, 2019).

[IUCN] INTERNATIONAL UNION FOR CONSERVATION OF NATURE. 2012. IUCN Red List Categories and Criteria: Version 3.1. Second edition. IUCN, Gland, Switzerland and Cambridge, UK.

JAEGER, E. C. 1965. The California deserts. Stanford University Press, Stanford, California.

JONES, T., and S. GOLDRICK. 2015. Petition to list the Joshua tree (*Yucca brevifolia*) under the Endangered Species Act. p. 48. WildEarth Guardians, Denver, Colorado.

JOSHUA TREE GENOME PROJECT. 2020. The Joshua tree genome project gets big boost with NSF funding. Available at: https://joshuatreegenome.org/archives/2020/07/the-joshua-tree-genome-project-gets-big-boost-with-nsf-funding/ (accessed June 7, 2020).

[JTNP] JOSHUA TREE NATIONAL PARK. 2017. Memorandum to field supervisor, Carlsbad Fish and Wildlife Office, subject: FWS-L&R 2017-07-031, request for information on the Joshua tree.

JURA-MORAWIEC, J., A. OSKOLSKI, and P. SIMPSON. 2021. Revisiting the anatomy of the monocot cambium, a novel meristem. Planta 254:6.

JURAND, B. S., and S. R. ABELLA. 2013. Soil seed banks of the exotic annual grass *Bromus rubens* on a burned desert landscape. Rangeland Ecology & Management 66:157–163.

KAISER, D. 2021. Dome Fire restoration plan. p. 19. National Park Service, Mojave National Preserve.

KARTESZ, J. T. 1987. A flora of Nevada. PhD Dissertation, University of Nevada, Reno.

KEARNEY, T. H., and R. H. PEEBLES. 1960. Arizona flora. second edition with supplement by J.T. Howell and E. McClintock. University of California Press.

KEELEY, J. E., W. J. BOND, R. A. BRADSTOCK, J. G. PAUSAS, and P. W. RUNDEL. 2011. Fire in Mediterranean ecosystems: ecology, evolution and management. Cambridge University Press, New York.

KEELEY, J. E., and A. MEYERS. 1985. Effect of heat on seed germination of southwestern *Yucca* species. The Southwestern Naturalist 30:303–304.

KEITH, D. A., H. R. AKÇAKAYA, W. THUILLER, G. F. MIDGLEY, R. G. PEARSON, S. J. PHILLIPS, H. M. REGAN, M. B. ARAÚJO, and T. G. REBELO. 2008. Predicting extinction risks under climate change: coupling stochastic population models with dynamic bioclimatic habitat models. Biology Letters 4:560–563.

KELLY, D., and V. L. SORK. 2002. Mast seeding in perennial plants: why, how, where? Annual Review of Ecology and Systematics 33:427–447.

KERNS, B. K., and M. A. DAY. 2017. The importance of disturbance by fire and other abiotic and biotic factors in driving cheatgrass invasion varies based on invasion stage. Biological Invasions 19:1853–1862.

KHATRI-CHHETRI, P., S. M. HENDRYX, K. A. HARTFIELD, M. A. CRIMMINS, W. J. D. VAN LEEUWEN, and V. R. KANE. 2021. Assessing Vegetation Response to Multi-Scalar Drought across the Mojave, Sonoran, Chihuahuan Deserts and Apache Highlands in the Southwest United States. Remote Sensing 13:1103.

KIMBALL, S., A. L. ANGERT, T. E. HUXMAN, and D. L. VENABLE. 2010. Contemporary climate change in the Sonoran Desert favors cold-adapted species. Global Change Biology 16:1555–1565.

VAN KLEUNEN, M., W. DAWSON, F. ESSL, J. PERGL, M. WINTER, E. WEBER, H. KREFT, P. WEIGELT, J. KARTESZ, M. NISHINO, L. A. ANTONOVA, J. F. BARCELONA, F. J. CABEZAS, D. CÁRDENAS, J. CÁRDENAS-TORO, N. CASTAÑO, E. CHACÓN, C. CHATELAIN, A. L. EBEL, E. FIGUEIREDO, N. FUENTES, Q. J. GROOM, L. HENDERSON, INDERJIT, A. KUPRIYANOV, S. MASCIADRI, J. MEERMAN, O. MOROZOVA, D. MOSER, D. L. NICKRENT, A. PATZELT, P. B. PELSER, M. P. BAPTISTE, M. POOPATH, M. SCHULZE, H. SEEBENS, W. SHU, J. THOMAS, M. VELAYOS, J. J. WIERINGA, and P. PYŠEK. 2015. Global exchange and accumulation of non-native plants. Nature 525:100–103.

KLINGER, R., and M. BROOKS. 2017. Alternative pathways to landscape transformation: invasive grasses, burn severity and fire frequency in arid ecosystems. Journal of Ecology 105:1521–1533.

KLINGER, R. C., M. L. BROOKS, and J. M. RANDALL. 2018. Fire and invasive plants, chapter 24. pp. 459–476 Fire in California's ecosystems. Second. University of California Press.

KNOWLES, N., M. D. DETTINGER, and D. R. CAYAN. 2006. Trends in snowfall versus rainfall in the western United States. Journal of Climate 19:4545–4559.

KOCSIS, M. 2011. Impacts of climate change on Lepidoptera species and communities. Applied Ecology and Environmental Research 9:43–72.

KUUSSAARI, M., R. BOMMARCO, R. K. HEIKKINEN, A. HELM, J. KRAUSS, R. LINDBORG, E. OCKINGER, M. PARTEL, J. PINO, F. RODA, C. STEFANESCU, T. TEDER, M. ZOBEL, and I. STEFFAN-DEWENTER. 2009. Extinction debt: a challenge for biodiversity conservation. Trends in Ecology and Evolution 24:564–571.

LAUDERMILK, J., and P. MUNZ. 1935. Plants in the dung of Nothrotherium from Gypsum Cave, Nevada. pp. 31–51. Carnegie Institute of Washington, Washington D.C.

LEÃO, T. C. C., C. R. FONSECA, C. A. PERES, and M. TABARELLI. 2014. Predicting Extinction Risk of Brazilian Atlantic Forest Angiosperms: Neotropical Plant Extinction Risk. Conservation Biology 28:1349–1359.

LEE-YAW, J. A., J. L. MCCUNE, S. PIRONON, and S. N. SHETH. 2021. Species distribution models rarely predict the biology of real populations. Ecography:ecog.05877.

LEGRAS, E. C., S. B. VANDER WALL, and D. I. BOARD. 2010. The role of germination microsite in the establishment of sugar pine and Jeffrey pine seedlings. Forest Ecology and Management 260:806–813.

LENZ, L. W. 2001. Seed dispersal in *Yucca brevifolia* (Agavaceae)-present and past, with consideration of the future of the species. Aliso 20:61–74.

LENZ, L. W. 2007. Reassessment of *Yucca brevifolia* and recognition of *Y. jaegeriana* as a distinct species. Aliso 24:97–104.

LEUNG, L. R., Y. QIAN, X. BIAN, W. M. WASHINGTON, J. HAN, and J. O. ROADS. 2004. Mid-century ensemble regional climate change scenarios for the western United States. Climatic Change 62:75–113.

LEVINE, J. M., M. VILÀ, C. M. D'ANTONIO, J. S. DUKES, K. GRIGULIS, and S. LAVOREL. 2003. Mechanisms underlying the impacts of exotic plant invasions. Proceedings of the Royal Society B: Biological Sciences 270:775–781.

LINDBORG, R., and O. ERIKSSON. 2004. Historical landscape connectivity affects present plant species diversity. Ecology 85:1840–1845.

LITTLE, E. L., JR. 1950. Southwestern trees; a guide to the native species of New Mexico and Arizona. U.S. Department of Agriculture, Washington D.C.

LOIK, M. E., T. E. HUXMAN, E. P. HAMERLYNCK, and S. D. SMITH. 2000a. Low temperature tolerance and cold acclimation for seedlings of three Mojave Desert *Yucca* species exposed to elevated CO_2. Journal of Arid Environments 46:43–56.

LOIK, M. E., C. D. ONGE, and J. ROGERS. 2000b. Post-fire recruitment of *Yucca brevifolia* and *Yucca schidigera* in Joshua Tree National Park, California. pp. 79–85. U.S. Geological Survey Open-File, Environmental Studies Department, Natural Sciences II, University of California, Santa Cruz.

LOVICH, J. E. 1999. Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration. Environmental Management 24:309–326.

LYBBERT, A. H., and S. B. ST. CLAIR. 2017. Wildfire and floral herbivory alter reproduction and pollinator mutualisms of yuccas and yucca moths. Journal of Plant Ecology 10:851–858.

MACE, G. M., N. J. COLLAR, K. J. GASTON, C. HILTON-TAYLOR, H. R. AKÇAKAYA, N. LEADER-WILLIAMS, E. J. MILNER-GULLAND, and S. N. STUART. 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. Conservation Biology 22:1424–1442.

MACK, R. N., D. SIMBERLOFF, W. MARK LONSDALE, H. EVANS, M. CLOUT, and F. A. BAZZAZ. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications 10:689–710.

MALANSON, G. P. 2008. Extinction debt: origins, developments, and applications of a biogeographical trope. Progress in Physical Geography: Earth and Environment 32:277–291.

VAN MANTGEM, P. J., N. L. STEPHENSON, J. C. BYRNE, L. D. DANIELS, J. F. FRANKLIN, P. Z. FULE, M. E. HARMON, A. J. LARSON, J. M. SMITH, A. H. TAYLOR, and T. T. VEBLEN. 2009. Widespread increase of tree mortality rates in the western United States. Science 323:521–524.

MANTUA, N. J., and S. R. HARE. 2002. The Pacific decadal oscillation. Journal of Oceanography 58:35–44.

MARR, D. L., and O. PELLMYR. 2003. Effect of pollinator-inflicted ovule damage on floral abscission in the yucca-yucca moth mutualism: the role of mechanical and chemical factors. Oecologia 136:236–243.

MASTER, L., D. FABER-LANGENDOEN, R. BITTMAN, G. A. HAMMERSON, B. HEIDEL, L. RAMSAY, K. SNOW, A. TEUCHER, and A. TOMAINO. 2012. NatureServe conservation status assessments: factors for evaluating species and ecosystem risk. p. 76. NatureServe, Arlington, VA.

MCCABE, G. J., and M. D. DETTINGER. 1999. Decadal variations in the strength of ENSO teleconnections with precipitation in the western United States. International Journal of Climatology 19:1399–1410.

MCCLEARY, J. A. 1973. Comparative germination and early growth studies of six species of the genus *Yucca*. American Midland Naturalist 90:503.

MCKELVEY, S. D. 1938. Yuccas of the southwestern United States, part 1. Harvard University, Jamaica Plain, Massachusetts: Arnold Arboretum.

MCKINNEY, K. K., and J. C. HICKMAN. 1993. *Yucca*. p. 1210 *in* J. C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, CA.

MCKINNEY, K. K., and J. C. HICKMAN. 2002. *Yucca*. pp. 551–552 *in* M. Weatherwax, B. Baldwin, S. Boyd, B. J. Ertter, R. W. Patterson, T. J. Rosatti, and D. H. Wilken, editors. Jepson desert manual; vascular plants of southeastern California. University of California Press, Berkeley, CA.

MCMINN, H. E. 1951. An illustrated manual of California shrubs. University of California Press, Berkeley, California.

[MDLT] MOJAVE DESERT LAND TRUST. 2021. Mojave Desert Land Trust 2020 Annual Report. Available at: https://www.mdlt.org/mdlt-annual-report-2020/ (accessed October 1, 2021).

MENKE, J., E. REYES, A. GLASS, D. JOHNSON, and J. REYES. 2013. 2013 California Vegetation Map in Support of the Desert Renewable Energy Conservation Plan. Aerial Information Systems, Inc. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=62826&inline.

MINNICH, R. A. 1995. Wildland fire and early postfire succession in Joshua tree woodland and blackbrush scrub of the Mojave Desert of California. pp. 99–106. San Bernardino County Museum Association Quarterly, San Bernardino, California.

MOLONEY, K. A., E. L. MUDRAK, A. FUENTES-RAMIREZ, H. PARAG, M. SCHAT, and C. HOLZAPFEL. 2019. Increased fire risk in Mojave and Sonoran shrublands due to exotic species and extreme rainfall events. Ecosphere 10:e02592.

MOTE, P. W., A. F. HAMLET, M. P. CLARK, and D. P. LETTENMAIER. 2005. Declining mountain snowpack in western North America. Bulletin of the American Meteorological Society 86:39–50.

MUNZ, P. A. 1959. A California flora. University of California Press, Berkeley, California.
NATURAL RESOURCES GROUP, INC. 2021. West Mojave Conservation Bank 2021 western Joshua tree census report. p. 21. Technical Memorandum.
NATURESERVE. 2016. Climate change vulnerability index. Available at: http://www.natureserve.org/conservation-tools/climate-change-vulnerability-index (accessed June 24, 2021).
NATURESERVE. 2021. NatureServe explorer. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.160735/Yucca_brevifolia (accessed August 24, 2021).
NEILSON, R. P., L. F. PITELKA, A. M. SOLOMON, R. NATHAN, G. F. MIDGLEY, J. M. V. FRAGOSO, H. LISCHKE, and K. THOMPSON. 2005. Forecasting regional to global plant migration in response to climate change. BioScience 55:749.
NEWBOLD, T., L. N. HUDSON, S. CONTU, S. L. L. HILL, J. BECK, Y. LIU, C. MEYER, H. R. P. PHILLIPS, J. P. W. SCHARLEMANN, and A. PURVIS. 2018. Widespread winners and narrow-ranged losers: land use homogenizes biodiversity in local assemblages worldwide. PLOS Biology 16:e2006841.
NIC LUGHADHA, E., S. P. BACHMAN, T. C. C. LEÃO, F. FOREST, J. M. HALLEY, J. MOAT, C. ACEDO, K. L. BACON, R. F. A. BREWER, G. GÂTEBLÉ, S. C. GONÇALVES, R. GOVAERTS, P. M. HOLLINGSWORTH, I. KRISAI-GREILHUBER, E. J. LIRIO, P. G. P. MOORE, R. NEGRÃO, J. M. ONANA, L. R. RAJAOVELONA, H. RAZANAJATOVO, P. B. REICH, S. L. RICHARDS, M. C. RIVERS, A. COOPER, J. IGANCI, G. P. LEWIS, E. C. SMIDT, A. ANTONELLI, G. M. MUELLER, and B. E. WALKER. 2020. Extinction risk and threats to plants and fungi. Plants, People, Planet 2:389–408.
NIEVOLA, C. C., C. P. CARVALHO, V. CARVALHO, and E. RODRIGUES. 2017. Rapid responses of plants to temperature changes. Temperature 4:371–405.
NOTARO, M., A. MAUSS, and J. W. WILLIAMS. 2012. Projected vegetation changes for the American southwest: combined dynamic modeling and bioclimatic-envelope approach. Ecological Applications 22:1365–1388.
[NPS] NATIONAL PARK SERVICE. 2012. Death Valley National Park wilderness and backcountry stewardship plan and environmental assessment. Available at: https://parkplanning.nps.gov/showFile.cfm?projectID=23311&MIMEType=applicati on%252Fpdf&filename=DEVA%5FWilderness%5F%5F%5FBackcountry%5FStewardship%5FPlan%2Epdf&sfid=139732 (accessed December 18, 2019).
[NPS] NATIONAL PARK SERVICE. 2020. Dome Fire. Available at: https://www.nps.gov/moja/learn/nature/dome-fire.htm (accessed February 10, 2022).
[NPS] NATIONAL PARK SERVICE. 2021. Joshua Tree National Park Annual Recreation Visits (1941 - Last Calendar Year). Available at: https://irma.nps.gov/STATS/Reports/Park/JOTR (accessed September 30, 2021).
OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT. 2018. Indicators of climate change in California. p. 351. California Environmental Protection Agency.
O'GRADY, J. J., D. H. REED, B. W. BROOK, and R. FRANKHAM. 2004. What are the best correlates of predicted extinction risk? Biological Conservation 118:513–520.

PARDO, L. H., M. E. FENN, C. L. GOODALE, L. H. GEISER, C. T. DRISCOLL, E. B. ALLEN, J. S. BARON, R. BOBBINK, W. D. BOWMAN, C. M. CLARK, B. EMMETT, F. S. GILLIAM, T. L. GREAVER, S. J. HALL, E. A. LILLESKOV, L. LIU, J. A. LYNCH, K. J. NADELHOFFER, S. S. PERAKIS, M. J. ROBIN-ABBOTT, J. L. STODDARD, K. C. WEATHERS, and R. L. DENNIS. 2011. Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States. Ecological Applications 21:3049–3082.

PARMESAN, C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution, and Systematics 37:637–669.

PARMESAN, C., and G. YOHE. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421:37–42.

PASCALE, S., W. R. BOOS, S. BORDONI, T. L. DELWORTH, S. B. KAPNICK, H. MURAKAMI, G. A. VECCHI, and W. ZHANG. 2017. Weakening of the North American monsoon with global warming. Nature Climate Change 7:806–812.

PATEL, S. 2012. *Yucca*: A medicinally significant genus with manifold therapeutic attributes. Natural Products and Bioprospecting 2:231–234.

PEARSON, R. G., and T. P. DAWSON. 2003. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? Global Ecology and Biogeography 12:361–371.

PELLMYR, O. 2003. Yuccas, yucca moths, and coevolution: a review. Annals of the Missouri Botanical Garden 90:35.

PELLMYR, O., and C. J. HUTH. 1994. Evolutionary stability of mutualism between yuccas and yucca moths. Nature 372:257–260.

PELLMYR, O., and K. A. SEGRAVES. 2003. Pollinator divergence within an obligate mutualism: two yucca moth species (Lepidoptera; Prodoxidae: *Tegeticula*) on the Joshua Tree (*Yucca brevifolia*; Agavaceae). Annals of the Entomological Society of America 96:716–722.

PERKINS, L. B., and G. HATFIELD. 2014. Competition, legacy, and priority and the success of three invasive species. Biological Invasions 16:2543–2550.

PHILLIPS, E. A., K. K. PAGE, and S. D. KNAPP. 1980. Vegetational characteristics of two stands of Joshua tree woodland. Madroño 27:43–47.

PHILLIPS, S. J., M. DUDÍK, and R. E. SCHAPIRE. 2021. Maxent software for modeling species niches and distributions. Available at: http://biodiversityinformatics.amnh.org/open_source/maxent/ (accessed September 24, 2021).

PIMENTEL, D., R. ZUNIGA, and D. MORRISON. 2004. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273–288.

PIMM, S. L. 2009. Climate disruption and biodiversity. Current Biology 19:R595–R601.

PIMM, S. L., C. N. JENKINS, R. ABELL, T. M. BROOKS, J. L. GITTLEMAN, L. N. JOPPA, P. H. RAVEN, C. M. ROBERTS, and J. O. SEXTON. 2014. The biodiversity of species and their rates of extinction, distribution, and protection. Science 344:1246752–1246752.

PIMM, S. L., H. L. JONES, and J. DIAMOND. 1988. On the risk of extinction. The American Naturalist 132:757–785.

PURVIS, A., J. L. GITTLEMAN, G. COWLISHAW, and G. M. MACE. 2000. Predicting extinction risk in declining species. Proceedings of the Royal Society of London. Series B: Biological Sciences 267:1947–1952.

RAO, L. E., J. R. MATCHETT, M. L. BROOKS, R. F. JOHNSON, R. A. MINNICH, and E. B. ALLEN. 2015. Relationships between annual plant productivity, nitrogen deposition and fire size in low-elevation California desert scrub. International Journal of Wildland Fire 24:48.

REED, D. H. 2005. Relationship between population size and fitness. Conservation Biology 19:563–568.

REVEAL, J. L. 1977. Agavaceae. pp. 526–538 Intermountain flora: vascular plants of the intermountain west, U.S. Columbia University Press, New York.

REYNOLDS, M. B. J., L. A. DEFALCO, and T. C. ESQUE. 2012. Short seed longevity, variable germination conditions, and infrequent establishment events provide a narrow window for *Yucca brevifolia* (Agavaceae) recruitment. American Journal of Botany 99:1647–1654.

RIDDELL, E. A., K. J. IKNAYAN, B. O. WOLF, B. SINERVO, and S. R. BEISSINGER. 2019. Cooling requirements fueled the collapse of a desert bird community from climate change. Proceedings of the National Academy of Sciences 116:21609–21615.

RILEY, C. 1873. On the oviposition of the yucca moth. The American Naturalist 7:619–623.

RILEY, C. V. 1892. The yucca moth and *Yucca* pollination. Missouri Botanical Garden Annual Report 1892:99.

ROUBICEK, A. J., J. VANDERWAL, L. J. BEAUMONT, A. J. PITMAN, P. WILSON, and L. HUGHES. 2010. Does the choice of climate baseline matter in ecological niche modelling? Ecological Modelling 221:2280–2286.

ROWLANDS, P. G. 1978. The vegetation dynamics of the Joshua tree (*Yucca brevifolia* Engelm.) in the southwestern United States of America. Dissertation, University of California Riverside.

ROYER, A. M., M. A. STREISFELD, and C. I. SMITH. 2016. Population genomics of divergence within an obligate pollination mutualism: selection maintains differences between Joshua tree species. American Journal of Botany 103:1730–1741.

ROYER, A. M., J. WAITE-HIMMELWRIGHT, and C. I. SMITH. 2020. Strong selection against early generation hybrids in Joshua tree hybrid zone not explained by pollinators alone. Frontiers in Plant Science 11:640.

RUNDEL, P. W., and A. C. GIBSON. 1996. Ecological communities and processes in a Mojave Desert ecosystem: Rock Valley, Nevada. Cambridge University Press, New York.

RUNYON, F. F. 1930. Our natural scenic spots. Desert Magazine:44.

SAFFORD, H. D., and K. M. VAN DE WATER. 2014. Using fire return interval departure (FRID) analysis to map spatial and temporal changes in fire frequency on national forest lands in California. USDA Forest Service Research Paper PSW-RP-266.

SANFORD, M. P., and N. HUNTLY. 2009. Selective herbivory by the desert woodrat (*Neotoma lepida*) on Joshua trees (*Yucca brevifolia*). Western North American Naturalist 69:165–170.

SAWYER, J. O., T. KEELER-WOLF, and J. M. EVANS. 2009. A manual of California vegetation. second edition. California Native Plant Society Press, Sacramento, California.
SCHEFFERS, B. R., L. DE MEESTER, T. C. L. BRIDGE, A. A. HOFFMANN, J. M. PANDOLFI, R. T. CORLETT, S. H. M. BUTCHART, P. PEARCE-KELLY, K. M. KOVACS, D. DUDGEON, M. PACIFICI, C. RONDININI, W. B. FODEN, T. G. MARTIN, C. MORA, D. BICKFORD, and J. E. M. WATSON. 2016. The broad footprint of climate change from genes to biomes to people. Science 354:aaf7671.
SCHWALM, C. R., S. GLENDON, and P. B. DUFFY. 2020. RCP8.5 tracks cumulative CO_2 emissions. Proceedings of the National Academy of Sciences 117:19656–19657.
SEAGER, R., and G. A. VECCHI. 2010. Greenhouse warming and the 21st century hydroclimate of southwestern North America. Proceedings of the National Academy of Sciences 107:21277–21282.
SHAFER, S. L., P. J. BARTLEIN, and R. S. THOMPSON. 2001. Potential changes in the distributions of western North America tree and shrub taxa under future climate scenarios. Ecosystems 4:200–215.
SHAFFER, M. L. 1981. Minimum population sizes for species conservation. BioScience 31:131–134.
SHAW, M. R., L. PENDLETON, D. R. CAMERON, B. MORRIS, D. BACHELET, K. KLAUSMEYER, J. MACKENZIE, D. R. CONKLIN, G. N. BRATMAN, J. LENIHAN, E. HAUNREITER, C. DALY, and P. R. ROEHRDANZ. 2011. The impact of climate change on California's ecosystem services. Climatic Change 109:465–484.
SHEPPARD, C. A., and R. A. OLIVER. 2004. Yucca moths and yucca plants: discovery of "the most wonderful case of fertilisation." American Entomologist 50:32–46.
SIEGMUND, J. F., T. G. M. SANDERS, I. HEINRICH, E. VAN DER MAATEN, S. SIMARD, G. HELLE, and R. V. DONNER. 2016. Meteorological Drivers of Extremes in Daily Stem Radius Variations of Beech, Oak, and Pine in Northeastern Germany: An Event Coincidence Analysis. Frontiers in Plant Science 7. Available at: http://journal.frontiersin.org/Article/10.3389/fpls.2016.00733/abstract (accessed January 27, 2022).
SILVA, J. M. C. D., A. RAPINI, L. C. F. BARBOSA, and R. R. TORRES. 2019. Extinction risk of narrowly distributed species of seed plants in Brazil due to habitat loss and climate change. PeerJ 7:e7333.
SILVERTOWN, J. 2008. The evolutionary maintenance of sexual reproduction: evidence from the ecological distribution of asexual reproduction in clonal plants. International Journal of Plant Sciences 169:157–168.
SIMPSON, P. G. 1975. Anatomy and morphology in the Joshua tree (*Yucca brevifolia*): an arborescent monocotyledon. Dissertation, University of California Santa Barbara.
SKINNER, C. N., and C. CHANG. 1996. Fire regimes, past and present. pp. 1041–106 Sierra Nevada ecosystem project: final report to Congress, assessments and scientific basis for management options. University of California, Centers for Water and Wildland Resources, Davis, CA.
SMALL, E. 2013. North American cornucopia: top 100 indigenous food plants. Taylor & Francis. Available at: https://books.google.com/books?id=iZBFAQAAQBAJ (accessed September 3, 2021).

SMITH, C. I., C. S. DRUMMOND, W. GODSOE, J. B. YODER, and O. PELLMYR. 2009. Host specificity and reproductive success of yucca moths (*Tegeticula* spp. Lepidoptera: Prodoxidae) mirror patterns of gene flow between host plant varieties of the Joshua tree (*Yucca brevifolia*: Agavaceae): pollinator host specificity in Joshua trees. Molecular Ecology 18:5218–5229.

SMITH, C. I., W. K. W. GODSOE, S. TANK, J. B. YODER, and O. PELLMYR. 2008a. Distinguishing coevolution from covariance in an obligate pollination mutualism: asynchronous divergence in Joshua tree and its pollinators. Evolution 62:2676–2687.

SMITH, C. I., M. R. MCKAIN, A. GUIMOND, and R. FLATZ. 2021. Genome-scale data resolves the timing of divergence in Joshua trees. American Journal of Botany 108:647–663.

SMITH, C. I., O. PELLMYR, D. M. ALTHOFF, M. BALCÁZAR-LARA, J. LEEBENS-MACK, and K. A. SEGRAVES. 2008b. Pattern and timing of diversification in *Yucca* (Agavaceae): specialized pollination does not escalate rates of diversification. Proceedings of the Royal Society B: Biological Sciences 275:249–258.

SMITH, C. I., S. TANK, W. GODSOE, J. LEVENICK, E. STRAND, T. ESQUE, and O. PELLMYR. 2011. Comparative phylogeography of a coevolved community: concerted population expansions in Joshua trees and four yucca moths. PLoS ONE 6:e25628.

SMITH, D. R., N. L. ALLAN, C. P. MCGOWAN, J. A. SZYMANSKI, S. R. OETKER, and H. M. BELL. 2018. Development of a Species Status Assessment Process for Decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management 9:302–320.

SMITH, S. D., T. L. HARTSOCK, and P. S. NOBEL. 1983. Ecophysiology of *Yucca brevifolia*, an arborescent monocot of the Mojave Desert. Oecologia (Berlin) 60:10–17.

SMITH, S. D., T. E. HUXMAN, S. F. ZITZER, T. N. CHARLET, D. C. HOUSMAN, J. S. COLEMAN, L. K. FENSTERMAKER, J. R. SEEMANN, and R. S. NOWAK. 2000. Elevated CO_2 increases productivity and invasive species success in an arid ecosystem. Nature 408:79–82.

SNYDER, M. A., J. L. BELL, L. C. SLOAN, P. B. DUFFY, and B. GOVINDASAMY. 2002. Climate responses to a doubling of atmospheric carbon dioxide for a climatically vulnerable region. Geophysical Research Letters 29:9–1 to 9–4.

SNYDER, M. A., and L. C. SLOAN. 2005. Transient future climate over the western United States using a regional climate model. Earth Interactions 9(11):1–21.

SOFAER, H. R., C. S. JARNEVICH, I. S. PEARSE, R. L. SMYTH, S. AUER, G. L. COOK, T. C. EDWARDS, G. F. GUALA, T. G. HOWARD, J. T. MORISETTE, and H. HAMILTON. 2019. Development and Delivery of Species Distribution Models to Inform Decision-Making. BioScience 69:544–557.

ST. CLAIR, S. B., and J. HOINES. 2018. Reproductive ecology and stand structure of Joshua tree forests across climate gradients of the Mojave Desert. PLOS ONE 13:e0193248.

STARK, J. M., and J. M. NORTON. 2015. The invasive annual cheatgrass increases nitrogen availability in 24-year-old replicated field plots. Oecologia 177:799–809.

STARR, T. N., K. E. GADEK, J. B. YODER, R. FLATZ, and C. I. SMITH. 2013. Asymmetric hybridization and gene flow between Joshua trees (Agavaceae: *Yucca*) reflect differences in pollinator host specificity. Molecular Ecology 22:437–449.

STAUDE, I. R., L. M. NAVARRO, and H. M. PEREIRA. 2020. Range size predicts the risk of local extinction from habitat loss. Global Ecology and Biogeography 29:16–25.

STEADMAN, D. W., P. S. MARTIN, R. D. E. MACPHEE, A. J. T. JULL, H. G. MCDONALD, C. A. WOODS, M. ITURRALDE-VINENT, and G. W. L. HODGINS. 2005. Asynchronous extinction of late Quaternary sloths on continents and islands. Proceedings of the National Academy of Sciences 102:11763–11768.

STEPHENSON, N. 1998. Actual evapotranspiration and deficit: biologically meaningful correlates of vegetation distribution across spatial scales. Journal of Biogeography 25:855–870.

STEWART, S. B., J. ELITH, M. FEDRIGO, S. KASEL, S. H. ROXBURGH, L. T. BENNETT, M. CHICK, T. FAIRMAN, S. LEONARD, M. KOHOUT, J. K. CRIPPS, L. DURKIN, and C. R. NITSCHKE. 2021. Climate extreme variables generated using monthly time-series data improve predicted distributions of plant species. Ecography 44:626–639.

STOFFER, P. 2004. Desert landforms and surface processes in the Mojave National Preserve and vicinity. U.S. Geological Survey. Available at: http://pubs.usgs.gov/of/2004/1007/index.html (accessed June 10, 2021).

STOFFLE, R. W., D. B. HALMO, M. J. EVANS, and J. E. OLMSTED. 1990. Calculating the cultural significance of American Indian plants: Paiute and Shoshone ethnobotany at Yucca Mountain, Nevada. American Anthropologist 92:416–432.

STOTZ, G. C., C. SALGADO-LUARTE, V. M. ESCOBEDO, F. VALLADARES, and E. GIANOLI. 2021. Global trends in phenotypic plasticity of plants. Ecology Letters:ele.13827.

SUGIHARA, N. G., J. W. VAN WAGTENDONK, and J. FITES-KAUFMAN. 2018. Fire as an ecological process. pp. 57–70 *in* J. W. van Wagtendonk, N. G. Sugihara, S. E. Stephens, A. E. Thode, K. E. Shaffer, and J. Fites-Kaufman, editors. Fire in California's ecosystems. second edition. University of California Press, Berkeley, California.

SUN, F., D. B. WALTON, and A. HALL. 2015. A hybrid dynamical–statistical downscaling technique. part II: end-of-century warming projections predict a new climate state in the Los Angeles region. Journal of Climate 28:4618–4636.

SVENNING, J.-C., and B. SANDEL. 2013. Disequilibrium vegetation dynamics under future climate change. American Journal of Botany 100:1266–1286.

SWARTZ, M. J., S. H. JENKINS, and N. A. DOCHTERMANN. 2010. Coexisting desert rodents differ in selection of microhabitats for cache placement and pilferage. Journal of Mammalogy 91:1261–1268.

SWEET, L. C., T. GREEN, J. G. C. HEINTZ, N. FRAKES, N. GRAVER, J. S. RANGITSCH, J. E. RODGERS, S. HEACOX, and C. W. BARROWS. 2019. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. Ecosphere 10:e02763.

SYPHARD, A. D., J. E. KEELEY, and J. T. ABATZOGLOU. 2017. Trends and drivers of fire activity vary across California aridland ecosystems. Journal of Arid Environments 144:110–122.

TAGESTAD, J., M. BROOKS, V. CULLINAN, J. DOWNS, and R. MCKINLEY. 2016. Precipitation regime classification for the Mojave Desert: implications for fire occurrence. Journal of Arid Environments 124:388–397.

TAYLOR, K. E., R. J. STOUFFER, and G. A. MEEHL. 2012. An Overview of CMIP5 and the Experiment Design. Bulletin of the American Meteorological Society 93:485–498.

THOMAS, K. 2002. Vegetation - central Mojave Desert [ds166]. US Geological Survey. Available at: http://bios.dfg.ca.gov (accessed December 12, 2019).

THOMAS, K. A., P. P. GUERTIN, and L. GASS. 2012. Plant distributions in the southwestern United States: a scenario assessment of the modern-day and future distribution ranges of 166 species. p. 87. U.S. Geological Survey, Reston, Virginia.

THOMAS, K., T. KEELER-WOLF, J. FRANKLIN, and P. STINE. 2004. Mojave Desert ecosystem program: central mojave vegetation database. p. 265. Final Report, U.S. Geological Survey, Sacramento, California.

THOMPSON, J. K. 2021. The last four decades of wildfire impacts on the western Joshua tree (*Yucca brevifolia*) in southern California. University of Redlands, Redlands, California.

THOMPSON, R. S., HOSTETLER, STEVEN W., BARTLEIN, PATRICK J., and ANDERSON, KATHERINE H. 1998. A strategy for assessing potential future changes in climate, hydrology, and vegetation in the western United States. U.S. Geological Survey Circular, United States Government Printing Office, Washington.

THORNE, J. H., R. M. BOYNTON, A. J. HOLGUIN, J. A. E. STEWART, and J. BJORKMAN. 2016. A climate change vulnerability assessment of California's terrestrial vegetation. p. 331. California Department of Fish and Wildlife, Sacramento, CA.

THORNE, R. F., B. A. PRIGGE, and J. HENRICKSON. 1981. A flora of the higher ranges and the Kelso Dunes of the eastern Mojave Desert in California. Aliso 10:71–186.

TILMAN, D., R. M. MAY, C. L. LEHMAN, and M. A. NOWAK. 1994. Habitat destruction and the extinction debt. Nature 371:65–66.

TRELEASE, W. 1893. Further studies of yuccas and their pollination. Missouri Botanical Garden Annual Report 1893:181–226.

TURNER, R. M. 1982. Mojave desertscrub. pp. 157–168 Biotic communtities southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City, Utah.

U2. 1987. The Joshua tree. Island.

U.S. AIR FORCE. 2020. Integrated natural resources management plan for Edwards Air Force Base 2020–2025. p. 244. 412th Civil Engineer Group Environmental Management Division.

U.S. ARMY. 2006. National Training Center and Fort Irwin integrated natural resources management plan and environmental assessment 2006–2011. p. 281. U.S. Army.

U.S. ENVIRONMENTAL PROTECTION AGENCY. 2016. Updates to the demographic and spatial allocation models to produce integrated climate and land use scenarios (ICLUS) version 2. National Center for Environmental Assessment, Washington D.C.

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA). 2009. Land-use scenarios: national-scale housing-density scenarios consistent with climate change storylines. Global

Change Research Program, National Center for Environmental Assessment, Washington D.C.

U.S. NAVY. (n.d.). Integrated Natural Resources Management Plan Naval Air Weapons Station China Lake (unsigned and undated). p. 531.

[USDA] U.S. DEPARTMENT OF AGRICULTURE. 2007. Forest Service LANDFIRE reference database version 0.32. Available at: https://www.landfire.gov/index.php (accessed September 3, 2021).

[USDA] U.S. DEPARTMENT OF AGRICULTURE. 2017. Ecological Subregions: Sections and Subsections for the Conterminous United States. ECOMAP Team. Available at: https://data.fs.usda.gov/geodata/edw/datasets.php?dsetParent=EcomapSections_2007 (accessed September 8, 2021).

[USFWS] U.S. FISH AND WILDLIFE SERVICE. 2018. Joshua tree species status assessment. p. 113 pp. + Appendices A-C.

[USFWS] U.S. FISH AND WILDLIFE SERVICE. 2019. Endangered and threatened wildlife and plants; 12-month findings on petitions to list eight species as endangered or threatened species. Federal Register 84:41694.

VAMSTAD, M. S., and J. T. ROTENBERRY. 2010. Effects of fire on vegetation and small mammal communities in a Mojave Desert Joshua tree woodland. Journal of Arid Environments 74:1309–1318.

VAN LINN, P. F., K. E. NUSSEAR, T. C. ESQUE, L. A. DEFALCO, R. D. INMAN, and S. R. ABELLA. 2013. Estimating wildfire risk on a Mojave Desert landscape using remote sensing and field sampling. International Journal of Wildland Fire 22:770.

VANDER WALL, S. B., T. ESQUE, D. HAINES, M. GARNETT, and B. A. WAITMAN. 2006. Joshua tree (*Yucca brevifolia*) seeds are dispersed by seed-caching rodents. Ecoscience 13:539–543.

VAURIE, P. 1971. Review of *Scyphophorus* (Curculionidae: Rhynchophorinae). Coleopterists Bulletin 25:1–8.

VÁZQUEZ, D. P., E. GIANOLI, W. F. MORRIS, and F. BOZINOVIC. 2017. Ecological and evolutionary impacts of changing climatic variability: impacts of changing climatic variability. Biological Reviews 92:22–42.

VELLEND, M., K. VERHEYEN, H. JACQUEMYN, A. KOLB, H. VAN CALSTER, G. PETERKEN, and M. HERMY. 2006. Extinction debt of forest plants persists for more than a century following habitat fragmentation. Ecology 87:542–548.

VOGL, R. J. 1967. Fire adaptations of some southern California plants. pp. 79–109 Proceedings. Tall Timbers Research Station, Lake County, California.

VAN WAGTENDONK, J. W., and D. R. CAYAN. 2008. Temporal and spatial distribution of lightning strikes in California in relation to large-scale weather patterns. Fire Ecology 4:34–56.

VAN WAGTENDONK, J. W., N. G. SUGIHARA, S. E. STEPHENS, A. E. THODE, K. E. SHAFFER, J. FITES-KAUFMAN, and J. K. AGEE, editors. 2018. Fire in California's ecosystems. second edition. University of California Press, Berkeley, California.

WAITMAN, B. A., S. B. VANDER WALL, and T. C. ESQUE. 2012. Seed dispersal and seed fate in Joshua tree (*Yucca brevifolia*). Journal of Arid Environments 81:1–8.

WALLACE, A., and E. M. ROMNEY. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. Rep. TID25954. Atomic Energy Commission, Office of Information Services, Washington D.C.

WALLACE, A., E. M. ROMNEY, and R. B. HUNTER. 1980. The challenge of a desert: revegetation of disturbed desert lands. Great Basin Naturalist Memoirs 4:216–225.

WALLACE, G. 2017. White paper on taxonomy and nomanclature related to the WEG 2015 petition to list *Yucca brevifolia*. p. 6. white paper, U.S. Fish and Wildlife Service, Carlsbad, California.

WARREN, R., J. PRICE, A. FISCHLIN, S. DE LA NAVA SANTOS, and G. MIDGLEY. 2011. Increasing impacts of climate change upon ecosystems with increasing global mean temperature rise. Climatic Change 106:141–177.

WARREN, S. D., L. S. BAGGETT, and H. WARREN. 2016. Directional floral orientation in Joshua trees (*Yucca brevifolia*). Western North American Naturalist 76:374–378.

WEATHERWAX, M., B. BALDWIN, S. BOYD, B. J. ERTTER, R. W. PATTERSON, T. J. ROSATTI, and D. H. WILKEN, editors. 2002. Jepson desert manual; vascular plants of southeastern California. University of California Press, Berkeley, CA.

WEBB, R. H., M. B. MURVOV, T. C. ESQUE, D. E. BOYER, L. A. DEFALCO, D. F. HAINES, D. OLDERSHAW, S. J. SCOLES, K. A. THOMAS, J. B. BLAINEY, and P. A. MEDICA. 2003. Perennial vegetation data from permanent plots on the Nevada Test Site, Nye County, Nevada. U.S. Geological Survey, Tucson, Arizona.

WEBBER, J. M. 1953. Yuccas of the southwest. U.S. Department of Agriculture, Washington D.C.

WENT, F. W. 1948. Ecology of desert plants. I. observations on germination in the Joshua Tree National Monument, California. Ecology 29:242–253.

WENT, F. W. 1957. The experimental control of plant growth. Chronica Botanica, Waltham, Massachusetts.

WEST INC. 2021a. Population size evaluation for the western Joshua tree prepared for: 8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen. p. 19. Cheyenne, Wyoming.

WEST INC. 2021b. Supplemental report regarding population abundance refinement and data needs for population trend for the western Joshua tree prepared for: 8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen. p. 13. Cheyenne, Wyoming.

WHISENANT, S. G. 1992. Changing fire frequencies on Idaho's Snake River plains: ecological and management implications. Biological Conservation 59:276.

WIEGAND, K., F. JELTSCH, and D. WARD. 2004. Minimum recruitment frequency in plants with episodic recruitment. Oecologia 141:363–372.

WIENS, J. J. 2016. Climate-related local extinctions are already widespread among plant and animal species. PLOS Biology 14:1–18.

WILCOVE, D. S., D. ROTHSTEIN, J. DUBOW, A. PHILLIPS, and E. LOSOS. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48:607–615.

WILLIAMSON, R. S. 1853. Report of the explorations in California for railroad routes. 33rd Congress, 2nd Sess., Sen. Ex. Doc. no. 78. p. 310.

WINKLER, E., and M. FISCHER. 2002. The role of vegetative spread and seed dispersal for optimal life histories of clonal plants: a simulation study. Ecology and Evolutionary Biology of Clonal Plants. Proceedings of Clone-2000. An International Workshop held in Obergurgl, Austria, 20–25 August 2000:59–79.

XIAO, Y., X. LI, Y. CAO, and M. DONG. 2016. The diverse effects of habitat fragmentation on plant–pollinator interactions. Plant Ecology 217:857–868.

YANG, Y. Y., and J. G. KIM. 2016. The optimal balance between sexual and asexual reproduction in variable environments: a systematic review. Available from: https://doi.org/10.1186/s41610-016-0013-0 [accessed 18 June 2021]. Journal of Ecology and Environment 40(12).

YODER, J. B., C. I. SMITH, D. J. ROWLEY, R. FLATZ, W. GODSOE, C. DRUMMOND, and O. PELLMYR. 2013. Effects of gene flow on phenotype matching between two varieties of Joshua tree (*Yucca brevifolia*; Agavaceae) and their pollinators. Journal of Evolutionary Biology 26:1220–1233.

YURKONIS, K. A., and S. J. MEINERS. 2004. Invasion impacts local species turnover in a successional system. Ecology Letters 7:764–769.

ZHANG, J., Y. GAO, L. R. LEUNG, K. LUO, H. LIU, J.-F. LAMARQUE, J. FAN, X. YAO, H. GAO, and T. NAGASHIMA. 2019. Impacts of climate change and emissions on atmospheric oxidized nitrogen deposition over East Asia. Atmospheric Chemistry and Physics 19:887–900.

ZIMMERMANN, N. E., N. G. YOCCOZ, T. C. EDWARDS, E. S. MEIER, W. THUILLER, A. GUISAN, D. R. SCHMATZ, and P. B. PEARMAN. 2009. Climatic extremes improve predictions of spatial patterns of tree species. Proceedings of the National Academy of Sciences 106:19723–19728.

ZINKGRAF, M., S. GERTTULA, and A. GROOVER. 2017. Transcript profiling of a novel plant meristem, the monocot cambium: monocot cambium. Journal of Integrative Plant Biology 59:436–449.

ZIV, Y., and J. L. BRONSTEIN. 1996. Infertile seeds of *Yucca schottii*: a beneficial role for the plant in the yucca-yucca moth mutualism? Evolutionary Ecology 10:63–76.

ZOUHAR, K., J. K. SMITH, S. SUTHERLAND, and M. L. BROOKS. 2008. Wildland fire in ecosystems: fire and nonnative invasive plants. p. RMRS-GTR-42-V6. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ft. Collins, Colorado. Available at: https://www.fs.usda.gov/treesearch/pubs/30622 (accessed September 2, 2021).

Personal Communication

BIRKER PERS. COMM. 2021. E-mail from Cheryl Birker, California Botanic Garden, regarding *Yucca brevifolia* germination study. April 5, 2021.

BORCHERT PERS. COMM. 2021. Letter from Mark Borchert. January 18, 2021.

FRAKES PERS. COMM. 2021. Discussion with Neil Frakes, Vegetation Manager, Joshua Tree National Park. January 20, 2021.

GAUGHEN PERS. COMM. 2020. Letter from Pala Band of Mission Indians Environmental Director/Tribal Historic Preservation Officer. November 17, 2020.

KRANTZ PERS. COMM. 2021. E-mail from Timothy Krantz, Professor and Chair, Environmental Studies Program, University of Redlands. September 16, 2021.

REYNOLDS PERS. COMM. 2021. Letter from Mike Reynolds, Superintendent, Death Valley National Park. February 8, 2021.

ROGERS PERS. COMM. 2021. E-mail from Jane Rogers, Acting Superintendent, Joshua Tree National Park. July 23, 2021.
TEJADA PERS. COMM. 2020. E-mail from Jonathan Tejada, Environmental Scientist, California Department of Parks and Recreation. November 2, 2020.

APPENDIX A: COMMENTS FROM AFFECTED AND INTERESTED PARTIES ON THE PETITIONED ACTION

APPENDIX B: COMMENTS FROM PEER REVIEWERS ON THE WESTERN JOSHUA TREE STATUS REVIEW REPORT

January 18, 2021

Dear California Department of Fish and Game,

My brief comments on western Joshua tree are limited to research and observations on high-elevation stands at the southwest edge of its distribution, primarily between Big Bear Lake and Lucerne Valley, California. I have been studying three areas intensively: a 74-year old stand (burned 1946) at Cactus Flat (CF, 8 years of study; (Borchert and DeFalco 2016), a late seral stand composed of pinyon pine and Joshua tree (LV, 6 years; Borchert 2016) and more recently an area within the Holcomb Fire of 2017 (HV, 3 years; submitted ms attached) that burned pinyon woodlands and forests at high intensity.

Joshua trees in all three stands reproduce almost entirely vegetatively. Generally, mature trees are multi-stemmed and produce both basal sprouts and root suckers. At CF and LV root suckers are found within 5 m of the much taller adults. Multi-stemmed, mature individuals arising from basal sprouts are common at both CF and LV. At HV, fire-killed Joshua trees regenerated primarily by basal sprouts along with a few suckers. Herbivory losses of basal sprouts was extremely high in the first year post-fire. Basal sprouts, however, were numerous in the second year when there were 8.7 (SD ± 9.8) basal sprouts per dead Joshua tree.

I have walked CF and LV extensively every year for many years but have never observed seedlings originating from seeds, even though in mast years adults produce millions of seeds (Borchert and DeFalco 2016). What appeared to be seedlings invariably turned out to be the small sucker sprouts < 4-5 m of a nearby adult. Regeneration from seed almost certainly occurs but I suspect it is rare.

Borchert, M. 2016. Rodent removal of fallen Joshua tree (*Yucca brevifolia*) fruits. Bulletin Southern California Academy of Sciences 115:146-155.

Borchert, M. I., and L. A. DeFalco. 2016. *Yucca brevifolia* fruit production, predispersal seed predation, and fruit removal by rodents during two years of contrasting reproduction. American Journal of Botany 103:830-836.

Borchert, M.I. 2021. Post-fire seedling establishment of *Prunus fasciculata* and *Yucca brevifolia* from simulated seed caches in the Mojave Desert. Submitted for publication at The Southwestern Naturalist. Pdf attached.

Sent via email

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Re: Western Joshua Tree Status Review

These comments are submitted on behalf of the Center for Biological Diversity regarding the status review that the California Department of Fish and Wildlife (DFW) is undertaking pursuant to Fish and Game Code section 2074.6 regarding the western Joshua tree (*Yucca brevifolia*). On October 15, 2019, the Center petitioned the California Fish and Game Commission to list the western Joshua tree as a threatened species under the California Endangered Species Act (CESA). Following DFW's evaluation of the Petition and recommendation to the Commission, on September 22, 2020 the Commission unanimously voted to advance the species to candidacy, finding the Petition presented substantial information indicating that listing may be warranted. *See* Cal. Reg. Notice Register 2020, No. 41-Z, p. 1349 (October 9, 2020).

The Center believes that the information contained in the Petition, along with the supporting scientific studies submitted with it, clearly demonstrates not only that listing as threatened "may be warranted," but also that such listing "is warranted" (Fish & G. Code, § 2074.6). As such, we will not repeat the information and analysis contained in the Petition here. Instead, these comments are submitted to provide additional information that has become available subsequent to the Petition, as well as to address arguments made by various parties against protection of the species. This information reinforces the information provided by the Petition and further demonstrates that threats to the species are ongoing, severe and certain to increase over time. While the species might not yet be "presently threatened with extinction" throughout it range, it certainly "is likely to become an endangered species in the foreseeable future" in, at a minimum, "a significant portion of its range," and consequently meets the statutory definition of a "threatened species" (Cal. Fish & Game Code § 2067).

New scientific studies support threatened status for the western Joshua tree

Since the Petition was filed, several new studies have reinforced the conclusion that the western Joshua tree meets the definition of a threatened species under CESA. These include, *inter alia*, studies looking at the genetics of the species; studies documenting the increasing scope, severity and impacts of fire; studies documenting localized declines of the species; and studies addressing current climate trajectories.

a) Taxonomy

As detailed in the Petition (p. 3-4), the recognition of western (*Yucca brevifolia*) and eastern Joshua trees (*Yucca jaegeriana*) as full species rather than varieties or subspecies is a relatively recent development. In 2007, Lenz formally described them as separate species based on differences in flower and fruit morphology as well as each having different obligate pollinators. While not yet uniformly adopted, the existence of two species is increasingly recognized, including by Royer et al. (2016), Cole et al. (2017), Wallace (2017), USFWS (2018) and USFWS (2019).

Subsequent to the Petition, Royer et al. (2020), in a study looking at morphology, pollinator relationships and genetics, reaffirmed the two-species taxonomy, noting that "the two *Yucca* species are highly genetically differentiated." Consistent with the best available science, for purposes of CESA, the western Joshua tree must be treated as a full species rather than as a subspecies or variety.

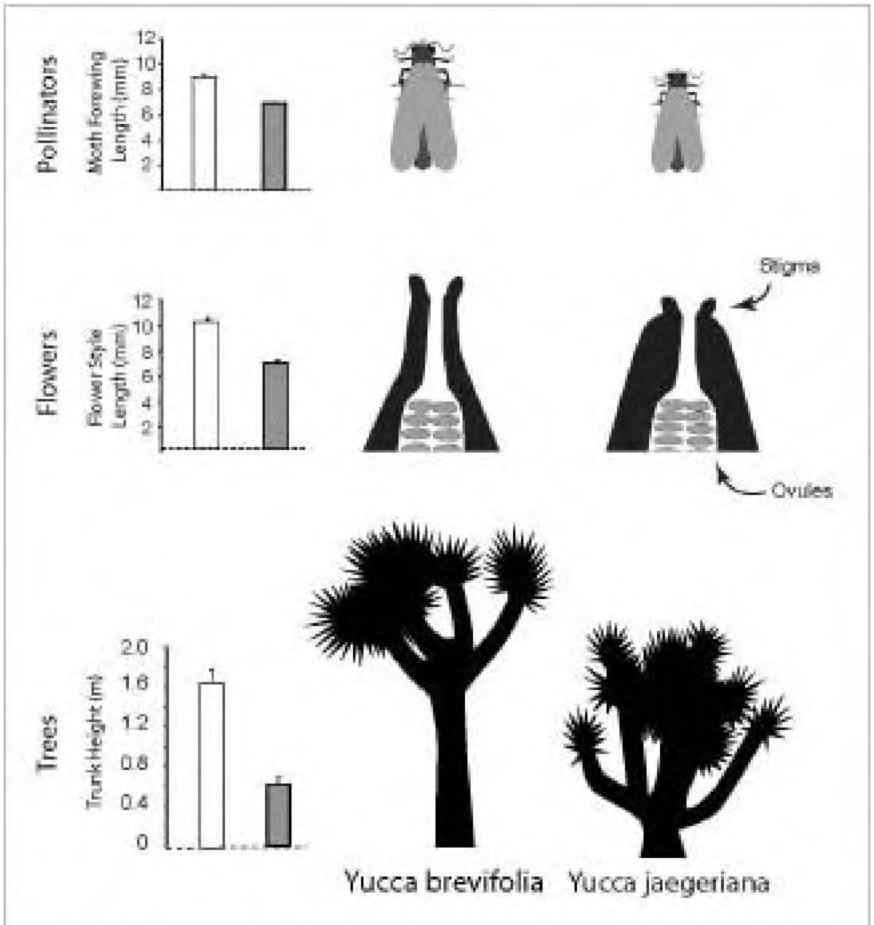


FIGURE 1 | Variation in body size in Joshua tree moth pollinators (graph illustrates a common proxy, wing length), and variation in two key characters differentiating the two species of Joshua tree: style length and trunk height.

Source: Royer et al. (2020)

b) Dispersal

While Royer et al. (2020) focused on the forces that drove the speciation of the western and eastern Joshua trees, the study is also useful in highlighting the geographical constraints on dispersal of Joshua trees and their pollinating moths. The very limited dispersal abilities of Joshua trees, and the consequences of those limitations in a warming climate are discussed in the Petition (p. 10-12, 17, 35, 38) and the studies cited therein (e.g. Lenz 2001; Vander Wall et al., 2006; Cole et al. 2011). The narrow hybrid zone between the two species that is the focus of the Royer et al. (2020) study is bordered by a largely inhospitable ancient lakebed that stretches ~1km to its west, across which gene flow is extremely limited. Royer et al. note that the very low density of trees in this zone "could be caused by sandier or saltier soil resulting in moisture levels too low for Joshua trees to tolerate," and that "[a]cross their range, Joshua trees are typically absent from pluvial lakebeds." This reinforces other evidence indicating that geneflow among Joshua tree populations separated by even relatively small gaps in habitat (~1km) is likely quite limited.

> This suggests that gene flow across the gap is relatively rare. That would be consistent with what we know about gene flow in Joshua trees; estimates of seed dispersal are around 30.0 ± 16.8m from the maternal tree, and measurements of movement in other species of *Tegeticula* estimate moths move less than 50m; as mentioned above, preliminary work in Joshua tree *Tegeticula* shows individual moths move an average of ~30m…Occasional long-distance dispersal events certainly occur, but at a scale of >30x the mean, they may be quite rare. (Royer et al., 2020) (internal citations omitted).

Given the ever-increasing fragmentation of western Joshua tree habitat from development and fire, along with the growing unsuitability of lower-elevation habitat due to climate change, continued gene flow between populations of the species, already naturally limited, will become increasingly difficult.

c) Fire

As detailed in the Petition (p. 24-31) fire is one of the greatest threats to the continued persistence of the western Joshua tree. Since the Petition was filed, new information further substantiates the scale and immediacy of that threat.

In a large-scale long-duration study of 31 fire sites, Abella et al. (2020) documented minimal recovery of Joshua trees and their host plants three decades post fire. Notably, in blackbrush (*Coleogyne*) dominated communities, the projected time to recovery to pre-burn species composition was 550 years. Given blackbrush is an important nurse plant for Joshua trees, this has obvious consequences for the species.

> In a 22-yr study, for example, 28% of *Y. brevifolia* seedlings survived below nurse plants in fertile islands, compared to zero survival for seedlings in interspaces. Burned areas likely select for species less dependent on nurse plants for recruitment, which may account for burned areas containing relatively small-statured perennial species capable of recruiting in open areas. (internal citations omitted).

Consistent with other studies (e.g. DeFalco et al. (2010), showing 64-95% post-fire mortality), limited resprouting of burned Joshua trees occurred, but minimal if any seedlings became established.

> Resprouting was less frequent for *Y. brevifolia*, but aided population persistence as the few resprouters constituted nearly all the species' live individuals on burned areas.

Abella et al. (2020) discussed the challenges facing Joshua trees recruiting into post-fire landscapes.

> Likely with similar challenges to recruitment, *Yucca brevifolia* forms a persistent but relatively short-lived soil seed bank (~4 yr) that is readily killed by temperatures sustained below shrubs during wildfire. Although the species can resprout at low frequencies, resprouts may require over 30 yr to produce seeds, indicating that plants on even the oldest burns (36 yr) we studied may not yet be capable of reproduction. Furthermore, seeds typically disperse only short distances (<25 m) from adults via small mammals, and seedling establishment is contingent on availability of nurse plants, which are sparse on burns….Collectively, previous research suggests that sparse seed availability, limited seed dispersal, and lack of suitable regeneration microsites (nurse plants) hinder these species' recruitment. These limitations could form feedbacks deterring resilience and promoting alternative states with low densities of these species, consistent with our data (internal citations omitted).

These dynamics can also impact the persistence of the Joshua tree's obligate pollinators, as even when post-fire resprouting occurs, the area is rendered unsuitable to pollinating moths for decades.

> Although limited resprouting fostered minimal resilience of *Yucca* density in our study, stems sufficiently large to flower were largely absent from burns, and thus, *Yucca* flowers were unavailable to pollinators for decades. This highlights that some resilience may not translate to functional resilience and that recovery debts can accrue while limited resilience is occurring. Multi-decade absences of *Yucca* floral resources from extensive burned areas and potential influences on specialized pollinators could trigger alternative stable states in pollinator networks.

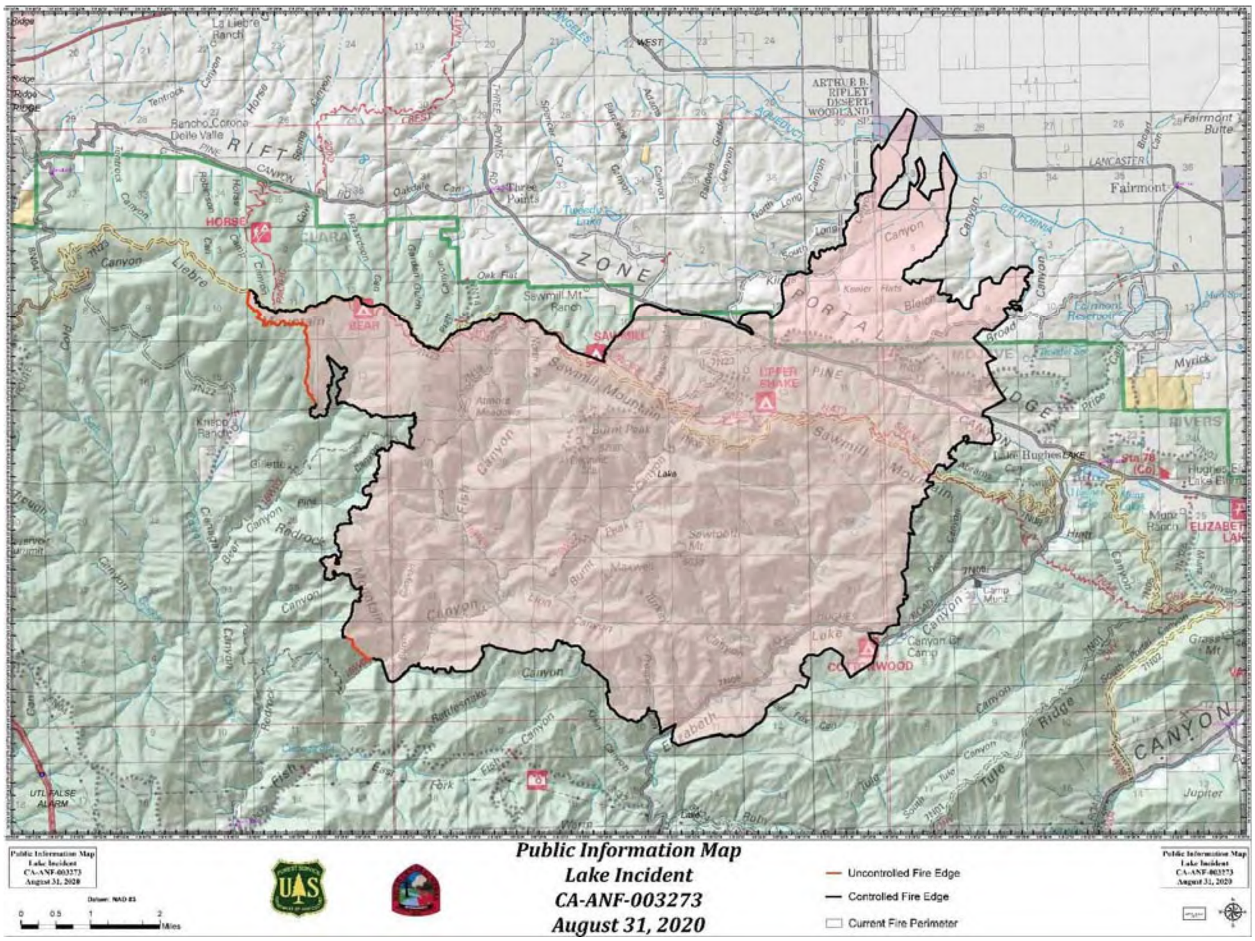
In sum, fire kills Joshua trees in all age classes, likely destroys the seed bank, and eliminates nurse plants that seedlings need to survive, while the few resprouting trees that survive take decades to flower, rendering the burn site inhospitable to pollinating moths. Given these challenges, burned Joshua tree woodlands are "entirely unlikely" to ever return to pre-fire densities or ecosystem function (Reynolds et al., 2012).

While the Abella et al. (2020)[1] study reinforces the information provided in the Petition on the

[1] Abella et al. (2020) have not yet adopted the two-species taxonomy and refer to *Yucca brevifolia* throughout. Joshua trees in their study areas are likely *Y. jaegeriana*. Nevertheless, given no studies to date have demonstrated differing vulnerabilities or responses to fire between the eastern and western species, their findings are still highly informative to the fate of the western Joshua tree.

impacts of fire on Joshua trees, actual fires in the range of the species since the filing of the Petition further demonstrate the scale and immediacy of the threat.

Over the course of 2020 alone, many thousands of acres of Joshua tree habitat burned. These include very large fires in the range of the western Joshua tree such as the Lake and Bobcat fires, which collectively burned thousands of acres of Joshua tree habitat, as well as smaller fires that burned significant patches of such habitat.



The Lake Fire in August 2020 was noteworthy in that it burned a small state park designated to protect the western Joshua tree, a nearby county preserve, as well as private conservation lands acquired for the protection of Joshua trees. These areas are the Arthur B, Ripley Desert Woodlands State Park, the George R. Bones Wildlife Sanctuary operated by Los Angeles County, and conservation lands purchased and managed by Transition Habitat Conservancy, all of which lost significant portions of their holdings in the fire. Additional private and public lands in the area containing Joshua trees also burned.

Photo of burned portion of Arthur B, Ripley Desert Woodlands State Park taken October 28, 2020.

Photo of burned portion of George R. Bones Wildlife Sanctuary taken October 28, 2020.

Photo of burned Transition Habitat Conservancy lands taken October 28, 2020.

These otherwise protected areas that burned in 2020 are roughly contiguous and represent the core of protected lands for Joshua trees in the western Antelope Valley, an area that has already lost most of its Joshua tree woodland to agricultural development and urban development.


Photo showing burned LA County preserve on right, burned THC lands on left and burned and unburned State Park lands in center. Solar projects visible in distance. Photo taken October 28, 2020.

As reflected in the photo above, remnant areas of Joshua tree woodland, visible as dark patches, represent a small fraction of land in the area. Much of the area was cleared for agriculture or pasture in the early 20th Century. Other than the identified protected lands, all lands containing Joshua trees visible in this image are private with no long-term protections in place other than the temporary prohibition against take provided by candidacy status.

While the Lake Fire burned into the western Antelope Valley, the Bobcat Fire in September 2020 burned important Joshua tree habitat in the eastern Antelope Valley and along the northern slopes of the San Gabriel Mountains. This fire scorched over 115,000 acres, upwards of 10,000 of which contained Joshua trees. Among the burned areas were nominally protected areas such as the Devil's Punchbowl Natural Area and portions of the San Gabriel Mountains National Monument.

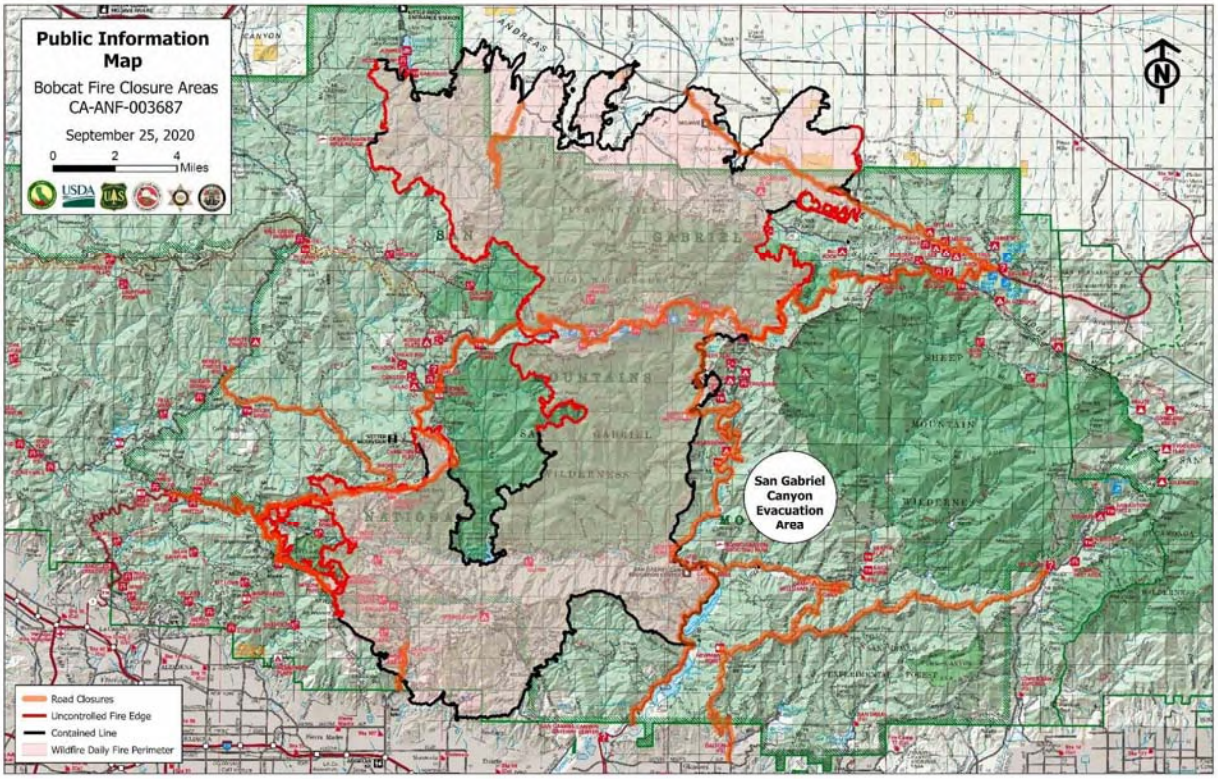


Photo of Bobcat Fire burning through Joshua tree habitat. Source CNN.

Another noteworthy fire of significant conservation impact occurred in May 2020 when a cigarette-caused fire burned over 150 acres of dense Joshua tree woodland on lands acquired for protection by the Mojave Desert Land Trust.

Photo showing boundary of burned area on MDLT land in Joshua Tree, CA. Photo taken May 20, 2020.

This fire, as with the Lake and Bobcat fires that followed it, demonstrate that even areas legally protected from development and otherwise managed for conservation, are not adequately protected from fire fueled by invasive grasses and the drought and heat conditions created by a changing climate.

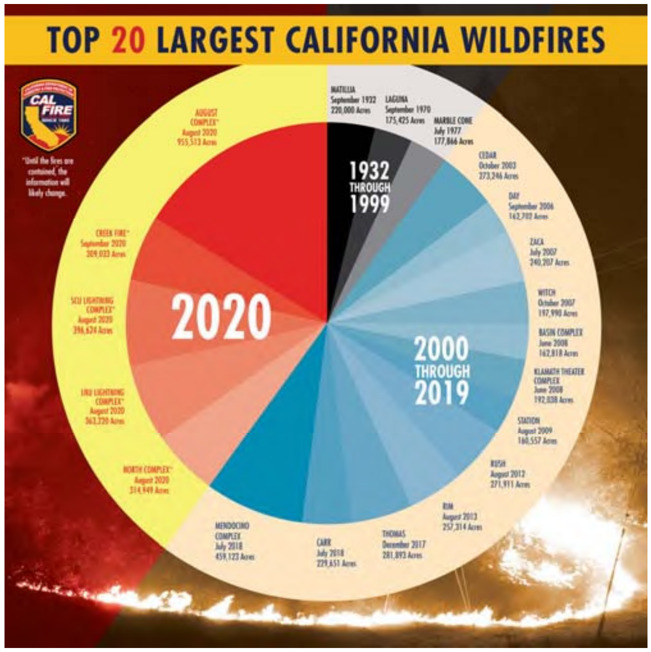
While the Lake, Bobcat and MDLT fires all burned otherwise protected areas in the range of the western Joshua tree, perhaps the most noteworthy fire of 2020 was the Dome Fire that burned over 40 thousand acres of what is arguably the largest Joshua tree forest on earth. This fire killed an estimated 1.3 million eastern Joshua trees in the Mojave National Preserve. As acknowledged by the National Park Service, "since the Dome Fire fully scorched most of the plants it touched, it's unlikely that many of the 1.3 million Joshua trees will recover."[2]

Among the factors that led to the lightening caused Dome Fire were a combination of extreme heat, thunderstorms and other wildfires across parts of California that the National Weather Service described as an "extraordinary unprecedented historic event."[3] As noted by the Park Service, due to simultaneous fires burning elsewhere in the state, requests for additional

[2] The National Park Service's description of the fire and its aftermath is available at https://www.nps.gov/moja/learn/nature/dome-fire.htm

[3] https://wsvn.com/news/us-world/a-heat-wave-in-california-is-fueling-more-than-30-wildfires-it-may-also-leave-millions-of-homes-without-power/

firefighting resources to fight the Dome Fire were denied: “A desert wilderness fire, while recognized as being serious, was not given high priority for limited firefighting resources.” With fires in California increasing in number and severity, and the majority of the state’s largest ever fires occurring in recent years, similar dynamics where remote Joshua tree woodlands are allowed to burn while scarce firefighting resources are deployed elsewhere can be expected to become ever more common.



CALFIRE Chart of largest fires in recent California history.

Photo of Dome Fire shortly after the fire was contained. Photo taken August 30, 2020.

While the Dome Fire devastated the eastern Joshua tree, the conditions that led to this unprecedented fire (e.g. carpets of invasive grasses, abnormally hot and dry climate conditions and widespread lightning strikes) are also prevalent in the range of the western species. The Dome Fire demonstrates that a significant portion of the species' range can be irrevocably devastated by fire over the course of a week due to a single incident. Even absent the impacts of climate change and habitat loss to development, fire is a widespread and imminent threat to the western Joshua tree.

d) Climate Change

The Petition described the various studies demonstrating that climate change represents an existential threat to the western Joshua tree (p. 32-45). The Petition also explained how existing regulatory mechanisms are not sufficient to address this threat (p. 48-50). Since the Petition was filed, no information of any kind has come to light that would indicate that climate change represents less of a threat to the western Joshua tree than identified in the studies cited in the Petition. However, national and global emissions have decreased slightly due to COVID-19 and a new federal administration has rejoined the Paris Agreement. Nevertheless, the most important metric – atmospheric CO_2 levels – continued it inexorable rise. On October 17, 2019, two days after the Petition was submitted, the level was 411.93 ppm; on January 30, 2021 it had risen to 415.95 ppm.[4]

Similarly, 2020 tied the record for the warmest year on record globally,[5] while August, September and October 2020 were the hottest of their respective months on record in California. On August 16, 2020, the highest temperature ever reliably recorded on earth, 130° F (54.4ºC), was reached in Death Valley.[6] And as noted in the Petition (p. 33), the counties in which western Joshua trees occur — Riverside, San Bernardino, Los Angeles, Kern and Inyo — have already experienced average annual temperature increases of 1.8, 1.9, 2.3, 1.7 and 2.3ºC respectively, which are significantly higher than the global average of 1.1ºC.

And temperatures will continue to warm. California's official Fourth Climate Change Assessment, Inland Deserts Summary Report (Hopkins 2018), projects that daily maximum temperatures will increase by 5-6ºF [2.8-3.3ºC] for 2006-2039, by 6-10ºF [3.3-5.6ºC] for 2040-2069, and 8-14ºF [4.4-7.8ºC] for 2070-2100 on average for the region, with ranges depending on future greenhouse gas emissions (RCP 4.5 and RCP 8.5 scenarios).

The various modelling efforts on the future of Joshua trees in a warming climate relied upon slightly different, albeit complementary, climate scenarios. Cole et al. (2011) relied upon a doubling of CO_2 levels, Barrows and Murphy-Mariscal (2012) on increasing summer maximum temperatures in 1, 2 and 3° C increments, and Sweet et al. (2019) on RCP 4.5, 6.0 and 8.5 scenarios.

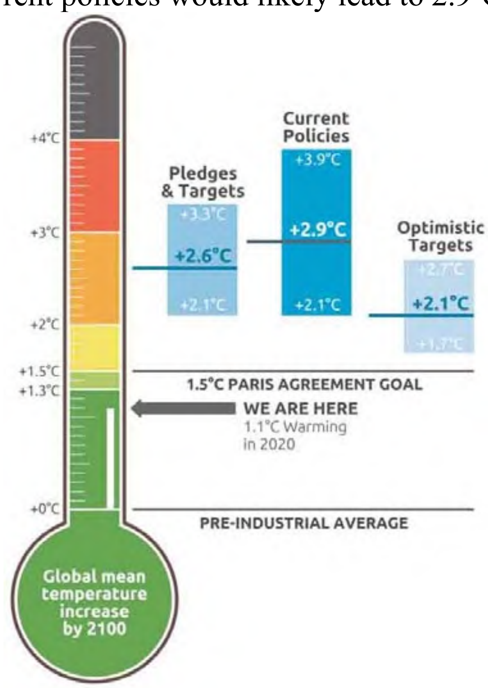
Recently, Schwalm et al. (2020) affirmed the relevance of RCP 8.5 for policy purposes. The various Representative Concentration Pathways (RCPs) scenarios as used in global climate models use historical greenhouse gas emissions until 2005, and projected emissions subsequently. Of these, Schwalm et al. describe how RCP 8.5 most closely tracks cumulative emissions from 2005

[4] https://climate.nasa.gov/vital-signs/carbon-dioxide/
[5] https://www.nasa.gov/press-release/2020-tied-for-warmest-year-on-record-nasa-analysis-shows
[6] https://www.noaa.gov/news/summer-2020-ranked-as-one-of-hottest-on-record-for-us

to the present. Because of this congruence, RCP 8.5 is often referred to as a "business as usual" scenario. Schwalm et al. further note that RCP 8.5 tracks close to expected cumulative emissions to 2030 as well as 2050, and there is at least a 35% chance that CO_2 concentrations will exceed those assumed by RCP 8.5 by 2100.

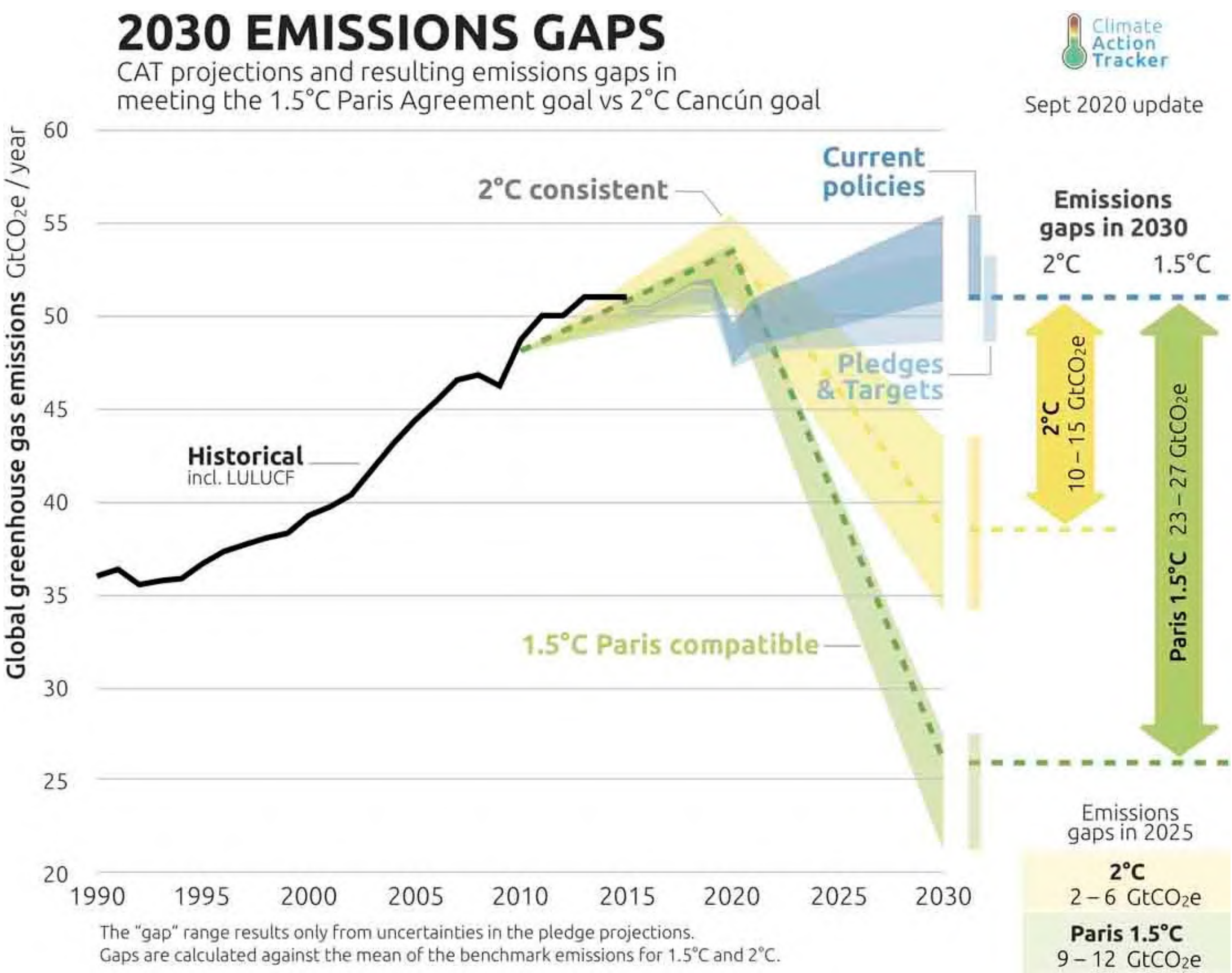
While RCP 8.5 remains the most appropriate scenario for assessing climate risk to the western Joshua tree, temperature increases well below those that would occur under that pathway would still have catastrophic impacts on the species. As described in the Petition (p. 40) Sweet et al. (2019) projected habitat suitable for Joshua trees would be reduced by 99.98% under RCP 8.5, 86.1% under RCP 6.0 and 81.4% under RCP 4.5 by the 2070-2090 period. Similarly, under a doubling of CO_2 levels as used by Cole et al. (2011) — a concentration less than projected to occur under RCP 8.5 — western Joshua trees would be almost completely extirpated from California on a similar timeframe (p. 37). Barrows and Murphy-Mariscal (2012) use of 1ºC, 2ºC, and then 3ºC increases in summer maximum temperature resulted in modeled reductions in the extent of suitable habitat for Joshua trees of 30-35%, 66-78% and 90-98% respectively, depending upon the precipitation variables used (p. 39). Frighteningly, even under the mid-range RCP 4.5 scenario, Hopkins (2018) projects a 3ºC increases in summer maximum temperature arriving in the Mojave as early as 2040, only 20 years from now.

At the time of the Petition, Climate Action Tracker (CAT)[7] estimated that current policies, if implemented, would result in an end-of-century global temperature increase of between 3.0 and 3.4ºC. Since that report, various countries have stated their intentions to reach net zero emissions in the coming decades. In light of these pledges and targets, including by the United States and China, the newest CAT report notes that under an "optimistic scenario" in which all 127 governments with net zero targets meet those targets, warming in the range of "only" 2.1ºC is possible. However, actual current policies would likely lead to 2.9ºC of warming.



[7] https://climateactiontracker.org/

However, as noted by CAT, "while 2050 net zero targets are commendable, governments must now adopt stronger 2030 targets (nationally determined contributions or NDCs) to deliver on their net zero goals, and close the remaining emissions gap." Unfortuneately, these targets remain just that, with no clear indication that they will actually come to pass. And even existing policies do not necessarily translate into actual emissions reductions. As shown on the CAT Emissions Gaps chart below, emissions must drop precipitously between now and 2030 to be compatable with meeting the 1.5 or 2.0ºC targets of the Paris Agreement.



In sum, even if the various net zero targets and pledges are cause for increased climate optomism, current policies (again, assuming they are implemented) put us on a trajectory for a likely increase of 2.9ºC. Such an increase is still greater than projected under RCP 6.0, a scenario in which western Joshua trees decline by over 86%, while the most "optimistic" outcome of a 2.1ºC global temperature increase is close to what is expected under the RCP 4.5 scenario, a scenario in which Joshua trees still decline by upwards of 80%. Western Joshua trees face a very difficult future in which they would still likely be extirpated from a significant portion of their range even under the most optimistic of climate outcomes.

e) Western Joshua Tree Population Declines

Over the past century, hundreds of thousands of acres of western Joshua tree habitat have been lost to agricultural conversion and industrial and residential development (Petition, p. 19, 46-48). Over the past few decades, unprecedented fires fueled by invasive grasses have consumed many tens of thousands of additional acres, killing most of the Joshua trees within the burn areas. Even without accounting for climate change, it is clear that there are far fewer acres of intact western Joshua tree habitat today than in the recent past; consequently, the species has undeniably declined in range and abundance. And of course, climate change must be considered. Increasing temperatures have already resulted in reduced reproduction and increased mortality in the lower and hotter portions of the western Joshua tree's range (p. 19-20). Over time, as temperatures continue to rise, these effects will manifest at higher elevations and latitudes. Even under the most optimistic climate scenarios, the species will be reduced over the next fifty or so years to a small fraction of its historic distribution (p. 32-45).

Opponents of listing have made much of a statement in the Petition that "no range-wide population trends have been documented" (p. 19). The Petition's statement regarding "range-wide population trends" reflects that outside of Joshua Tree National Park, much of the currently existing intact habitat for the species remains unstudied and therefore the question of whether or not trees are *already* declining in these areas due to climate change has yet to be answered. However, given hundreds of thousands of acres of formerly occupied habitat have been lost to development while fires have killed scores of trees in other areas, there can be no doubt that *overall* there are fewer Joshua trees today than existed only a few decades ago. In that sense there has been a range-wide population decline of the species that is ongoing.

Since the filing of the Petition, at least one additional study has been made public regarding the status of Joshua tree populations outside of Joshua Tree National Park. Cornett (2020) reported on a long-term study plot in Red Rock Canyon State Park, which is located near the northern edge of the southern population (YUBR South ESU). The number of trees declined by 46% over the 21-year study period, with young trees (<1m) declining at a greater rate than older trees (>1m). Tree vigor, measured by comparing ratio of live to dead rosettes of trees larger than 1m, also declined from 0.97 in 1995 to 0.63 in 2016, suggesting surviving trees were more stressed at the end of the study than at the start. The time period of the study corresponded with an increase in temperature and a decline in precipitation in the region. Non-quantitative observations outside the study plot indicated similar declines in abundance and vigor were occurring throughout the park. Cornett concluded that the population in the park may have reached "a tipping point where it may no longer be self-sustaining."

The threats of climate change, as well as of fire and habitat loss to development, collectively would be sufficient to warrant protection of the western Joshua tree as a threatened species *even in the absence of already observed declines* (when a ship starts taking on water, you don't have to wait until the first passenger drowns before calling in a Mayday). The fact that the species is *already* declining on otherwise protected habitat in widely separately portions of its range as a result of the limited warming that has occurred to date, serves to validate the dire projections of the various climate modeling studies of the species. Listing is clearly warranted.

f) Development

Habitat loss to development has been the greatest historic threat to the western Joshua tree and remains a significant obstacle to its conservation. Untold thousands of acres were lost to agricultural conversion and other forms of development in the Antelope Valley in the early 20th Century, while the growth of cities and towns in the Antelope Valley, West Mojave and Morongo Basin in more recent decades have resulted in the loss of thousands of additional acres.

As documented in the Petition (p. 46) over 50% of the land area comprising the YUBR South population is privately owned, with virtually no effective conservation measures for Joshua trees other than those provided by the interim take prohibition of candidacy. In 2018, USFWS projected that over 40% of suitable habitat in YUBR South would be lost to housing development absent changes in land-use protection. Other forms of additional habitat loss are also likely.

As of 2018, USFWS estimated that 68,000 acres of Joshua tree habitat had been lost to renewable energy development. Enacted subsequent to candidacy, 14 C.C.R § 749.10 authorizes the loss of several tens of thousands of additional acres to 15 additional solar projects, primarily in Kern County. And while these projects will contribute to a mitigation fund that will ultimately be used to secure additional lands for protection, there can be no question that substantial amounts of irreplaceable occupied western Joshua tree habitat will be permanently lost.

Aerial imagery showing solar projects and other development fragmenting *Y. brevifolia* habitat.

Loss of habitat to renewable energy is likely to continue. While much of the western Joshua tree habitat lost to renewable energy development to date has been on private land, federal lands are increasingly at threat as well. In December 2020, as part of the COVID relief and omnibus spending bill, Congress passed, and President Trump signed into law, a provision mandating a five-fold increase of renewable energy on public lands with a goal of generating 25 gigawatts by 2025 (Section 3104 of the Consolidated Appropriations Act, 2021). Similarly, on January 13, 2021, the Bureau of Land Management announced proposed changes to the Desert Renewable Energy Conservation Plan that would remove protections from 2.2 million acres of National

Conservation Lands and 1.8 million acres of areas of critical environmental concern (ACECs) in an effort to foster additional renewable energy development.[8] Many of these areas contain intact western Joshua tree woodlands. While a rapid transition to 100% renewable energy is an essential component of western Joshua tree recovery, it cannot be at the expense of losing tens of thousands of additional acres of Joshua tree habitat.

Habitat loss, whether historic, ongoing, or projected represents a significant threat to the continued viability of the western Joshua tree and is a factor dictating that the species be found to warrant listing as threatened. At the same time, it is also the threat that protection under CESA is most likely to ameliorate. CESA listing is both scientifically warranted, and prudent as a matter of good policy.

Conclusion

Thank you for the opportunity to submit comments on the status review that DFW is undertaking regarding the western Joshua tree (*Yucca brevifolia*). We look forward to reading the status review and recommendation. We believe a recommendation for rangewide listing of the species as threatened is warranted based upon the science and the legal standard under CESA. Please do not hesitate to contact me with any questions at the email address listed below.

Sincerely,

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[8] https://www.blm.gov/press-release/bureau-land-management-announces-draft-environmental-impact-statement-desert-plan

References

Abella, S. R., D. M. Gentilcore, and L. P. Chiquoine. 2020. Resilience and alternative stable states after desert wildfires. Ecological Monographs 00(00):e01432. 10.1002/ecm.1432

Barrows, C.W. and M.L. Murphy-Mariscal. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions. Biological Conservation 152:29–36.

[CAT] Climate Action Tracker. 2020. https://climateactiontracker.org/

Cole, K.L., K. Ironside, J. Eischeid, G. Garfin, P.B. Duffy, and C. Toney. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications 21(1):137–149.

Cornett, J.W. 2020. Dynamics of a western Joshua tree (*Yucca brevifolia*) population, Red Rock Canyon State Park, California in Miller, D. M ed. *The 2020 Desert Symposium Field Guide and Proceedings*.

DeFalco, L.A., T.C. Esque, S.J. Scoles-Sciulla, and J. Rodgers. 2010. Desert wildfire and severe drought diminish survivorship of the long-lived Joshua tree (*Yucca brevifolia*; Agavaceae). American Journal of Botany 97(2):243–250.

Gonzalez, P. 2019. Anthropogenic Climate Change in Joshua Tree National Park, California, USA. US National Park Service, Berkeley, CA.

Hopkins, F. (University of California, Riverside). 2018. Inland Deserts Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-008.

Lenz, L.W. 2001. Seed dispersal in *Yucca brevifolia* (Agavaceae) present and past, with consideration of the future of the species. Aliso 20:61–74.

Lenz, L.W. 2007. Reassessment of *Yucca brevifolia* and recognition of *Y. jaegeriana* as a distinct species. Aliso: A Journal of Systematic and Evolutionary Botany 24(1):97–104.

Reynolds, M.B.J., L.A. DeFalco, and T.C. Esque. 2012. Short seed longevity, variable germination conditions and infrequent establishment events provide a narrow window for *Yucca brevifolia* (Agavaceae) recruitment. American Journal of Botany 99(10):1647–1654.

Royer, A.M., M.A. Streisfeld, and C.I. Smith. 2016. Population genomics of divergence within an obligate pollination mutualism: Selection maintains differences between Joshua tree species. American Journal of Botany 03(10):1730–1741.

Royer A.M., Waite-Himmelwright J. and Smith C.I. 2020. Strong Selection Against Early Generation Hybrids in Joshua Tree Hybrid Zone Not Explained by Pollinators Alone. Front. Plant Sci. 11:640. doi: 10.3389/fpls.2020.00640

Sweet, L.C., T. Green, J.G.C. Heintz, N. Frakes, N. Graver, J.S. Rangitsch, J.E. Rodgers, S. Heacox, and C.W. Barrows. 2019. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. Ecosphere 10(6):e02763/ecs2.2763.

[USFWS] U.S. Fish and Wildlife Service. 2018. Joshua Tree Species Status Assessment. Dated July 20, 2018. 113 pp. + Appendices A–C.

[USFWS] U.S. Fish and Wildlife Service. 2019. Endangered and Threatened Wildlife and Plants; 12-Month Findings on Petitions to List Eight Species as Endangered or Threatened Species, 84 Fed. Reg. 41694 (August 15, 2019).

Vander Wall, S.B., T. Esque, D. Haines, M. Garnett, and B. Waitman. 2006. Joshua tree (*Yucca brevifolia*) seeds are dispersed by seed-caching rodents. Ecoscience 13:539–543.

Wallace, G. 2017. WEG 2015 petition to list *Yucca brevifolia*. U.S. Fish and Wildlife Service White Paper, 6 p. Carlsbad, CA

From:	ZIMMERMAN, LARRY P NH-03 USAF AFMC 412 CEG/CEVA
To:	Wildlife Native Plants
Subject:	western Joshua tree Edwards AFB
Date:	Tuesday, October 27, 2020 4:51:07 PM
Attachments:	~~Joshua Tree [redacted] AFB.PDF~~ ~~Joshua Tree [redacted] Fire Area.pdf~~

Warning: This email originated from outside of CDFW and should be treated with extra caution.

Attached are two reports on Joshua tree population status on Edwards Air Force Base.

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January 28, 2021

VIA EMAIL

California Department of Fish and Wildlife
Habitat Conservation Planning Branch
Attn: Native Plant Program
P.O. Box 944209
Sacramento, CA 94244-2090
nativeplants@wildlife.ca.gov

Re: Informational Submittal on the Petition to List the Western Joshua Tree (*Yucca brevifolia*) as Threatened Under the California Endangered Species Act

The County of San Bernardino (County) submits this informational package in response to the notice issued by California Department of Fish and Wildlife (CDFW) pursuant to Fish and Game Code section 2074.4 to solicit data and comments regarding the proposed listing of the western Joshua tree (*Yucca brevifolia*) as a threatened or endangered species under the California Endangered Species Act (Fish & Game Code § 2050 *et seq.*) (CESA).

As a key stakeholder, the County appreciates the opportunity to submit information on this important matter and to work with CDFW as it engages in the status review process. This submittal is divided into three sections: (1) the County's request to participate in the status review process; (2) the submission of data and information regarding the western Joshua tree from County programs; and (3) additional informational resources that CDFW should consider as part of its status review process.

1. Request to Participate in Status Review Process

At little more than 20,000 square miles, San Bernardino County is the largest county in the nation. Nearly 95% of the County is within a desert region. The

Mojave Desert covers a large portion of the central, northern and eastern parts of the County and is nearly the exclusive habitat of the western Joshua tree. Joshua tree woodland (with its alliance species) is widespread and very characteristic of the Mojave Desert. As a result, the County has a long history of land use management, planning and permitting involving the Joshua tree, and has unique insight on the species' range and abundancy, needs and challenges not possessed by other jurisdictions or entities.

Given that the western Joshua tree habitat largely falls within its borders and that the County has an established role in managing and protecting the species, the County is a key stakeholder and serves as an important informational resource for CDFW in its review process. Specifically, the County seeks to participate or contribute in the following ways:

- To provide CDFW with recommendations for experts to consider for the peer review panel.
- To be given the opportunity to review a draft of the status report to provide comments or feedback based on the County's experience in desert land management, mining reclamation and landscape rehabilitation, and regional planning.
- To submit independent scientific data or reports, under 14 CCR § 670.1(h), in a timely manner to assist CDFW.
- To engage with CDFW and other stakeholders in developing alternative, non-regulatory approaches for managing and protecting the western Joshua tree.

The County will be contacting CDFW staff on how best to engage in each of these and other efforts.

With respect to the last bullet point, the County recognizes the importance in preserving the western Joshua tree, given its vital role as a keystone species and as an emblem for promoting the region's unique desert culture and tourism. Although the County remains strongly opposed to listing the western Joshua tree under CESA, the County is supportive of non-regulatory activities to promote greater collaboration among agencies, and to further research and methods for improving natural recruitment of the western Joshua tree. Regional planning efforts, such as the ongoing Regional Conservation Investment

Strategy (RCIS) program, are better-suited for addressing multi-species impacts such as climate change. The County hopes CDFW will treat the County as a partner in investigating and collaborating on management tools as an alternative to listing and to better protect the western Joshua tree and the region.

2. Data and Information from the County's Programs

As noted above, the County has a long history of being at the forefront of enforcing robust conservation measures at the local level and across industry sectors to protect the western Joshua tree through a variety of local regulatory programs and participation in regional planning efforts. To assist CDFW in its status review, the County has compiled information from these programs in the enclosed "Report on Local Oversight, Management and Planning Programs Involving the Western Joshua Tree." This Report, specially prepared for CDFW, also includes contact information, both within the County and other agencies and entities, for CDFW to use to solicit further information and guidance.

3. Other Informational Resources

The status review of the western Joshua tree is fundamentally different from the process conducted for other candidate species. As CDFW has acknowledged,[1] the population of the western Joshua tree is abundant. Indeed, anyone who lives within, or is otherwise familiar with, the western Joshua tree range can attest to its ubiquity. Thus, CDFW's review must assess the likelihood that a commonplace species, one that is found in many yards and streets, is threatened with extinction absent the special protection and management tools of CESA.[2]

In evaluating whether such a threat exists, the County urges CDFW to carefully review the available data and literature, as well as the limitations and scope of the CESA. CDFW should look for guidance and support from its sister agency, United States Fish and Wildlife Service (USFWS), which engaged in a similar review of the species under the federal Endangered Species Act and ultimately determined that listing was not warranted. To assist CDFW, the County has compiled the enclosed chart of informational resources on the western Joshua

[1] California Department of Fish and Wildlife, Evaluation of a Petition from the Center for Biological Diversity to List Western Joshua Tree (*Yucca Brevifolia*) as Threatened under the California Endangered Species Act, February 2020 (CDFW Report), p. 2; *see also id.,* pp. 13-14.
[2] Fish & Game Code § 2067.

tree, which includes information from USFWS and the National Park Service (NPS).

USFWS carefully assessed the best scientific and commercial information available on the past, present and future threats to the western Joshua tree, and evaluated the potential stressors to the species, including climate change and other factors being considered by CDFW, to conclude that western Joshua tree was not in danger of becoming extinct within the foreseeable future. The 2018 study published by USFWS,[3] provides that threats to individual Joshua trees are not likely influencing population resiliency on a population or species scale since there is no evidence to indicate any recent population size reductions or range contractions over the past 40 years, based on distribution mapping and limited demographic studies that indicate recruitment is occurring. USFWS further concluded that most of habitat of the western Joshua tree is federally managed by NPS and other federal agencies, and that further protections under the federal Endangered Species Act were not warranted. The County encourages CDFW to not only include these materials in its literature review, but contact and coordinate directly with USFWS and NPS during the preparation of the status report.

The County has also enclosed two technical memoranda from Heritage Environmental Consultants, which provide a peer review of the Petition and the scientific basis for listing the western Joshua tree as threatened under the CESA. As explained in these technical memoranda, with respect to the degree and immediacy of the threat to the western Joshua tree, the Petition relied heavily on the contention that extirpation of the western Joshua tree is a foregone conclusion due to the predicted effects of climate change. The Petition cites certain studies to support the assertion that climate change will cause the extirpation of the western Joshua tree from California by the end of the 21st century. However, other studies have predicted growth and expansion of the range of the western Joshua tree as a result of a warming climate,[4] while others have predicted a more modest contraction of the tree's range.[5] This range of outcomes is highly inexact, and this uncertainty increases as projections extend deeper into the 21st century. This is not the standard under

[3] U.S. Fish and Wildlife Service. 2018. Joshua Tree Species Status Assessment. Dated July 20, 2018. 113 pp. + Appendices A–C (USFWS Assessment).
[4] Petition, p. 38; *see also* Steven R. Archer and Katharine I. Predick, Climate Change and Ecosystems of the Southwestern United States, Rangelands 30(3): 23-38 (June 2008).
[5] *See, e.g.,* Cameron W. Barrows, Michelle L. Murphy-Mariscal, Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions, Biological Conservation 152: 29-36 (2012).

CESA, which requires a documented immediacy of the threat to the species. As noted in the August 2020 Technical Memorandum, there is also no evidence that this global concern would be unique to the western Joshua tree, would directly affect the tree's migration and other resiliency factors, and would be redressed through specific management to address climate change impacts to the trees. Given the overall abundance of western Joshua tree in comparison to historical trends, and the highly uncertain outcome of current climate modeling, listing the western Joshua tree as a threatened species would not be supported by the best available science as required by CESA.[6]

The County does not dispute that climate change may affect the ability of many plant species, including California desert species like the western Joshua tree, to adapt and survive. However, climate change is a global condition not shown to have unique impacts on the western Joshua tree or can be redressed through CESA mitigation and management actions. As noted in the technical memoranda and the County's Report, other planning mechanisms, including RCIS, *are* designed to address multi-species threats and focus investment and funding for climate change adaptation and other integrated management tools. Protections focused only on western Joshua tree conservation may actually discourage sustainable development projects, such as utility-scale solar or other renewable energy facilities, undermining California's ability to achieve renewable energy goals designed to reduce emissions contributing to climate change. It would be irresponsible to elevate the western Joshua tree for special protection while ignoring the greater threat and these regional planning needs and statewide objectives.

* * * * * * *

In closing, it remains the County's position that listing the western Joshua tree under CESA would do little to address any long-term threat to the species and is not warranted under the law or science. Listing under CESA would not result in the reduction of greenhouse gas emissions or other means of minimizing additional global warming. The County believes it is in the best interest of all stakeholders for the parties to work collaboratively on other methods that would protect the western Joshua tree and manage them responsibly in light of the

[6] Fish & Game Code § 2070.

global climate change threat, balancing the goals of conservation and the need for economic wellbeing in these challenging times.

The County thanks the Department for the opportunity to submit this information and looks forward to working in partnership on this important issue. If you have any questions regarding this submission, please contact me at 415-808-2075, or at sdiveley@meyersnave.com.

Sincerely yours,

Shaye Diveley
Special Counsel
County of San Bernardino

c: Charlton Bonham, Director, California Department of Fish and Wildlife

Enclosures:

1. County of San Bernardino, Report on Local Oversight, Management and Planning Programs Involving the Western Joshua Tree, January 2021

2. County of San Bernardino, Chart of Informational Resources, CDFW Status Review – Western Joshua Tree, January 2021

3. Heritage Environmental Consultants, Technical Memorandum on Review of scientific basis for listing the western Joshua tree as threatened under the California Endangered Species Act, dated August 5, 2020

4. Heritage Environmental Consultants, Technical Memorandum on Scientific basis for listing the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act, June 10, 2020

3666910.3

County of San Bernardino

Report on Local Oversight, Management and Planning Programs Involving the Western Joshua Tree

January 2021

I. INTRODUCTION

The County of San Bernardino ("County") has prepared this Report on Local Oversight, Management and Planning Programs Involving the Western Joshua Tree ("Report") to provide the California Department of Fish and Wildlife ("CDFW") with information and data regarding trends, the adequacy of existing management, management recommendations, or other factors related to the status of the western Joshua tree. This Report is based on information from the County's local programs and planning activities, and includes the following information:

- Summary of the County's regulatory regime designed specifically to protect the Joshua tree under the California Desert Native Plants Act.
- A compilation of the County's success stories in facilitating projects that protect and enhance the western Joshua tree under other state and local programs, including examples of successful relocations and nursery operations through coordination with sister agencies.
- Summary of existing regional planning efforts that protect and enhance the species, including the County's groundbreaking Regional Conservation Investment Strategy ("RCIS") in conjunction with CDFW.

As discussed in this Report, the County has a long history of stewardship and management of the western Joshua tree, under its mining, desert plant and other regulatory programs. Given this history, the County can serve as an important informational resource for CDFW in its review process, and the County welcomes and encourages CDFW to reach out with questions and requests. This Report identifies specific contacts, at the County and other entities, for CDFW to obtain further information.

II. EXISTING JOSHUA TREE MANAGEMENT AND REGULATORY PROGRAMS

The Joshua tree[1] is subject to several special protection and management efforts pursuant to federal, state and local law, regulation and policy. To get a better idea of the scope of these laws and programs, it is important to set the geographical and jurisdictional framework for the area.

At little more than 20,000 square miles, San Bernardino County is the largest county in the nation, with four geographical subregions—the Valley, Mountain, North Desert, and East Desert. The Mojave Desert covers a large portion of the central, northern and eastern parts of the County. However, only approximately 12 percent of the Desert Region is under County jurisdiction, with the remainder under either tribal, local cities and towns, or federal jurisdiction, including National Park Service ("NPS"), U.S. Bureau of Land Management, and Department of Defense.[2] Indeed, much of the western Joshua tree's distribution is on federal land, primarily within the Mojave Desert.[3]

A. Federal and State Programs

Enacted by Congress in 1994, the California Desert Protection Act ("CDPA") established the Death Valley and Joshua Tree National Parks, and the Mojave national preserve.[4] Pursuant to CDPA, the NPS manages 189 square miles of Joshua Tree National Park within the Desert Region of the County. The NPS also manages the Mojave National Preserve, encompassing 1.4 million acres in the heart of the Mojave Desert and the third largest national park system in the contiguous United States. The preserve is primarily composed of Joshua tree forest and dunes, and features an abundance of wildlife such as desert bighorn sheep, mule deer, coyotes, and desert tortoises.[5]

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[1] The County regulates the Joshua tree as a single species and makes no regulatory distinction between *Y. brevifolia* (the western Joshua tree) and *Y. jaegeriana* (the eastern Joshua tree). All references to the Joshua tree include both species.
[2] County of San Bernardino, June 2019, Draft Environmental Impact Report for San Bernardino Countywide Plan, State Clearinghouse No. 2017101033 (available at http://countywideplan.com/eir/).
[3] U. S. Fish and Wildlife Service. 2018. Joshua tree species status assessment. July 20, 2018
[4] Pub. L. No. 103-433, 108 Stat. 4471 (1994).
[5] Note 2, supra.

Through the CDPA, Congress declared its policy that public lands in California desert be included in the national park and national wilderness preservation systems in order to perpetuate the diverse ecosystem of the California desert in its natural state. The CDPA withdrew designated areas from "all forms of entry, appropriation, or disposal under the public land laws" and effectively functions to preserve and protect the very habitat necessary for the Joshua tree's survival. 16 U.S.C. §§ 410aaa-42, 410aaa-47. Indeed, 96 percent of the western Joshua tree population in the northern part of its range occurs on federal land protected under the CDPA and ten percent of the species occurring in the northern part of its range occurs on NPS land.[6] The California Endangered Species Act ("CESA") has no legal standing with respect to federal agencies' management of these lands. Accordingly, the County encourages CDFW to take into consideration the wide-spread protections afforded by CDPA and contact the NPS regarding its existing management efforts.

At the state and local level, numerous laws and ordinances also serve to provide significant additional protection for the western Joshua tree. For example, under the California Desert Native Plant Acts ("CDNPA") the western Joshua tree may not be harvested without a permit in Imperial, Inyo, Kern, Los Angeles, Mono, Riverside, San Bernardino, and San Diego counties.[7] Local jurisdictions have adopted measures similar to those set forth in CDNPA, including specific prohibitions on removing Joshua trees. For example, the County has a comprehensive regulatory program designed to protect and preserve the western Joshua tree, the Plant Protection and Management Ordinance (Ordinance) discussed in greater detail below.[8] The County asks that CDFW take into consideration state and local laws mentioned above and herein, including the County's existing Joshua tree management efforts and regulatory program. A copy of the County's Plant Protection and Management Ordinance can be accessed utilizing the link below.[9]

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[6] U. S. Fish and Wildlife Service. 2018. Joshua tree species status assessment. July 20, 2018
[7] Food & Agr. Code §§ 80073(a), 80003.
[8] San Bernardino County Code ("SBCC") §§ 88.01.010 – 88.01.090
[9] https://codelibrary.amlegal.com/codes/sanbernardino/latest/overview

Should the Department have any questions related to the County's Plant Protection and Management Ordinance or other existing management efforts, the County asks that you contact the following county representatives:

Terri Rahhal, AICP
Director of Land Use Services
(909) 387-4431
Terri.Rahhal@lus.sbcounty.gov

George Kenline, Pg CHg CEG
Environmental Compliance Manager
Land Use Services Department
(909) 387-0145
George.Kenline@lus.sbcounty.gov

B. Local Codified Regulations

As noted above, the County's regulatory program is rooted in a stringent set of codified regulations adopted under the California Native Desert Plants Act, which are reinforced by a dedicated culture of mitigation, monitoring, and enforcement.

1. Overview

The County's Plant Protection and Management Ordinance provides for the management of native tree and plant resources in the unincorporated areas of the County on property under private and public ownership. SBCC § 88.01.010. The expressed intent of the Ordinance includes, but is not limited to, "[p]romot[ing] and sustain[ing] the health, vigor and productivity of [the Joshua tree] and aesthetic values within the County through appropriate management techniques" and "[c]onserv[ing] the [Joshua tree] heritage for the benefit of all, including future generations." *Id.* § 88.01.010(a) and (b).

With a county the size of 20,105 square miles,[10] the Ordinance contains a comprehensive set of regulations for a wide range of diverse species within three

[10] "2010 Census Gazetteer files." United States Census Bureau. August 22, 2012.

unique regions of the County (i.e., Desert, Mountain, and Valley Regions). Of the many regulated species, the Joshua tree is identified as a regulated desert native plant and thus the subject of many protections. SBCC § 88.01.060(c)(4). As with an incidental take permit issued pursuant to the CESA, the indiscriminate removal of a Joshua tree is prohibited by the Ordinance without first obtaining a tree removal permit ("Permit") unless an exception applies. *Id.* §§ 88.01.040(b) and 88.01.060(c).

An application for a Permit can be submitted in conjunction with a development application, a stand-alone permit, or when required for mitigating fire hazards. SBCC § 88.01.050(a). Before a Permit is issued, however, an applicant must demonstrate to the satisfaction of the County that the removal is necessary based on one of the following reasons:

(A) The location of the regulated tree or plant and/or its dripline interferes with an allowed structure, sewage disposal area, paved area, or other improvement or ground disturbing activity and *there is no other alternative feasible location for the improvement*.

(B) The location of the regulated tree or plant and/or its dripline interferes with the planned improvement of a street or development of an approved access to the subject or adjoining private property and *there is no other alternative feasible location for the improvement*.

(C) The location of the regulated tree or plant is hazardous to pedestrian or vehicular travel or safety.

(D) The regulated tree or plant or its presence interferes with or is causing extensive damage to utility services or facilities, roadways, sidewalks, curbs, gutters, pavement sewer line(s), drainage or flood control improvements, foundations, existing structures, or municipal improvements.

(E) The condition or location of the regulated tree or plant is adjacent to and in such close proximity to an existing or proposed structure that the regulated tree or plant has or will sustain significant damage. SBCC § 88.01.050(f)(1)(A)-(E) (emphasis added).

In addition to one of the justifications above, the Ordinance requires the following additional unique findings before authorizing the removal of a Joshua tree:

(A) Joshua trees that are proposed to be removed will be transplanted or stockpiled for future transplanting wherever possible.
(B) In the instance of stockpiling, the permittee has complied with Department policy to ensure that Joshua trees are transplanted appropriately. Transplanting shall comply with the provisions of the Desert Native Plants Act (Food and Agricultural Code Section 80001 et seq.), as required by Subsection 88.01.060(d) (Compliance with Desert Native Plants Act).
(C) No other reasonable alternative exists for the development of the land when the removal of specimen size Joshua trees is requested. Specimen size trees are defined as meeting with one or more of the following criteria:
    (I) A circumference measurement equal to or greater than 50 inches measured at 4.5 feet above natural grade level.
    (II) Total tree height of 15 feet or greater
    (III) Trees possessing a bark-like trunk.
    (IV) A cluster of 10 or more individual trees, of any size, growing in close proximity to each other." SBCC § 88.01.050(f)(3).

The findings and requirements above ensure the project or activity for which a Permit is sought considers feasible alternative designs to avoid indiscriminate take of a Joshua tree and, where unfeasible, requires transplantation or stockpiling when possible.

If a Permit is warranted, the County is authorized to impose conditions of approval specifying additional criteria, methods, and/or persons authorized to conduct the proposed activity not otherwise required by the Ordinance; require transplanting or stockpiling; the posting and maintenance of a monetary security deposit to ensure the completion of the required conditions; and perform other mitigation measures as may be required. SBCC § 88.01.050(e). This broad discretionary authority allows the County to minimize, and in some cases fully mitigate, the impacts of the proposed activity on the Joshua tree. The requirements of the County's regulatory program therefore minimize the impact to the Joshua tree and reinforce the County's continued management efforts to promote and sustain the future health, vigor, and productivity of the Joshua tree for years-to-come.

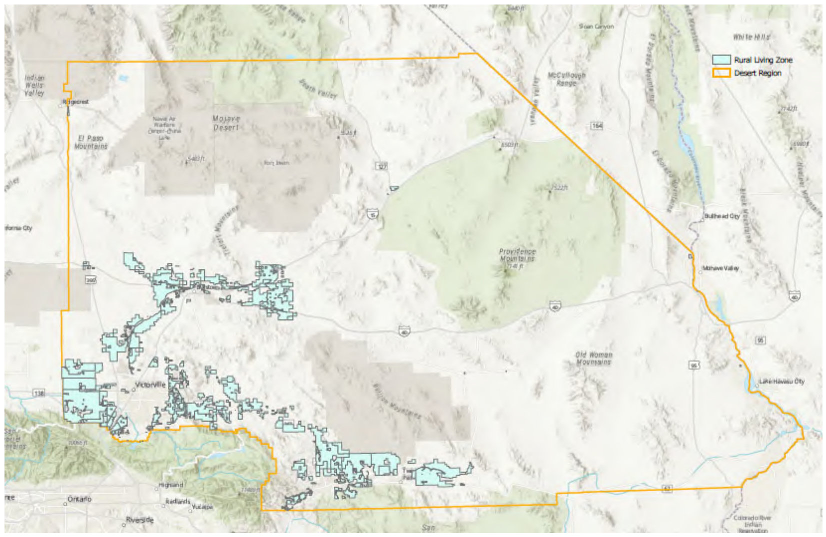
2. Exemptions

Although critics of the County's local regulatory program will assert the allowance of any type of exemption hinders the County's ability to protect the Joshua tree, as explained below, the exemptions included in the Ordinance are of limited applicability to the Joshua tree. SBCC § 88.01.030. The most common exemption utilized in the Ordinance is an authorized removal associated with the development of a primary structure (excluding a sign structure) on a parcel with a net area of 20,000 square feet or less. *Id.* § 88.01.030(j). This exception is typically used in conjunction with the construction of a single-family home within a residential zoning district.

Within the County's Desert Region there are three residential zoning districts: Single Residential (RS) with 33,176 acres; Multiple-Residential (RM) with 2,165 acres; and Rural Living (RL) with 610,297 acres. The RL Land Use Zoning District for the 610,297 acres in the Desert Region requires a minimum lot area of 2.5-acres for each parcel. SBCC § 82.04.050. Accordingly, a majority of property owners within the Desert Region will not qualify for this exemption since the net area of a 2.5-acre minimum lot in the RL Land Use Zoning District exceeds 20,000 square feet[11] and allows ample area for avoidance of protected plants in the placement of a single-family dwelling. Figure 1, below, depicts the land area of the RL zones within the Desert Region.

[11] The 20,000 square feet is net area requirement roughly equivalent to ½ -acre on a gross basis, which is one-fifth the size of the minimum lot size for a parcel located within a Rural Living Land Use Zoning District.

<u>Figure 1</u>



Thus, while a critic might claim the exemptions within the Ordinance defeat the County's management efforts in protecting the Joshua tree, the reality is that very little exempt activity is applicable to this species.

3. Enforcement

The County's Ordinance and management efforts for the Joshua tree are reinforced through a dedicated enforcement program. SBCC § 88.01.050(i). Any violation of the Ordinance is considered a misdemeanor offense, with the removal of each Joshua tree being considered a new and separate offense. *Id.* § 88.01.050(j). The penalty for each offense is a fine of not less than $500.00 nor more than $1,000.00, or six months in jail, or both. *Ibid*.

Payment of a penalty does not relieve an offending party from the responsibility of correcting the unauthorized removal or destruction of a Joshua tree or its habitat. The offending party must also retain, as appropriate, a desert native plant expert to develop and implement a replacement program for each Joshua tree improperly removed. SBCC § 88.01.050(j)(2). To ensure replacement, the offending party must post a bond in the amount sufficient to remove and reinstall the Joshua tree in the event the replacement fails within two years. *Ibid*.

III. JOSHUA TREE MANAGEMENT EFFORTS UNDER OTHER PROGRAMS

An additional set of local regulatory programs provide added protection for the Joshua tree from projects common to the Desert Region of the County. For example, renewable energy generation facilities, like wind and solar, and surface mining projects, are subject to decommissioning requirements that require the submission of a closure, revegetation, and rehabilitation plan designed to restore the impacted property to its pre-construction state. SBCC §§ 84.29.070(a) and 88.03.090. Restoration of vegetation and wildlife habitat is required for disturbed lands to a condition at least as good as the pre-disturbed condition for renewable energy projects and surface mining operations in accordance with the Surface Mining and Reclamation Act of 1975 ("SMARA").[12] SBCC § 88.03.090. If avoidance cannot be achieved through feasible alternatives, mitigations are often proposed in general conformance with the provisions of CESA, F&G Code section 2050 et seq., and the federal Endangered Species Act of 1973, 16 U.S.C. section 1531 et seq.

In addition, financial assurances in connection with renewable energy generation facilities and surface mining operations ensure that decommissioning and reclamation can be carried out by the individual or entity, in accordance with the provisions of an approved restoration or reclamation plan. Added measures of assurance include increasing the financial assurances to cover the cost to replace unsuccessful transplants with seedlings and/or nursery stock when identified during inspections.

Provided below are some of the many different examples[13] evidencing the County's management efforts in conjunction with sister-state agencies and pursuant to state and local law. These represent success stories on how coordination and holistic management of the species at the critical stages of projects can enhance and protect the Joshua tree.

[12] Public Resources Code Section 2710 *et seq*.
[13] The County does not intend the cited examples to be exhaustive and reserves the right to present additional examples and data.

Figure 2, below, depicts an example of empirical restoration of the Joshua tree that is occurring within the historic Nett Hill Quarry as part of the Furnace Canyon Quarry permit.

Figure 2

The Furnace Canyon Quarry permit was conditioned to reclaim the abandoned Nett Hill quarry with soil islands and Joshua trees. The County recognizes that reclamation of abandoned mines can be addressed with current permits, despite the SMARA legislation that exempts such requirement after 1976.

Figures 3 through 6 are another example of a County mine permit for an overburden dump expansion in which the County required the operator to implement a pinyon-juniper woodland seed collection and propagation program and the transplantation of Joshua trees. Figure 3 shows the restoration of vegetation and establishment of the Joshua trees.

Figure 3

In 2012, an inspection of the mine revealed successful re-establishment of Joshua trees within the extremely irregular terrain as depicted in Figure 4.

Figure 4

More Joshua trees successfully re-established at the toe of the overburden dump are shown in Figure 5.

Figure 5

As of December 11, 2019, the same mine is depicted below with a thriving Joshua tree nursery established for future reclamation as shown in Figure 6.

Figure 6

The photograph in Figure 7 depicts Joshua tree seedlings within a County-approved nursery and revegetation research program. Approved nursery programs are part of mine permit approvals involving Joshua trees along the north slope of the San Bernardino Mountains. The native plant stock nurseries provide for reliable propagation and increase the number of re-establishment of Joshua trees and related endemic plants during required reclamation. The methodology for germination in a controlled environment also ensures protection from harvesting rodents and other opportunistic wildlife. When revegetating quarry benches, often, the young trees are caged until they reach maturity to minimize trampling by big horn sheep.

Figure 7

The photograph in Figure 8 depicts another mine site with a barrier/top soil berm along the east side of a borrow pit. The berm provides for a protected nursery of transplanted Joshua trees and Yucca (est. 60-70 Joshua trees). The financial assurances have also been secured with $300,000 designated for protection and/or nursery replacement of these trees until final reclamation.

Figure 8

The above examples are just a few of the many efforts taken by the County to support its countywide vision to develop habitat preservation and conservation strategies that further protect and preserve the Joshua tree and other native plant species. The County encourages CDFW to take into consideration regulations of sister-agencies and laws, such as SMARA, as part of its evaluation of existing management efforts for the Joshua tree. Should you have any questions regarding these programs, we recommend CDFW contact the following individuals:

George Kenline, Pg CHg CEG
Environmental Compliance Manager
Land Use Services Department
(909) 387-0145
George.Kenline@lus.sbcounty.gov

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Another program that warrants consideration is the body of policy governing siting and development of renewable energy generation projects; primarily solar energy generation. The expansive open space and favorable climate of the Mojave desert make San Bernardino County very attractive to developers of solar energy. In response to this development interest, the County Board of Supervisors adopted a new Renewable Energy and Conservation Element (RECE) as an amendment to its General Plan.[14] The RECE policies and County development standards for solar energy reflect the same environmental values and stewardship that are evident in the County mining and reclamation program. This includes requiring decommissioning plans with financial assurances to guarantee restoration of the site, very similar to the requirements of SMARA. Unlike mineral resource extraction that must be located where the resource occurs, there is a degree of flexibility in siting solar energy power generation. This allows for avoidance of impacts to sensitive habitat, which is a very high priority for the County.

Siting criteria for utility-scale solar energy generation, as detailed in RECE Policy 5.2, direct these projects to previously disturbed sites, with a preference for sites with existing transmission infrastructure. A good example of this policy in application is the recent approval of the 650 MW Daggett Solar project, which will completely replace a gas-fired power plant on agricultural fields surrounding the plant. Not a single Joshua tree nor any other native plant will be affected by development of this project. Prior to adoption of the RECE, solar energy development was extremely controversial in San Bernardino County, and project proposals sprang up in many undisturbed areas. Residents of the County insisted on development policies that would respect and conserve the desert environment, and the County Board of Supervisors responded with the RECE. For more

[14] http://www.sbcounty.gov/uploads/LUS/Renewable/2019_WEBSITE/REC%20Element.pdf

information about County renewable energy policies, we recommend CDFW contact the following individuals:

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IV. REGIONAL PLANNING EFFORTS AND MANAGEMENT RECOMMENDATION

On October 4, 2016, the San Bernardino County Board of Supervisors passed Resolution No. 2016-189 authorizing the County, in collaboration with San Bernardino Associated Governments (now San Bernardino Council of Governments) and Southern California Association of Governments, to pursue the establishment of the San Bernardino County Regional Conservation Investment Strategy ("SBC RCIS") under the authority established by Assembly Bill 2087.[15] The RCIS program is promoted on CDFW's web site[16] as follows: "Program Overview: The new Program encourages a voluntary, non-regulatory regional planning process intended to result in higher-quality conservation outcomes and includes an advance mitigation tool. The Program uses a science-based approach to identify conservation and enhancement opportunities that, if implemented, will help California's declining and vulnerable species by protecting, creating, restoring, and reconnecting habitat and may contribute to a species recovery and adaptation to climate change and resiliency."

With the encouragement and support of CDFW, the County and its partners have opted to pursue "higher quality conservation outcomes" through the SBC

[15] Fish and Game Code §§ 2087, *et seq*.
[16] https://wildlife.ca.gov/Conservation/Planning/Regional-Conservation

RCIS. Habitat conservation and species adaptation in response to climate change must be addressed on a landscape level. The RCIS program is ideally suited to address challenges faced by the western Joshua tree, along with many other associated focal species of transitional scrub, chaparral and woodland habitats in the western Mojave Desert. Conservation strategies for habitat connectivity, adaptation to climate change and resiliency of multiple species form the core of the SBC RCIS. An individual species listing under CESA, on the other hand, is designed to preserve an individual species facing imminent decline or extinction. That is clearly not the case for the western Joshua tree, which is abundant by all accounts. The California Native Plant Society considered the western Joshua tree for inclusion in its rare plants database, but ranked the species "CBR" (considered but rejected) with the added note that the species was "too common" to be included in its inventory of over 2,000 rare plant species.[17]

A draft of the SBC RCIS was released in December of 2018. Although not yet finalized and approved by CDFW, SBC RCIS has established a framework for landscape level habitat conservation strategies, including western Joshua tree as a Focal Species. Many local agencies and individuals have contributed to the SBC RCIS, which began as a habitat conservation planning gap analysis conducted by the Environmental Element Group (EEG) associated with the Countywide Vision. Many stakeholders are committed to the SBC RCIS. The volunteer EEG membership guided preparation of the Draft SBC RCIS and was successful in obtaining a grant of $562,210.00 from the State Wildlife Conservation Board (WCB) to complete a final RCIS.

The SBC RCIS stakeholders have common goals of implementing conservation strategies that maximize benefits of habitat conservation and enhancement activities informed by science and on-going research. For example, the SBC RCIS will likely include practical, community-based conservation strategies that will complement the Joshua Tree Genome Project.[18] As the Joshua Tree Genome Project identifies science-based opportunities to enhance climate resiliency of the western Joshua tree, the SBC RCIS will be able to incorporate the

[17] California Native Plant Society, Rare Plant Program. 2021. Inventory of Rare and Endangered Plants of California (online edition, v8-03 0.39). Website http://www.rareplants.cnps.org [accessed 05 January 2021].
[18] https://joshuatreegenome.org/

Project findings in strategies that will benefit the species and provide a broader lift in conservation value to associated desert habitats. Potential strategies such as seed collection, propagation, planting of climate-hardy seedlings and adoption programs for specimens in need of care would engage the community in conservation. Unfortunately, these activities would conflict with CESA protection.

The County asks that CDFW take into consideration the data, goals and conservation priorities of the draft SBC RCIS in its assessment of the western Joshua tree. In fact, we request that CDFW focus its limited resources on continued collaboration with the SBC RCIS partners on 21st century habitat strategies that will benefit not only the western Joshua tree but many other species. A copy of the draft SBC RCIS can be accessed utilizing the link below.[19]

Should the Department have questions related to the SBC RCIS, we ask that you contact the following representatives:

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[19] https://www.gosbcta.com/wp-content/uploads/2019/08/SBC_RCIS_Draft_December_018.pdf

Chart of Informational Resources
CDFW Status Review – Western Joshua Tree
Submitted by County of San Bernardino - January 2021

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Abatzoglou, J.T. and C.A. Kolden. 2011. Climate change in western US deserts: potential for increased wildfire and invasive annual grasses. Rangeland Ecology & Management, 64(5), 471–478.	Abatzoglou, J.T. and C.A. Kolden.	Climate change in western US deserts: potential for increased wildfire and invasive annual grasses.	Rangeland Ecology & Management, 64(5), 471–478. (2011)
Abella, S. 2010. Disturbance and Plant Succession in the Mojave and Sonoran Deserts of the American Southwest. International Journal of Environmental Research and Public Health, 7:1248–1284.	Abella, S.	Disturbance and Plant Succession in the Mojave and Sonoran Deserts of the American Southwest	International Journal of Environmental Research and Public Health, 7:1248–1284 [2010].
Abella, S.R., E.C. Engel, C.L. Lund, and J.E. Spencer. 2009. Early post-fire plant establishment on a Mojave Desert burn. Madroño 56:137–148.	Abella, S.R., E.C. Engel, C.L. Lund, and J.E. Spencer.	Early post-fire plant establishment on a Mojave Desert burn.	Madroño 56:137–148. (2009)
Agri Chemical and Supply, Inc. 2008. Vegetation of Twentynine Palms, CA. Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019.	Agri Chemical and Supply, Inc.	Vegetation of Twentynine Palms, CA	Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019. (2008)
Alexander, R.R, F.W. Pond, and J.E. Rodgers. 2008. Yucca L. In Bonner, F.T. and R.P. Karrfalt, (Eds.), The Woody Plant Seed Manual. Agric. Handbook No. 727. Washington, DC. U.S. Department of Agriculture, Forest Service. 1223 pp.	Alexander, R.R, F.W. Pond, and J.E. Rodgers.	Yucca L.	In Bonner, F.T. and R.P. Karrfalt, (Eds.), The Woody Plant Seed Manual. Agric. Handbook No. 727. Washington, DC. U.S. Department of Agriculture, Forest Service. 1223 pp. (2008)
Allen, E B. and L.H. Geiser. 2011. North American deserts. In L.H. Pardo, M.J. Robin-Abbott, and C T. Driscoll (Eds.). Assessment of Nitrogen Deposition Effects and Empirical Critical Loads of Nitrogen for Ecoregions of the United States (pp. 133–142): General Technical Report NRS-80.	Allen, E B. and L.H. Geiser.	North American deserts.	In L.H. Pardo, M.J. Robin-Abbott, and C T. Driscoll (Eds.). Assessment of Nitrogen Deposition Effects and Empirical Critical Loads of Nitrogen for Ecoregions of the United States (pp. 133–142): General Technical Report NRS-80. (2011)
Allen, E.B., L.E. Rao, R.J. Steers, A. Bytnerowicz, and M.E. Fenn. 2009. Impacts of atmospheric nitrogen deposition on vegetation and soils at Joshua Tree National Park. In R.H. Webb, L.F. Fenstermaker, J.S. Heaton, D.L. Hughson, E.V. McDonald, and D.M. Miller (eds.). The Mojave Desert: Ecosystem Processes and Sustainability (pp. 78–100). Las Vegas, NV: University of Nevada Press.	Allen, E.B., L.E. Rao, R.J. Steers, A. Bytnerowicz, and M.E. Fenn.	Impacts of atmospheric nitrogen deposition on vegetation and soils at Joshua Tree National Park.	In R.H. Webb, L.F. Fenstermaker, J.S. Heaton, D.L. Hughson, E.V. McDonald, and D.M. Miller (eds.). The Mojave Desert: Ecosystem Processes and Sustainability (pp. 78–100). Las Vegas, NV: University of Nevada Press. (2009)
Althoff, D.M., K.A. Segraves, and J.P. Sparks. 2004. Characterizing the interaction between the bogus yucca moths and yuccas: do bogus yucca moths impact yucca reproductive success? Oecologia 140:321–327.	Althoff, D.M., K.A. Segraves, and J.P. Sparks.	Characterizing the interaction between the bogus yucca moths and yuccas: do bogus yucca moths impact yucca reproductive success?	Oecologia 140:321–327. (2004)
Angiosperm Phylogeny Group. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181:1–20.	Angiosperm Phylogeny Group.	An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV.	Botanical Journal of the Linnean Society 181:1–20. (2016)
Archer, S.R., and K.I. Predick. 2008. Climate change and ecosystems of the southwestern United States. Rangelands, 30(3):23–28.	Archer, S.R., and K.I. Predick.	Climate change and ecosystems of the southwestern United States.	Rangelands, 30(3):23–28. (2008)
Arizona Department of Agriculture. 2015. Protected native plants by categories. Online at: https://agriculture.az.gov/protected-native-plants-categories [June 29, 2015]	Arizona Department of Agriculture.	Protected native plants by categories.	[ADOA] Arizona Department of Agriculture. (2015). Online at: https://agriculture.az.gov/protected-native-plants-categories [June 29, 2015]
Arizona Game and Fish Department. 2015. Status definitions. Online at: http://www.azgfd.gov/w_c/edits/hdms_status_definitions.shtml [June 29, 2015].	Arizona Game and Fish Department.	Status definitions.	Online at: http://www.azgfd.gov/w_c/edits/hdms_status_definitions.shtml [June 29, 2015].
Barrows, C. 2018. Peer review comments on the draft Joshua Tree Species Status Assessment. Received May 31, 2018.	Barrows, C.	Peer review comments on the draft Joshua Tree Species Status Assessment	Personal communications. 2018. Received May 31, 2018.
Barrows, C.W. and M.L. Murphy-Mariscal. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions. Biological Conservation 152:29–36.	Barrows, C.W. and M.L. Murphy-Mariscal.	Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions.	Biological Conservation 152:29–36. (2012)
Borchert, M.I. and L.A. DeFalco. 2016. Yucca brevifolia fruit production, predispersal seed predation, and fruit removal by rodents during two years of contrasting reproduction. American Journal of Botany 103:830–836.	Borchert, M.I. and L.A. DeFalco.	Yucca brevifolia fruit production, predispersal seed predation, and fruit removal by rodents during two years of contrasting reproduction.	American Journal of Botany 103:830–836. (2016)
Brittingham, S. and L.R. Walker. 2000. Facilitation of Yucca brevifolia recruitment by Mojave Desert shrubs. Western North American Naturalist 60:374–383.	Brittingham, S. and L.R. Walker.	Facilitation of Yucca brevifolia recruitment by Mojave Desert shrubs.	Western North American Naturalist 60:374–383. (2000)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Brooks, M.L. 2003. Effects of increased soil nitrogen on the dominance of annual plants in the Mojave Desert. Journal of Applied Ecology 40:344–353.	Brooks, M.L	Effects of increased soil nitrogen on the dominance of annual plants in the Mojave Desert.	Journal of Applied Ecology 40:344–353. (2003)
Brooks, M.L. and J.R. Matchett. 2006. Spatial and temporal patterns of wildfires in the Mojave Desert, 1980-2004. Journal of Arid Environments 67:148–164.	Brooks, M.L. and J.R. Matchett.	Spatial and temporal patterns of wildfires in the Mojave Desert, 1980-2004	Journal of Arid Environments 67:148–164. (2006)
Brooks, M.L. and K.H. Berry. 2006. Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA. Journal of Arid Environments 67:100–124.	Brooks, M.L. and K.H. Berry.	Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA.	Journal of Arid Environments 67:100–124. (2006)
Brooks, M.L., R.A. Minnich, J. Matchett. 2018. Southeastern Deserts Bioregion. In N.G. Sugihara, J. van Wagtendonk, K.E. Shaffer, J. Fites-Kaufman, A.E. Thode (eds.). Fire in California's Ecosystems 2nd Edition. University of California Press.	Brooks, M.L., R.A. Minnich, J. Matchett.	Southeastern Deserts Bioregion.	In N.G. Sugihara, J. van Wagtendonk, K.E. Shaffer, J. Fites-Kaufman, A.E. Thode (eds.). Fire in California's Ecosystems 2nd Edition. University of California Press. (2018)
Brooks, M.L; S. Ostoja, and R. Klinger. 2013. Fire Effects on Seed banks and Vegetation in the Eastern Mojave Desert: Implications for Post-fire Management. U.S. Joint Fire Science Program. 81. Lincoln, Nebraska.	Brooks, M.L; S. Ostoja, and R. Klinger.	Fire Effects on Seed banks and Vegetation in the Eastern Mojave Desert: Implications for Post-fire Management.	U.S. Joint Fire Science Program. 81. Lincoln, Nebraska. (2013)
Bureau of Land Management. BLM. 2019. West Mojave Route Network Project (WMRNP). DOI-BLM-CA-D080-2018-0008-EIS (West Mojave Route Network Project SEIS) https://eplanning.blm.gov/epl-frontoffice/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=93521 [Accessed December 18, 2019]	Bureau of Land Management. BLM.	West Mojave Route Network Project (WMRNP). DOI-BLM-CA-D080-2018-0008-EIS (West Mojave Route Network Project SEIS)	https://eplanning.blm.gov/epl-frontoffice/eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=93521 [Accessed December 18, 2019]
Bureau of Land Management. BLM. 2016. Desert Renewable Energy Conservation Plan (DRECP). DOI-BLM-CA-D010-2014-0001-RMP-EIS (DRECP Amendment). https://eplanning.blm.gov/epl-frontoffice/ eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=95675 [Accessed December 18, 2019]	Bureau of Land Management. BLM.	Desert Renewable Energy Conservation Plan (DRECP). DOI-BLM-CA-D010-2014-0001-RMP-EIS (DRECP Amendment).	https://eplanning.blm.gov/epl-frontoffice/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&cu rrentPageId=95675 [Accessed December 18, 2019]
Bureau of Land Management. BLM. 2002. Northern and Eastern Mojave Plan (NEMO). DOIBLM-CA-D010-2002-0001-RMP-EIS (Northern and Eastern Mojave RMP Amendment). https://eplanning.blm.gov/epl-frontoffice/ eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=73191 [Accessed December 18, 2019].	Bureau of Land Management. BLM.	Northern and Eastern Mojave Plan (NEMO). DOIBLM-CA-D010-2002-0001-RMP-EIS (Northern and Eastern Mojave RMP Amendment).	https://eplanning.blm.gov/epl-frontoffice/ eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=73191 [Accessed December 18, 2019].
Bureau of Land Management. BLM. 2011. Southern Nevada Complex Emergancy Stabilization and Rehabilitation Final Report. U.S. Department of the Interior, Bureau of Land Management. 273 pp.	Bureau of Land Management. BLM.	Southern Nevada Complex Emergancy Stabilization and Rehabilitation Final Report.	U.S. Department of the Interior, Bureau of Land Management. 273 pp. (2011)
Bureau of Land Management. BLM. 2006. West Mojave Plan (WEMO). DOI-BLM-CAD010-2003-0001-RMP-EIS (West Mojave RMP Amendment). https://eplanning.blm.gov/epl-frontoffice/ eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=72544 [Accessed December 18, 2019].	Bureau of Land Management. BLM.	West Mojave Plan (WEMO). DOI-BLM-CAD010-2003-0001-RMP-EIS (West Mojave RMP Amendment).	https://eplanning.blm.gov/epl-frontoffice/ eplanning/planAndProjectSite.do?methodName=renderDefaultPlanOrProjectSite&projectId=72544 [Accessed December 18, 2019].
Bytnerowicz, A., Fenn, M.E., Allen, E.B., and Cisneros, R. 2016. Ecologically relevant atmospheric chemistry. In E. Zavaleta and H.A. Mooney (eds.). Ecosystems of California. Chapter 7. Edited by University of California Press, Berkeley, Calif. pp. 107–128.	Bytnerowicz, A., Fenn, M.E., Allen, E.B., and Cisneros, R.	Ecologically relevant atmospheric chemistry.	In E. Zavaleta and H.A. Mooney (eds.). Ecosystems of California. Chapter 7. Edited by University of California Press, Berkeley, Calif. pp. 107–128. (2016)
California Department of Fish and Wildlife, Vegetation Classification and Mapping Program; [AIS] Aerial Information Systems. 2013 California Desert Vegetation Map and Accuracy Assessment in Support of the Desert Renewable Energy Conservation Plan. California Department of Fish and Wildlife Vegetation Classification and Mapping Program; 3/27/2013. [Cited 2019 December 5]. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=62825	California Department of Fish and Wildlife, Vegetation Classification and Mapping Program; [AIS] Aerial Information Systems.	California Desert Vegetation Map and Accuracy Assessment in Support of the Desert Renewable Energy Conservation Plan.	California Department of Fish and Wildlife Vegetation Classification and Mapping Program; 3/27/2013. [Cited 2019 December 5]. Available from: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=62825

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
California Department of Fish and Wildlife, Vegetation Classification and Mapping Program; and Chico State University, Geographic Information Center. 2015. Vegetation - Proposed Tehachapi Pass High Speed Rail Corridor [ds1328]. Retrieved from http://bios.dfg.ca.gov on November 25, 2019.	California Department of Fish and Wildlife, Vegetation Classification and Mapping Program; and Chico State University, Geographic Information Center.	Vegetation - Proposed Tehachapi Pass High Speed Rail Corridor [ds1328].	CDFW. (2015). Retrieved from http://bios.dfg.ca.gov on November 25, 2019.
California Department of Fish and Wildlife, Vegetation Classification and Mapping Program; U.S. Geological Survey. 2014. Vegetation Map -Johnson Valley [ds1019]. Retrieved from http://bios.dfg.ca.gov on November 25, 2019.	California Department of Fish and Wildlife, Vegetation Classification and Mapping Program; U.S. Geological Survey.	Vegetation Map -Johnson Valley [ds1019].	CDFW. (2014). Retrieved from http://bios.dfg.ca.gov on November 25, 2019.
California Department of Fish and Wildlife. 2019. Vegetation Survey Points [ds1020]. Received from California Department of Fish and Wildlife (VegCAMP) on December 5, 2019.	California Department of Fish and Wildlife.	Vegetation Survey Points [ds1020].	Received from California Department of Fish and Wildlife (VegCAMP) on December 5, 2019.
California Department of Fish and Wildlife; [AIS] Aerial Information Systems. 2019a. Jawbone North for AA. Unpublished data. Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019.	California Department of Fish and Wildlife; [AIS] Aerial Information Systems.	Jawbone North for AA. Unpublished data.	Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019. (2019a)
California Department of Fish and Wildlife; [AIS] Aerial Information Systems. 2019c. Jawbone South for AA. Unpublished data. Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019.	California Department of Fish and Wildlife; [AIS] Aerial Information Systems.	Jawbone South for AA. Unpublished data.	Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019. (2019c)
California Department of Fish and Wildlife; [AIS] Aerial Information Systems. 2019b. Owens Valley for AA. Unpublished data. Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019.	California Department of Fish and Wildlife; [AIS] Aerial Information Systems.	Owens Valley for AA. Unpublished data	Received from California Department of Fish and Wildlife (VegCAMP) on November 25, 2019. (2019b)
California Department of Fish and Wildlife; Aerial Information Systems, Inc., and University of California Riverside Center for Conservation Biology. 2017. Vegetation - Mojave Desert for DRECP [ds735] Retrieved from http://bios.dfg.ca.gov on December 12, 2019.	California Department of Fish and Wildlife; Aerial Information Systems, Inc., and University of California Riverside Center for Conservation Biology.	Vegetation - Mojave Desert for DRECP [ds735]	CDFW. (2017). Retrieved from http://bios.dfg.ca.gov on December 12, 2019.
California Fish and Game Commission. 2015. California Policy for Native Plants. Adopted June 11, 2015. https://fgc.ca.gov/About/Policies/Miscellaneous#NativePlants [Accessed December 18, 2019]	California Fish and Game Commission.	California Policy for Native Plants. Adopted June 11, 2015.	California Fish and Game Commission. 2015. https://fgc.ca.gov/About/Policies/Miscellaneous#NativePlants [Accessed December 18, 2019]
California Legislative Information. 1981. California Desert Native Plants Act, Chapter 5: Harvesting of Native Plants. Available at: https://www.wildlife.ca.gov/conservation/plants/ca-desert-plant-act	California Legislative Information.	California Desert Native Plants Act, Chapter 5: Harvesting of Native Plants.	[CLI] California Legislative Information. (1981.) Available at: https://www.wildlife.ca.gov/conservation/plants/ca-desert-plant-act
California Native Plant Society. 2019. A Manual of California Vegetation, Online Edition. http://www.cnps.org/cnps/vegetation/. California Native Plant Society, Sacramento, CA. [Accessed December 18, 2019]	California Native Plant Society.	A Manual of California Vegetation, Online Edition.	http://www.cnps.org/cnps/vegetation/. California Native Plant Society, Sacramento, CA. [Accessed December 18, 2019]
Carroll, C., J.A. Vucetich, M.P. Nelson, D.J. Rohlf, and M.K. Phillips. 2010. Geography and recovery under the US Endangered Species Act. Conservation Biology 24:395–403.	Carroll, C., J.A. Vucetich, M.P. Nelson, D.J. Rohlf, and M.K. Phillips.	Geography and recovery under the US Endangered Species Act.	Conservation Biology 24:395–403. (2010)
Cayan D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate change scenarios for the California region. Climate Change 87:21–42.	Cayan D.R., E.P. Maurer, M.D. Dettinger, M. Tyree, and K. Hayhoe.	Climate change scenarios for the California region.	Climate Change 87:21–42. (2008)
Climate Action Tracker, USA. 2019. http://climateactiontracker.org/countries/usa. (updated version September 19, 2019). [Accessed December 18, 2019].	Climate Action Tracker, USA.	Climate Action Tracker, USA.	http://climateactiontracker.org/countries/usa. (updated version September 19, 2019). [Accessed December 18, 2019].
Cody, M.L. 2000. Slow-motion population dynamics in Mojave Desert perennial plants. Journal of Vegetation Science 11:351–358.	Cody, M.L.	Slow-motion population dynamics in Mojave Desert perennial plants.	Journal of Vegetation Science 11:351–358. (2000)
Cole, K.L., K. Ironside, J. Eischeid, G. Garfin, P.B. Duffy, and C. Toney. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications 21:137–149.	Cole, K.L., K. Ironside, J. Eischeid, G. Garfin, P.B. Duffy, and C. Toney.	Past and ongoing shifts in Joshua tree distribution support future modeled range contraction.	Ecological Applications 21:137–149. (2011)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Cole, K.L., K. Pohs, and J.A. Cannella. 2003. Digital range map of Joshua tree (Yucca brevifolia). U.S. Geological Survey. Online at: http:// sbsc.wr.usgs.gov/cprs/research/projects/global_change/RangeMaps.asp [October 1, 2017].	Cole, K.L., K. Pohs, and J.A. Cannella.	Digital range map of Joshua tree (Yucca brevifolia).	U.S. Geological Survey. (2003). Online at: http:// sbsc.wr.usgs.gov/cprs/research/projects/global_change/RangeMaps.asp [October 1, 2017].
Cole, W.S., A.S. James, and C.I. Smith. 2017. First Recorded Observations of Pollination and Oviposition Behavior in Tegeticula antithetica (Lepidoptera: Prodoxidae) Suggest a Functional Basis for Coevolution with Joshua Tree (Yucca) Hosts. Annals of the Entomological Society of America 110:390–397.	Cole, W.S., A.S. James, and C.I. Smith.	First Recorded Observations of Pollination and Oviposition Behavior in Tegeticula antithetica (Lepidoptera: Prodoxidae) Suggest a Functional Basis for Coevolution with Joshua Tree (Yucca) Hosts.	Annals of the Entomological Society of America 110:390–397. (2017)
Comanor, P.L. and W.H. Clark. 2000. Preliminary growth rates and a proposed age-form classification for the Joshua tree, Yucca brevifolia (Agavaceae). Haseltonia 7:37-45.	Comanor, P.L. and W.H. Clark.	Preliminary growth rates and a proposed age-form classification for the Joshua tree, Yucca brevifolia (Agavaceae).	Haseltonia 7:37-45. (2000)
Comer, P., P. Crist, M. Reid, J. Hak, H. Hamilton, D. Braun, G. Kittel, I. Varley, B. Unnasch, S. Auer, M. Creutzburg, D. Theobald, and L. Kutner. 2013. Mojave Basin and Range Rapid Ecoregional Assessment Report. Prepared for the U.S. Department of the Interior, Bureau of Land Management. 173 p. (plus appendices).	Comer, P., P. Crist, M. Reid, J. Hak, H. Hamilton, D. Braun, G. Kittel, I. Varley, B. Unnasch, S. Auer, M. Creutzburg, D. Theobald, and L. Kutner.	Mojave Basin and Range Rapid Ecoregional Assessment Report.	Prepared for the U.S. Department of the Interior, Bureau of Land Management. 173 p. (plus appendices). (2013)
Cook, B. I., T.R. Ault, and J.E. Smerdon. 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. Science Advances, 1: e1400082.	Cook, B. I., T.R. Ault, and J.E. Smerdon.	Unprecedented 21st century drought risk in the American Southwest and Central Plains.	Science Advances, 1: e1400082. (2015)
Cornett, J.W. 2018. Joshua trees are blooming early in the desert. It's not a good thing— you can thank climate change. DESERT magazine. Jan. 30, 2019	Cornett, J.W.	Joshua trees are blooming early in the desert. It's not a good thing— you can thank climate change.	DESERT magazine. (2018). Jan. 30, 2019
Cornett, J.W. 2014. Population dynamics of the Joshua tree (Yucca brevifolia): Twentythree year analysis, Lost Horse Valley, Joshua Tree National Park. In R. E. Reynolds (Ed.), Not a Drop Left to Drink (pp. 71–73): California State University Desert Studies Center, 2014 Desert Symposium.	Cornett, J.W.	Population dynamics of the Joshua tree (Yucca brevifolia): Twentythree year analysis, Lost Horse Valley, Joshua Tree National Park.	In R. E. Reynolds (Ed.), Not a Drop Left to Drink (pp. 71–73): California State University Desert Studies Center, 2014 Desert Symposium.
Cornett, J.W. 2017. Population dynamics of the Joshua tree, Yucca brevifolia. Unpublished white paper, JWC Ecological Consultants, Palm Springs, CA.	Cornett, J.W.	Population dynamics of the Joshua tree, Yucca brevifolia.	Unpublished white paper, JWC Ecological Consultants, Palm Springs, CA. (2017)
Cummings, Brendan. 2019. A petition to list the western Joshua tree (Yucca brevifolia) as threatened under the California Endangered Species Act (CESA). Center for Biological Diversity	Cummings, Brendan.	A petition to list the western Joshua tree (Yucca brevifolia) as threatened under the California Endangered Species Act (CESA).	Center for Biological Diversity (2019)
DeFalco, L.A., and T.C. Esque. 2014. Soil seed banks: preserving native biodiversity and repairing damaged desert shrublands. Fremontia 42:17–23.	DeFalco, L.A., and T.C. Esque.	Soil seed banks: preserving native biodiversity and repairing damaged desert shrublands.	Fremontia 42:17–23. (2014)
DeFalco, L.A., G.C.J. Fernandez, and R.S. Nowak. 2007. Variation in the establishment of a non-native annual grass influences competitive interactions with Mojave Desert perennials. Biological Invasions 9:293–307.	DeFalco, L.A., G.C.J. Fernandez, and R.S. Nowak.	Variation in the establishment of a non-native annual grass influences competitive interactions with Mojave Desert perennials.	Biological Invasions 9:293–307. (2007)
DeFalco, L.A., T.C. Esque, S.J. Scoles-Sciulla, and J. Rodgers. 2010. Desert wildfire and severe drought diminish survivorship of the long-lived Joshua tree (Yucca brevifolia; Agavaceae). American Journal of Botany 97:243–250.	DeFalco, L.A., T.C. Esque, S.J. Scoles-Sciulla, and J. Rodgers.	Desert wildfire and severe drought diminish survivorship of the long-lived Joshua tree (Yucca brevifolia; Agavaceae).	American Journal of Botany 97:243–250. (2010)
DiChristopher, T., 2019. US crude oil exports hit a record last week at 3.6 million barrels a day. Feb. 21, 2019. https://www.cnbc.com/2019/02/21/us-crude-oil-exports-hit-arecord-high-last-week.html. [Accessed December 18, 2019].	DiChristopher, T.	US crude oil exports hit a record last week at 3.6 million barrels a day.	Feb. 21, 2019. https://www.cnbc.com/2019/02/21/us-crude-oil-exports-hit-arecord-high-last-week.html. [Accessed December 18, 2019].
Dole, K.P., M.E. Loik, and L.C. Sloan. 2003. The relative importance of climate change and the physiological effects of CO2 on freezing tolerance for the future distribution of Yucca brevifolia. Global and Planetary Change 36:137–146.	Dole, K.P., M.E. Loik, and L.C. Sloan.	The relative importance of climate change and the physiological effects of CO2 on freezing tolerance for the future distribution of Yucca brevifolia.	Global and Planetary Change 36:137–146. (2003)
Electronic Code of Federal Regulations. 2018. Title 36, Parks, Forests, and Public Property: Part 2, Resource Protection, Public Use, and Recreation. Available at: https:// www.ecfr.gov/cgi-bin/text-idx?SID=6cb1fcfc0a96a6dfeb16f150ceb3df29&mc= true&node= se36.1.2_11&rgn=div8.	Electronic Code of Federal Regulations.	Title 36, Parks, Forests, and Public Property: Part 2, Resource Protection, Public Use, and Recreation.	Electronic Code of Federal Regulations. (2018). Available at: https:// www.ecfr.gov/cgi-bin/text-idx?SID=6cb1fcfc0a96a6dfeb16f150ceb3df29&mc= true&node= se36.1.2_11&rgn=div8.

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Engelmann, G. 1871. Yucca brevifolia, p. 496. In C. King, Report No. 5, Geological exploration of the fortieth parallel. Government Printing Office, Washington.	Engelmann, G.	Yucca brevifolia, p. 496.	In C. King, Report No. 5, Geological exploration of the fortieth parallel. Government Printing Office, Washington. (1871)
Erickson, P., A. Down, M. Lazarus, and D. Koplow. 2017. Effect of subsidies to fossil fuel companies on United States crude oil production. Nature Energy 2:891-898	Erickson, P., A. Down, M. Lazarus, and D. Koplow.	Effect of subsidies to fossil fuel companies on United States crude oil production.	Nature Energy 2:891-898 (2017)
Esque, T.C., B. Reynolds, L.A. DeFalco, and B.A. Waitman. 2010. Demographic studies of Joshua tree in Mojave Desert National Parks: demography with emphasis on germination and recruitment. Mojave National Preserve Science Newsletter 1:9–12.	Esque, T.C., B. Reynolds, L.A. DeFalco, and B.A. Waitman.	Demographic studies of Joshua tree in Mojave Desert National Parks: demography with emphasis on germination and recruitment.	Mojave National Preserve Science Newsletter 1:9–12. (2010)
Esque, T.C., P.A. Medica, D.F. Shrylock, L.A. DeFalco, R.H. Webb, and R.B. Hunter. 2015. Direct and indirect effects of environmental variability on growth and survivorship of prereproductive Joshua trees, Yucca brevifolia Engelm. (Agavaceae). American Journal of Botany. 102:85–91.	Esque, T.C., P.A. Medica, D.F. Shrylock, L.A. DeFalco, R.H. Webb, and R.B. Hunter.	Direct and indirect effects of environmental variability on growth and survivorship of prereproductive Joshua trees, Yucca brevifolia Engelm. (Agavaceae).	American Journal of Botany. 102:85–91. (2015)
Esque, T.C., R.H. Webb, C.S.A. Wallace, C. van Riper III, C. McCreedy, and L. Smythe. 2013. Desert Fires Fueled by Native Annual Forbs: Effects of Fire on Communities of Plants and Birds of the Lower Sonoran Desert of Arizona. Southwestern Naturalist 58(2):223–233.	Esque, T.C., R.H. Webb, C.S.A. Wallace, C. van Riper III, C. McCreedy, and L. Smythe.	Desert Fires Fueled by Native Annual Forbs: Effects of Fire on Communities of Plants and Birds of the Lower Sonoran Desert of Arizona.	Southwestern Naturalist 58(2):223–233. (2013)
Fitzpatrick, M.C. and W.W. Hargrove. 2009. The projection of species distribution models and the problem of non-analog climate. Biodiversity Conservation 18:2255–2261.	Fitzpatrick, M.C. and W.W. Hargrove.	The projection of species distribution models and the problem of non-analog climate.	Biodiversity Conservation 18:2255–2261. (2009)
Frakes, N. 2017. Invasive Plant Management at Joshua Tree National Park. Presentation at California Invasive Plant Council Symposium, October 2017.	Frakes, N.	Invasive Plant Management at Joshua Tree National Park.	Presentation at California Invasive Plant Council Symposium, October 2017. (2017)
Freckleton, R.P. and A.R. Watkinson. 2002. Large-scale spatial dynamics of plants: metapopulations, regional ensembles and patchy populations. Journal of Ecology 90:419–434.	Freckleton, R.P. and A.R. Watkinson. 2	Large-scale spatial dynamics of plants: metapopulations, regional ensembles and patchy populations.	Journal of Ecology 90:419–434. (2002)
Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, et al. 2014. Southwest. In J.M. Melillo, T.C. Richmond and G.W. Yohe (Eds.), Climate Change Impacts in the United States: The Third National Climate Assessment (pp. 462–486): U.S. Global Change Research Program	Garfin, G., G. Franco, H. Blanco, A. Comrie, P. Gonzalez, T. Piechota, et al.	Southwest.	In J.M. Melillo, T.C. Richmond and G.W. Yohe (Eds.), Climate Change Impacts in the United States: The Third National Climate Assessment (pp. 462–486): U.S. Global Change Research Program (2014)
Gilliland, K.D., N.J. Huntly, and J.E. Anderson. 2006. Age and population structure of Joshua trees (Yucca brevifolia) in the northwestern Mojave Desert. Western North American Naturalist 66:202–208.	Gilliland, K.D., N.J. Huntly, and J.E. Anderson.	Age and population structure of Joshua trees (Yucca brevifolia) in the northwestern Mojave Desert.	Western North American Naturalist 66:202–208. (2006)
Given, D.R. 1994. Principles and practice of plant conservation. Timber Press, Portland, Oregon, USA, pp. 292.	Given, D.R.	Principles and practice of plant conservation.	Timber Press, Portland, Oregon, USA, pp. 292. (1994)
Godsoe, W., E. Strand, C.I. Smith, J.B. Yoder, T.C. Esque, and O. Pellmyr. 2009. Divergence in an obligate mutualism is not explained by divergent climatic factors. New Phytologist 183:589–599.	Godsoe, W., E. Strand, C.I. Smith, J.B. Yoder, T.C. Esque, and O. Pellmyr.	Divergence in an obligate mutualism is not explained by divergent climatic factors.	New Phytologist 183:589–599. (2009)
Godsoe, W., J.B. Yoder, C.I. Smith, and O. Pellmyr. 2008. Coevolution and divergence in the Joshua tree/yucca moth mutualism. The American Naturalist 171(6):816–823.	Godsoe, W., J.B. Yoder, C.I. Smith, and O. Pellmyr.	Coevolution and divergence in the Joshua tree/yucca moth mutualism.	The American Naturalist 171(6):816–823. (2008)
Gonzalez, P. 2017. Climate Change Trends, Impacts, and Vulnerabilities in US National Parks. In Beissinger, S. R., D. D. Ackerly, H. Doremus, and G. E. Machlis (eds.) Science, Conservation, and National Parks. University of Chicago Press, Chicago, IL.	Gonzalez, P.	Climate Change Trends, Impacts, and Vulnerabilities in US National Parks.	In Beissinger, S. R., D. D. Ackerly, H. Doremus, and G. E. Machlis (eds.) Science, Conservation, and National Parks. University of Chicago Press, Chicago, IL. (2017)
Gucker, C. L. 2006. Yucca brevifolia Fire Effects Information System (Online). U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.	Gucker, C. L.	Yucca brevifolia Fire Effects Information System (Online).	U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory [2006].
Hanski, I. 1999. Metapopulation ecology. Oxford University Press.	Hanski, I.	Metapopulation ecology.	Oxford University Press. (1999)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Harrower, J. and G. S. Gilbert. 2018. Context-dependent mutualisms in the Joshua tree–yucca moth system shift along a climate gradient. Ecosphere 9(9):e02439. https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.2439. [Accessed December 18, 2019].	Harrower, J. and G. S. Gilbert.	Context-dependent mutualisms in the Joshua tree–yucca moth system shift along a climate gradient.	Ecosphere 9(9):e02439. (2018) https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.2439. [Accessed December 18, 2019].
Hereford, R., R. H. Webb, and C. I. Longpré. 2006. Precipitation history and ecosystem response to multidecadal precipitation variability in the Mojave desert region, 1893–2001. Journal of Arid Environments, 67:13–34.	Hereford, R., R. H. Webb, and C. I. Longpré.	Precipitation history and ecosystem response to multidecadal precipitation variability in the Mojave desert region, 1893–2001.	Journal of Arid Environments, 67:13–34. (2006)
Hess, W.J. 2012. Yucca brevifolia. In Jepson Flora Project (eds.) Jepson eFlora, http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=48766 [Accessed December 18, 2019].	Hess, W.J	Yucca brevifolia.	In Jepson Flora Project (eds.) Jepson eFlora, http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=48766 [Accessed December 18, 2019].
Hoar, T., & D. Nychka. 2008. Statistical downscaling of the Community Climate System Model (CCSM) monthly temperature and precipitation projections. White Paper. Boulder.	Hoar, T., & D. Nychka.	Statistical downscaling of the Community Climate System Model (CCSM) monthly temperature and precipitation projections.	White Paper. Boulder. (2008)
Holmgren, C.A., J.L. Betancourt, and K.A. Rylander. 2010. A long-term vegetation history of the Mojave-Colorado Desert ecotone at Joshua Tree National Park. Journal of Quarternary Science 25:222–236.	Holmgren, C.A., J.L. Betancourt, and K.A. Rylander.	A long-term vegetation history of the Mojave-Colorado Desert ecotone at Joshua Tree National Park.	Journal of Quarternary Science 25:222–236. (2010)
Hopkins, F. 2018. Inland Deserts Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-008. https://www.energy.ca.gov/sites/default/files/2019-07/Reg%20Report-%20SUMCCCA4-2018-008%20InlandDeserts.pdf. [Accessed December 18, 2019].	Hopkins, F	Inland Deserts Summary Report. California's Fourth Climate Change Assessment.	Publication number: SUM-CCCA4-2018-008. https://www.energy.ca.gov/sites/default/files/2019-07/Reg%20Report-%20SUMCCCA4-2018-008%20InlandDeserts.pdf. [Accessed December 18, 2019].
Hunning, J.R. and R.M. Peterson. 1973. Use of Yucca brevifolia as a surrogate for detection of near-surface moisture retention. University of California Technical Report N-73-1. 30 pp.	Hunning, J.R. and R.M. Peterson.	Use of Yucca brevifolia as a surrogate for detection of near-surface moisture retention.	University of California Technical Report N-73-1. 30 pp. (1973)
Iknayan, K.J. and S.R. Beissinger. 2018. Collapse of a desert bird community over the past century driven by climate change. Proc. Natl. Acad. Sci. U.S.A. 115:8597–8602.	Iknayan, K.J. and S.R. Beissinger.	Collapse of a desert bird community over the past century driven by climate change.	Proc. Natl. Acad. Sci. U.S.A. 115:8597–8602. (2018)
Integrated Taxonomic Information System. ITIS. 2019. ITIS Database. [Online]. Available: http://www.itis.gov/index.html. [Accessed December 18, 2019].	Integrated Taxonomic Information System. ITIS	ITIS Database. [Online].	Available: http://www.itis.gov/index.html. [Accessed December 18, 2019].
Intergovernmental Panel on Climate Change. IIPCC. 2018. Global Warming of 1.5° C: An IPCC Special Report on the Impacts of Global Warming of 1.5° C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. Intergovernmental Panel on Climate Change. Available at: http://www.ipcc.ch/report/sr15/. [Accessed December 18, 2019].	Intergovernmental Panel on Climate Change. IPCC.	Global Warming of 1.5° C: An IPCC Special Report on the Impacts of Global Warming of 1.5° C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty.	Intergovernmental Panel on Climate Change. Available at: http://www.ipcc.ch/report/sr15/. [Accessed December 18, 2019].
International Panel on Climate Change. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summary for Policymakers. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 44 pp. URL: http://ipcc wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf	International Panel on Climate Change. IPCC.	Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summary for Policymakers.	Summary for Policymakers. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 44 pp. (2014) URL: http://ipcc wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf
International Panel on Climate Change Synthesis Report. IPCC. 2007. Impacts, Adaptation and Vulnerability. In: Canziani OF, Parry ML, Palutikof JP, van der Linden PJ, Hanson CE, editors. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.	International Panel on Climate Change. IPCC.	Synthesis Report. Impacts, Adaptation and Vulnerability. In: Canziani OF, Parry ML, Palutikof JP, van der Linden PJ, Hanson CE, editors.	Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press. (2007)
Jepson, M., T. Clabough, C. Caudill, and R. Qualls. 2016. An evaluation of temperature and precipitation data for parks of the Mojave Desert Network. Natural Resource Report NPS/MOJN/NRR—2016/1339. National Park Service, Fort Collins, Colorado.	Jepson, M., T. Clabough, C. Caudill, and R. Qualls.	An evaluation of temperature and precipitation data for parks of the Mojave Desert Network. Natural Resource Report NPS/MOJN/NRR—2016/1339.	National Park Service, Fort Collins, Colorado. (2016)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Jones, J. 2015. California's Most Significant Droughts, Comparing Historical and Recent Conditions. California Department of Water Resources, Sacramento, California (2015), p. 126.	Jones, J.	California's Most Significant Droughts, Comparing Historical and Recent Conditions.	California Department of Water Resources, Sacramento, California (2015), p. 126. (2015)
Jurand, B.S. and S.R. Abella. 2013. Soil seed banks of the exotic annual grass Bromus rubens on a burned desert landscape. Rangeland Ecology and Management. 66:157–163.	Jurand, B.S. and S.R. Abella.	Soil seed banks of the exotic annual grass Bromus rubens on a burned desert landscape.	Rangeland Ecology and Management. 66:157–163. (2013)
Keeley, J.E. 2009. Fire intensity, fire severity and burn severity: a brief review and suggested usage. International Journal of Wildland Fire 18:116–126.	Keeley, J.E.	Fire intensity, fire severity and burn severity: a brief review and suggested usage.	International Journal of Wildland Fire 18:116–126. (2009)
Keeley, J.E. and A. Meyers. 1985. Effect of heat on seed germination of southwestern Yucca species. The Southwestern Naturalist. 30: 303–304.	Keeley, J.E. and A. Meyers.	Effect of heat on seed germination of southwestern Yucca species. The Southwestern Naturalist.	The Southwestern Naturalist. 30: 303–304. (1985)
Keith, S.L. 1982. A tree named Joshua. American Forests 88:40–42.	Keith, S.L.	A tree named Joshua.	American Forests 88:40–42. (1982)
Kimball, S., A.L. Angert, T.E. Huxman, and D.L. Veneble. 2010. Contemporary climate change in the Sonoran Desert favors cold-adapted species. Global Change Biology 16:1555–1565. doi: 1 0.1 111/j.1 365-2486.2009.021 06	Kimball, S., A.L. Angert, T.E. Huxman, and D.L. Veneble.	Contemporary climate change in the Sonoran Desert favors cold-adapted species.	Global Change Biology 16:1555–1565. doi: 1 0.1 111/j.1 365-2486.2009.021 06 (2010)
Klinger, R. and M. Brooks. 2017. Alternative pathways to landscape transformation: invasive grasses, burn severity and fire frequency in arid ecosystems. Journal of Ecology. 105:1521–1533.	Klinger, R. and M. Brooks.	Alternative pathways to landscape transformation: invasive grasses, burn severity and fire frequency in arid ecosystems.	Journal of Ecology. 105:1521–1533. (2017)
Kocsis M., and L. Hufnagel. 2011. Impacts of climate change on Lepidoptera species and communities. Applied Ecology and Environmental Research 9:43–72.	Kocsis M., and L. Hufnagel.	Impacts of climate change on Lepidoptera species and communities.	Applied Ecology and Environmental Research 9:43–72. (2011)
LANDFIRE Reference Database. 2007. Version 0.32. USDA Forest Service, U.S. Department of Interior, Missoula, Montana, USA. hwww.landfire.govi	LANDFIRE Reference Database.	Database. 2007. Version 0.32.	USDA Forest Service, U.S. Department of Interior, Missoula, Montana, USA. hwww.landfire.govi (2007)
Le Quéré, C. et al. 2018. Global carbon budget 2018, 10 Earth Syst. Sci. Data 10:2141–2194.	Le Quéré, C.	Global carbon budget 2018	10 Earth Syst. Sci. Data 10:2141–2194. (2018)
Lenz, L.W. 2007. Reassessment of Yucca brevifolia and recognition of Y. jaegeriana as a distinct species. Aliso: A Journal of Systematic and Evolutionary Botany 24(1):97–104.	Lenz, L.W.	Reassessment of Yucca brevifolia and recognition of Y. jaegeriana as a distinct species.	Aliso: A Journal of Systematic and Evolutionary Botany 24(1):97–104. (2007)
Lenz, L.W. 2001. Seed dispersal in Yucca brevifolia (Agavaceae) present and past, with consideration of the future of the species. Aliso 20:61–74.	Lenz, L.W.	Seed dispersal in Yucca brevifolia (Agavaceae) present and past, with consideration of the future of the species.	Aliso 20:61–74. (2001)
Loik, M.E., C.D. St. Onge, and J. Rogers. 2000. Post-fire recruitment of Yucca brevifolia and Yucca schidigera in Joshua Tree National Park, California. In J.E. Keeley, M. Baer-Keeley, and C.J. Fotheringham (eds.). Second interface between ecology and land development in California, pp. 79–85. Open-File Report 00-62, U.S. Geological Survey, Sacramento, California, USA.	Loik, M.E., C.D. St. Onge, and J. Rogers.	Post-fire recruitment of Yucca brevifolia and Yucca schidigera in Joshua Tree National Park, California. In J.E. Keeley, M. Baer-Keeley, and C.J. Fotheringham (eds.). Second interface between ecology and land development in California, pp. 79–85.	Open-File Report 00-62, U.S. Geological Survey, Sacramento, California, USA. (2000)
Loik, M.E., T.E. Huxman, E.P. Hamerlynck, and S.D. Smith. 2000. Low temperature tolerance and cold acclimation for seedlings of three Mojave Desert Yucca species exposed to elevated CO2. Journal of Arid Environments, 46(1):43–56	Loik, M.E., T.E. Huxman, E.P. Hamerlynck, and S.D. Smith.	Low temperature tolerance and cold acclimation for seedlings of three Mojave Desert Yucca species exposed to elevated CO2.	Journal of Arid Environments, 46(1):43–56 (2000)
Lybbert, A.H. and S.B. St. Clair. 2017. Wildfire and floral herbivory alter reproduction and pollinator mutualisms of Yuccas and Yucca moths. Journal of Plant Ecology. 10:851-858.	Lybbert, A.H. and S.B. St. Clair.	Wildfire and floral herbivory alter reproduction and pollinator mutualisms of Yuccas and Yucca moths.	Journal of Plant Ecology. 10:851-858. (2017)
Maloney, K.A., E.L. Mudrak, A. Fuentes-Ramirez, H. Parag, M. Schat, and C. Holzapfel. 2019. Increased fire risk in Mojave and Sonoran shrublands due to exotic species and extreme rainfall events. Ecosphere 10:e02592.	Maloney, K.A., E.L. Mudrak, A. Fuentes-Ramirez, H. Parag, M. Schat, and C. Holzapfel.	Increased fire risk in Mojave and Sonoran shrublands due to exotic species and extreme rainfall events	Ecosphere 10:e02592. (2019).
McAuliffe, J.R. 2016. Perennial, Grass-dominated Plant Communities of the Eastern Mojave Desert Region. Desert Plants, Volume 32 Number 1. University of Arizona, Tucson, AZ.	McAuliffe, J.R.	Perennial, Grass-dominated Plant Communities of the Eastern Mojave Desert Region.	Desert Plants, Volume 32 Number 1. University of Arizona, Tucson, AZ. (2016)
McCleary, J.A. 1973. Comparative germination and early growth studies of six species of the genus Yucca. American Midland Naturalist 90(2):503–508.	McCleary, J.A.	Comparative germination and early growth studies of six species of the genus Yucca.	American Midland Naturalist 90(2):503–508. (1973)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
McKelvey, S.D. 1938. Yuccas of the Southwestern United States, Part 1. Jamaica Plain, MA: Arnold Arboretum, Harvard University. 150 pp.	McKelvey, S.D.	Yuccas of the Southwestern United States, Part 1.	Jamaica Plain, MA: Arnold Arboretum, Harvard University. 150 pp. (1938)
Mufson, S., C. Mooney, J. Eilperin, and J. Muyskens. 2019. 2°C: Beyond the Limit: Extreme climate change has arrived in America. Washington Post. https://www.washingtonpost.com/graphics/2019/national/climateenvironment/climate-change-america/. [Accessed December 18, 2019].	Mufson, S., C. Mooney, J. Eilperin, and J. Muyskens.	2°C: Beyond the Limit: Extreme climate change has arrived in America.	Washington Post. https://www.washingtonpost.com/graphics/2019/national/climateenvironment/climate-change-america/. [Accessed December 18, 2019].
Munz, P.A. 1958. California Miscellany IV. Aliso 4(1):87–100.	Munz, P.A.	California Miscellany IV.	Aliso 4(1):87–100. (1958)
National Park Service. NPS. 2012. Death Valley National Park Wilderness and Backcountry Stewardship Plan and Environmental Assessment. https://parkplanning.nps.gov/showFile.cfm?projectID=23311&MIMEType=application%252Fpdf&filename=DEVA%5FWilderness%5F%5F%5FBackcountry%5FStewardship%5FPlan%2Epdf&sfid=139732. [Accessed December 18, 2019].	National Park Service. NPS.	Death Valley National Park Wilderness and Backcountry Stewardship Plan and Environmental Assessment.	https://parkplanning.nps.gov/showFile.cfm?projectID=23311&MIMEType=application%252Fpdf&filename=DEVA%5FWilderness%5F%5F%5FBackcountry%5FStewardship%5FPlan%2Epdf&sfid=139732. [Accessed December 18, 2019].
National Park Service. NPS. 2010. Geospatial data for the Vegetation Mapping Inventory Project of Joshua Tree National Park. https://www.nps.gov/im/vmijotr. htm on [Accessed December 6, 2019].	National Park Service. NPS.	Geospatial data for the Vegetation Mapping Inventory Project of Joshua Tree National Park.	https://www.nps.gov/im/vmijotr. htm on [Accessed December 6, 2019]
National Park Service. NPS. 2017. Memorandum response: Request for information on the Joshua tree (Yucca brevifolia, Yucca jaegeriana). Joshua Tree National Park, Twentynine Palms, CA, 18 pp.	National Park Service. NPS.	Memorandum response: Request for information on the Joshua tree (Yucca brevifolia, Yucca jaegeriana).	Joshua Tree National Park, Twentynine Palms, CA, 18 pp. (2017)
Neilson, R. P., Pitelka, L. F., Solomon, A. M., Nathan, R., Midgley, G. F., Fragoso, J. M. V. 2005. Forecasting regional to global plant migration in response to climate change. BioScience, 55(9), 749-759.	Neilson, R. P., Pitelka, L. F., Solomon, A. M., Nathan, R., Midgley, G. F., Fragoso, J. M. V.	Forecasting regional to global plant migration in response to climate change.	BioScience, 55(9), 749-759 [2005].
Nevada Department of Forestry. NDF. Undated. State of Nevada Native Plant Laws. Las Vegas, NV: Nevada Department of Forestry, Department of Conservation & Natural Resources.	Nevada Department of Forestry. NDF.	State of Nevada Native Plant Laws.	Las Vegas, NV: Nevada Department of Forestry, Department of Conservation & Natural Resources. (Undated)
Noss R.F., M.A. O'Connell, and D.D. Murphy. 1997. The Science of Conservation Planning: Habitat Conservation under the Endangered Species Act. Washington, DC: Island Press	Noss R.F., M.A. O'Connell, and D.D. Murphy.	The Science of Conservation Planning: Habitat Conservation under the Endangered Species Act.	Washington, DC: Island Press (1997)
Notaro, M., A. Mauss, and J.W. Williams. 2012. Projected vegetation changes for the American Southwest: Combined dynamic modeling and bioclimatic-envelope approach. Ecological Applications 22:1365–1388.	Notaro, M., A. Mauss, and J.W. Williams.	Projected vegetation changes for the American Southwest: Combined dynamic modeling and bioclimatic-envelope approach.	Ecological Applications 22:1365–1388. (2012).
Oil Change International (OCI.) Drilling Toward Disaster: Why U.S. Oil and Gas Expansion Is Incompatible with Climate Limits (January 2019), http://priceofoil.org/drilling-towards-disaster. [Accessed December 18, 2019].	Oil Change International. OCI.	Drilling Toward Disaster: Why U.S. Oil and Gas Expansion Is Incompatible with Climate Limits (January 2019)	http://priceofoil.org/drilling-towards-disaster. [Accessed December 18, 2019].
Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77:118–125.	Omernik, J.M.	Ecoregions of the conterminous United States.	Annals of the Association of American Geographers 77:118–125. (1987)
Omernik, J.M. and G.E. Griffith. 2014. Ecoregions of the Conterminous United States: Evolution of a Hierarchical Spatial Framework. Environmental Management 54:1249–1266	Omernik, J.M. and G.E. Griffith.	Ecoregions of the Conterminous United States: Evolution of a Hierarchical Spatial Framework.	Environmental Management 54:1249–1266 (2014)
Pardo, L.H., M.E. Fenn, C.L. Goodale, L.H. Geiser, C.T. Driscoll, E.B. Allen, J.S. Baron, R. Bobbink, W.D. Bowman, C.M. Clark, B. Emmett, F.S. Gilliam, T.L. Greaver, S.J. Hall, E.A. Lilleskov, L. Liu, J.A. Lynch, K.J. Nadelhoffer, S.S. Perakis, M.J. Robin-Abbott, J.L. Stoddard, K.C. Weathers, and R.L. Dennis. 2011. Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States. Ecological Applications 21:3049–3082.	Pardo, L.H., M.E. Fenn, C.L. Goodale, L.H. Geiser, C.T. Driscoll, E.B. Allen, J.S. Baron, R. Bobbink, W.D. Bowman, C.M. Clark, B. Emmett, F.S. Gilliam, T.L. Greaver, S.J. Hall, E.A. Lilleskov, L. Liu, J.A. Lynch, K.J. Nadelhoffer, S.S. Perakis, M.J. Robin-Abbott, J.L. Stoddard, K.C. Weathers, and R.L. Dennis.	Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States.	Ecological Applications 21:3049–3082. (2011)
Pearson, R.G. and T.P. Dawson. 2003. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? Global Ecology & Biogeography 12:361–371.	Pearson, R.G. and T.P. Dawson.	Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful?	Global Ecology & Biogeography 12:361–371. (2003).
Pellmyr, O. 2003. Yuccas, yucca moths, and coevolution: A review. Annals of the Missouri Botanical Garden 90(1):35–55.	Pellmyr, O.	Yuccas, yucca moths, and coevolution: A review.	Annals of the Missouri Botanical Garden 90(1):35–55. (2003)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Pellmyr, O. and K.A. Segraves. 2003. Pollinator divergence within an obligate mutualism: Two yucca moth species (Lepidoptera; Prodoxidae: Tegeticula) on the Joshua tree (Yucca brevifolia; Agavaceae). Annals of the Entomological Society of America 96:716–722.	Pellmyr, O. and K.A. Segraves.	Pollinator divergence within an obligate mutualism: Two yucca moth species (Lepidoptera; Prodoxidae: Tegeticula) on the Joshua tree (Yucca brevifolia; Agavaceae).	Annals of the Entomological Society of America 96:716–722. (2003).
Polley, H.W., D.D. Briske, J.A. Morgan, K. Wolter, D.W. Bailey, and J.R. Brown. 2013. Climate change and North American rangelands: trends, projections, and implications. Rangeland Ecology and Management 66:493–511.	Polley, H.W., D.D. Briske, J.A. Morgan, K. Wolter, D.W. Bailey, and J.R. Brown.	Climate change and North American rangelands: trends, projections, and implications.	Rangeland Ecology and Management 66:493–511. (2013)
Powell, J.A. 2001. Longest insect dormancy: yucca moth larvae (Lepidoptera: Prodoxidae) metamorphose after 20, 25, and 30 years in diapause. Annals of the Entomological Society of America 94:677–680.	Powell, J.A.	Longest insect dormancy: yucca moth larvae (Lepidoptera: Prodoxidae) metamorphose after 20, 25, and 30 years in diapause.	Annals of the Entomological Society of America 94:677–680. (2001)
Reveal, J.L. 1977. Agavaceae pp. 526-538. In Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, and P.K. Holmgren, Intermountain Flora: Vascular plants of the Intermountain west, U.S.S. vol. six. Columbia University Press, New York.	Reveal, J.L.	Agavaceae pp. 526-538.	In Cronquist, A., A.H. Holmgren, N.H. Holmgren, J.L. Reveal, and P.K. Holmgren, Intermountain Flora: Vascular plants of the Intermountain west, U.S.S. vol. six. Columbia University Press, New York. (1977)
Reynolds, M.B.J., L.A. DeFalco, and T.C. Esque. 2012. Short seed longevity, variable germination conditions and infrequent establishment events provide a narrow window for Yucca brevifolia (Agavaceae) recruitment. American Journal of Botany 99:1647–1654.	Reynolds, M.B.J., L.A. DeFalco, and T.C. Esque.	Short seed longevity, variable germination conditions and infrequent establishment events provide a narrow window for Yucca brevifolia (Agavaceae) recruitment.	American Journal of Botany 99:1647–1654. (2012).
Riddell, E.A., K.J. Iknayana, B.O. Wolf, B.S. Sinervo, and S.R. Beissinger. 2019. Cooling requirements fueled the collapse of a desert bird community from climate change. Proc. Natl. Acad. Sci. 116:21609-21615.	Riddell, E.A., K.J. Iknayana, B.O. Wolf, B.S. Sinervo, and S.R. Beissinger.	Cooling requirements fueled the collapse of a desert bird community from climate change.	Proc. Natl. Acad. Sci. 116:21609-21615. (2019).
Rogelj, J., G. Luderer, R.C. Pietzker, E. Kriegler, M. Schaeffer, V. Krey, and K. Riahi. 2015. Energy system transformations for limiting end-of-century warming to below 1.5°C, Nature Climate Change 5:519-527.	Rogelj, J., G. Luderer, R.C. Pietzker, E. Kriegler, M. Schaeffer, V. Krey, and K. Riahi.	Energy system transformations for limiting end-of-century warming to below 1.5°C	Nature Climate Change 5:519-527. (2015)
Rowlands, P.G. 1978. The vegetation dynamics of the Joshua tree (Yucca brevifolia Engelm.) in the southwestern United States of America. Riverside, CA: University of California. Dissertation, 192 pp.	Rowlands, P.G.	The vegetation dynamics of the Joshua tree (Yucca brevifolia Engelm.) in the southwestern United States of America.	Riverside, CA: University of California. Dissertation, 192 pp. (1978)
Royer, A.M., M.A. Streisfeld, and C.I. Smith. 2016. Population genomics of divergence within an obligate pollination mutualism: Selection maintains differences between Joshua tree species. American Journal of Botany 03(10):1730–1741.	Royer, A.M., M.A. Streisfeld, and C.I. Smith.	Population genomics of divergence within an obligate pollination mutualism: Selection maintains differences between Joshua tree species.	American Journal of Botany 03(10):1730–1741. (2016)
Rundel, P.W. and A.C. Gibson. 1996. Ecological communities and processes in a Mojave Desert ecosystem: Rock Valley, Nevada. Cambridge; New York: Cambridge University Press. 369 p.	Rundel, P.W. and A.C. Gibson.	Ecological communities and processes in a Mojave Desert ecosystem: Rock Valley, Nevada.	Cambridge; New York: Cambridge University Press. 369 p. (1996)
Sanford, M.P. and N. Huntly. 2009. Selective herbivory by the desert woodrat (Neotoma lepida) on Joshua trees (Yucca brevifolia). Western North American Naturalist 69:165–170.	Sanford, M.P. and N. Huntly.	Selective herbivory by the desert woodrat (Neotoma lepida) on Joshua trees (Yucca brevifolia).	Western North American Naturalist 69:165–170. (2009)
Scheffers, B.R., L. De Meester, T.C.L. Bridge, A.A. Hoffmann, J.M. Pandolfi, R.T. Corlett, S.H.M. Butchart, P. Pearce-Kelly, K.M. Kovacs, D. Dudgeon, M. Pacifici, C. Rondinini, W.B. Foden, T. G. Martin, C. Mora, D. Bickford, and J.E.M. Watson. 2016. The broad footprint of climate change from genes to biomes to people. Science 354(6313).	Scheffers, B.R., L. De Meester, T.C.L. Bridge, A.A. Hoffmann, J.M. Pandolfi, R.T. Corlett, S.H.M. Butchart, P. Pearce-Kelly, K.M. Kovacs, D. Dudgeon, M. Pacifici, C. Rondinini, W.B. Foden, T. G. Martin, C. Mora, D. Bickford, and J.E.M. Watson.	The broad footprint of climate change from genes to biomes to people.	Science 354(6313). (2016).
Seager, R., M. Ting, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H. P. Huang, N. Harnik, A. Leetmaa, N. C. Lau, and C. Li. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. Science 316(5828):1181–1184.	Seager, R., M. Ting, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H. P. Huang, N. Harnik, A. Leetmaa, N. C. Lau, and C. Li.	Model projections of an imminent transition to a more arid climate in southwestern North America.	Science 316(5828):1181–1184. (2007)
Shafer, S.L., P.J. Bartlein, and R.S. Thompson. 2001. Potential changes in the distributions of western North America tree and shrub taxa under future climate scenarios. Ecosystems 4:200–215.	Shafer, S.L., P.J. Bartlein, and R.S. Thompson.	Potential changes in the distributions of western North America tree and shrub taxa under future climate scenarios.	Ecosystems 4:200–215.
Shaffer, M. and B.A. Stein. 2000. Safeguarding Our Precious Heritage. Chapter 11, in Precious Heritage. The Status of Biodiversity in the United States. B.A. Stein, L.S. Kutner, and J.S. Adams editors. The Nature Conservancy and Biodiversity Information. Oxford University Press.	Shaffer, M. and B.A. Stein.	Safeguarding Our Precious Heritage. Chapter 11, in Precious Heritage.	The Status of Biodiversity in the United States. B.A. Stein, L.S. Kutner, and J.S. Adams editors. The Nature Conservancy and Biodiversity Information. Oxford University Press. (2000)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Short, K.C. 2017. Spatial wildfire occurrence data for the United States, 1992-2015 [FPA_FOD_20170508]. 4th Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2013-0009.4. [Accessed December 18, 2019].	Short, K.C.	Spatial wildfire occurrence data for the United States, 1992-2015 [FPA_FOD_20170508].	4th Edition. Fort Collins, CO: Forest Service Research Data Archive. (2017). https://doi.org/10.2737/RDS-2013-0009.4. [Accessed December 18, 2019].
Simpson, P.G. 1975. Anatomy and morphology of the Joshua tree (Yucca brevifolia): an arborescent monocot. Santa Barbara, CA: University of California. Dissertation, 524 pp.	Simpson, P.G.	Anatomy and morphology of the Joshua tree (Yucca brevifolia): an arborescent monocot.	Santa Barbara, CA: University of California. Dissertation, 524 pp. (1975)
Smith C.I., O. Pellmyr, D.M. Althoff, M. Balcázar-Lara, J. Leebens-Mack, K.A. Segraves. 2008a. Pattern and timing of diversification in Yucca (Agavaceae): specialized pollination does not escalate rates of diversification. Proceedings of the Royal Society of London, Series B: Biological Sciences 275:249–258.	Smith C.I., O. Pellmyr, D.M. Althoff, M. Balcázar-Lara, J. Leebens-Mack, K.A. Segraves.	Pattern and timing of diversification in Yucca (Agavaceae): specialized pollination does not escalate rates of diversification.	Proceedings of the Royal Society of London, Series B: Biological Sciences 275:249–258. (2008a)
Smith D.R., N.L. Allan, C.P. McGowan, J.A. Szymanski, S.R. Oetker, and H.M. Bell. 2018. Development of a Species Status Assessment Process for Decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management, Vol 9 (1), pp. 1–19. https://doi.org/10.3996/052017-JFWM-041.	Smith D.R., N.L. Allan, C.P. McGowan, J.A. Szymanski, S.R. Oetker, and H.M. Bell.	Development of a Species Status Assessment Process for Decisions under the U.S. Endangered Species Act.	Journal of Fish and Wildlife Management, Vol 9 (1), pp. 1–19 (2018). https://doi.org/10.3996/052017-JFWM-041.
Smith, C.I., C.S. Drummond, W. Godsoe, J.B. Yoder, and O. Pellmyr. 2009. Host specificity and reproductive success of yucca moths (Tegeticula spp. Lepidoptera: Prodoxidae) mirror patterns of gene flow between host plant varieties of the Joshua tree (Yucca brevifolia: Agavaceae). Molecular Ecology 18:5218–5229.	Smith, C.I., C.S. Drummond, W. Godsoe, J.B. Yoder, and O. Pellmyr.	Host specificity and reproductive success of yucca moths (Tegeticula spp. Lepidoptera: Prodoxidae) mirror patterns of gene flow between host plant varieties of the Joshua tree (Yucca brevifolia: Agavaceae).	Molecular Ecology 18:5218–5229. (2009)
Smith, C.I., S. Tank, W. Godsoe, J. Levenick, E. Strand, T.C. Esque. 2011. Comparative phylogeography of a coevolved community: Concerted population expansions in Joshua trees and four yucca moths. PLoS One 6(10):1–18.	Smith, C.I., S. Tank, W. Godsoe, J. Levenick, E. Strand, T.C. Esque.	Comparative phylogeography of a coevolved community: Concerted population expansions in Joshua trees and four yucca moths.	PLoS One 6(10):1–18. (2011)
Smith, C.I., W. Godsoe, S. Tank, J.B. Yoder, and O. Pellmyr. 2008b. Distinguishing coevolution from covariance in an obligate pollination mutualism: Asynchronous divergence in Joshua tree and its pollinators. Evolution 62:2676–2687.	Smith, C.I., W. Godsoe, S. Tank, J.B. Yoder, and O. Pellmyr.	Distinguishing coevolution from covariance in an obligate pollination mutualism: Asynchronous divergence in Joshua tree and its pollinators.	Evolution 62:2676–2687. (2008b).
Smith, S.D., T.E. Huxman, S.F. Zitzer, T.N. Charlet, D.C. Housman, and J.S. Coleman. 2000. Elevated CO2 increases productivity and invasive species success in an arid ecosystem. Nature 408:79–82.	Smith, S.D., T.E. Huxman, S.F. Zitzer, T.N. Charlet, D.C. Housman, and J.S. Coleman.	Elevated CO2 increases productivity and invasive species success in an arid ecosystem.	Nature 408:79–82. (2000)
Smith, S.D., T.L. Hartsock, and P.S. Nobel. 1983. Ecophysiology of Yucca brevifolia, an arborescent monocot of the Mojave Desert. Oecologia 60:10–17.	Smith, S.D., T.L. Hartsock, and P.S. Nobel.	Ecophysiology of Yucca brevifolia, an arborescent monocot of the Mojave Desert.	Oecologia 60:10–17. (1983)
Southern California Association of Governments. SCAG. 2019. Local Profiles. http://www.scag.ca.gov/DataAndTools/Pages/LocalProfiles.aspx. [Accessed December 18, 2019].	Southern California Association of Governments. SCAG.	Local Profiles.	http://www.scag.ca.gov/DataAndTools/Pages/LocalProfiles.aspx. [Accessed December 18, 2019].
St. Clair, S.B. and J. Hoines. 2018. Reproductive ecology and stand structure of Joshua tree forests across climate gradients of the Mojave Desert. PLoS ONE 13:e0193248. https://doi.org/10.1371/journal.pone.0193248. [Accessed December 18, 2019].	St. Clair, S.B. and J. Hoines.	Reproductive ecology and stand structure of Joshua tree forests across climate gradients of the Mojave Desert	PLoS ONE 13:e0193248. (2018). https://doi.org/10.1371/journal.pone.0193248. [Accessed December 18, 2019].
Starr, T.N., K.E. Gadek, J.B. Yoder, R. Flatz, and C.I. Smith. 2013. Asymmetric hybridization and gene flow between Joshua trees (Agavaceae: Yucca) reflect differences in pollinator host specificity. Molecular Ecology 22:437-49.	Starr, T.N., K.E. Gadek, J.B. Yoder, R. Flatz, and C.I. Smith.	Asymmetric hybridization and gene flow between Joshua trees (Agavaceae: Yucca) reflect differences in pollinator host specificity.	Molecular Ecology 22:437-49. (2013)
Sugihara, N.G., J.W. VanWagtendonk, J. Fites-Kaufman. 2006. Fire as an ecological process. In Fire in California's Ecosystems. Eds N.G. Sugihara, J.W. van Wagtendonk, K.E. Shaffer, J. Fites-Kaufman, and A.E. Thode) pp. 58–74. University of California: Los Angeles, CA	Sugihara, N.G., J.W. VanWagtendonk, J. Fites-Kaufman.	Fire as an ecological process.	In Fire in California's Ecosystems. Eds N.G. Sugihara, J.W. van Wagtendonk, K.E. Shaffer, J. Fites-Kaufman, and A.E. Thode) pp. 58–74. University of California: Los Angeles, CA (2006)
Sweet, L.C., T. Green, J.G.C. Heintz, N. Frakes, N. Graver, J.S. Rangitsch, J.E. Rodgers, S. Heacox, and C.W. Barrows. 2019. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. Ecosphere 10:e02763. https://doi.org/10.1002/ecs2.2763. [Accessed December 18, 2019].	Sweet, L.C., T. Green, J.G.C. Heintz, N. Frakes, N. Graver, J.S. Rangitsch, J.E. Rodgers, S. Heacox, and C.W. Barrows.	Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park.	Ecosphere 10:e02763. (2019). https://doi.org/10.1002/ecs2.2763. [Accessed December 18, 2019].

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Syphard, A D., H. Rustigian-romsos, M. Mann, E. Conlisk, M.A. Moritz, and D. Ackerly. 2019. The relative influence of climate and housing development on current and projected future fire patterns and structure loss across three California landscapes. Global Environmental Change. 56:41–55.	Syphard, A D., H. Rustigian-romsos, M. Mann, E. Conlisk, M.A. Moritz, and D. Ackerly.	The relative influence of climate and housing development on current and projected future fire patterns and structure loss across three California landscapes.	Global Environmental Change. 56:41–55. (2019).
Syphard, A.D., J.E. Keeley, and J.T. Abatzoglou. 2017. Trends and drivers of fire activity vary across California aridland ecosystems. Journal of Arid Environments 144:110–122.	Syphard, A.D., J.E. Keeley, and J.T. Abatzoglou.	Trends and drivers of fire activity vary across California aridland ecosystems.	Journal of Arid Environments 144:110–122. (2017)
Tagestad J., M. Brooks, V. Cullinan, J. Downs, and R. Mckinley. 2016. Precipitation Regime Classification for the Mojave Desert: Implications for fire occurrence. Journal of Arid Environments 124:388–397.	Tagestad J., M. Brooks, V. Cullinan, J. Downs, and R. Mckinley.	Precipitation Regime Classification for the Mojave Desert: Implications for fire occurrence.	Journal of Arid Environments 124:388–397. (2016)
Thomas, K. 2002. Vegetation - Central Mojave Desert [ds166]. US Geological Survey. Retrieved from http://bios.dfg.ca.gov on December 12, 2019.	Thomas, K.	Vegetation - Central Mojave Desert [ds166].	US Geological Survey. (2002). Retrieved from http://bios.dfg.ca.gov on December 12, 2019.
Thomas, K., T. Keeler-Wolf, and J. Thorne. 2002. Central Mojave field data. A digital database (Access). USGS, Forest and Rangeland Ecosystem Science Center, Colorado Plateau Field Station, Flagstaff, Arizona, USA.	Thomas, K., T. Keeler-Wolf, and J. Thorne.	Central Mojave field data. A digital database (Access).	USGS, Forest and Rangeland Ecosystem Science Center, Colorado Plateau Field Station, Flagstaff, Arizona, USA. (2002)
Thompson, R.S. and K.H. Anderson. 2017. Past Climate and Vegetation Changes in the Southwestern United States (April 19, 2017). Retrieved from: https://geochange.er.usgs.gov/sw/impacts/biology/pastclim/	Thompson, R.S. and K.H. Anderson.	Past Climate and Vegetation Changes in the Southwestern United States (April 19, 2017).	Retrieved from: https://geochange.er.usgs.gov/sw/impacts/biology/pastclim/ (2017)
Thompson, R.S., S.W. Hostetler, P.J. Bartlein, and K.H. Anderson. 1998. A Strategy for Assessing Potential Future Changes in Climate, Hydrology, and Vegetation in the Western United States. U.S. Geological Survey Circular 1153. United States Government Printing Office, Washington.	Thompson, R.S., S.W. Hostetler, P.J. Bartlein, and K.H. Anderson.	A Strategy for Assessing Potential Future Changes in Climate, Hydrology, and Vegetation in the Western United States.	U.S. Geological Survey Circular 1153. United States Government Printing Office, Washington. (1998)
Torrey, J. 1856. Descriptions of the General Botanical Collections—No. 4, p. 147 in Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean. War Department; Route Near the Thirty-Fifth Parallel, Explored by Lieutenant A.W. Whipple, Topographical Engineers, in 1853 and 1854; Report on The Botany of the Exploration, Washington, D.C. 1856.	Torrey, J.	Descriptions of the General Botanical Collections—No. 4, p. 147 in Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean.	War Department; Route Near the Thirty-Fifth Parallel, Explored by Lieutenant A.W. Whipple, Topographical Engineers, in 1853 and 1854; Report on The Botany of the Exploration, Washington, D.C. 1856.
Trelease, W. 1892. Detail illustrations of Yucca. Mo. Bot. Gard. Annu. Rep. 15:9–166.	Trelease, W.	Detail illustrations of Yucca. Mo.	Bot. Gard. Annu. Rep. 15:9–166.
Trelease, W. 1893. Further Studies of Yuccas and Their Pollination. Missouri Botanical Garden Annual Report, Vol. 1893, pp. 181-226.	Trelease, W.	Further Studies of Yuccas and Their Pollination.	Missouri Botanical Garden Annual Report, Vol. 1893, pp. 181-226. (1893)
Turner, R.M. 1982. Mohave desert scrub. In D. Brown (ed.), Biotic Communities: Southwestern United States and Northwestern Mexico. Salt Lake City, UT: University of Utah Press.	Turner, R.M.	Mohave desert scrub. In D. Brown (ed.), Biotic Communities: Southwestern United States and Northwestern Mexico.	Salt Lake City, UT: University of Utah Press. (1982)
U.S. Air Force. USAF. 2015. Edwards Air Force Base Integrated Natural Resource Management Plan Final 2015-2019. Prepared by the 412th Civil Engineer Group Environmental Management Division Environmental Assets Branch. Edwards AFB, CA.	U.S. Air Force. USAF.	Edwards Air Force Base Integrated Natural Resource Management Plan Final 2015-2019.	Prepared by the 412th Civil Engineer Group Environmental Management Division Environmental Assets Branch. Edwards AFB, CA. (2015)
U.S. Air Force. USAF. 2010. Final Integrated Natural Resources Management Plan Nellis Air Force Base, Creech Air Force Base, and Nevada Test And Training Range, NV. Nellis Air Force Base, Nevada, 99th Civil Engineering Squadron, Environmental Management Flight	U.S. Air Force. USAF.	Final Integrated Natural Resources Management Plan Nellis Air Force Base, Creech Air Force Base, and Nevada Test And Training Range, NV.	Nellis Air Force Base, Nevada, 99th Civil Engineering Squadron, Environmental Management Flight. (2010)
U.S. Air Force. USAF. 2017a. Joshua Tree Historical Status on Edwards AFB. 412th Civil Engineering Group. Environmental Management Division. Edwards Air Force Base.	U.S. Air Force. USAF.	Joshua Tree Historical Status on Edwards AFB.	412th Civil Engineering Group. Environmental Management Division. Edwards Air Force Base. (2017a).
U.S. Air Force. 2017. USAF. Joshua Tree Survivorship and/or Regeneration in Fire Area on Edwards Air Force Base (AFB). Prepared by the 412th Civil Engineer Group Environmental Management Division Environmental Assets Branch. Edwards AFB, CA.	U.S. Air Force. USAF.	Joshua Tree Survivorship and/or Regeneration in Fire Area on Edwards Air Force Base (AFB).	412th Civil Engineer Group Environmental Management Division Environmental Assets Branch. Edwards AFB, CA. (2017)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
U.S. Army. 2006. Integrated Natural Resource Management Plan and Environmental Assessment, National Training Center and Fort Irwin, California. Natural and Cultural Resources Section Environmental Division Directorate of Public Works, Fort Irwin, CA.	U.S. Army.	Integrated Natural Resource Management Plan and Environmental Assessment, National Training Center and Fort Irwin, California.	Natural and Cultural Resources Section Environmental Division Directorate of Public Works, Fort Irwin, CA. (2006)
U.S. Energy Information Administration. USEIA. 2016b. Hydraulic fracturing accounts for about half of current U.S. crude oil production (March 15, 2016). https://www.eia.gov/todayinenergy/detail.php?id=25372. [Accessed December 18, 2019].	U.S. Energy Information Administration. USEIA.	Hydraulic fracturing accounts for about half of current U.S. crude oil production (March 15, 2016).	https://www.eia.gov/todayinenergy/detail.php?id=25372. [Accessed December 18, 2019]. (2016b).
U.S. Energy Information Administration. USEIA. 2016a. Hydraulically fractured wells provide two-thirds of U.S. natural gas production (May 5, 2016). https://www.eia.gov/todayinenergy/detail.php?id=26112. [Accessed December 18, 2019]	U.S. Energy Information Administration. USEIA.	Hydraulically fractured wells provide two-thirds of U.S. natural gas production	https://www.eia.gov/todayinenergy/detail.php?id=26112. [Accessed December 18, 2019] (2016a).
U.S. Environmental Protection Agency. 2009. Land-Use Scenarios: National-Scale Housing-Density Scenarios Consistent with Climate Change Storylines (Final Report). U.S. Environmental Protection Agency, Washington, DC; EPA/600/R-08/076F. Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea.	U.S. Environmental Protection Agency.	Land-Use Scenarios: National-Scale Housing-Density Scenarios Consistent with Climate Change Storylines (Final Report).	U.S. Environmental Protection Agency, Washington, DC; EPA/600/R-08/076F. (2009). Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea.
U.S. Fish and Wildlife Service. 2003. Recovery Plan for the Quino Checkerspot Butterfly (Euphydryas editha quino). Portland, Oregon. x + 179 pp.	U.S. Fish and Wildlife Service.	Recovery Plan for the Quino Checkerspot Butterfly (Euphydryas editha quino).	U.S. Fish and Wildlife Service. 2003. Portland, Oregon. x + 179 pp.
U.S. Fish and Wildlife Service. USFWS. 2019. Endangered and Threatened Wildlife and Plants; 12-Month Findings on Petitions to List Eight Species as Endangered or Threatened Species, 84 Fed. Reg. 41694 (August 15, 2019).	U.S. Fish and Wildlife Service. USFWS.	Endangered and Threatened Wildlife and Plants; 12-Month Findings on Petitions to List Eight Species as Endangered or Threatened Species	84 Fed. Reg. 41694 (August 15, 2019).
U.S. Fish and Wildlife Service. USFWS. 2016. Formal section 7 consultation (FWS-RN/SBD/INY/LA/IMP/RIV-16B0138-16F0200), Biological Opinion on the Proposed Land Use Plan Amendment under the Desert Renewable Energy Plan [1340 (CA 930) P, 1150 (CA 930) P]. Carlsbad, CA.	U.S. Fish and Wildlife Service. USFWS.	Formal section 7 consultation (FWS-RN/SBD/INY/LA/IMP/RIV-16B0138-16F0200), Biological Opinion on the Proposed Land Use Plan Amendment under the Desert Renewable Energy Plan	[1340 (CA 930) P, 1150 (CA 930) P]. Carlsbad, CA. (2016)
U.S. Fish and Wildlife Service. USFWS. 2018. Joshua Tree Species Status Assessment. Dated July 20, 2018. 113 pp. + Appendices A–C.	U.S. Fish and Wildlife Service. USFWS.	Joshua Tree Species Status Assessment.	Dated July 20, 2018. 113 pp. + Appendices A–C.
U.S. Forest Service. Undated. Wildflower Ethic and Native Plants. Available at: https://www.fs.fed. us/wildflowers/ethics/index.shtml.	U.S. Forest Service	Wildflower Ethic and Native Plants	Available at: https://www.fs.fed. us/wildflowers/ethics/index.shtml (Undated)
U.S. Geological Survey. USGS. 2004. Precipitation History of the Mojave Desert Region, 1893–2001. USGS Fact Sheet 117-03, Richard Hereford, Robert H. Webb, and Claire I. Longpre. Downloaded from https://pubs.usgs.gov/fs/fs117-03/ on February 14, 2018.	U.S. Geological Survey. USGS.	Precipitation History of the Mojave Desert Region, 1893–2001.	USGS Fact Sheet 117-03, Richard Hereford, Robert H. Webb, and Claire I. Longpre (2004). Downloaded from https://pubs.usgs.gov/fs/fs117-03/ on February 14, 2018.
U.S. Global Change Research Program. 2017. Climate Science Special Report, Fourth National Climate Assessment, Volume I. https://science2017.globalchange.gov/. [Accessed December 18, 2019].	U.S. Global Change Research Program.	Climate Science Special Report, Fourth National Climate Assessment, Volume I.	Fourth National Climate Assessment, Volume I (2017). https://science2017.globalchange.gov/. [Accessed December 18, 2019].
U.S. Global Change Research Program. USGCRP. 2018. Impacts, Risks, and Adaptation in the United States, Fourth National Climate Assessment, Volume II. https://nca2018.globalchange.gov/. [Accessed December 18, 2019].	U.S. Global Change Research Program. USGCRP.	Impacts, Risks, and Adaptation in the United States	Fourth National Climate Assessment, Volume II (2018). https://nca2018.globalchange.gov/. [Accessed December 18, 2019].
U.S. Navy. 2014. Integrated Natural Resource Management Plan, Naval Air Weapons Station China Lake, California. Prepared by:Tierra Data, Inc., Escondido, CA.	U.S. Navy.	Integrated Natural Resource Management Plan, Naval Air Weapons Station China Lake, California.	Prepared by:Tierra Data, Inc., Escondido, CA. (2014)
Vamstad, M.S. and J.T. Rotenberry. 2010. Effects of fire on vegetation and small mammal communities in a Mojave Desert Joshua tree woodland. Journal of Arid Environments. 74:1309–1318.	Vamstad, M.S. and J.T. Rotenberry.	Effects of fire on vegetation and small mammal communities in a Mojave Desert Joshua tree woodland.	Journal of Arid Environments. 74:1309–1318. (2010)
Vander Wall, S.B., T. Esque, D. Haines, M. Garnett, and B. Waitman. 2006. Joshua tree (Yucca brevifolia) seeds are dispersed by seed-caching rodents. Ecoscience 13:539–543.	Vander Wall, S.B., T. Esque, D. Haines, M. Garnett, and B. Waitman.	Joshua tree (Yucca brevifolia) seeds are dispersed by seed-caching rodents.	Ecoscience 13:539–543. (2006)

REFERENCE (Full Cite)	REFERENCE AUTHOR(S)	REFERENCE TITLE	REFERENCE PUBLICATION
Waitman, B.A., S.B. Vander Wall, and T.C. Esque. 2012. Seed dispersal and seed fate in Joshua tree (Yucca brevifolia). Journal of Arid Environments 81:1–8.	Waitman, B.A., S.B. Vander Wall, and T.C. Esque.	Seed dispersal and seed fate in Joshua tree (Yucca brevifolia)	Journal of Arid Environments 81:1–8. (2012)
Wallace, A. and E.M. Romney. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. Rep. TID25954. Washington, DC. U.S. Atomic Energy Commission, Office of Information Services. 439 pp.	Wallace, A. and E.M. Romney.	Radioecology and ecophysiology of desert plants at the Nevada Test Site. Rep. TID25954. Washington, DC.	Atomic Energy Commission, Office of Information Services. 439 pp. (1972)
Wallace, G. 2017. WEG 2015 petition to list Yucca brevifolia. U.S. Fish and Wildlife Service White Paper, 6 pp. Carlsbad, CA.	Wallace, G.	WEG 2015 petition to list Yucca brevifolia.	U.S. Fish and Wildlife Service White Paper, 6 pp. Carlsbad, CA. (2017)
Warren, R., J. Price, A. Fischlin, S. de la Nava Santos, and G. Midgley. 2011. Increasing impacts of climate change upon ecosystems with increasing global mean temperature rise. Climatic Change 106:141–177.	Warren, R., J. Price, A. Fischlin, S. de la Nava Santos, and G. Midgley.	Increasing impacts of climate change upon ecosystems with increasing global mean temperature rise.	Climatic Change 106:141–177. (2011)
Webb, R.H., M.B. Murov, T.C. Esque, D.E. Boyer, L.A. DeFalco, D.F. Haines, D. Oldershaw, S.J. Scoles, K.A. Thomas, J.B. Blainey, and P.A. Medica. 2003. Perennial vegetation data from permanent plots on the Nevada Test Site, Nye County, Nevada. Open-File Report 03-336. USGS,Washington, D.C., USA.	Webb, R.H., M.B. Murov, T.C. Esque, D.E. Boyer, L.A. DeFalco, D.F. Haines, D. Oldershaw, S.J. Scoles, K.A. Thomas, J.B. Blainey, and P.A. Medica	Perennial vegetation data from permanent plots on the Nevada Test Site, Nye County, Nevada.	Open-File Report 03-336. USGS,Washington, D.C., USA. (2003)
Webber, J.M. 1953. Yuccas of the Southwest. Agriculture Monograph No. 17. Washington, DC: U.S. Department of Agriculture, Forest Service. 97 pp.	Webber, J.M.	Yuccas of the Southwest. Agriculture Monograph No. 17.	Agriculture Monograph No. 17. Washington, DC: U.S. Department of Agriculture, Forest Service. 97 pp. (1953)
Went, F.W. 1957. The experimental control of plant growth. Chronica Botanica Volume 17. Waltham, MA: Chronica Botanica.	Went, F.W.	The experimental control of plant growth.	Chronica Botanica Volume 17. Waltham, MA: Chronica Botanica. (1957)
Went, F.W. 1948. Ecology of desert plants. I. Observations on germination in the Joshua Tree National Monument, California. Ecology 29(3):242–253.	Went, F.W.	Ecology of desert plants. I. Observations on germination in the Joshua Tree National Monument, California.	Ecology 29(3):242–253. (1948)
Wiens, J. J. 2016. Climate-related local extinctions are already widespread among plant and animal species. PLoS Biology 14(12):1–18.	Wiens, J. J.	Climate-related local extinctions are already widespread among plant and animal species.	PLoS Biology 14(12):1–18. (2016)
Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: Why recovery under the Endangered Species Act is more than population viability. BioScience 65(2):200–207	Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald.	Beyond PVA: Why recovery under the Endangered Species Act is more than population viability.	BioScience 65(2):200–207 (2015)
World Meteorological Organization. WMO. 2018. Statement on the State of the Global Climate in 2017. WMO-No. 1212, World Meteorological Organization, Geneva, Switzerland.	World Meteorological Organization. WMO.	Statement on the State of the Global Climate in 2017.	WMO-No. 1212, World Meteorological Organization, Geneva, Switzerland. (2018)
Yoder, J.B., C.I. Smith, D.J. Rowley, R. Flatz, W. Godsoe, C. Drummond, and O. Pellmyr. 2013. Effects of gene flow on phenotype matching between two varieties of Joshua tree (Yucca brevifolia, Agavaceae) and their pollinators. Journal of Evolutionary Biology 26:1220–1233.	Yoder, J.B., C.I. Smith, D.J. Rowley, R. Flatz, W. Godsoe, C. Drummond, and O. Pellmyr.	Effects of gene flow on phenotype matching between two varieties of Joshua tree (Yucca brevifolia, Agavaceae) and their pollinators.	Journal of Evolutionary Biology 26:1220–1233. (2013)

Heritage Environmental Consultants Technical Memorandum on Review of Scientific Basis for Listing the Western Joshua Tree as Threatened Under the California Endangered Species Act Dated August 5, 2020

Technical Memorandum

Prepared For: County of San Bernardino

Prepared By: Heritage Environmental Consultants

Subject: Review of scientific basis for listing the western Joshua tree as threatened under the California Endangered Species Act

Date: August 5, 2020

Background

On October 15, 2019, the Center for Biological Diversity (CBD) submitted a petition to the California Fish and Game Commission to list the western Joshua tree as threatened under the California Endangered Species Act (CESA) (CBD 2019). In February 2020, the California Department of Fish and Wildlife (CDFW) completed a review of the petition, as well as other scientific information available to CDFW. In its review, CDFW determined that "the petition provides sufficient scientific information to indicate that the petitioned action may be warranted" and recommended that the commission "accept the petition for further consideration under CESA" (CDFW 2020a). In the event that the commission accepts the petition, YUBR would become a candidate species for listing as threatened under CESA.

Petition Review

Heritage Environmental Consultants was asked to review existing information and provide expert opinion regarding the scientific basis for listing YUBR as threatened under the CESA. We began by reviewing the petition itself (CBD 2019) and CDFW's subsequent review of the petition (CDFW 2020a). We also reviewed supporting literature cited in these documents to the extent that they were readily available. The following sections provide review comments following the same outline as CBD's petition.

Taxonomy

The current accepted taxonomy of the Joshua tree is a single species (*Yucca brevifolia*) with two varieties (*Y. b.* var. *brevifolia*, western Joshua tree) and (*Y. b.* var. *jaegeriana*, eastern Joshua tree) (Integrated Taxonomic Information System 2020).

The CESA defines a threatened species (California Fish and Game Code, Section 2067, in part) as:

> "…a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered

> species in the foreseeable future in the absence of the special protection and management efforts…"

Note that this definition does not explicitly provide for listing of a plant at the varietal level, only at the species or subspecies level. A strict interpretation of the accepted taxonomy would be that the western Joshua tree, as *Y. b.* var. *brevifolia*, is not eligible for CESA listing as threatened separately from its parent species, *Y. brevifolia*. Candidate species and endangered species are similarly defined.

The listing petition (CBD 2019) suggests that the Joshua tree is better viewed as two distinct species (*Y. brevifolia*, western Joshua tree) and (*Y. jaegeriana*, eastern Joshua tree). This approach is supported by Lenz (2007), who described the two species as distinct based on geographical distribution as well as differences in morphology and obligate pollinators. Recent genetic investigations (Royer and others 2016) also support the concept of the Joshua tree as two distinct species.

The National Plant Materials Manual (Natural Resource Conservation Service 2010), Section 542.2 provides the following definitions:

> "The terms 'subspecies' and 'variety' are used to designate the first and second divisions of a species. A subspecies is a grouping within a species used to describe geographically isolated variants, a category above variety… A variety consists of more or less recognizable entities within species that are not genetically isolated from each other, below the level of subspecies…"

Considering that the western and eastern Joshua trees are more or less geographically isolated (Lenz 2007), and more or less genetically isolated (Royer and others 2016), it would be reasonable to argue that these two taxa are at least subspecies if not distinct species and, therefore, eligible for listing under the CESA as threatened. In addition, it appears that other varieties of plants have been listed under the CESA in the past, based on the 44 varieties of plants (out of a total of 222 state-listed taxa) on the current list (CDFW 2020b).

The U. S. Fish and Wildlife Service (USFWS) (2018), in its status assessment of the Joshua tree, acknowledged that the western and eastern Joshua trees are distinct species. Our review accepts the results of Lenz (2007), Royer and others (2016), and the USFWS (2018), referring in the remainder of this memo to the western Joshua tree (*Yucca brevifolia*) (YUBR) as a species distinct from the eastern Joshua tree (*Yucca jaegeriana*) (YUJA).

Life History

Most aspects of the life history of YUBR have been well-researched and are generally accepted. Flowering, seed production, dispersal, predation, germination, and growth are generally understood, although several points are worth noting, as follows.

Seed production is an episodic event, correlated with increased winter and spring precipitation. Sufficient moisture is also required for establishment and survival of young YUBR. In a desert environment, conditions for recruitment of YUBR seedlings may only occur a few times in a century and no seed production or seedling survival can be expected in drought years. Esque and others (2015) documented growth and survivorship of a cohort of YUBR that established in 1983-1984, a period of high precipitation. St. Clair and Hoines (2018) documented a widespread event of flowering and seed production across the range of YUBR and YUJA in 2013, although they did not report subsequent establishment or survival of young Joshua trees.

Individual YUBR cannot be aged in the same way as true trees because they lack annual growth rings. In previous studies (for example, Esque and others 2015), height has been used as a surrogate for age on the assumption that larger individuals are older. While this approach is conceptually valid, a high degree of variability exists such that only broad generalizations are possible and precise aging is not. Esque and others (2015) identified a growth rate (with standard deviation) of 3.12 ± 1.96 cm/year for individuals in their 22-year study, a result that is similar to other recent studies they reviewed. This means that a 1-meter-tall individual could be somewhere between about 20 and 86 years old and suggests that any estimate of the demographic structure of Joshua tree populations contains a high degree of uncertainty.

CBD (2019, page 12) asserts that a "…demographic change to low recruitment is already underway" based on an assumption of low and infrequent recruitment of YUBR, exacerbated by climate change. Considering that seedling recruitment is a rare event, and that age structure in the existing population is not well defined, it is questionable whether a demographic shift (reduced frequency of younger YUBR) has actually occurred. Esque and others (2015) noted that the cohort of individuals established in 1983-1984 had not yet reached reproductive age, which they estimate to be 50 to 70 years, and that this cohort may lead to an increase in reproductive individuals in the future. A similar cohort may have developed following the reproductive event in 2013 documented by St. Clair and Hoines (2018). The work of Sweet and others (2019), which CBD (2019, page 12) cites to show that a shift to low recruitment has occurred, does not in fact demonstrate this shift. Sweet and others (2019) show that some sites at Joshua Tree National Park (JTNP) exhibit low recruitment, while others exhibit high recruitment. It appears that CBD's assertion of low recruitment is based on a subset of sites at JTNP and not on any more general observations of low recruitment. In fact, the existing literature provides support for high (or at least not low) recruitment at some sites in JTNP (Sweet and others 2019), in southern Nevada (Esque and other 2015), and across the range of both YUBR and YUJA (St. Clair and Hoines 2018).

Current and Historical Distribution

The current range of YUBR is essentially the same as its historical distribution (post-European contact), demonstrating that human actions have not affected its distribution at present. Cole and others (2011) reported model results that indicate the potential for future reductions in the southern portion of the range caused by warmer temperatures associated with climate change. This same model showed a substantial northward expansion of suitable habitat, albeit without consideration of the dispersal ability of YUBR, which is thought to be slow.

It has been suggested that the range of YUBR can be divided into two populations, YUBR North and YUBR South, along with a small hybrid population (USFWS 2018). The separation between YUBR North and YUBR South is a relatively short distance ("a small gap", CBD 2019, page 64) that appears similar to some within-population gaps (CBD 2019, page 17, Figure 8). Most studies do not use this division within YUBR, and some (for example, Royer and others 2016,

Figure 1) map the range of YUBR as continuous between the two purported populations. The USFWS (2018) provides little support for the delineation of YUBR North and YUBR South populations, other than citing Rowlands (1978, in USFWS 2018) and Cole and others (2011).

Habitat differences have been suggested between the two populations, with more creosote bush in the south, and more pinyon pine, juniper, and sagebrush in the north. No evidence was provided to show that this gradient causes any sort of separation between the two purported populations, other than being a convenient correlation. Other differences between populations, in terms of temperature and precipitation, show substantial overlap and are not likely to be statistically valid.

Royer and others (2016) examined the genetic variation between YUBR and YUJA, as well as within populations of both species. They found that while there is significant genetic divergence between YUBR and YUJA, there is very low divergence among populations within each species. This result supports the concept of YUBR as a single population with a number of separate, but genetically similar, occurrences separated by areas of unsuitable habitat.

Abundance and Population Trends

The petition stated that "a reliable estimate of Joshua tree population size is not available" and that "no range-wide population trends have been documented" (CBD 2019, page 19). Similarly, the USFWS (2018) listed several uncertainties in the best available information on Joshua tree abundance and populations, including:

- Population abundance and trends
- Regional population structure and connectivity
- Natural variability in demographic vital rates across the range
- Effective population size
- Joshua tree population structure's influence on dispersal of yucca moths
- Joshua tree occupancy and distribution within the current mapped (modeled) distribution
- Effects of an altered fire regime on demographic vital rates
- Relationship between recruitment rates and changing environmental conditions (e.g., increasing temperatures and altered drought patterns)
- Urban area influence on demographic vital rates and population structure
- Grazing effects on Joshua tree populations
- Yucca moth population abundance and trends

Estimates of population abundance and trend typically form an important part of the basis for listing recommendations and decisions. We examined several recent species status reviews and listing petitions, including those for Clara Hunt's milkvetch (*Astragalus claranus*) (CDFW 2019a), Shasta snow-wreath (*Neviusia cliftonii*) (Roche 2019), Lassics lupine (*Lupinus constancei*) (CBD 2016), and coast yellow leptosiphon (*Leptosiphon croceus*) (Corelli 2016). While each of these documents is somewhat different in content, detailed information on distribution and abundance of each of these species was provided. In every case, not only were data on population abundance and trends provided, but the species in question were limited in distribution, limited in the number of occurrences, and limited in abundance of individuals within occurrences and range-wide. This provides a strong contrast with YUBR, which lacks robust data on population abundance and trends, but is known to occur in large numbers across an extensive range.

Lacking any range-wide information on population or abundance, the petition referred to several studies at Joshua Tree National Park (JTNP) to demonstrate that recruitment is limited and mortality is increasing, as well as showing a correlation between higher temperatures and lower density, and contraction of the species' range at lower elevations. CBD (2019) asserted that these results all point to a population in decline.

One study by DeFalco and others (2010) examined the effects of wildfire and drought on YUBR in a portion of JTNP. This study found that many (80%) burned individuals died, as did some (26%) unburned individuals. Another study by Cornett (2014) documented a decline of 33% in the number of YUBR on one site at JTNP and mentioned two previous similar studies by the same author showing declines of 16% and 73% (caused in part by wildfire) at two other sites. Note the petition (CBD 2019, page 20) contains an error, listing this decline as 93%, not the 33% reported by Cornett (2014).

It is important to note that the studies referenced by CBD were all conducted at JTNP, which is located at the extreme southern edge of YUBR's current and historical range, at the transition between the Mojave Desert to the north and the hotter, drier Sonoran Desert to the south. Study results from JTNP may not accurately represent population trends farther north in the species' range, where conditions may be cooler and wetter.

A third study (Harrower and Gilbert 2018) referred to in the petition to support the assertion of a declining population reported that mortality of YUBR was highest at lower, warmer, drier sites. This study also reported that abundance and performance (in terms of reproductive output) peaked at intermediate (cooler, wetter) elevations. Sweet and others (2019) obtained similar results. While these studies were conducted across an elevational gradient at JTNP, they support the concept that population abundance and trends observed at the warmer and drier southern edge of YUBR's range may not be representative of abundance and trend in the middle or northern parts of its range, where temperatures are generally cooler and precipitation generally higher.

CDFW (2020a) cited two studies at Edwards Air Force Base, near the center of the range of YUBR, which appeared to show stable or increasing populations, although at least one of these studies was not without some uncertainty. CDFW (2020a, page 13) stated that "the range, distribution, and density information available to the Department indicates that the abundance of western Joshua tree is currently relatively high". St. Clair and Hoines (2018) found that population density of YUBR was higher at cooler sites, and lower at hotter sites (including two sites at JTNP), but they did not find any significant correlations between density and precipitation.

Without robust range-wide abundance and population trend data, it is uncertain what the actual abundance and population trends are for YUBR; however, a rough estimate can be made using the limited existing data on plant density and suitable habitat. Across all five sites (and with six transects per site) within the range of YUBR that were studied by St. Clair and Hoines (2018), the average density of YUBR was about 135 individuals per hectare. The USFWS (2018) reported mean densities of about 95 per hectare at JTNP (ranging from 4 to 112 per hectare) and 62 per hectare at Death Valley National Park (ranging from 4 to 340 per hectare). Based on these limited data, a conservative range-wide density estimate may be 60 individuals per hectare.

The USFWS (2018) used habitat as a proxy for population distribution and abundance, equating larger, more diverse, more secure, and less disturbed habitat patches with higher potential for those patches to promote long-term persistence of the species. The USFWS (2018) estimated that about 2.1 million hectares within the range of YUBR may support its habitat requirements and that about 724,000 of those hectares may provide substantial management or conservation potential. No data exist on how much of this area is actually occupied by YUBR; however, if we assume that 10% to 50% of the suitable habitats with conservation potential are occupied, and that 5% to 25% of other suitable lands are occupied, using a density of 60 individuals per hectare yields an estimate of between 8,472,000 and 42,360,000 individuals of YUBR across its range. This estimate is best regarded as speculative, given the lack of existing data and broad assumptions it requires; however, it demonstrates the potential abundance of YUBR.

The USFWS (2018) did not attempt a similar estimate, but concluded that the species currently has a broad distribution across a diversity of large, intact habitats. The USFWS (2018) used this distribution and abundance of habitats to infer that populations of the Joshua tree (both YUBR and YUJA) currently have a high capacity to withstand or recover from stochastic disturbance events, recover from catastrophic events, and adapt to changing conditions. After examining potential threats to the future viability of YUBR and YUJA, the USFWS (2018) concluded that "because of their wide-spread distributions and adaptive capability, both species would likely continue to include a large number of individuals distributed across a regional landscape-scale area with high ecological diversity and large areas that are conserved or restricted from development."

Factors Affecting Ability to Survive and Reproduce

The petition states that factors including climate change, predation, invasive species, wildfires, and habitat loss to development "collectively threaten the continued viability of the species" (CBD 2019, page 20). This is a bold statement considering the lack of population abundance and trend data, much less the level of demographic data needed to truly assess long-term viability of the species across its range. Regardless of the extent to which they could affect the viability of YUBR in the future, these factors appear valid in a general sense. Further discussion of some of these factors is provided below.

The petition states that "climate change represents the single greatest threat to the continued existence of *Yucca brevifolia*" and describes the existing literature on climate change and its potential effects on the Joshua tree (CBD 2019, pages 32 to 45). The climate models described in the literature (for example, Cole and others 2011, Sweet and others 2019) agree in a general sense that the range of YUBR is likely be substantially reduced in the future, particularly at its southern edge. Combined with its apparently slow natural dispersal ability, it is reasonable to assume that the overall distribution of YUBR (and correspondingly its abundance) will shrink in the future with a warming climate. Studies have shown a similar response in other plant species that are long-lived and exhibit slow dispersal (for example, Krapek and Buma 2018).

It is important to note that even under severe climate scenarios, refugia would remain and total extirpation of YUBR from JTNP is not predicted (Sweet and others 2019). However, the smaller populations that will inhabit these refugia, and other likely refugia across the species' range, will be more vulnerable to other threats than the larger, more widespread, existing populations.

JTNP has hosted several large wildfires in recent years. It appears that most of the recent studies on the effects of fire on YUBR (for example, DeFalco and others 2010) were carried out at JTNP and showed a significant reduction in the local population in burned areas. The petition (CBD 2019, pages 24 to 31) discussed the effects of fire on the Joshua tree and its habitats, as well as the increasing frequency of fires in the Mojave Desert exacerbated by increased human population and invasive grasses. The petition used this discussion to suggest that wildfire poses a significant risk to the species; however, it appears that the recent large fires at JTNP represent a local anomaly and not a range-wide trend.

Brooks and Minnich (in press) reviewed recent fire records for the deserts of California and concluded that although fire frequency and burned area had increased, the proportion of total area burned by year remained very small. In the Mojave Desert ecoregion, which encompasses all of YUBR South (including JTNP) and part of YUBR North, 0.047% of the area burned per year, suggesting a fire return interval of about 2,128 years. In the SE Great Basin ecoregion, which encompasses the remainder of YUBR North, 0.023% of the area burned per year and the estimated fire return interval was about 4,348 years. CDFW (2020a) cited a study at Edwards Air Force Base that showed a stable long-term local population following wildfire.

The USFWS (2018, page 68 to 71) examined future effects of invasive grasses and altered fire regimes on YUBR under two future climate scenarios: a "low" emission Scenario 1; and a "medium-high" emission Scenario 2. Under Scenario 1, an estimated 1% of YUBR South and 3.9% of YUBR North would be vulnerable to an altered fire regime (larger, more frequent fires and higher burn severity). Under Scenario 2, an estimated 1.4% of YUBR South and 8.8% of YUBR North would be vulnerable to an altered fire regime. Collectively, these results suggest that although the recent fires at JTNP may have had a significant effect on YUBR locally, and there are predictions of altered fire regimes more broadly, wildfires do not present a substantial risk across the range of the species.

Habitat loss is another threat to YUBR; however, the extent of this threat is uncertain. The petition stated that an estimated 41.6% of suitable habitat in the YUBR South population would be lost to development by 2095 (CBD 2019, page 46), based on an U. S. Environmental Protection Agency (EPA) model used by the USFWS (2018). It is important to note that this was one of two different model results developed by the USFWS (2018). The other result showed habitat loss of 21.7% in YUBR South. Habitat loss was estimated at 0.6% or 0.7% in YUBR North, depending on scenario; thus, habitat loss across the range of YUBR was estimated at 13.8% under Scenario 1 and 26.3% under Scenario 2 (USFWS 2018, page 83).

The petition (CBD 2019, page 46) states that the modelling conducted by the USFWS (2018) only considered residential development, not industrial, military, or other development and likely underestimates total development. While it is correct that the modelling only estimated residential development, the USFWS (2018, page 83) included renewable energy development (the most land-intensive potential development) in its estimates of habitat loss.

Considering the near doubling of the estimated habitat loss between the two scenarios, it may be best to view these results as speculative or at least highly uncertain. In its sensitivity testing of the demographic model, with regard to differences between its model and state-level growth models, the EPA (2009, page B-6) noted that because its "…model was designed to be a relatively simple national model, it was not possible to include some of the specialized local details that the states included in their projections." While growth has certainly occurred in the range of YUBR, and it is reasonable to expect that more will occur in the foreseeable future, factors such as the increasingly hot desert climate, lack of water, distance from the greater Los Angeles area (as a source of jobs), and perhaps others suggest that projections of extensive development in the range of YUBR need to be questioned.

Inadequacy of Existing Regulatory Mechanisms

While existing regulatory mechanisms that protect YUBR as a species may be limited at the state and federal levels, it is unclear how a CESA listing would lead to a substantial change in the current situation. For example, the petition acknowledged climate change as the greatest risk and that "ultimately the species cannot be saved absent global action to reduce such emissions" (CBD 2019, page 48). A CESA listing of YUBR would have little or no bearing on efforts to reduce carbon emissions at a national or global scale.

The CESA has no legal standing on federal lands, which make up 48% of the south population area and 96% of the north population area (USFWS 2018). In practice, state-listed species are sometimes considered during analyses of federal projects under the National Environmental Policy Act (NEPA); however, there is no requirement for such consideration. The federal entities that manage lands in the range of YUBR include the Bureau of Land Management, National Park Service, U. S. Forest Service, and Department of Defense. Each of these entities have laws, regulations, or policies that protect the Joshua tree and its habitats (USFWS 2018, Table 3, pages 42 to 43).

The petition gives relatively little space to local ordinances, although it does list Hesperia, Palmdale, Victorville, Yucca Valley, and Los Angeles and San Bernardino Counties as local jurisdictions that have plant protection ordinances or similar measures (CBD 2019, page 53). At the level of this review, these ordinances were not reviewed to determine if they "nominally protect" YUBR, or if in fact they provide substantial protections within the limits of local control over private land use.

The petition suggested that CESA listing would bring focus to preservation of YUBR and its habitat for projects analyzed pursuant to the California Environmental Quality Act (CEQA). While listing may increase findings of significance on the basis of effects to YUBR, this may not necessarily equate to a reduction of effects to YUBR because agencies can still approve projects that may have a significant effect, as acknowledged in the petition (CBD 2019, page 55).

Recommended Management and Recovery Actions

The list of recommended management and recovery actions (CBD 2019, page 65), while ambitious, is notable in that only one (a recovery plan) is directly related to CESA listing. The remainder could easily be enacted independently, although a CESA listing may provide focus for

YUBR and increase the priority for such actions. CDFW (2020a, page 27) noted that "some of the suggestions are not within the Department's jurisdiction."

Conclusions

Several broad, general conclusions can be drawn from our review of the petition, related documents, and the available literature.

- YUBR is a valid taxon, suitable for listing consideration under the CESA.
- YUBR is widespread and abundant, at least relative to other plant species being considered for listing, or already listed, under the CESA.
- Significant gaps exist in the scientific understanding of trends in abundance, demographics, and viability of YUBR.
- Reproductive events are uncommon, but have been documented in at least some portion of YUBR's range at least twice in the last 50 years.
- Climate change appears likely to reduce the range of YUBR, particularly at its southern edge; however, suitable habitats will remain in refugia and more broadly at its northern extent.
- Wildfire, invasive species, and habitat loss are threats to YUBR; however, they are currently relatively minor threats in central and northern portions of its range.
- There is uncertainty as to how relevant these threats may become to the continued viability of YUBR in the foreseeable future.

The ultimate question to be answered by this review is whether the existing scientific information in CBD's petition and the supporting literature demonstrate that YUBR, "…although not presently threatened with extinction, is <u>likely</u> to become an endangered species in the <u>foreseeable future</u> in the absence of the <u>special protection and management efforts</u>…" (California Fish and Game Code Section 2067, in part, emphasis added).

Other entities have examined the rarity and threats to YUBR and found that it is not at sufficiently high risk at this time to warrant special status. The USFWS (2019) determined that YUBR is not "…in danger of extinction or likely to become so within the foreseeable future throughout all or a significant portion…" of its range and declined to list YUBR as either threatened or endangered at the federal level. The California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants of California, which is considered a definitive source on the rarity of plants in the state, lists the Joshua tree as "Considered But Rejected" because it is "too common" (CNPS 2020).

It appears that CDFW previously defined "foreseeable future" to include the contemplated timeline in the petition, which examines climate change modeling through the end of the 21st century (CBD 2019, page 63). In this case, the prolonged timeline complicates some of the questionable assumptions raised above, and increases the substantial uncertainty as to the actual effects of some threats to YUBR, such as wildfire and human development, particularly at the farther reaches of the foreseeable future. It may be that these threats, while seemingly real at present, would not reach the level of actually threatening the viability of YUBR for an uncertain and perhaps lengthy period of time, if at all.

The conclusion to the petition makes sweeping statements about the listing of YUBR as a symbolic action, as "an emblem of our society's failure to address the climate crisis" (CBD 2019, page 66). It should be noted that symbolism is not one of the criteria used to consider listings under the CESA. Nor is symbolism a noteworthy scientific principle. A symbolic listing of YUBR would likely divert staff time and funding to special protection and management actions. There are 286 taxa of federally- and/or state-listed plants in the state of California, including 100 taxa that are only listed by the state (CDFW 2020b). In addition, there are 168 taxa of federally- and/or state-listed wildlife in the state of California, including 39 taxa that are only listed by the state (CDFW 2019). The great majority of these taxa are more rare, and more likely to be threatened with extinction, than YUBR. Yet, a listing of YUBR would likely draw some staff resources and funding away from these other species, increasing their risk of extinction. While admittedly the CESA contains no provision for weighing risk of extinction of other species in a listing decision, it is a valid question to ask if a symbolic listing is worth that risk.

Based on our review of CBD's petition and the existing scientific literature, we believe that it may not be appropriate to list YUBR as threatened under the CESA at this time. We believe the petition does not sufficiently demonstrate that YUBR is likely to become an endangered species in the foreseeable future, particularly given the lack of information on abundance and population trends across its range, as well as the broad areas of its range that are conserved or restricted from development. This conclusion was supported by the USFWS (2019), which declined to list the species as threatened or endangered at the federal level, and by the CNPS (2020), which declined to add the species to its Inventory of Rare and Endangered Plants because it is too common.

References

Brooks, M. L., and R. A. Minnich. In press. Fire in the Southeastern Deserts Bioregion. *In*: Van Wagtendonk, J. W., N. G. Sugihara, S. L. Stephens, A. E. Thode, K. E. Shaffer, and J. A. Fites-Kaufman (editors). Fire in California's Ecosystems. 2nd Edition. University of California Press. Available online at: https://www.nps.gov/moja/learn/nature/upload/desert%20fire%20book%20chapter_Brooks%20and%20Minnich.pdf. Accessed July 23, 2020.

California Department of Fish and Wildlife. 2020a. Evaluation of a petition from the Center for Biological Diversity to list the western Joshua tree (Yucca brevifolia) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178625&inline. Accessed June 9, 2020.

California Department of Fish and Wildlife. 2020b. State and Federally Listed Endangered, Threatened, and Rare Plants of California. January 2, 2020.

California Department of Fish and Wildlife. 2019a. Five-year status review of the Clara Hunt's milkvetch (*Astragalus claranus*). Report to the Fish and Game Commission. September

2019. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=177476&inline. Accessed July 22, 2020.

California Department of Fish and Wildlife. 2019b. State and Federally Listed Endangered, Threatened Animals of California. August 7, 2019.

California Native Plant Society. 2020. Inventory of Rare and Endangered Plants of California. Available online at: http://www.rareplants.cnps.org. Accessed June 9, 2020.

Center for Biological Diversity. 2019. A petition to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175218&inline. Accessed June 3, 2020.

Center for Biological Diversity. 2016. Petition to the State of California Fish and Game Commission to list the Lassics lupine (*Lupinus constancei*) as endangered under the California Endangered Species Act. July 14, 2016. Available online at: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165478&inline. Accessed July 22, 2020.

Corelli, T. 2016. A petition to the State of California Fish and Game Commission to list the coast yellow leptosiphon (*Leptosiphon croceus*) as endangered. May 23, 2016. Available online at: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165474&inline. Accessed July 22, 2020.

Cornett, J. W. 2014. Population dynamics of the Joshua tree (*Yucca brevifolia*): twenty-three year analysis, Lost Horse Valley, Joshua Tree National Park. In R. E. Reynolds (editor): Not a Drop Left to Drink: California State University Desert Studies Center, 2014 Desert Symposium. Pages 71 to 73.

DeFalco, L. A., T. C. Esque, S. J. Scoles-Sciulla, and J. Rodgers. 2010. Desert wildfire and severe drought diminish survivorship of the long-lived Joshua tree (*Yucca brevifolia*; Agavaceae). American Journal of Botany 97(2): 243-250.

Esque, T. C., P. A. Medica, D. F. Shryock, L. A. DeFalco, R. H. Webb, and R. B. Hunter. 2015. Direct and indirect effects of environmental variability on growth and survivorship of pre-reproductive Joshua trees, *Yucca brevifolia* Engelm. (Agavaceae). American Journal of Botany 102(1): 85-91.

Harrower, J., and G. S. Gilbert. 2018. Context-dependent mutualisms in the Joshua tree–yucca moth system shift along a climate gradient. Ecosphere 9(9): 1-17.

Integrated Taxonomic Information System. 2020. *Yucca brevifolia* Engelm. Available online at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=565605#null. Accessed July 22, 2020.

Krapek, J., and B. Buma. 2018. Limited stand expansion by a long-lived conifer at a leading northern range edge, despite available habitat. Journal of Ecology 106: 911-924.

Lenz, L. W. 2007. Reassessment of *Yucca brevifolia* and recognition of *Y. jaegeriana* as a distinct species. Aliso: A Journal of Systematic and Evolutional Biology 24(1): 97-104.

Heritage Environmental Consultants, Technical Memorandum on Scientific basis for listing the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act dated June 10, 2020

Technical Memorandum

Prepared For: County of San Bernardino

Prepared By: Heritage Environmental Consultants

Subject: Scientific basis for listing the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act

Date: June 10, 2020

Background

On October 15, 2019, the Center for Biological Diversity (CBD) submitted a petition to the California Fish and Game Commission to list the western Joshua tree (*Yucca brevifolia* [YUBR]) as threatened under the California Endangered Species Act (CESA) (CBD 2019). In February 2020, the California Department of Fish and Wildlife (CDFW) completed a review of the petition, as well as other scientific information available to CDFW. In its review, CDFW determined that "the petition provides sufficient scientific information to indicate that the petitioned action may be warranted" and recommended that the commission "accept the petition for further consideration under CESA" (CDFW 2020a). In the event that the commission accepts the petition, YUBR would become a candidate for listing as threatened under CESA.

Petition Review

Heritage Environmental Consultants was asked to review existing information and provide expert opinion regarding the scientific basis for listing YUBR as threatened under the CESA. The following review is based primarily on the petition itself (CBD 2019) and CDFW's subsequent review of the petition (CDFW 2020a) because of the limited time available for a more in-depth review of the supporting literature for these two documents. As such, this review accepts in a general sense that both CBD and CDFW have reviewed the existing literature and represent it accurately in their respective documents. The following sections provide review comments following the same outline as CBD's petition.

Life History

Most aspects of the life history of YUBR have been well-researched and are generally accepted. The current taxonomy of *Y. brevifolia* as a distinct species from *Y. jaegeriana* has been accepted. The previous taxonomy, with two subspecies (*Y. brevifolia brevifolia*) and (*Y. brevifolia jaegeriana*), would also provide a suitable basis for listing of either one or both subspecies under the CESA, if the current taxonomy were to be rejected.

Flowering, seed production, dispersal, predation, germination, and growth are generally understood, although several points are worth noting, as follows.

Seed production is an episodic event, correlated with increased precipitation. Sufficient moisture is also required for survival of young YUBR. In a desert environment, conditions for recruitment of YUBR seedlings may only occur "a few times in a century" (Esque and others 2015, in CBD 2019) and no seed production or seedling survival can be expected in drought years.

Individual YUBR cannot be aged in the same way as true trees because they lack annual growth rings. In previous studies, growth (size) has been used as a surrogate for age, on the assumption that larger trees must be older. At the level of this review, it is unclear how well previous studies have been able to correlate size with age, or if any studies have been conducted for sufficient time to even demonstrate a statistically significant correlation.

Considering that seedling recruitment is a rare event, and that age structure in the existing population is uncertain, it is questionable whether a demographic shift (reduced frequency of younger YUBR) has actually occurred, or if the observed reduction of younger plants is an artifact of the infrequent nature of recruitment events. That is, has it just been a long time since the last recruitment event, such that no younger plants are present? In asking this question, it is important to acknowledge the role of climate change, which may have reduced the probability of recruitment events by increasing temperature and the incidence of drought.

Current and Historical Distribution

The current range of YUBR is essentially the same as its historical distribution (post-European contact), demonstrating that human actions have not affected its distribution at present. Some studies (for example, Cole et al. 2011, in CBD 2019) reported model results that indicate future reductions in the southern portion of the range. This same model showed a substantial northward expansion of suitable habitat, albeit without consideration of the dispersal ability of YUBR, which appears to be relatively slow.

It has been suggested that the species is divided into two populations; however, the separation between these populations is a relatively short distance ("a small gap", CBD 2019, page 64) that appears similar to within-population gaps. Habitat differences have been suggested between the two populations, with more creosote bush in the south, and more pinyon pine, juniper, and sagebrush in the north. No evidence was provided to show that this gradient causes any sort of separation between the two purported populations, other than being a convenient correlation. Other differences between populations, in terms of temperature and precipitation, show substantial overlap and are not likely to be statistically valid.

Abundance and Population Trends

The petition stated that "a reliable estimate of Joshua tree population size is not available" and that "no range-wide population trends have been documented" (CBD 2019, page 19). In the absence of any estimate of population size or trend, and for a species that is relatively abundant and widespread, it is not clear how it is "likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts" (California Fish and Game Code Section 2067, in part).

Nevertheless, the petition provided information from several studies at Joshua Tree National Park (JTNP) that showed recruitment is limited and mortality is increasing, as well as a correlation between higher temperatures and lower density, and contraction of the species' range at lower elevations. CBD (2019) asserted that these results all point to a population in decline. It is important to note that the studies referenced by CBD were all conducted at JTNP, which is located at the extreme southern edge of the species current and historical range, at the transition between the Mojave Desert to the north and the hotter Sonoran Desert to the south. It seems possible that study results from JTNP may not accurately represent population trends farther north in the species' range.

CDFW (2020a) cited two studies at Edwards Air Force Base, near the center of the range of YUBR, that appeared to show stable or increasing populations, although at least one of these studies was not without some uncertainty. CDFW (2020a, page 13) stated that "the range, distribution, and density information available to the Department indicates that the abundance of western Joshua tree is currently relatively high". In the absence of robust range-wide abundance and population trend data, or at least additional samples from other locations within the species' range, it is uncertain what the actual abundance and population trends are for YUBR.

Factors Affecting Ability to Survive and Reproduce

The petition suggested that factors including predation, invasive species, wildfires, climate change, and habitat loss to development "collectively threaten the continued viability of the species" (CBD 2019, page 20). This is a bold statement considering the lack of population abundance and trend data, much less the level of demographic data needed to truly assess long-term viability. Regardless, the threats listed in the petition were generally reasonable, with a few exceptions noted here.

JTNP has hosted several large wildfires in recent years. The petition used this fact to suggest that fire risk has increased across the range of YUBR; however, it is not clear that this is the case, or if the recent large fires at JTNP represent a more local anomaly. Recent studies (for example, Brooks and others 2018, in CBD 2019, page 28) found that "although fire occurrence across large parts of the warm deserts may be relatively low, they can be much higher and pose significant land management challenges in localized areas."

It appears that most of the recent studies on the effects of fire on YUBR were carried out at JTNP and showed a significant reduction in the local population in burned areas (CBD 2019). However, CDFW (2020a) cited a study at Edwards Air Force Base (located in the center of the species range) that showed a stable long-term local population following wildfire. This result reinforces the idea that studies in a small area on the edge of the species' range (JTNP) may not be applicable across its entire range.

There is no doubt that human-caused climate change is an ongoing process that may increase temperatures within the range of YUBR. Existing studies suggest that precipitation may increase in the area, but that it will also become more variable, meaning long periods of drought can be expected. “Climate change represents the single greatest threat to the continued existence of *Yucca brevifolia*” (CBD 2019, page 32). The question is, how will YUBR as a species be affected, given the uncertainty among different climate model scenarios? And perhaps more importantly, how does listing YUBR as threatened under the CESA improve the situation, given that climate change is best addressed at the regional and global levels?

In answer to the first question, the petition (CBD 2019, pages 34 to 45) reviewed a number of studies that examined the effects of climate change on YUBR at several scales. The most detailed of these studies, and the ones most relied on by the petition to demonstrate ongoing and future effects of climate change on the species, were focused on JTNP. As noted above, it is unclear if results obtained at JTNP are applicable across the range of the species.

Habitat loss to development is another likely threat to YUBR; however, the extent of this threat is uncertain. The petition stated (CBD 2019, page 46) that an estimated 41.6% of suitable habitat for YUBR in the south population area would be lost to development by 2095, based on an Environmental Protection Agency model (cited to USFWS 2018 in CBD 2019, page 46). The parameters and assumptions of this model were not examined, but this result seems speculative. It appears that the model predicted that almost all private lands in the western Mojave Desert would be developed. Given the desert climate, lack of water, distance from the greater Los Angeles area (as a source of jobs), and perhaps other factors, this projection needs to be strongly questioned.

Inadequacy of Existing Regulatory Mechanisms

While existing regulatory mechanisms that protect YUBR as a species may be limited at the state and federal levels, it is unclear how a CESA listing would lead to substantial changes in the current situation. For example, the petition acknowledged climate change as the greatest risk and that “ultimately the species cannot be saved absent global action to reduce such emissions” (CBD 2019, page 48). A CESA listing of YUBR would have little or no bearing on efforts to reduce carbon emissions at a global scale. Similarly, the CESA has no legal standing on federal lands, which make up 48% of the south population area and 96% of the north population area. In practice, state-listed species are sometimes considered during project analysis under the National Environmental Policy Act (NEPA); however, there is no requirement for such consideration.

The petition suggested that CESA listing would bring focus to preservation of YUBR and its habitat for projects analyzed pursuant to the California Environmental Quality Act (CEQA). While listing may increase findings of significance on the basis of effects to YUBR, this may not necessarily equate to a reduction of effects to YUBR because agencies can still approve projects that may have a significant effect, as acknowledged in the petition (CBD 2019, page 55).

The petition gives relatively little space to local ordinances, although it does list Hesperia, Palmdale, Victorville, Yucca Valley, and Los Angeles and San Bernardino Counties as local jurisdictions that have plant protection ordinances or similar measures (CBD 2019, page 53). At the level of this review, these ordinances were not reviewed to determine if they “nominally protect” YUBR, or if in fact they provide substantial protections within the limits of local control over private land use.

Recommended Management and Recovery Actions

The list of recommended management and recovery actions (CBD 2019, page 65), while ambitious, is notable in that only one (a recovery plan) is directly related to CESA listing. The remainder could easily be enacted independently, although a CESA listing may provide focus for YUBR and spur such actions. CDFW (2020a, page 27) noted that "some of the suggestions are not within the Department's jurisdiction."

Conclusions

The ultimate question to be answered by this review is whether the existing scientific information in CBD's petition and the CDFW's review of that petition demonstrates that the YUBR, "…although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts…" (California Fish and Game Code Section 2067, in part, emphasis added).

It appears that CDFW has previously defined "foreseeable future" to include the contemplated timeline in the petition, which examines climate change modeling through the end of the 21st century (CBD 2019, page 63). In this case, the prolonged timeline further complicates some of the questionable assumptions raised above, which further increases the substantial uncertainty as to the actual effects of some threats to YUBR, including wildfire, climate change, and human development, particularly at the farther reaches of the foreseeable future. It may be that these threats, while seemingly real at present, would not reach the level of actually threatening YUBR for an uncertain and perhaps lengthy period of time, if at all.

Other entities have examined the rarity and threats to YUBR and found that it is not at sufficiently high risk at this time to warrant special status. At the federal level, the U. S. Fish and Wildlife Service (USFWS) determined that listing the Joshua tree as threatened or endangered under the federal Endangered Species Act (ESA) was not warranted on August 15, 2019. The California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants of California, which is considered a definitive source on the rarity of plants in the state, lists the Joshua tree as "Considered But Rejected" because it is "too common" (CNPS 2020).

The conclusion to the petition makes sweeping statements about the listing of YUBR as a symbolic action, as "an emblem of our society's failure to address the climate crisis" (CBD 2019, page 66). It should be noted that symbolism is not one of the criteria used to consider listings under the CESA. Nor is symbolism a noteworthy scientific principle. A symbolic listing of YUBR would likely divert staff time and funding to special protection and management actions. There are 286 taxa of federally- and/or state-listed plants in the state of California, including 100 taxa that are only listed by the state (CDFW 2020b). In addition, there are 168 taxa of federally- and/or state-listed wildlife in the state of California, including 39 taxa that are only listed by the state (CDFW 2019). The great majority of these taxa are rarer, and more likely to be threatened with extinction, than YUBR. Yet, a listing of YUBR would likely draw some staff resources and funding away from these other species, increasing their risk of extinction. While admittedly the CESA contains no provision for weighing risk of extinction of other species in a listing decision, it is worth asking if a symbolic listing is worth that risk.

References

California Department of Fish and Wildlife. 2020a. Evaluation of a Petition from the Center for Biological Diversity to List the Western Joshua Tree (*Yucca brevifolia*) as Threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178625&inline. Accessed June 9, 2020.

California Department of Fish and Wildlife. 2020b. State and Federally Listed Endangered, Threatened, and Rare Plants of California. January 2, 2020.

California Department of Fish and Wildlife. 2019. State and Federally Listed Endangered, Threatened Animals of California. August 7, 2019.

California Native Plant Society. 2020. Inventory of Rare and Endangered Plants of California. Available online at: http://www.rareplants.cnps.org. Accessed June 9, 2020.

Center for Biological Diversity. 2019. A Petition to list the Western Joshua Tree (*Yucca brevifolia*) as Threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175218&inline. Accessed June 3, 2020.

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SAN BERNARDINO COUNTY

County Administrative Office

Leonard X. Hernandez
Chief Executive Officer

May 11, 2021

VIA EMAIL

Charlton Bonham
Director
California Department of Fish and Wildlife
Sacramento, CA 94244

Re: Additional Information on the Petition to List the Western Joshua Tree *(Yucca brevifolia)* as Threatened Under the California Endangered Species Act

Director Bonham,

As you are aware, San Bernardino County (County) is deeply interested and invested in the proposed listing of the western Joshua tree (Yucca brevifolia) as a threatened or endangered species under the California Endangered Species Act (Fish & Game Code § 2050 et seq.) (CESA), as currently being reviewed by the California Department of Fish and Wildlife (CDFW). As a key stakeholder, the County appreciates the opportunity to work with CDFW as it engages in the status review process.

To further that process, the County engaged Heritage Environmental Consultants (Heritage) to conduct an independent review of the scientific basis for the proposed listing of the western Joshua tree, including studies identified in the petition for listing and CDFW's 2020 review. The County had submitted the technical memoranda from Heritage detailing its review as part of the County's informational submittal in January 2021.

As part of that prior review, Heritage examined several recent status reviews and listing petitions on plant species, such as Clara Hunt's milkvetch, Shasta snow-wreath, Lassics lupine and coast yellow leptosiphon. Reviewing the data on distribution, abundance and population trends for these species provided a helpful comparison to the data available for the western Joshua tree. Recognizing that this type of study would be useful to CDFW, the County asked Heritage to expand its analysis to include other species and prepare the enclosed Technical Memorandum (Technical Memorandum) that focuses on distribution and abundance of the western Joshua tree in comparison with other plant species listed or being considered for listing under CESA.

Technical Memorandum Demonstrates the Wide Range and Abundance of the Western Joshua Tree Stands in Stark Contrast to the Listed Plants and Other Species

Heritage conducted two sets of analysis for comparison with the western Joshua tree: first, it examined the data from seven recent listing decisions or proposed listings for plant species; and second, it expanded the scope to include all 219 plant species listed under the CESA. Based on these sets of data, the Technical Memorandum concludes that the western Joshua tree is both widespread and abundant relative to the recent listing proposals and the entire set of CESA-listed plants. The key findings of the Technical Memorandum include:

- **The western Joshua tree range is much more extensive than any CESA-listed species.** This conclusion is based on an analysis of the number of U.S. Geological Survey (USGS) 7.5-minute quadrangle (quad) maps in which each tracked species is known to occur, as listed in the California Natural Diversity Database (CNDDB). Quad data is a good surrogate for distribution (range) of a species—the more quads a species occupies, the broader its range. Of the 219 plaints species analyzed, 171 species are known from 10 or fewer quads, while only two species are known from more than 50 quads. In contrast, the western Joshua tree occupies 243 quads, making its range a significant outlier compared to other species.

- **The western Joshua tree is significantly more abundant than any CESA-listed species.** This conclusion is based on the estimated number of Element Occurrences (EO) of the western Joshua tree, compared with the number of EOs in the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants of California (Inventory) for other species. An EO is defined as a group of a species found within 0.25 miles and not separated by substantial habitat discontinuities. EO data provide a rough surrogate for abundance—the more EOs are known for a species, the more abundant it generally is. Of the 219 listed plants analyzed, 104 species are known from 10 or fewer EOs, while only 14 species are known from more than 50 EOs, and only three are known from more than 100 EOs. Although EO data is not available for western Joshua tree because it is not listed in the Inventory, the Technical Memorandum (page 7) applied the ratio of EOs to quads for all CESA-listed species to provide an estimate of 2.55 EOs per quad. Multiplying this ratio by the 243 quads occupied by the western Joshua tree yields a conservative estimate of 620 EOs—again an order of magnitude greater than for any of the other CESA-listed species

- **The western Joshua tree is substantially less rare than CESA-listed species.** This conclusion is based on the CNPS rare plant, state, and global ranks for each species. The majority (95%) of CESA-listed species are assigned CNPS rare plant ranks of 1A (extirpated in California) or 1B (rare, threatened or endangered in California). The western Joshua tree has a rare plant rank of CBR (Considered But Rejected) and was rejected as "too common." No other CESA-listed species has this rank in the CNPS. Indeed, the western Joshua tree shares many characteristics with the giant sequoia, an iconic species not listed at the state or federal level and rejected for inclusion in the CNPS Inventory, despite being subject to current and future threats including climate change.

- **Threats to the western Joshua tree are shared by all plant species, but risks to western Joshua tree are offset by range and abundance.** The western Joshua tree is subject to some of the same threats as CESA-listed species, including climate change. However, the western Joshua tree is not subject to threats that pose a high risk to species that have small population sizes or narrow distributions, such as those caused by local, stochastic threats. As an abundant and widespread species, the western Joshua tree is also less threatened by climate change than species with small population sizes or narrow distributions. Plants with the smallest range or most exacting habitat requirements (such as a single mountaintop) are the most threatened by climate change. In contrast, the western Joshua tree occurs across a wide swath of desert, with substantial variation in temperature and precipitation across its range, and, thus, more potential to survive than other truly rare CESA-listed species.

Listing the Western Joshua Tree under CESA Is Not Warranted

Given the extensive range and overall abundance of western Joshua tree in comparison to other plant species listed or considered for listing under the CESA, the Technical Memorandum supports the conclusion that listing the western Joshua tree as a threatened species would not be supported by the best available science as required by CESA. The County continues to advocate that listing the western Joshua tree under CESA would do little to address any long-term threat to the species and is not warranted under the law or science.

The Technical Memorandum's findings and conclusions also highlight the management limitations and policy implications of listing the western Joshua tree. Listing the species of such range and abundance would pose significant oversight and administrative hurdles, even without taking into account CDFW's limited staffing and funding. No other agency has ever taken on the regulation and active management of a species on such a scale. Furthermore, elevating the western Joshua tree for special protection over other, more threatened species would appear to be a misuse of scarce public resources. As discussed in the Technical Memorandum, there are 2,108 species of plants in the Inventory that are not listed under either the CESA or the federal Endangered Species Act (ESA).

These are species that the CNPS considered rare enough to rank (unlike the western Joshua tree, which was rejected as being too common), but that do not have any legal protections such as those provided by the ESA and CESA. Of these species, 285 are considered seriously threatened. The County would advocate that CDFW prioritize its limited resources on the conservation of plant and wildlife species that are already listed and focus future listing actions on species that are comparably rare and threatened, with a real risk of extinction.

Furthermore, the vast majority of western Joshua tree habitat is under federal jurisdiction and management with restrictions on development. Indeed, 48% of the southern population area and 96% of the northern population area is under federal ownership, as recognized by the U.S. Fish and Wildlife Service in 2018 when it declined to list the species. The federal entities that manage lands in the range include the Bureau of Land Management, National Park Service, U.S. Forest Service, and Department of Defense, each of which has laws, regulations or policies that protect the western Joshua tree and its habitat.

On the state level, the County would encourage CDFW to focus its resources on the ongoing Regional Conservation Investment Strategy (RCIS) program, which is better-suited for addressing multi-species impacts such as climate change. The RCIS program has already laid the regional groundwork for the protection and management of the western Joshua tree in light of the global climate change threat, balancing the goals of conservation and the need for economic stability in these challenging times. This program should be not be abandoned, but supported and expanded.

The County remains committed to being a partner with CDFW in investigating and collaborating on management tools as an alternative to listing and to better protect the western Joshua tree and the region. The County thanks the Department for the opportunity to submit this information and looks forward to working in partnership on this important issue. If you have any questions regarding this submission, please contact David Doublet, Assistant Director of Public Works at ddoublet@dpw.sbcounty.gov or 909-387-7918.

Sincerely,

Leonard X. Hernandez
Chief Executive Officer

c: Habitat Conservation Planning Branch, Attn: Native Plant Program
nativeplants@wildlife.ca.gov

Enclosure: Heritage Environmental Consultants, Technical Memorandum on Review of CESA-listed Species and Comparison with the Western Joshua Tree (May 2021)

Technical Memorandum

Prepared For: County of San Bernardino

Prepared By: Heritage Environmental Consultants

Subject: Review of CESA-listed Species and Comparison with the Western Joshua Tree

Date: May 7, 2021

Background

In October 2019, the Center for Biological Diversity (CBD) submitted a petition to the California Fish and Game Commission (CFGC) to list the western Joshua tree (WJT) as threatened under the California Endangered Species Act (CESA) (CBD 2019). CBD (2019) listed several factors that are "often related, synergistic, and collectively threaten the continued viability" of the WJT, including "predation, invasive species, wildfire, drought, climate change, and habitat loss". Further, CBD (2019) suggested that "climate change represents the single greatest threat to the continued existence" of the WJT.

In February 2020, the California Department of Fish and Wildlife (CDFW) completed a review of the petition and other scientific information, determined that the petitioned action may be warranted, and recommended that the Commission accept the petition for further consideration (CDFW 2020a). In September 2020, the CFGC accepted the petition for consideration and the WJT became a candidate for listing as threatened or endangered (CFGC 2020). The CDFW is preparing a status review report for the WJT to determine whether the petitioned action is warranted.

Heritage Environmental Consultants (Heritage) previously reviewed the scientific basis for listing the WJT under the CESA (Heritage 2020), including studies identified in CBD's (2019) petition and CDFW's (2020) review. As part of this effort, we examined several recent status reviews and listing petitions, including those for Clara Hunt's milkvetch (*Astragalus claranus*) (CDFW 2019a), Shasta snow-wreath (*Neviusia cliftonii*) (Roche 2019), Lassics lupine (*Lupinus constancei*) (CBD 2016), and coast yellow leptosiphon (*Leptosiphon croceus*) (Corelli 2016). These species were selected because their petitions and supporting documentation were readily available on CDFW's web site (https://fgc.ca.gov/CESA).

While the documents for each of these species are variable in content, detailed information on distribution and abundance was provided. In every case, not only were data on population abundance and trends provided, but the species in question were limited in distribution, limited in the number of occurrences, and limited in abundance of individuals both within occurrences and range-wide. CDFW and the CFGC likely considered these factors, along with known and potential threats, in making their recent listing decisions.

This contrasts distinctly with the WJT, which lacks robust data on population abundance and trend, but is known to occur in large numbers across an extensive range. Our previous review concluded that the WJT is widespread and abundant relative to other plant species being considered for listing or already listed under the CESA. Given this contrast with other CESA-listed species, we concluded that it may not be appropriate to list the WJT as threatened under the CESA at this time.

Comparison with Recent CESA Actions

As a follow-up to our previous review, we expanded our comparison of the WJT with other CESA-listed species, an effort that is reported in the remainder of this memorandum. One purpose of this effort was to gather additional information on distribution and abundance of the WJT and compare it with other species subject to recent CESA listing actions. Another purpose was to examine the threats identified for each of these species and compare them with alleged threats to the WJT.

Since we completed our previous review, documents for several additional CESA-listed species, including Baker's larkspur (*Delphinium bakeri*) (CDFW 2019b), Kenwood Marsh checkerbloom (*Sidalcea oregana* ssp. *valida*) (CDFW 2020b), and Milo Baker's lupine (*Lupinus milo-bakeri*) (CDFW 2020c), were placed on CDFW's web site. For each of these three additional species, we reviewed data on range, abundance, distribution, trends, and threats. We also reviewed the threats that were described for the four original species (Clara Hunt's milkvetch, Shasta snow-wreath, Lassics lupine, and coast yellow leptosiphon) that we examined in our previous review.

Distribution and Abundance

The three additional species (Baker's larkspur, Kenwood Marsh checkerbloom, and Milo Baker's lupine) are extremely limited in distribution, number of occurrences, and abundance of individuals both within occurrences and range-wide. These findings are consistent with the other four species we previously examined and provide additional contrast with the WJT.

Relevant data from the status reviews and related documents were combined with information on the WJT to develop **Table 1**, which illustrates the differences between the WJT and other CESA-listed or candidate species, in terms of distribution and abundance. The remainder of this section discusses components of **Table 1** in detail.

The California Natural Diversity Database (CNDDB) (CDFW 2021a) lists the number of U. S. Geological Survey (USGS) 7.5-minute quadrangle (quad) maps in which each tracked species is known to occur. The CNDDB quad data are based on existing records and may not represent the entirety of a species' range. For example, a species may be present in additional quads, but has not yet been documented there. In addition, geographic data may not be sufficiently detailed, especially for older records, to determine exactly which quads are or are not occupied by a species. Nevertheless, quad data provide a rough surrogate for distribution (range) of a species – the more quads a species occupies, the broader its range. **Table 1** lists the number of quads within which the CNDDB data show presence of each species. Excluding the WJT, the average number of quads occupied by a species is 3.9, a statistically significant difference ($p < 0.0001$) from the 243 quads occupied by the WJT.

An Element Occurrence (EO) is defined as a group of individuals of a species found within 0.25 miles and not separated by substantial habitat discontinuities. Data on EOs were obtained from the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants of California (Inventory) (CNPS 2021). EOs are based on documented occurrences and may not represent all occurrences in existence. For example, unsurveyed portions of a species' range may support undocumented occurrences. EO data provide a rough surrogate for abundance – the more EOs are known for a species, the more abundant it generally is. **Table 1** lists the number of known EOs for each species except the WJT, because it is not included in the Inventory.

Table 1 Status and Occurrence for Recent CESA Listing Actions

Common Name	Scientific Name	Quads	EOs	Status*		CA Rare Plant Rank*	State Rank*	Global Rank*
				Federal	State			
Baker's larkspur	*Delphinium bakeri*	6	6	FE	SE	1B.1	S1	G1
Clara Hunt's milkvetch	*Astragalus claranus*	5	6	FE	ST (CE)[1]	1B.1	S1	G1
Coast yellow leptosiphon	*Leptosiphon croceus*	1	1	n/a	SE	1B.1	S1	G1
Kenwood Marsh checkerbloom	*Sidalcea oregana* ssp. *valida*	2	2	FE	SE	1B.1	S1	G5T1
Lassics lupine	*Lupinus constancei*	1	2	n/a	SE	1B.1	S1	G1
Milo Baker's lupine	*Lupinus milo-baker*	3	11	n/a	ST[2]	1B.1	S1	G1Q
Shasta snow-wreath	*Neviusia cliftonii*	9	26	n/a	CE[3]	1B.2	S2	G2
Western Joshua tree	*Yucca brevifolia*	243	n/a	n/a	CT[4]	CBR	SNR	G3

* See **Attachment A** for an explanation of codes for federal and state status and CA rare plant, state, and global ranks.

[1] Clara Hunt's milkvetch is currently listed as threatened under the CESA and is a candidate for up-listing to endangered.

[2] The CDFW has recommended that Milo-Baker's lupine be up-listed from threatened to endangered; however, the CFGC has not yet ruled on this recommendation.

[3] The Shasta snow-wreath is not currently listed under the CESA but is a candidate for listing as endangered.

[4] The WJT is not currently listed under the CESA but is a candidate for listing as threatened.

For the species listed in **Table 1**, with the exception of the WJT, it appears that extensive surveys have been conducted and few undocumented occurrences are anticipated; therefore, the number of EOs is likely a close representation of their abundance. Of these species, the average number of EOs is 7.7. While the WJT is not tracked at the EO level, it would be reasonable to assume that there are substantially more potential EOs, considering the relatively broad distribution and abundance of the WJT across its range. Based on the number of quads occupied by the WJT, we believe the number of potential EOs across its range is likely in the hundreds. To refine this approximation, we used the ratio of EOs to quads for the other species listed in **Table 1** (7.7 EOs per 3.9 quads, or 1.97 EOs per quad) multiplied by 243 quads to develop a theoretical estimate of 480 EOs for the WJT. Unfortunately, the small sample size and high variance mean that statistically this estimate could range from 49 to 2,082 EOs (95% confidence interval). Even though this estimate is far from definitive, it suggests that the abundance of WJT is at least an order of magnitude greater than for any of the other CESA-listed species in **Table 1**.

The CNPS (2021) established rare plant ranks for each species in the Inventory, based on factors including rarity, distribution, and threats. **Attachment A** contains a complete explanation of rare plant ranks. Each of the species in **Table 1** except the WJT has a rare plant rank of 1B.1 or 1B.2 (rare, threatened, or endangered in California and elsewhere, with moderate to serious threats). The WJT has a rare plant rank of CBR (Considered But Rejected) and was rejected as "too common".

Similar to the CNPS rare plant ranks, state and global ranks provide a measure of rarity and endangerment. The state rank refers to the imperilment status of a taxon only within California, while the global rank reflects the status of a taxon throughout its global range. **Attachment A** contains a complete explanation of state and global ranks. **Table 1** shows that each species other than the WJT is ranked as S1 or S2 (imperiled or critically imperiled in the state) and G1, G2, or T1 (imperiled or critically imperiled globally). The WJT has a global rank of G3 (vulnerable), but is not ranked at the state level, which is typical of G3, G4, and G5 ranked species.

The CNPS (2021) maintains a list of species that were considered for inclusion in the Inventory, but that were rejected for one reason or another. This list currently contains 862 species, including the WJT. Reasons for rejection typically include the species being too common, not occurring in California, or being taxonomically invalid. We conducted a cursory review of this list to identify any species that are comparable to the WJT. One species that is comparable to the WJT is the giant sequoia (*Sequoiadendron giganteum*).

Like the WJT, the giant sequoia was considered but rejected because it is too common, has a global rank of G3, and is not ranked in the state. It is also an easily recognizable and even iconic component of the ecosystem in which it appears, and is vulnerable to altered fire regimes and climate change, among other threats. In contrast with the WJT, the giant sequoia occupies a somewhat smaller and better mapped range and likely has a smaller number of EOs that are generally better documented. Despite the better understanding of its smaller range, lower abundance, and substantial threats, the giant sequoia has not been proposed for listing under the CESA. This comparison, combined with the information summarized in **Table 1**, suggests that the WJT has little in common with species that are truly threatened or endangered and much more in common with species that are more abundant, more widely distributed, and not under consideration for listing under the CESA.

Threats

The types of threats posed to a species and the magnitude of those threats should be among the primary factors in any listing consideration. Identified threats to one or more of the seven species subject to recent CESA listing actions that we reviewed include:

- Climate change (including increased temperature, drought)
- Habitat modification or loss
- Herbivory / predation (including livestock grazing)
- Human activities (herbicide use, mowing, recreation, water diversion / use)
- Inadequacy of existing regulatory mechanisms
- Invasive species (including management of invasive species)
- Life history traits (including slow reproduction)

- Over-collection / over-exploitation
- Small population size (loss of genetic diversity, risk of stochastic [random] extinction events)
- Vegetation community succession (including competition)
- Wildfire (primarily wildfire outside the historic range of variability)

This list encompasses all of the primary threats to the WJT, namely predation, invasive species, wildfire, drought, climate change, and habitat loss. This list also included threats that are unique to species with extremely limited distribution and abundance, unlike the WJT. Small populations are much more likely to be signficantly affected by single, stochastic events. For example, one wildfire can damage or destroy a significant portion of the individuals of a species with a small range. For the WJT, individual stochastic events may harm an occurrence, but the wide range and abundance of the species mean that small, local events are not relevant to the continued viability of the species.

Climate change, which CBD identifed as the single greatest threat to the WJT, is also a threat to almost every other plant species. Plants of all types across the world will be challenged to adapt to climate change. Plants with the smallest range, or most exacting habitat requirements will be the most threatened. The Lassics lupine, which only grows on two nearby mountain tops, is one example of a plant that is likely to be extremely threatened by climate change. Even slight warming or drying may render all of its current habitat unsuitable. And in the absence of assisted migration (human movement of the species), it has nowhere else to go. That is, it can't move up to a cooler, wetter elevation, since it is already growing on mountain tops. In contrast, the WJT occurs across a wide swath of desert, with substantial variation in temperature and precipitation across its range. While there are significant unknowns in the ability of the WJT to migrate with climate change, it appears to have more potential to survive than other truly rare CESA-listed species.

Comparison With All CESA-Listed Species

To expand on our comparison of the WJT with CESA-listed species, we analyzed data for all 219 plant species listed under CESA or the Native Plant Protection Act (NPPA). The purpose of this expansion was two-fold: 1) to increase sample size for statistical comparison; and 2) to determine if the recent CESA listing actions are for a group of rare species that differ significantly from those in earlier listing actions (that is, is the WJT similar to some previously-listed species, or does it remain an outlier when compared with all listed species?).

Table 2 provides a summary of this analysis. In general, the results of the expanded analysis are similar to the analysis of recent CESA listings actions summarized in **Table 1**. Similarities and differences in the two analyses are discussed in the remainder of this section.

Table 2 Comparison of CESA-listed species with the WJT

Parameter		State Status*				WJT
		SE	ST	SR	All	
Number of Species		133	22	64	219	1
Quads (average)		8.1	6.2	7.1	7.6	243
Quads (median)		4.0	6.0	4.5	5.0	
Quads (minimum-maximum)		1-57	1-17	1-63	1-63	
EOs (average)		20.6	13.8	18.7	19.4	n/a
EOs (median)		10.0	11.5	12.0	11.0	
EOs (minimum-maximum)		1-114	1-29	2-198	1-198	
Federal Status*	FE	72	9	11	92	
	FT	19	5	5	29	
	FC	1	0	0	1	
	FD	0	0	1	1	
	n/a	41	8	47	96	✓
CA Rare Plant Rank*	1A	2	0	0	2	
	1B.1	98	16	14	128	
	1B.2	23	6	37	66	
	1B.3	4	0	8	12	
	2B.1	3	0	1	4	
	2B.2	0	0	1	1	
	3.1	1	0	0	1	
	3.2	0	0	1	1	
	4.2	1	0	1	2	
	4.3	1	0	1	2	
	CBR	0	0	0	0	✓
State Rank*	S1	100	19	29	148	
	S2	24	3	28	55	
	S3	6	0	7	13	
	SNR	0	0	0	0	✓
	SX / SXC	3	0	0	3	
Global Rank*	G1	97	19	26	142	
	G2	25	2	30	57	
	G3	9	1	8	18	✓
	GX / GXQ	2	0	0	2	

* See **Attachment A** for an explanation of codes for federal and state status and CA rare plant, state, and global ranks.

The average number of EOs and occupied quads is noticeably higher for all CESA-listed species (**Table 2**) compared with recent listing actions (**Table 1**). This appears to be a function of species-specific details of the recent listing actions. In **Table 1**, two of the species are candidates for up-listing from threatened to endangered, while two species were recently listed as endangered, and status reviews confirmed endangered status for two other species. In each of these six cases, it appears that extreme rarity and impending threats led to the recent listing actions. The remaining species in **Table 1**, Shasta snow-wreath, has EO and quad numbers similar to the averages for the broader group of species in **Table 2**. It appears that the species subject to recent listing actions, other than the Shasta snow-wreath, are substantially less abundant and more narrowly distributed than CESA-listed species in general. Despite this difference, the WJT is significantly more abundant and more widely distributed than the entire group of CESA-listed species, confirming that it is not comparable to these species.

Table 2 provides the average and median number of EOs per species by CESA listing group. Both average and median are provided because EOs do not appear to be normally distributed among species. That is, most species have relatively few EOs, while a few species have a relatively high number of EOs. For example, 104 of the 219 species (47%) analyzed for **Table 2** are known from 10 or fewer EOs, while only 14 species are known from more than 50 EOs and only three are known from more than 100 EOs.

Table 2 also provides the average and median number of quads per species, again because the number of quads does not appear to be normally distributed among species. That is, most species are documented from a few quads, while a few species are documented from a relatively high number of quads. For example, 171 of the 219 species (78%) analyzed for **Table 2** are known from 10 or fewer quads, while only two species are known from more than 50 quads. **Figure 1** illustrates this distribution. The WJT is called out in this figure to show how much it is an outlier from the group of listed species.

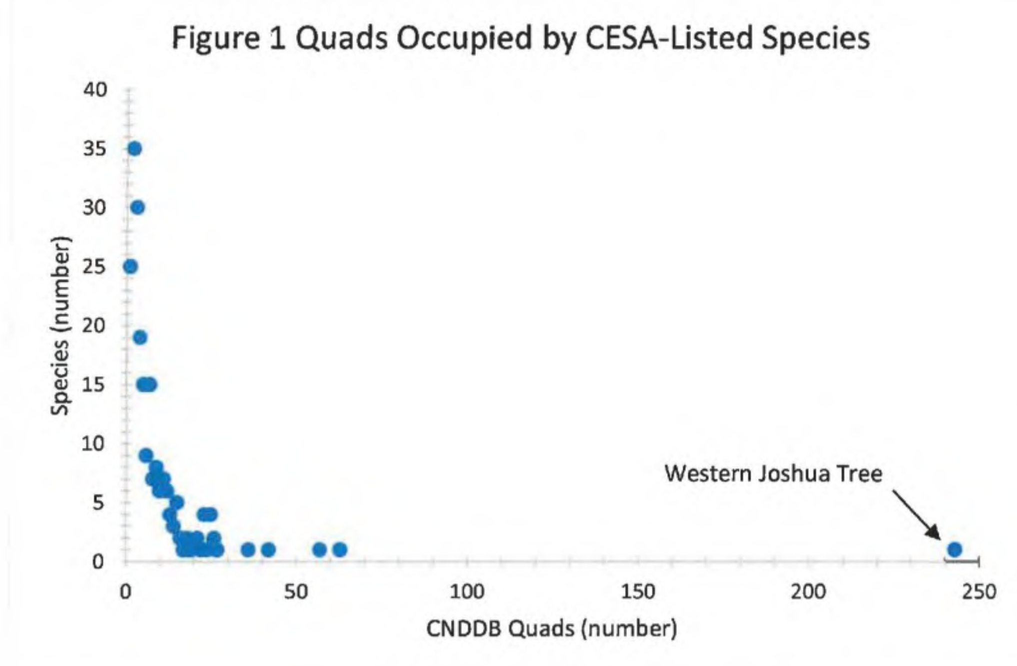
With the larger sample size afforded by the entire group of CESA-listed species, we repeated our theoretical estimate of the potential number of EOs for the WJT. The ratio of EOs to quads was 19.4 EOs per 7.6 quads, or 2.55 EOs per quad. Multiplying this ratio by the 243 quads occupied by the WJT yields an estimate of 620 EOs for the WJT. Statistically, this estimate could range from 450 to 849 (95% confidence interval). This estimate is substantially higher and more precise than the estimate based on the smaller group of species in **Table 1**. Regardless of where the WJT might fall within this range, it is clear that the abundance of WJT (in terms of the number of potential EOs) is at least an order of magnitude greater than for any of the other CESA-listed species in **Table 2**.

Almost half (44 percent) of CESA-listed species are not listed at the federal level (**Table 2**), likely reflecting differing priorities for listing at the state and federal levels. A similar case exists for the WJT, which the U. S. Fish and Wildlife Service (2019) declined to list, although the WJT is also substantially more abundant and widely distributed than many of the other CESA-listed species that are not federally-listed.

The majority (95%) of CESA-listed species are assigned CNPS rare plant ranks of 1A or 1B (**Table 2**). No CESA-listed species are on the CNPS (2021) CBR list. If it were listed under the CESA, the WJT would be the only species with a rare plant status of CBR.

The majority (93%) of CESA-listed species are assigned state ranks of 1 or 2 (**Table 2**). No CESA-listed species have state ranks of SNR. If it were listed under the CESA, the WJT would be the only species with a state rank of SNR; however, it is also likely that it would be ranked at the state level and by CNPS if it were listed.

The majority (91%) of CESA-listed species are assigned global ranks of 1 or 2 (**Table 2**). About 8% of CESA-listed species are assigned a global rank of 3, a group that would include the WJT if it were listed.



Conclusions

In our previous review of the scientific basis for listing the WJT, we concluded that the WJT is both widespread and abundant relative to other plants being considered for listing or already listed under the CESA. Our new analysis confirms that this conclusion is still valid, considering additional recent CESA-listing actions as well as the entire set of CESA-listed plants. The data shown in **Table 1**, **Table 2**, and **Figure 1**, as well as the discussion and references in this memo, support the following conclusions:

- The WJT is documented from a significantly larger area than CESA-listed species. This conclusion is based on the number of quads in the CNDDB for each species.
- The WJT is significantly more abundant than CESA-listed species. This conclusion is based on the estimated number of EOs of WJT, compared with the number of EOs in the CNDDB for each species.
- The WJT is substantially less rare than CESA-listed species. This conclusion is based on the CNPS rare plant, state, and global ranks for each species.

- The WJT shares many characteristics with plant species, such as the giant sequoia, that are not listed at the state or federal level, and that have been considered but rejected for inclusion in the CNPS Inventory, despite having limited ranges, limited population sizes, and being subject to current and future threats including climate change.

- The WJT is subject to some of the same threats as CESA-listed species; however, the WJT is not subject to threats that pose a high risk to species that have small population sizes or narrow distributions. That is, the WJT is not subject to potential extinction or significant loss of abundance or distribution caused by local, stochastic threats.

- Climate change is a threat to most plants, including the WJT and CESA-listed species; however, as an abundant and widespread species, the WJT is less threatened by climate change than species with small population sizes or narrow distributions (for example, CESA-listed species).

These conclusions reinforce our previous conclusion that it is not appropriate to list the WJT under the CESA at this time. There are 286 taxa of federally- and/or state-listed plants in California, including 100 taxa that are only listed by the state (CDFW 2021b). In addition, there are 173 taxa of federally- and/or state-listed wildlife in California, including 43 taxa that are only listed by the state (CDFW 2021c). The vast majority of these taxa are more rare and more likely to be threatened with extinction than the WJT.

Beyond currently listed species, there are 2,108 species of plants in the Inventory (CNPS 2021) that are not listed under either the CESA or the federal Endangered Species Act (ESA) (**Table 3**). These are species that the CNPS (2021) considered rare enough to rank (unlike the WJT, which was rejected as being too common), but that do not have any legal protections such as those provided by the ESA and CESA. Of these species, 285 are considered seriously threatened and should be the focus of upcoming CESA-listing actions, not the WJT, which is much more common and less threatened.

It is our opinion that a listing would divert staff time and funding toward special protection and management actions for the WJT and away from many other species that are more rare and more threatened, increasing their risk of extinction. We recommend that the CDFW prioritize conservation of plant and wildlife species that are already listed and focus future listing actions on species that are comparably rare and threatened.

Table 3 CNPS Rare Plant Ranks for Species Not Listed under the ESA and CESA

Rare Plant Rank*	Threat Rank				Total
	Not ranked	0.1 Seriously Threatened	0.2 Moderately Threatened	0.3 Not Very Threatened	
1A – Presumed extirpated in CA and either rare or extinct elsewhere	20	n/a	n/a	n/a	20
1B – Rare, threatened, or endangered in CA and elsewhere	n/a	200	501	214	915
2A – Presumed extirpated in CA, but common elsewhere	6	n/a	n/a	n/a	6

Table 3 CNPS Rare Plant Ranks for Species Not Listed under the ESA and CESA

Rare Plant Rank*	Threat Rank				Total
	Not ranked	0.1 Seriously Threatened	0.2 Moderately Threatened	0.3 Not Very Threatened	
2B – Rare, threatened, or endangered in CA, but more common elsewhere	n/a	75	211	216	502
3 – more information is needed – a review list	23	8	26	13	70
4 – Plants of limited distribution – a watch list	n/a	2	217	376	595
Total	49	285	955	819	2,108

* All species with a rare plant rank 1A, 1B, 2A, 2B are eligible for listing under the CESA. Many of the plants with a rare plant rank of 3 are also eligible for listing under the CESA, while few, if any, species with a rank of 4 are eligible for state listing (CNPS 2021).

References

California Department of Fish and Wildlife. 2021a. California Natural Diversity Database QuickView Tool. Available online at: https://apps.wildlife.ca.gov/bios/?tool=cnddbQuick. Accessed on February 23 to 25, 2021.

California Department of Fish and Wildlife. 2021b. State and Federally Listed Endangered, Threatened, and Rare Plants of California. January 2021.

California Department of Fish and Wildlife. 2021c. State and Federally Listed Endangered Threatened Animals of California. February 9, 2021.

California Department of Fish and Wildlife. 2020a. Evaluation of a petition from the Center for Biological Diversity to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178625&inline. Accessed June 9, 2020.

California Department of Fish and Wildlife. 2020b. Five-year status review of Kenwood Marsh checkerbloom (*Sidalcea oregana* ssp. *valida*). Report to the Fish and Game Commission. August 2020. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=184805&inline. Accessed February 26, 2021.

California Department of Fish and Wildlife. 2020c. Five-year status review of Milo Baker's lupine (*Lupinus milo-bakeri*). Report to the Fish and Game Commission. December 2020. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=187221&inline. Accessed February 23, 2021.

California Department of Fish and Wildlife. 2019a. Five-year status review of Clara Hunt's milkvetch (*Astragalus claranus*). Report to the Fish and Game Commission. September 2019. Available online at:

https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=177476&inline. Accessed July 22, 2020.

California Department of Fish and Wildlife. 2019b. Five-year status review of Baker's larkspur (*Delphinium bakeri*). Report to the Fish and Game Commission. December 2019. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178637&inline. Accessed July 22, 2020.

California Fish and Game Commission. 2020. Notice of Findings. Western Joshua Tree (*Yucca brevifolia*). September 24, 2020. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=183565&inline. Accessed December 2, 2020.

California Native Plant Society. 2021. Inventory of Rare and Endangered Plants of California. Online edition. V8-03 0.39. Available online at: http://www.rareplants.cnps.org. Accessed February 23 to 25, 2021.

Center for Biological Diversity. 2019. A petition to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175218&inline. Accessed June 3, 2020.

Center for Biological Diversity. 2016. Petition to the State of California Fish and Game Commission to list the Lassics lupine (*Lupinus constancei*) as endangered under the California Endangered Species Act. July 14, 2016. Available online at: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165478&inline. Accessed July 22, 2020.

Corelli, T. 2016. A petition to the State of California Fish and Game Commission to list the coast yellow leptosiphon (*Leptosiphon croceus*) as endangered. May 23, 2016. Available online at: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165474&inline. Accessed July 22, 2020.

Heritage Environmental Consultants. 2020. Review of scientific basis for listing the western Joshua tree as threatened under the California Endangered Species Act. Technical memorandum prepared for the County of San Bernardino. August 5, 2020.

NatureServe. 2021. NatureServe Explorer. *Yucca brevifolia*. Western Joshua Tree. Available online at: https://explorer.natureserve.org/taxon/element_global.2.160735/yucca_brevifolia. Accessed on February 23, 2021.

Roche, K. S. 2019. Petition to the California Fish and Game Commission to list the Shasta snow-wreath (*Neviusia cliftonii*) as endangered under the California Endangered Species Act/ September 30, 2019. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175216&inline. Accessed July 22, 2020.

U. S. Fish and Wildlife Service. 2019. Endangered and threatened wildlife and plants; 12-month findings on petitions to list eight species as endangered or threatened species. Federal Register 84(158): 41694-41699.

Attachment A
Key to Status and Rank Codes

Federal Status

Provides official status under the federal Endangered Species Act (ESA), with definitions based on federal regulations. Data on federal status were obtained from the Inventory (CNPS 2021).

FC: Candidate for listing as threatened or endangered under the ESA.

FD: Previously listed as threatened or endangered under the ESA, but has been de-listed. These species have no current status under the ESA.

FE: Listed as endangered under the ESA.

FT: Listed as threatened under the ESA.

n/a: no status under the ESA.

State Status

Provides official status under the CESA or NPPA, with definitions based on state law. Data on state status were obtained from the Inventory (CNPS 2021), modified by recent listing decisions that are not reflected in the Inventory.

CE: Candidate for listing as endangered under the CESA.

CT: Candidate for listing as threatened under the CESA.

SE: Listed as endangered under the CESA.

SR: Listed as rare under the NPPA.

ST: Listed as threatened under the CESA.

n/a: no status under the CESA or NPPA.

CA Rare Plant Rank

Provides a rank for each species in the Inventory (CNPS 2021), based on factors including rarity, distribution, and threats.

1A: Plants Presumed Extirpated in California and Either Rare or Extinct Elsewhere

Plants with a rank of 1A are presumed extirpated or extinct because they have not been seen or collected in the wild in California for many years. A plant is extinct if it no longer occurs anywhere. A plant that is extirpated from California has been eliminated from California, but may still occur elsewhere in its range.

1B: Plants Rare, Threatened, or Endangered in California and Elsewhere

Plants with a rank of 1B are rare throughout their range with the majority of them endemic to California. Most of the plants that are ranked 1B have declined significantly over the last century. California Rare Plant Rank 1B plants constitute the majority of taxa in the CNPS Inventory, with more than 1,000 plants assigned to this category of rarity.

2A: Plants Presumed Extirpated in California, But Common Elsewhere

Plants with a rank of 2A are presumed extirpated because they have not been observed or documented in California for many years. This list only includes plants that are presumed extirpated in California, but more common elsewhere in their range.

2B: Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere

Except for being common beyond the boundaries of California, plants with a rank of 2B would have been ranked 1B. From the federal perspective, plants common in other states or countries are not eligible for consideration under the provisions of the Federal Endangered Species Act. With California Rare Plant Rank 2B, we recognize the importance of protecting the geographic range of widespread species. In this way we protect the diversity of our own state's flora and help maintain evolutionary processes and genetic diversity within species.

3: Plants About Which More Information is Needed - A Review List

Plants with a rank of 3 are united by one common theme - we lack the necessary information to assign them to one of the other ranks or to reject them. Nearly all of the plants constituting California Rare Plant Rank 3 are taxonomically problematic. For each California Rare Plant Rank 3 plant we have provided the known information and indicated in the "Notes" section of the CNPS Inventory record where assistance is needed.

4: Plants of Limited Distribution - A Watch List

Plants with a rank of 4 are of limited distribution or infrequent throughout a broader area in California, and their status should be monitored regularly. Should the degree of endangerment or rarity of a California Rare Plant Rank 4 plant change, we will transfer it to a more appropriate rank.

CBR: Considered But Rejected

Species that were considered for inclusion in the Inventory, but that were rejected (for one reason or another. This list currently contains 862 species. Reasons for rejection typically include the species being too common, not occurring in California, or being taxonomically invalid (CNPS 2021).

Threat Ranks

0.1-Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat)

0.2-Moderately threatened in California (20-80% occurrences threatened / moderate degree and immediacy of threat)

0.3-Not very threatened in California (less than 20% of occurrences threatened / low degree and immediacy of threat or no current threats known)

State Rank

Refers to the imperilment status of a taxon only within California's boundaries. Data on state ranks were obtained from the Inventory (CNPS 2021) except for the WJT, which was obtained from NatureServe (2021).

S1: Critically imperiled in the state because of extreme rarity (often five or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2: Imperiled in the state because of a very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

S3: Vulnerable in the state because of a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation from the state.

S4: Apparently secure, uncommon but not rare in the state; some cause for long-term concern because of declines or other factors.

S5: Secure, common, widespread, and abundant in the state.

S#?: Denotes inexact numeric rank, the rank listed is the best available estimate.

S#S#: A numeric range rank (for example, S1S2) is used to indicate any range of uncertainty about the status of the taxon.

SNR: Not ranked – a state conservation status has not been assessed.

SX: Presumed extirpated, the taxon is believed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

SXC: Presumed extirpated or eliminated in the wild in the state but is extant in cultivation, in captivity, as a naturalized population (or populations) outside its native range, or as a reintroduced population or ecosystem restoration, not yet established.

To simplify **Table 2**, several state ranks were combined as follows: S1 includes S1, S1?, and S1S2. S2 includes S2 and S2S3. S3 includes S3, S3?, and S3S4.

Global Rank

Reflects of the overall status of a taxon throughout its global range. Data on global ranks were obtained from the Inventory (CNPS 2021) except for the WJT, which was obtained from NatureServe (2021).

G1: Critically imperiled, at very high risk of extinction due to extreme rarity (often five or fewer populations), very steep declines, or other factors.

G2: Imperiled, at high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.

G3: Vulnerable, at moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.

G4: Apparently secure, uncommon but not rare; some cause for long-term concern because of declines or other factors.

G5: Demonstrably secure, common, widespread, and abundant.

G#?: Denotes inexact numeric rank, the rank listed is the best available estimate.

G#G#: A numeric range rank (for example, G1G2) is used to indicate any range of uncertainty about the status of the taxon.

G#Q: Questionable taxonomy that may reduce conservation priority. Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank.

G#T#: The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles for species. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1.

GX: Presumed extinct. Not located despite intensive searches and virtually no likelihood of rediscovery.

To simplify **Table 2**, several global ranks were combined based on their taxon (T) rank as follows: G1 includes G1, G1?, G1G2, G1Q, G1T1, G2T1, G2T1T2, G3T1, G3G4T1, G4T1, G4?T1, G4G5T1, G4G5T1T2, and G5T1. G2 includes G2, G2G3, G2T2, G3T2, G3G4T2, G4T2, G4T2T3, G4?T2, G4?T2T3, G4G5T2, G5T2, G5T2Q, and G5T2T3. G3 contains G3, G3G4, G3Q, G4T3, G5T3, G5T3?, and G5T3Q.

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AUGUSTINE BAND OF CAHUILLA INDIANS

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Tribal Chairperson: Amanda Vance
Tribal Vice-Chairperson: William Vance
Tribal Secretary: Victoria Martin

Date: November 30, 2020

PO Box 944209
Sacramento, CA 94244

RE: NOTIFICATION OF STATUS REVIEW FOR WESTERN JOSHUA TREE

Dear: Jeb Bjerke, Senior Environmental Scientist
Habitat Conservation Planning Branch

Thank you for the opportunity to offer input concerning the development of the above-identified project. We appreciate your sensitivity to the cultural resources that may be impacted by your project and the importance of these cultural resources to the Native American peoples that have occupied the land surrounding the area of your project for thousands of years. Unfortunately, increased development and lack of sensitivity to cultural resources have resulted in many significant cultural resources being destroyed or substantially altered and impacted. Your invitation to consult on this project is greatly appreciated.

At this time, we are unaware of specific cultural resources that may be affected by the proposed project, however, in the event, you should discover any cultural resources during the development of this project please contact our office immediately for further evaluation.

Very truly yours,

Victoria Martin

Victoria Martin, Tribal Secretary
Augustine Band of Cahuilla Indians

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Making Conservation
a California Way of Life.

January 29, 2021

California Department of Fish and Wildlife
Habitat Conservation Planning Branch
Attn: Native Plant Program
P.O. Box 944209
Sacramento, CA 94244-2090

Dear Native Plant Program:

We appreciate the current opportunity to comment on the status review by the California Department of Fish and Wildlife (CDFW) regarding the status of western Joshua tree (*Yucca brevifolia*) under the California Endangered Species Act (CESA).

As owner-operator of the State Highway System (SHS), the California Department of Transportation (Caltrans) works to avoid, minimize, and mitigate impacts to natural resources and wildlife as part of our transportation project development process. As a State agency, our actions must comply with State and federal regulations including the National Environmental Policy Act (NEPA), California Environmental Quality Act (CEQA) and CESA.

Caltrans has reviewed this proposed listing in relation to implementation of our programs. Based on Caltrans review of the listing, it is likely that highway projects will result in take of the species in dozens of projects that will now require an Incidental Take Permit (ITP). We are concerned with the effect this regulation may have on the time and cost required to complete our transportation projects. Furthermore, with the recent passage of the Road Repair and Accountability Act of 2017 (SB 1), we expect an increase in the volume of projects. We are interested in ensuring that any change in process does not stall the flow of delivery and cause an undue challenge to meet our mission. Caltrans requests an opportunity to discuss further options related to protection of western Joshua tree, improved coordination, and potential ramifications on project delivery from the proposed CESA listing.

Below is a summary of additional information and our concerns followed by additional detailed discussion of each. After we present comments and concerns with the listing of western Joshua tree under CESA (1-4) we share some overall management concerns (5-6) and then include a section with suggestions regarding the CESA listing and management process (a-d) as it affects cooperative State agencies and environmental planners in general.

1) Population size of the species does not appear to be established, is described by CDFW as abundant, and may only be declining in a portion of its range.

The Petition acknowledges that a reliable estimate of western Joshua tree population size is not available. Information stated in the Petition and the CDFW evaluation indicated a small portion of the population is declining in Joshua Tree National Park and another, larger portion of the population was found to be stable within military lands such as Edwards Airforce Base. The information cited in these studies is not indicative of a population-wide decrease in abundance. The CDFW evaluation indicates that the abundance of western Joshua tree is currently relatively high. The USFWS cited a lack of information showing a decline of the species across its range, and determined that "populations of both Joshua tree species have large distributions, ecological diversity, and a large amount of intact habitat" in its decision not to list the western Joshua tree in the federal Endangered Species Act.

Caltrans can provide additional evidence of the abundance of this species. Individuals are often resilient to roadside disturbance and occur within State owned right of way. Caltrans Districts 7, 8 and 9 regularly find western Joshua tree within its range within the right of way. District 9 has determined over 200 individual western Joshua trees are within the project limits of a single project. District 8 has provided a list of 9 different projects that contain 1-60 individual mature trees within the project limits of each project. District 8 has translocated mature western Joshua trees in the responsible management of the surrounding natural communities within its project limits over the years. Caltrans biology teams have extensive experience working with the conservation and management of this species due to its abundance and resiliency.

Western Joshua tree is described as comprising two geographically separate populations named YUBR South and YUBR North in the CDFW Petition. Additionally, the Petitions states that these may be listed together or separately as Evolutionarily Significant Units (ESUs) by CDFW. Since YUBR South is expected to be suitable on only 2% of state-owned land and YUBR North is overwhelmingly on federal lands, Caltrans does not anticipate having a significant affect to habitat of either population solely on a project by project basis. The YUBR North population is shown by modeling to have potential to expand northward if climate change models are accurate; this population does not seem at risk. The YUBR South population does experience risks due to modeled climate changes and development on private lands, and currently does not benefit from any protections under California laws or regulations. The YUBR South population could qualify to be listed as a Species of Special Concern by CDFW or gain a more protective rating on the California Native Plant Society's Inventory of Rare Plants.

The Petition and CDFW evaluation focus on climate change modeling to predict a near loss of the species in its current range within 60-100 years. Some of the models predict recruitment of new western Joshua tree in areas within California north of its current range, which is not discussed in the Petition or CDFW evaluation. The use of CESA to protect a species that is currently abundant and does not face an imminent threat or appreciable declines does not seem consistent with prior application of these laws and regulations. CESA listing of species that have demonstrated range-wide declines and face imminent threat of continued and accelerated declines within California warrant CESA listing, and western Joshua tree does not appear to meet these criteria at this time.

2) <u>Consideration should be made of the State's Greenhouse Emissions (CA GHG) emission reduction efforts in listing decision</u>

Transportation networks are a significant contributor to climate change and as such, Caltrans has put forth considerable efforts toward climate change guidance and policies. Caltrans has analyzed and completed climate change reports, analyzed wildfire, temperature, storm events, and is working steadily to address and stay on track to meet the CA GHG emission reduction goals. The petition analyzed global and national policies but failed to detail CA CHG polices and goals. Neither the Petition or CDFW cite, address or analyze any CA laws or policies addressing climate change and therefore Caltrans' efforts and goals are most likely overlooked.

Therefore, Caltrans role and CDFW main threat to Joshua Tree, as cited in the listing, are impacts to climate change. The Petition failed to adequately analyze or cite any of CA climate change efforts and policies, and instead focused on global and national shortfalls. Although climate change is a worldwide phenomenon, this Petition, for a state listing, should acknowledge and analyze actions at the state level. Therefore, Caltrans requests further analysis of the statement that "no existing regulatory mechanism are currently in place at the international, national, state or local level that adequately address the threats." Caltrans is committed to and required by law to address climate change impacts through EO B-30-15, AB 32, S-13-08, SB 246, AB 1482, and AB 2800. Caltrans has established climate change experts within the Department that has focused on doing our part to mitigate greenhouse gas (GHG) emissions from our operations, and to adapt to the changing climate. In 2013, Caltrans released "Caltrans Activities to Address Climate Change - Reducing Greenhouse Gas Emissions and Adapting to Impacts" – a report that highlights Caltrans' statewide climate change efforts. Caltrans recently completed a vulnerability assessment in District 8 (Riverside and San Bernardino Counties) in 2019. This assessment identifies the sections of the highway system at highest risk to extreme weather events related to climate change and represents the latest phase of this effort. Caltrans has also received several grants including SB1 Adaptation Planning Grants. It is envisioned that these planning grants will provide much needed funding to support regional sustainable communities' strategies and ultimately achieve the State's greenhouse gas reductions targets of 40 and 80 percent below 1990 levels by 2030 and 2050, respectively. Caltrans climate change analyses, active role in reducing GHG emissions and planning ahead helps to meet California's climate change goals and thereby contributes to addressing the threat to western Joshua tree. Given the large contribution of the transportation sector to California's GHG emissions, Caltrans and other state agencies have an important role to play in fostering solutions. Caltrans requests collaboration between agencies to either establish a method of credit for GHG emissions reductions and JT mitigation or develop and implement common strategies for GHG emission reduction that can be programmed into projects and addresses JT project concerns.

3) <u>Consideration should be made of State land ownership in listing decision</u>

The Petition and CDFW petition evaluation describes western Joshua tree distribution, range, and land ownership of lands it occupies and concludes that roughly 2% of the total area occupied by the species is California state-owned lands. Caltrans activities will not have much of an affect to habitat loss or loss of significant numbers of trees due to the small percent of the total western Joshua tree population on state lands. The species is described as comprising two geographically separate populations named YUBR South and YUBR North. Just over 50% of the YUBR South population is on private land, 48 percent is on federal land, and 1.9% is under State ownership. The YUBR North population is of western Joshua tree is split between California and Nevada, and approximately 96% of the total area of the YUBR North population is on federal land and 0.5% is on land owned by the state of California. The future management of the species by federal agencies will not be affected by the CESA listing. Caltrans sees the value in increased protections for the species on private lands, with 50%of the YUBR South population potentially seeing the benefit of CESA listing protections. We are concerned on the regulatory burden the listing places on State agencies that manage very little overall land occupied by the species.

4) <u>Concerns when comparing to federal listing decision and lack of consistency.</u>

The US Fish and Wildlife Services (USFWS) on August 15, 2019 determined, *"that neither <u>Yucca jaegeriana</u> nor <u>Yucca brevifolia</u> are in danger of extinction or likely to become so within the foreseeable future throughout all or a significant portion of their ranges. Therefore, we [USFWS] find that listing the Joshua tree as an endangered or threatened species is not warranted* (Federal Register FWS–R8–ES–2016–0088)."

Federal wildlife experts carefully assessed the best scientific and commercial information regarding the past, present, and future threats to Joshua tree and determined not to list the species because threats to the population are not imminent to jeopardize its continued existence. As stated by USFWS findings, "*We [USFWS] evaluated environmental conditions and threat factors acting on the two species into the future (approximately 80 years) and developed two future scenarios to assist in determining the potential future conditions for the two species. Because the two species are long-lived, have such large ranges and distributions, mostly occur on Federal land, and occupy numerous ecological settings, we have determined that future stochastic and catastrophic events would not lead to population- or species-level declines in the foreseeable future.*"

The USFWS decision was made after a thorough analysis of the best available scientific and commercially information. The information provided in the Petition and CDFW evaluation indicate "*populations of both Joshua tree species have large distributions, ecological diversity, and a large amount of intact habitat.*" Caltrans recognizes that shortcomings of the federal assessment discussed in the Petition, and also recognizes that the population modeling done for western

Joshua tree indicates the species may expand its range north in California at the same time it's southern extend is diminished.

5) <u>Caltrans wants to explore completing mitigation during the candidacy period with the measures created in the 2084 emergency rules.</u>

The FGC allowed inclusion of Section 749.10 for take of western Joshua tree whereas specific renewable energy projects could complete mitigation by paying a "*mitigation fee of $10,521.95 per acre to be deposited into the Western Joshua Tree Mitigation Fund*." By paying into the Fund, FGC has approved an in-lieu fee type of mitigation with the 2084 emergency rule like what Caltrans has been promoting to CDFW for many years as a viable mitigation solution allowable by some federal partners. Additionally, this approach is supported by recommendations from the inter-agency AB 1282 Permitting Task Force. Also, the Section 749.10 states that CDFW should allow for Credit for Existing Mitigation. Many of the Caltrans projects described in concern 1) above have already completed desert tortoise or other NCCP lands mitigation that should qualify for and meet the definitions of Credit For Existing Mitigation. Caltrans wants to explore this immediately as relief and take part in these mitigation solutions for the candidate western Joshua tree.

<u>6) Transplanting roadside trees potentially moves hazardous soils with aerially deposited lead.</u>

Roadside pollution may affect the management of western Joshua tree when transplanting individual trees is proposed for avoidance, minimization or mitigation. Transplantation of individual trees has been completed for past projects in many situations. However, the ability to transplant trees at some sites may be limited due to aerially deposited lead (ADL). ADL is found predominantly along older roads as a legacy pollutant from when cars used lead-based gasoline in years prior to1980. The lead is typically found within 30 feet of the edge of the pavement and within the top six inches of the soil. In some cases, the lead is as deep as two to three feet below the surface. The habitat for western Joshua tree adjacent to these older roads has degraded to low quality. Transplantation of western Joshua trees to meet avoidance, minimization or mitigation requirements from areas deemed to contain hazardous soils contaminated with ADL should not occur to any offsite locations due to the high potential of spreading ADL to uncontaminated areas. State hazmat laws for ADL soils add significant expense and complication to transportation projects, and consideration should be made when Caltrans is requested to relocate trees within its right of way. Trees in areas of high ADL soils should not be required to be translocated as part of the mitigation process for impacted trees within 30 feet of these older road facilities due to the regulations and liabilities involved.

Caltrans will continue to collaborate with its agency partners on improving environmental compliance efficiencies through programs it leads mandated by AB 1282 and in the spirit of the California Natural Resource Agency's "Cutting the Green Tape" initiative. This section below reflects comments and concerns we wish to share regarding the overall CESA process and management.

a) A peer-reviewed report prepared by CDFW using the best available scientific information should be used to support moving a species to candidate status.

The CESA listing process in its current state allows FGC to declare a species a candidate based on a cursory evaluation of the petitioners supplied information. The petition is authored with the goal of advancing the species to CESA candidacy and is not required to have a peer-reviewed assessment of the best available scientific information available. The CDFW evaluation of the petition completed in February 2020 contains many instances where it is declared "the petition contains sufficient information…" for CDFW. During CDFW's review of the candidacy, they have 12-18 months to produce "a peer reviewed report based on the best scientific information available that indicates whether the petition action is warranted" (FGC 2074.6). Unlike the federal listing process, CDFW requires full protection of the species and triggers all permitting processes as a candidate before it conducts any of its own scientific analysis of the species status and threats. In perhaps the most important section of CDFW's petition evaluation, the Population Trend, CDFW states in its Conclusion that:

"*The Petition does not present as estimate of western Joshua tree population size, nor does it provide evidence of a range-wide population trend; nevertheless, the Petition does not provide information showing that some populations of western Joshua tree are declining, particularly within Joshua Tree National Park.*"

CDFW failed to include other studies in the petition showing no change in the abundance of Joshua tree on military lands such as Edwards Airforce Base, which represents 318,223 acres of habitat (8.55% of YUBR South total distribution, USFWS). The Joshua Tree NP represented 214,133 acres of habitat (5.75% of YUBR South total distribution, USFWS). CDFW's focus on the results of studies in the smaller area that support the petition suggest a lack of a complete analysis and does not seem to include all the best scientific information available. Caltrans supports having CDFW complete a peer-reviewed evaluation of the status of the species and requiring the best available scientific information be used prior to FGC advancing a species to candidacy status. Alternatively, Caltrans supports another step in the process whereas the regulatory burden of seeking an ITP is not required during CDFW's thorough evaluation of status of a petitioned species.

b) CDFW CESA process would benefit from better definition of "fully mitigate" and a consistent application of this concept across Regions.

FGC regulations and CDFW guidance has not established a definition of "fully mitigate" that is consistently applied across CDFW Regions. The "fully mitigate" standard typically contains compensation ratios above those required by federal management of dual-listed species, but FGC code does not provide rationale to support why this is necessary. Instead, we see a pattern whereas CDFW transfers the burden of species-specific mitigation development onto partners with less expertise. We see the progress developed towards establishing mitigation guidelines for western Joshua tree in the 2084 emergency rules approved by the FGC and are supportive of these measures meeting the standard to fully mitigate impacts. Caltrans supports CDFW providing improved guidance ahead of regulatory changes for CESA listed species to allow environmental planners the tools they need to efficiency produce evaluations that are cooperative, accurate, and agreeable.

c) CDFW can provide better guidance to partners regarding the species it manages under CESA.

Caltrans relies on the best available scientific information in its biology assessment work. Information from CDFW on CESA listed species is often lacking, and Caltrans refers to federal recovery plans for dual-listed species. CDFW has not developed species-specific conservation guidelines or recovery plans for all CESA listed species to assist environmental planers. We would prefer to see CDFW not transfer the burden of species-specific evaluation, assessment, and mitigation development onto partners with less expertise, which often occurs when permit applications are completed for newly listed species. Caltrans supports that CDFW provide improved guidance ahead of regulatory changes for CESA listed species to allow environmental planners the tools they need to efficiency produce evaluations that are cooperative, accurate, and agreeable.

d) CDFW should engage in cooperative outreach to State agencies for CESA listings

CDFW should confer with other State agencies regarding proposed species and their progress towards CESA candidacy to allow other State agencies to properly plan for cooperation, collaboration and compliance needs that affect schedules and budgets. Currently, Caltrans has working diligently to deliver planned safety improvement projects on schedule and within budget but is now faced with cost and schedule changes due to the CESA candidacy status of western Joshua tree. More information relevant to the regulatory burden faced by the candidacy status of the species is provided in previous comments and concerns above.

Additionally, at the directive of the Legislature, Caltrans operates the Advance Mitigation Program (AMP) which provides funding through a structured program to establish mitigation solutions, including for CESA listed species. Without inter-agency coordination, any newly listed species is not part of any existing efforts to fund mitigation. Our District 8 Regional Advanced Mitigation Needs Assessment (RAMNA), which when through a public process and received comments from CDFW, did not include western Joshua tree. The final D8 RAMNA is now complete, and District 8 will need to determine if they want to re-evaluate their RAMNA if they want to use any AMP funds for future efforts directed at this species. Our District 7 RAMNA is in development and could benefit from more information on mitigation needs for this species. Caltrans AMP would benefit from learning from CDFW more about the timelines and schedules for listing decisions and what would be required for mitigation for listed species so we could include all listed species in AMP efforts.

CDFW should develop scientifically sound guidance on proposed priority areas of interest and specificity on overall level of improvements needed to prevent or address the proposed CESA listing of western Joshua tree. Caltrans strongly supports the advancement of CDFW internal efforts to understand what the species needs and its priorities for recovery and for fully mitigating species impacts. The biology teams at Caltrans focus on environmental compliance to facilitate the construction of transportation improvements within programmed costs and schedules and relies on its partners at CDFW to provide species-specific conservation needs analysis and recommendations.

Caltrans would appreciate the opportunity to build and improve on our current partnering efforts with CDFW related to the western Joshua tree and other important natural resources.

If you have any questions, please contact Jennifer Gillies at [redacted] or [redacted] or me directly at [redacted] or [redacted]

Sincerely,

Philip J. Stolarski

PHILIP J. STOLARSKI
Chief, Division of Environmental Analysis

United States Department of the Interior

NATIONAL PARK SERVICE
Death Valley National Park
P.O. Box 579
Death Valley, CA 92328

IN REPLY REFER TO:

February 8, 2021

California Department of Fish and Wildlife
Habitat Conservation Planning Branch
Attention: Native Plant Program
P.O. Box 944209
Sacramento, CA 94244-2090
nativeplants@wildlife.ca.gov

To Whom it May Concern:

Thank you for the opportunity to comment on the proposed action by the State of California. The National Park Service does not oppose or support actions by state and local government but provides advisory comments on potential impacts to National Park System resources and their enjoyment by the visiting public.

Death Valley National Park contains roughly 51,660 acres of western Joshua tree (*Yucca brevifolia*) habitat with significant populations in the Lee Flat, Hunter Mountain, and Joshua Flats areas (Thomas et al. 2004). Although these populations appear to have good recruitment (Jim Cornett personal communication), they face the same increasing threats of invasive species, wildfire, and climate variation that devastated large populations of the eastern Joshua tree (*Yucca jaegeriana*) in the Dome Fire at Mojave National Preserve, which killed over one million individuals this past summer (Drew Kaiser personal communication). Because western Joshua trees in Death Valley National Park constitute populations in the northern portion of their range, we expect the impacts of continued climate variation to be less pronounced than in populations in Joshua Tree National Park. The National Park Service supports scientific research on these species through the permitting system and recognizes their keystone role in the Mojave Desert ecosystem.

One of the park's primary interpretive themes is "From below sea level to high mountain ranges, the environmental conditions and isolated habitats of Death Valley shape life and support diversity." The pockets of Joshua trees within Death Valley National Park provide an excellent opportunity for reinforcing this theme as they often live in areas where both snowy mountain tops and windswept sand dunes can be found within a few miles in either direction. In fact, these areas with western Joshua trees are some of the most popular backcountry use locations in the park and are extremely popular with the visiting public because of their uniqueness and scenic diversity.

Please do not hesitate to contact me if I may provide you with additional information about the relevance of stable, widespread Joshua tree populations to healthy park ecosystems and positive visitor experience in Death Valley National Park.

Sincerely,

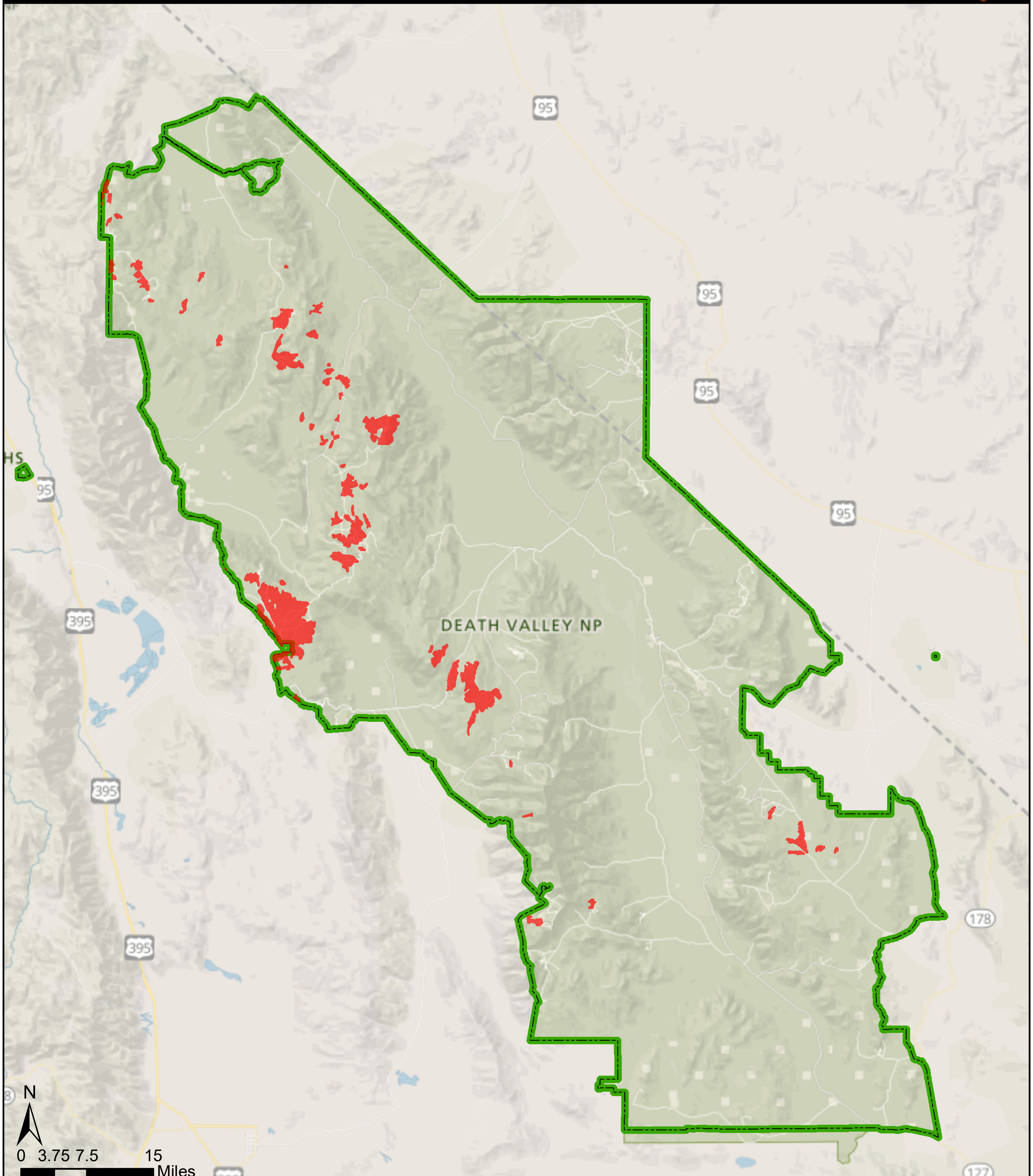
Mike Reynolds

Mike Reynolds
Superintendent

Yucca brevifolia Woodland

Death Valley National Park

National Park Service
U.S. Department of the Interior



Produced by MOJA S&RS

November 2020

Data Sources: Thomas et al. 2004, NPS Boundaries 2018
NPS Park Tiles Standard 2020

From:	Engelhardt, Blake M -FS
To:	Wildlife Native Plants
Cc:	Sill, Nathan -FS
Subject:	western Joshua tree- comments for status review under CESA
Date:	Tuesday, December 1, 2020 1:28:27 PM
Attachments:	~~image001.png~~

Hello,
In response to the request for data/comments regarding the status review of western Joshua tree, the Inyo NF has limited information to share:

There is only one known observation located on the Inyo National Forest, which consists of a small mature tree and several younger plants. These individuals are located along Crooked Creek just above the confluence with Wyman Creek, at the northeast end of Deep Springs Valley in Inyo County. These individuals were documented by Martin Purdy in 2019 (see Calflora 27114838/iNaturalist observation) and previously observed by me in 2018. This site is nearly accessible by road and is within an active cattle grazing allotment. No immediate threats are known.

There are several other locations where Joshua trees grow quite close to, but not within, the Inyo NF boundary, such as along Wyman Creek, below Haiwee Canyon and at Sage Flat on the east slope of the southern Sierra Nevada, and along the Death Valley Road at Joshua Flat, several miles east of the INF/BLM boundary.

The western Joshua tree currently does not have any special status or specific conservation goals on the INF, and due to its limited range on the forest, is unlikely to be affected by management actions at this time.

If you have any further questions please feel free to contact me.
Thanks, Blake

Blake M Engelhardt
Forest Botanist

Forest Service
Inyo National Forest

p: 760-873-2495
f: 760-873-2458
[redacted]

351 Pacu Lane
Bishop, CA 93514
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Caring for the land and serving plants

Mojave Desert Land Trust
P.O. Box 1544
60124 29 Palms Highway
Joshua Tree, CA 92252

Transition Habitat Conservancy
1681 Hillview Road
Pinon Hills, CA 92372

January 30, 2021

Subject: Western Joshua tree

Dear Department of California Fish and Wildlife Staff,

On behalf of the Mojave Desert Land Trust (MDLT) and Transition Habitat Conservancy (THC), we are writing to express support for the permanent listing of the western Joshua tree, an action that is urgently needed to address threats to its survival and recovery. They are increasing at a rate which threatens the species continued existence without additional protections.

MDLT is a nonprofit conservation organization headquartered in Joshua Tree, CA. Its service area encompasses the California Desert Conservation Area and includes the Mojave and eastern Colorado desert ecosystems. To date, MDLT has acquired nearly 90,000 acres of desert lands for conservation within national park units, national monuments, wilderness areas, wildlife corridors and other important conservation lands such as Palisades Ranch on the Mojave River. throughout the region. While the inholdings in protected areas we acquired are ultimately conveyed to federal partners, MDLT is a significant long-term stakeholder, with long-term ownership and management commitments 9,324 acres, including western Joshua tree woodland. We also have 5,960 acres of conservation easements.

Transition Habitat Conservancy is a non-profit organization focused on the protection of open space wildlands in the West Mojave Desert and adjoining North Slope of the San Gabriel Mountains. To date THC has about 8,000 acres of conservation lands, much of it in western Joshua tree woodland.

Both MDLT and THC have partnerships with the State of California including developing and implementing Conceptual Area Protection Plans.

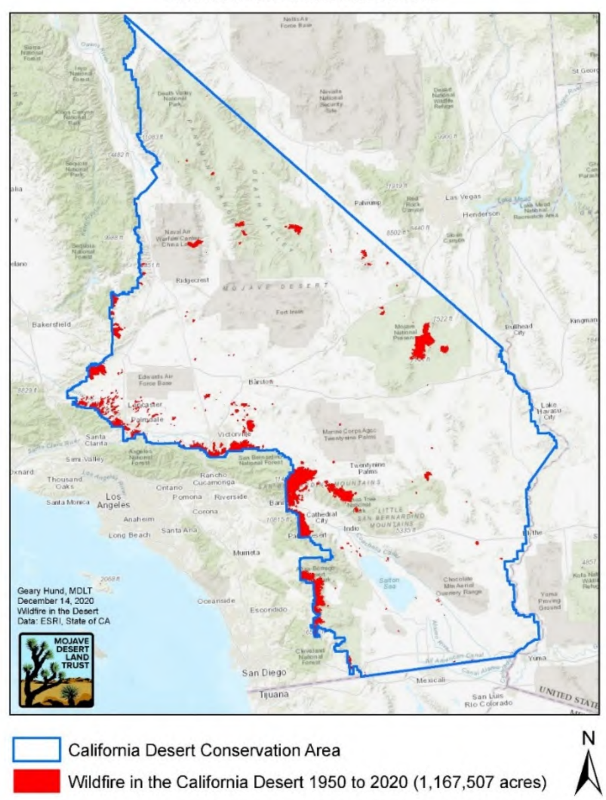
We are writing to strongly recommend that the western Joshua tree be given protection as a threatened or endangered species under the California Endangered Species Act. Threats to western Joshua tree are manifold including climate change, which is predicted to dramatically reduce the recruitment and thus the range of the western Joshua tree (Sweet, et al. 2019), increases in the number, acreage and intensity of wildfires in the desert due to climate change, increases in the extent and biomass of non-native grasses resulting in increased frequency and intensity of fire (Brooks and Berry, 2006, Zouhar et al. 2008), nitrogen deposition from air pollution, which can increase the production of non-native grasses above the fire threshold (Rao and Allen 2010), and loss of habitat due to increased residential, commercial, and industrial development, including renewable energy facilities, across the desert.

Wildfire

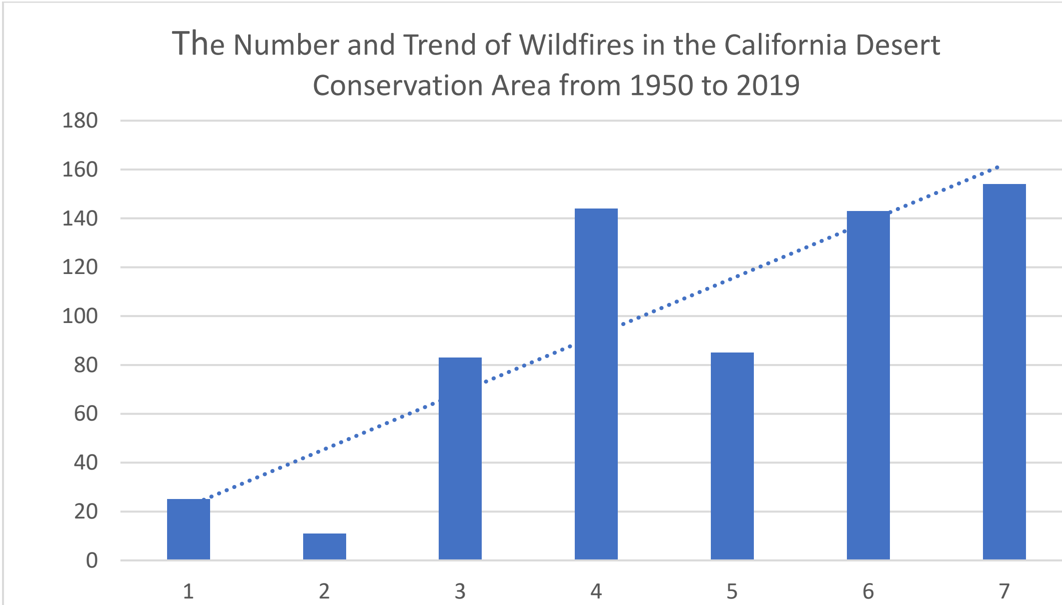
Wildfires have increased significantly in size and number across the California desert landscape in the past seven decades (see figure and tables below), particularly in the vicinity of developed areas, the extent of which has increased greatly during this time. Although some of the wildfires during this period were due to natural causes, lightening, many were human caused fires.

The map and figures below were created from an analysis of fire in the California Desert using a subset of the data found in the State of California's Geoportal(GIS) of wildfire perimeters 1950 plus. During the period between 1950 and 2019 more than 1.1 million acres burned.
The trend in the number of fires and acres burned increased dramatically over time. For example, in the decade between 1950 and 1959, the total number of reported fires was 25 and the acreage 45,079. In the decade between 2010 and 2019, the number of fires was 154 and the acreage was 187,502.[1]

Wildfire in the California Desert



[1] In the Inland Deserts Summary report in the California 4^{th} Annual Climate Change Assessment (2018), Hopkins said "A brief analysis was performed on historical fire data across the region the consisted of 9,784 [fire] records which spanned the years 1992-2015. We are not sure why his is a significantly higher number than found in the database we queried, but the trend remains the same – an ever-increasing number of fires in the desert.



Wildfire Acreage in the California Deserts		
Decade	Acres	Number
1950 to 1959	45,079	25
1960 to 1969	11,994	11
1970 to 1979	131,338	83
1980 to 1989	200,242	144
1990 to 1999	154,358	85
2000 to 2009	434,473	143
2010 to 2019	187,502	154
1950 to 2019	1,164,986	645

Western Joshua tree woodland was burned on both MDLT and THC land in 2020, illustrating the continued threat of wildfire to this species.

Both MDLT and THC have experienced wildfires in and around their conservation areas in 2020 which affected western Joshua tree woodland. In May of 2020, a wildfire in a 623-ac area of western Joshua tree woodland owned by MDLT burned 155 acres before being extinguished. It resulted in significant mortality to western Joshua trees, Mojave yuccas, and other shrub species.

In August of 2020 the Lake Fire in Los Angeles County, in the west Antelope Valley burned 1,000 acres of western Joshua tree woodland. 350 acres of that was on THC conservation land, about 140 acres on State Park land and about 100 acres on LA County Parks land.

In September of 2020 the Bobcat fire burned tens of thousands of acres of western Joshua Tree woodland in LA County. Most of this burned occurred on private land in the rural towns of Little Rock, Valyermo, .Juniper Hills, Pearblossom and Llano. 1,200 acres of the Devil's Punchbowl burned, which is part of LA County's park.

Development

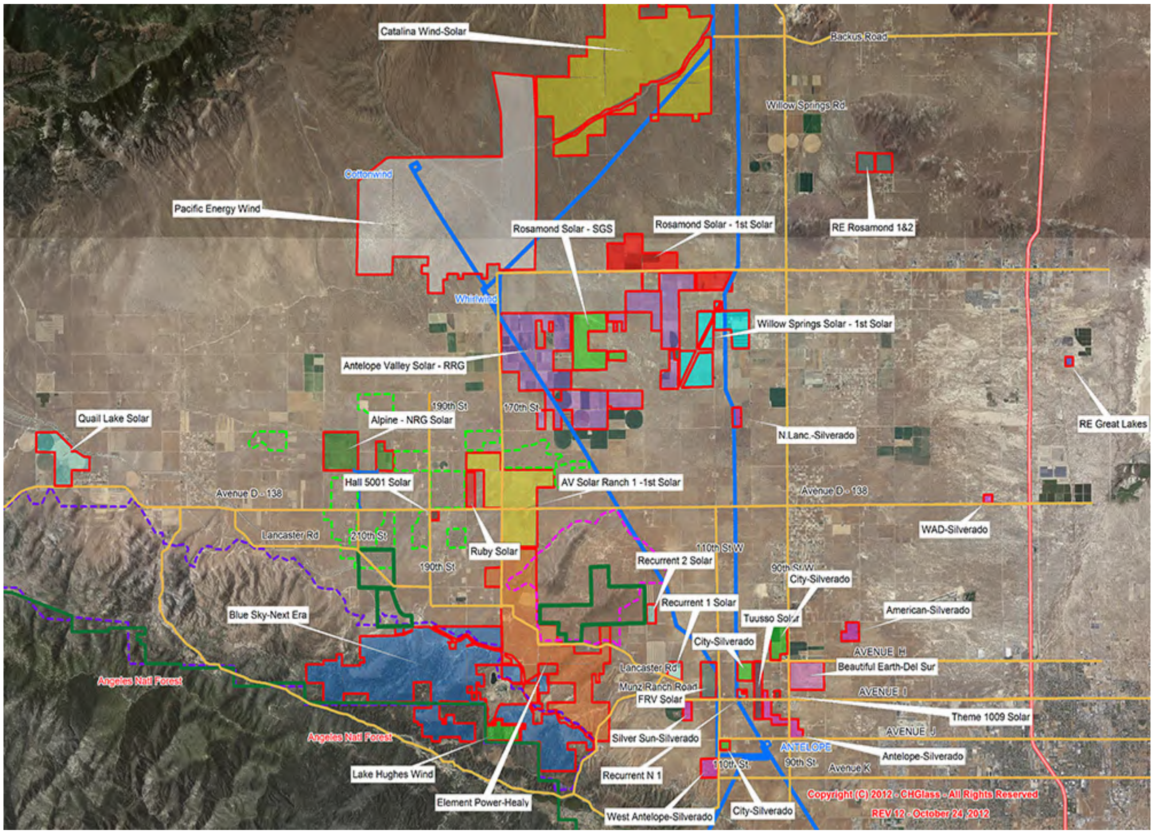
An example of the increasing threat to western Joshua tree is illustrated by proposed renewable energy projects and other development can be found in the Western Mojave.

- There are over 100,000 acres of renewable energy development in this area that were built in the last 10 years. A large portion of this used to be Joshua tree woodland.

- All of the parcels Transition Habitat Conservancy owns or holds easements on or that are in the Conceptual Area Preservation Plan have been under option by Renewable Energy Developers within the last 8 years.

- Tejon Ranch's Centennial development project is planned for 23,000 homes just across the valley a few miles away. This land also has significant western Joshua tree woodland.
- Caltrans is widening Highway 138 near this project.

- The Caltrans highway/rail High Desert Corridor will traverse the area from Hwy 15 to I-5 in the next 5 years. It is mapped through significant swaths of Joshua tree woodland in the Victor Valley as well as in the Antelope Valley.



Threats from Renewable Energy Projects in the Western Mojave Desert – Actual and Proposed

Regulations Prior to Candidacy

The local regulations to comply with state law concerning Joshua trees, prior to the designation of the western Joshua tree as a candidate species and the development of interim 2084 regulations providing for compensation for impacts to the species, including habitat loss, were far from sufficient to provide the level of protection and management of the species which is needed for its survival and recovery. In most cases, some avoidance and relocation of trees was provided for as a condition of projects. Compensation for the loss of western Joshua tree habitat for habitat acquisition, management and monitoring was not provided. Given that approximately 40 percent of the extant western Joshua tree woodland is on private land, protections on public land, while providing and important contribution to the species conservation, are not sufficient to ensure its long-term survival and recovery, including the adequate provision of climate refugia sites, seedbank and pollinator habitat, sufficient habitat to ensure sufficient healthy unburned habitat, and linkages to provide for changes in distribution in response to climate change, and repopulation, i.e., seed and pollinator movement, after catastrophic events. Having sufficient funding to provide for the long-term management of the species is also a critical component of mitigation. Active measures including, fire prevention and reduction work, e.g., the control of non-native annual grasses and other invasive plants, seeding and out planting of nurse plants, and the protection of western Joshua tree seedlings will be necessary to ensure the species survival. Funding for such measures will not be possible without state listing and associated mitigation requirements.

In summary, threats to the western Joshua tree – climate change, wildfire, the spread of invasive plant species, nitrogen deposition, and development – are substantial and increasing. The western Joshua tree will require much greater protection and management than it was receiving prior to its designation as a candidate species if it is to persist long-term. This species is iconic and emblematic of the desert as well as threats to this world-renowned resource. Its protection and the protection of desert biological diversity is essential to preserve our state's heritage, to the tourism-based economy of the desert and to the climate itself, as the vegetated areas of the desert has been shown to be an important carbon sink. As stakeholders who represent the desert and who have a strong presence in and support from our desert communities and supporters of the desert far and wide, we strongly urge you to provide CSEA protection to the western Joshua tree. Thank you for your consideration of our comments.

Sincerely,

Geary Hund
Executive Director
Mojave Desert Land Trust

Jill Bays
President
Transition Habitat Conservancy

Literature Cited

Brooks M.L., Berry K.H. Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA. J Arid Environ 67:100–124 (2006)

Hopkins, F. (University of California, Riverside). Inland Deserts Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-008 (2018)

Rao, L.E., Allen, E.B. Combined effects of precipitation and nitrogen deposition on native and invasive winter annual production in California deserts. *Oecologia* **162,** 1035–1046 (2010)

Sweet, L.C., et al. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. Ecosphere. 10 (6): pp. 1–17 (2019)

Zouhar K, Smith JK, Sutherland S, Brooks ML Wildland fire in ecosystems: fire and nonnative invasive plants. General technical report. RMRS-GTR-42-vol. 6. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden (2008)

PALA ENVIRONMENTAL DEPARTMENT
PALA BAND OF MISSION INDIANS
PMB 50, 35008 Pala Temecula Road | Pala, CA 92059
Phone 760-891-3510 | Fax 760-742-3189

RE: Western Joshua Tree Status Review

To Whom It May Concern:

Western Joshua trees (*Yucca brevifolia*) are vitally important to both the health of the environment of Southern California and to the history and culture of the Native peoples. The peoples of the deserts used the leaves for bindings in clothing and materials, and used the seeds and flowers as food. The Joshua tree is also an important symbol of the Mojave Desert and important to the life history of associated moths, lizards, birds, and other animals of the deserts. We expect that climate change and human encroachment are damaging regeneration of the population.

Our stance is to support the best available science and the indigenous peoples of the deserts who may also comment on the listing. The Joshua tree has been here for untold generations and we wish to see it persist. Please direct any questions or comments on this response to Kurt Broz, Pala's wildlife biologist, at kbroz@palatribe.com.

Sincerely,

Shasta Gaughen, PhD
Pala Band of Mission Indians
Environmental Director/Tribal Historic Preservation Officer

NOSSAMAN LLP

ATTORNEYS AT LAW

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Paul S. Weiland
D 949.477.7644
pweiland@nossaman.com

Refer To File # 501803-0004

VIA EMAIL

January 29, 2021

California Department of Fish and Wildlife
Habitat Conservation Planning Branch
Attn: Native Plant Program
P.O. Box 944209
Sacramento, CA 94244-2090
nativeplants@wildlife.ca.gov

Re: Information relevant to California Department of Fish and Wildlife's status review for the western Joshua tree (*Yucca brevifolia*)

To Whom It May Concern:

This letter is submitted on behalf of QuadState Local Governments Authority ("QuadState")[1] in response to the California Department of Fish and Wildlife's ("Department") October 21, 2020 Notification of Status Review for Western Joshua Tree ("Notice"). In addition to the comments provided by this letter, QuadState has also enclosed and fully incorporates herein certain information pertinent to the status review of the western Joshua tree ("Status Review") that previously was provided to the California Fish and Game Commission ("Commission") in connection with the Commission's review of the petition ("Petition") to list the species under the California Endangered Species Act ("CESA") (hereafter, QuadState's previous submission is referred to as "Previous Comments"). QuadState believes its Previous Comments are both helpful and pertinent to the Department's current Status Review.

The Petition submitted by the Center for Biological Diversity requests the western Joshua tree be listed as a threatened species under CESA primarily because of the alleged ill effects of climate change on the species.[2] On September 24, 2020, the Commission determined that the Petition, comments received on the petitioned action, and the administrative record "would lead a reasonable person to conclude there is a substantial possibility the requested listing could occur." Commission Notice of Findings for Western Joshua Tree (*Yucca brevifolia*) (September 24,

[1] QuadState is a joint exercise of powers authority with seven members (six counties and one municipality) across four Western states. QuadState membership includes several desert counties in which the western Joshua tree may be found.

[2] A threatened species under CESA is one that "although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts" required by the Cal. Fish and Game Code. Fish & Game Code § 2067.

2020); *found at*: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=183565&inline. The ongoing Status Review is required pursuant to the Commission's September 24, 2020 determination.

As set forth in the Notice, when making a recommendation to the Commission as to whether or not a species warrants listing under CESA, "[t]he Department's recommendation must be based on the best scientific information available to the Department." Notice at 1. Section 2074.6 of the Fish and Game Code requires that a draft species status report prepared by the Department receive peer review. Cal. Fish & Game Code § 2074.6. As described in greater detail below, **QuadState believes it is vitally important that the Department conduct a rigorous and independent scientific review of information provided to the Department in connection with the Status Review, as well as information available to the Department in its administrative files**.

In 2017, the Department updated its *Guidelines for Conducting Peer Review and Convening ad hoc Independent Scientific Advisory Committees* (Oct. 16, 2017) ("Peer Review Policy"). The Peer Review Policy indicates that the Department will use peer review to "provide objective evaluation of scientific information used to inform resource management decisions." The Policy further states that the level of formality of a peer review is dependent upon, among other things, the "potential significance to policy formation or management decisions as well as the impact or importance of those policies and decisions. Peer Review Policy at 1-2. The Peer Review Policy further explains that "[t]he more influential and impactful the product may be, the more rigorous the corresponding peer review." *Id*. at 2. Listing of the western Joshua tree that numbers in the tens of millions in all likelihood and is spread across millions of acres would have a significant impact on local governments, regulated utilities, businesses, and homeowners and property owners in California, as well as a significant impact on the resources of the Department and Commission, who must oversee the species' management and recovery and process applications for permitting once the species was listed. **The Department's recommendation with respect to the status of the western Joshua tree, therefore, requires rigorous peer review**. As stated in the Peer Review Policy, informal feedback from professional colleagues "is not a substitute for formal peer review." *Id*.

QuadState notes that an improperly conducted peer review could result in a flawed result. Murphy, et al. 2019. Independent and Scientific Review under the Endangered Species Act. BioScience: 69(3): 198-208. Of particular concern here, with a high-visibility species, is the potential for a peer review panel to have underlying bias or conflicts of interest, even where they "otherwise may offer requisite diverse expertise to a review." *Id*. at 203. Accordingly, **QuadState encourages the Department to select peer reviewers who are free from any actual or perceived conflicts of interest**. Conflicts of interest include, but are not limited to: playing a part in drafting or publicly supporting the petition to list the western Joshua tree; drafting, editing, or reviewing comments on the petition to list the species; having financial interests in the listing of the western Joshua tree; and opportunity to gain an unfair competitive advantage for the panelist or his or her home institution. *Id*. at 204.

In addition to ensuring that any peer review panel is free of conflicts of interest, QuadState encourages the Department to follow other accepted principles of scientific review. These include, but are not limited to, the following:

- Peer review panel should be made up of at least three members, in order to encourage deliberation. Peer reviewers should possess familiarity in experimental design, quantitative ecology, ecological theory, and species-habitat relationships.
- Peer reviewers should be balanced in their perspectives.
- A neutral third party should administer the peer review and serve as an intermediary between the Department and the panel in order to enhance stakeholder confidence in the peer review process.
- A task statement should be provided to the panel and make clear that the purpose of the peer review is to critically evaluate and interpret the information and is not to make policy recommendations. Peer reviewers should evaluate and identify data and modeling limitations and uncertainties, if any.
- Peer reviewers should be provided supporting materials necessary to allow them to ascertain the process that the Department followed in reaching its determination, and how the relevant technical information was synthesized, interpreted, and integrated into that process.
- Peer reviewers should be afforded sufficient time and resources to complete a comprehensive assessment of the data provided.
- The Department should indicate in its charge to the peer review panel how the agency will respond to the review. The Department should acknowledge recommendations and substantive input from the panel, including providing justification for nonresponses or rejections of comments.

Murphy at 202-206. QuadState notes that peer reviewers examining the Department's draft species status report do not need to be experts on the western Joshua tree. Rather, these reviewers should be experts in applying scientific data and, in particular, the kind of data set forth in the information received in connection with the Status Review. In light of the issues being considered by the Department, one or more reviewers should have expertise in conservation biology, quantitative biology, and modeling climate change at pertinent scale and in pertinent time frames.

As described in greater detail in the Previous Comments, it is QuadState's position that the western Joshua tree does not meet the definition of a threatened species under CESA because it is not likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by section 2067 of the California Fish and Game Code.[3] The Commission previously has elected not to list species where "the best scientific information currently available indicates [the species] is not in serious danger in the next few

[3] QuadState notes that the petition to list the western Joshua tree admits that the species is not faced with "imminent risk of extinction." *See* Petition at 32.

decades of becoming extinct throughout all or a significant portion of the species' range in the state…" Memorandum concerning the American pika from Charlton H. Bonham, Director of California Dep't of Fish and Wildlife to Sonke Mastrup, Exec. Director of Fish and Game Comm'n (May 5, 2013). QuadState believes that the best scientific information currently available demonstrates that the western Joshua tree is not in serious danger of becoming extinct throughout all or a significant portion of the species' range in the state in the next few decades, and that the Department and any peer review panel should reasonably come to the same conclusion.

Finally, it is QuadState's position that the Department should endeavor to make a quantitative assessment of available habitat for the western Joshua tree (in acres) and a quantitative assessment of the number of western Joshua trees currently present on the landscape. Providing a quantitative number trees and acres of available habitat would establish a baseline from which the Department may later assess the trajectory of the species and conduct future status reviews. Without a quantitative assessment of the species, any conclusions are informed by educated guesswork rather than empirical research.

Very truly yours,

Paul S. Weiland
Nossaman LLP

PSW:art
Enclosure

NOSSAMAN LLP

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pweiland@nossaman.com

Refer To File # 501803-0004

VIA EMAIL

June 10, 2020

Erik Sklar, President
California Fish and Game Commission
1416 9th Street, Suite 1320
Sacramento, CA 95814
fgc@fgc.ca.gov

Re: Petition to list the western Joshua tree as threatened or endangered under the California Endangered Species Act

Dear President Sklar:

This letter is prepared and submitted on behalf of QuadState Local Governments Authority ("QuadState").[1] We are writing to oppose a petition ("Petition") submitted by the Center for Biological Diversity ("Petitioner") to list the western Joshua tree (*Yucca brevifolia*)[2] as threatened as either a full species or as the subspecies (*Yucca brevifolia brevifolia*) under the California Endangered Species Act ("CESA"), Fish & G. Code ("Code"), § 2050 *et seq*. We understand that at its June 24-25, 2020 meeting, the California Fish and Game Commission ("Commission") will consider whether listing the western Joshua tree under CESA, as requested by the Petition, may be warranted. We request the Commission reject the Petition.

While QuadState is confident that CESA and its implementing regulations require rejection of the Petition, QuadState supports the Commission deferring any decision until the next Commission meeting in order to provide our County members and their constituents with a meaningful opportunity to participate in the listing process. We understand that Commission staff have also recommended the decision be deferred until the August 19-20, 2020 Commission meeting.[3] As you

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[1] QuadState is a joint exercise of powers authority established between eight counties and one city in four Western states. QuadState membership includes three desert counties in California—Imperial County, Inyo County, and San Bernadino County—in which the western Joshua tree may be found.

[2] Due to the species' treatment in the majority of existing scientific literature, the Petition primarily refers to Joshua tree as a single species rather than distinguishing between *Y. brevifolia* (the western Joshua tree) and *Y. jaegeriana* (the eastern Joshua tree); however, the Petition adopts the recent view that *Y. brevifolia* is distinct from *Y. jaegeriana* and requests listing of only *Y. brevifolia*. *See* Petition at 1, 4. In this letter, QuadState refers to the petitioned species as the western Joshua tree.

[3] *See* June 24-25, 2020 Commission Agenda *available* at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=180395&inline.

are well aware, governments and their citizens are facing a raft of challenges at this moment in time largely as a consequence of the COVID-19 pandemic and its devastating societal impacts. These circumstances have made it difficult for our members to give the Petition and the Department of Fish and Wildlife's ("Department") March 11, 2020 Initial Evaluation of the Petition ("Department Evaluation") appropriate attention.

Deferral will also allow the County members and their constituents with an opportunity to confer with Commission staff and Department personnel regarding the potential to adopt a 2084 regulation in the event that the Commission determines, over our objections, that listing the western Joshua tree under CESA may be warranted. As we are in the midst of a recession of uncertain depth and length, and because all agree that the threat to the species is not by any stretch a near-term threat, a 2084 regulation could be invaluable as a tool to limit the economic consequences of candidacy while ensuring adequate protection for the species, should the Commission pursue that route.

As set forth in greater detail below, QuadState does not believe that the Petition demonstrates that the western Joshua tree meets the definition of a threatened species under CESA. Rather, the Petition relies substantially on effects to the species that may be caused by climate change that Petitioner admits may not be evident for 50 or more years into the future. Such a request is unprecedented. Neither CESA nor its implementing regulations contemplate listing species where the data do not indicate existing and demonstrable threats. To date, the Commission has not listed a species primarily on the basis of potential, future adverse effects of climate change and doing so would establish a precedent not rooted in principles of sound science.

QuadState urges the Commission not to simply accept Petitioner's assertions regarding threats to the western Joshua tree and its habitats; rather, QuadState requests the Commission fulfill its legal obligation to evaluate the information in the Petition and other available information and determine whether the Petition's claims are credible and provide a lawful basis for a candidacy determination.

1. LEGAL BACKGROUND

Section 2070 of the Code provides that the Commission "shall establish a list of endangered species and a list of threatened species." CESA defines a threatened species as:

> a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by this chapter.

Fish & G. Code § 2067. The statute defines endangered species as a species:

> which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease.

Id. at § 2062.

A. Petition requirements

Any person can submit a petition to list a species under CESA. In order for a petition to be accepted by the Commission, the Code requires the petition include sufficient scientific information that the petitioned action may be warranted. Fish & G. Code, § 2072.3. Specifically, the CESA requires that a petition include information regarding the "population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information," as well as the "kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant." *Id*.

Caselaw clarifies that a species does not qualify as a candidate for "endangered" or "threatened" classification if the petition does not provide sufficient information that would lead a reasonable person to conclude the petitioned action may be warranted. *Natural Resources Defense Council v. Fish & Game Com*., 28 Cal. App. 4th 1104, 1119 (1994) (citing Fish & G. Code, § 2074.2).

B. Obligations of California Department of Fish and Wildlife in evaluating petitions

Pursuant to section 2073.5 of the Code and Title 14 of the California Code of Regulations, the Department must address each of the following petition components when evaluating whether the petitioned action (here, listing the western Joshua tree as threatened) may be warranted:

1. Population trend;
2. Range;
3. Distribution;
4. Abundance;
5. Life history;
6. Kind of habitat necessary for survival;
7. Factors affecting the ability to survive and reproduce;
8. Degree and immediacy of threat;
9. Impact of existing management efforts;
10. Suggestions for future management;
11. Availability and sources of information; and
12. A detailed distribution map.

Cal. Code Regs., tit. 14, § 670.1(d)(1). As set forth below, QuadState believes neither the information presented by the Petition nor the information contained in the Department Evaluation are sufficient to indicate that listing the western Joshua tree may, in fact, be warranted.

2. NEITHER THE PETITION NOR THE DEPARTMENT EVALUATION ESTABLISH SUBSTANTIAL POSSIBILITY THAT LISTING THE WESTERN JOSHUA TREE MAY BE WARRANTED

As noted above, a threatened species under CESA is one that is not presently threatened with extinction, but is "likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by this chapter." Fish & G. Code § 2067. The Petition requests the western Joshua tree be listed as threatened under CESA. Thus, the question for the Commission is whether the species is likely to become in danger of extinction in the *foreseeable future* without *special protection and management* afforded by the Code. Below, we provide information establishing that the western Joshua tree does not meet the criteria for listing under the Code.

A. Western Joshua tree unlikely to become an endangered species in the foreseeable future

The Petition is clear that the western Joshua tree is not faced with "imminent risk of extinction," and, admits that "extirpation [of the species] is likely decades away[.]" Petition at 1, 48. While the Petition predicts that western Joshua trees will be "close to being functionally extinct" in California by "century's end" (that is, 80 years from now), the Petition also explains that "researchers have been raising the alarm about threats to Joshua trees for decades." *Id*. at 32. For example, a study cited by Petitioner from 1953 stated that "regardless of the present wide distribution and large concentration of yuccas, [the Joshua tree's] future appears very dim." *Id*. at 34. And yet, more than 70 years after that grim assessment, there has been no observable downward trend in the population of the Joshua tree, as stated in the Petition and reiterated in the Department Evaluation. *See* Petition at 19 ("no range-wide population trends have been documented"), at 20 ("Regardless of whether Joshua tree abundance is already declining, it is virtually certain that abundance will decline in the foreseeable future"), and at 9 ("The Petition does not present an estimate of western Joshua tree population size, nor does it provide evidence of a range-wide population trend…"); *see also* Department Evaluation at 2 ("Although a reliable estimate of western Joshua tree population size is not available, information available to the Department indicates that the Joshua tree is currently relatively abundant"). Indeed, the Petition itself notes that "while the threats facing *Y. brevifolia* in the coming decades are dire, unlike more narrowly-endemic species, the species has the benefit of being long-lived, with a relatively large current distribution, spread across the elevational and latitudinal gradients, much of which is in protected areas." Petition at 65.

Neither CESA nor its implementing regulations provide guidance on how the Commission should apply the "foreseeable future." Nevertheless, the Petition cites to a 2013 memorandum from the Director of the Department to the Executive Director of the Commission ("2013 Memorandum") concerning a petition to list the American pika on the basis of climate change-induced threats as precedent for the theory that the end of the 21st century may be an appropriate measure. Petition at 63; Memorandum from Charlton H. Bonham, Director of California Dep't of Fish and Wildlife to Sonke Mastrup, Exec. Director of Fish and Game Comm'n, (May 5, 2013) at 1 (emphasis added).

Petitioners fail to mention, however, that the Department ultimately recommended in the 2013 Memorandum that the Commission not list the American pika as a result of the potential threat of climate change. Instead, the Department noted in the 2013 Memorandum that "the best scientific information currently available indicates [the American pika] is not in serious danger in the ***next few decades*** of becoming extinct throughout all or a significant portion of the species' range in the state, nor by the end of the century should the existing climate change models and predicted trajectory of suitable pika habitat come to fruition." 2013 Memorandum at 1 (emphasis added).

Given that supposed extirpation of the Joshua tree is likely "decades" in the future and that there currently is no demonstrable downward trend in the species' abundance or range, QuadState fails to see how the Petition provides the best scientific evidence that the species is in danger of extinction in the foreseeable future.

B. Climate change modeling and relevant studies diverge on the effects of climate change on the Joshua tree

The Petition relies heavily on certain select studies to support the contention that extirpation of the western Joshua tree in California is a foregone conclusion due to the predicted effects of climate change. But multiple studies predict growth and expansion of the range of the tree as a result of a warming climate, while others predict a modest contraction of the tree's range, and still others predict total extirpation. This range of outcomes indicates uncertainty that increases as one looks further into the future.

For example, and as mentioned by Petitioners in a footnote, Notaro et al. (2012) predicted a "robust range expansion" of the species of nearly 150 percent as a result of climate change. Petition at 38, n. 38. Petitioners discount Notaro et al. because that study did not examine the species' response to climate change in California, but fail to mention other studies that also predict potential expansion of the species' range in California.

Archer et al. (2008) notes that "limited available data suggest increases in atmospheric [carbon dioxide] concentrations could promote Joshua Tree seedling survival, and could result in an increase of this native species' range." Steven R. Archer and Katharine I. Predick, *Climate Change and Ecosystems of the Southwestern United States*, Rangelands 30(3): 23-38 (June 2008). The same study further provides that:

> Although the deserts of southwestern North America have been the sites of many important ecological studies, there have been relatively few long-term monitoring studies that provide the opportunity to observe changes in ecosystem structure and function in response to climate change per se… Current observation systems are inadequate to separate the effects of changes in climate from the effects of other drivers…
>
> …

> In climate simulations for the Intergovernmental Panel on Climate Change emission scenarios, novel climates arise by 2100 AD. These future novel climates (warmer than any present climates, with spatially variable shifts in precipitation) increase the likelihood of species reshuffling into novel communities and other ecological surprises… Most ecological models are based upon modern observations, and so might fail to accurately predict ecological responses to future climates occurring in conjunction with elevated atmospheric CO2, nitrogen deposition, and nonnative species introductions.

Id. at 27-28.

Likewise, a study published in 2012 demonstrated that where there was a 3 degree Celsius increase in mean July maximum temperature, Joshua tree distribution within the Joshua Tree National Park ("JTNP") declined by a predicted 90 percent, but a suitable Joshua tree refugium remained in the park. Cameron W. Barrows, Michelle L. Murphy-Mariscal, *Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions*, Biological Conservation 152: 29-36 (2012). The study's authors noted that statistical analyses used in previous larger-scale climate modeling homogenized different local conditions and adaptations and, as a result, failed to accurately characterize "the unique niches of statistical outliers, individual populations at the periphery of a species' distribution." *Id*. at 30. To better understand Joshua trees' response to changing climactic conditions, the study's authors employed niche modeling, which considers habitat variables (e.g., climate and terrain) to assess the "complex interaction of factors" constraining species distribution. *Id*. Using this niche modeling, Barrows and Murphy-Mariscal explained that their results contrasted with those of two studies cited heavily by Petitioner: Dole e al. (2003) and Cole et al. (2011) (collectively "Dole and Cole"). While Dole and Cole constructed models wherein similar levels of climate change resulted in no suitable habitat for Joshua trees within the central or southern portions of their current distribution, Barrows and Murphy-Mariscal's results indicated suitable habitat would, indeed, remain. *Id*. at 34. Barrow and Murphy-Mariscal opined that the differences were due to scales of analyses used by Cole and Dole rather than differences in modeling or model assumptions. *Id*. Put simply, Barrows and Murphy-Marsical "were able to incorporate local adaptations as well as topographic-climate complexities, a perspective that would almost certainly be lost with the homogenizing of climate adaptations and landscape features inherent with larger scale analyses." *Id*. (citing Pennington et al. 2010). Importantly, and unlike Cole et al. (2011), Barrows and Murphy-Mariscal found no evidence of Joshua tree mortality within JTNP that was unrelated to fires, despite specifically searching for such causes. *Id*.

Finally, QuadState wishes to bring to the Commission's attention a paper presented at the 2018 Desert Symposium demonstrating that young *Y. jaegeriana* within the Cima Dome in the Mojave National Preserve (located in San Bernadino County, California) appear to survive and grow even through periods of long-term drought. *See* James W. Cornett, *Eastern Joshua tree (Yucca jaegeriana) growth rates and survivability on Cima Dome, Mojave National Preserve*, 2018 Desert Symposium (2018) ("The… study indicates young Joshua trees established near the species' elevational limit have the capacity to survive and continue to grow despite the long-term drought experienced during the… study"). While this paper was written based on a study of *Y. jaegeriana*, one could reasonably postulate that *Y. brevifolia* occurring at similar elevations elsewhere in California would respond in much the same fashion in response to climate change-induced drought and temperature increases as their eastern counterpart. At a minimum, this paper provides further support for QuadState's position that the potential impacts to Joshua tree as a result of climate change do not form a reasonable basis on which to list the Joshua tree or place the species on the list of CESA candidates.

The varying results of studies and models demonstrate that specific effects of climate change on the western Joshua tree are uncertain, and, therefore, the Commission should decline to find the species may warrant listing under CESA at this time.

C. Special protection and management unlikely to address primary alleged threat of climate change

Even assuming that the species is, in fact, in danger of extinction in the foreseeable future, the Petition still fails to meet the test for listing the western Joshua tree as threatened under CESA. As is described in greater detail below, because the primary threat identified by the Petition is that of climate change, there would not appear to be relevant special protection or management efforts that the Commission could put into place that would reverse the supposed trajectory of the species.

The Petition acknowledges its position that "[c]limate change represents the single greatest threat to the continued existence of the *Yucca brevifolia*." Petition at 31. Indeed, the Petition states that "***[e]ven under the most optimistic climate scenarios, western Joshua trees will be eliminated from significant portions of their range by the end of the century***…" *Id*. (emphasis added).

Consequently, the Petition explains that the "lack of effective regulatory mechanisms to address greenhouse pollution is largely determinative as to the question of whether *Y. brevifolia* qualifies for CESA protection." Petition at 50-51. And the first remedy suggested in the Petition for ameliorating threats to the species and to manage and recover the species is for the governor of the State of California to declare a "climate emergency and take[] all necessary action to set California on a path to full decarbonization of [the state's] economy by no later than 2045 (e.g., banning the sale of new fossil fuel vehicles by 2030 and requiring the generation of all electricity from carbon-free sources 2030)." *Id*. at 65. The Department Evaluation also acknowledges that the most important recovery actions for the species are those leading to rapid and steep greenhouse gas emission reductions to minimize climate change. Department Evaluation at 27.

QuadState notes that the Petition neither explains nor substantiates how state-level action to address climate change would lead to a reduction in greenhouse gas emissions at a level necessary to ameliorate threats of climate change on western Joshua trees located in the State of California. Moreover, the Code explicitly states that the relevant management actions and protections must be available under Chapter 1.5 of the Code itself.[4] Fish & G. Code at § 2067. These provisions relate

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[4] As noted above, the definition of a "threatened" species under CESA is a "native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that…is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [Chapter 1.5 of the Code]." Fish & G. Code

to regulation of "take" of CESA-listed species and not to broad orders by the governor regulating GHG emissions.

Other protective or special management measures recommended by Petitioner include preparation of recovery plans, development of Natural Community Conservation Plans, acquisition of habitat to expand and connect existing state parks to protect Joshua trees, and development of fire protocols within the species range, among others. While these measures may be beneficial to the Joshua tree, the Petition states – and the Department Evaluation recognized – that threats to the Joshua tree due to habitat destruction, fire, and invasive species merely exacerbate the larger threat caused by climate change. *See* Department Evaluation at 2. As such, the measures recommended by Petitioner would not, without a reversal of the climate change trajectory, provide sufficient benefit to counter the purported threat to the species. If the climate change predictions espoused by the Petition prove true, the presence or absence of any protective measures would make no difference to the species' status. As noted above, the Petition admits that even under the best climate change scenario, the species will become close to functionally extinct. Petition at 32.

D. Joshua tree is adequately protected in the State of California

QuadState notes that the western Joshua tree already benefits from substantial on-the-ground conservation pursuant to federal, state, and local law, regulation, and policy, and believes that the Petition's claim that the western Joshua Tree is inadequately protected is wholly without merit. Petition at 48, 58.

For example, under the California Desert Protection Act of 1994 ("CDPA"), Congress expanded environmental protections to millions of acres of desert "wilderness" by establishing the Death Valley and Joshua Tree National Parks, and the Mojave National Preserve. Pub. L. No. 103-433, 108 Stat. 4471 (1994). Through the CDPA, Congress declared its policy that public lands in the California desert be included in the national park and national wilderness preservation systems in order to perpetuate the diverse ecosystems of the California desert in its natural state. *Id*. The CDPA withdrew designated areas from "all forms of entry, appropriation, or disposal under the public land laws" and effectively functions to preserve and protect the very habitat necessary for the Joshua tree's survival. *Id.;* 16 U.S.C. §§ 410aaa–42, 410aaa–47.

The Petition acknowledges that 96 percent of the western Joshua Tree population in the northern part of its range occurs on federal lands protected under the CDPA and other mechanisms and that ten percent of the species occurring in the northern part of its range occurs on National Park Service land which is "generally well-managed and should prevent significant habitat loss or degradation from activities such as [off-road vehicle] use, cattle grazing, road building, or other forms of development." Petition at 55. Nevertheless, Petitioners attempt to minimize the significance of this protection by noting without additional commentary the existence of a single grazing allotment (the 86,400-acre Hunter Mountain Allotment) within Death Valley National Park that supposedly

§ 2067. The term "special protection and management efforts" is not further defined by the Code. Chapter 1.5 of the Code does not set forth any required special protection and management obligations relating to state-listed species outside of the application of prohibitions on import, export, and take established in § 2080 and activities relating thereto.

overlaps with the "range of *Y. breviolia*". *Id*. Petitioners cite the National Park Service's Death Valley National Park Wilderness and Backcountry Stewardship Plan and Environmental Assessment (2012) ("Park Service EA"). The Park Service EA, however, does not address whether the western Joshua tree occurs within the Hunter Mountain Allotment, and the Petition does not explore whether the current grazing allotment (which permits grazing of no more than 150 head of cattle between November 20 to June 30 of each year), in fact, negatively affects the species. *See* Park Service EA at 122.

At the state and local level, numerous laws and ordinances serve to provide significant additional protection for the western Joshua tree. For example, under the California Desert Native Plants Act, the western Joshua tree may not be harvested without a permit in Imperial, Inyo, Kern, Los Angeles, Mono, Riverside, San Bernardino, and San Diego Counties. Food & Agr. Code, §§ 80073(a), 80003. Local jurisdictions have adopted measures similar to those set forth in the California Desert Native Plants Act, including specific prohibitions on harvesting or removing Joshua trees. *See* San Bernadino County Code 88.01.060(c)(4). Chapter 14 of the City of Palmdale Municipal Code declares as its policy that "appropriate action must be taken in order to protect and preserve desert vegetation, ***and particularly Joshua trees***, so as to retain the unique natural desert aesthetics on some areas of this City[.]" Palmdale, Cal., Ordinance Ch. 14.04, § 14.04.010 (1992) (emphasis added).

QuadState fails to see how preservation and protection of such significant portions of a species' current habitat in addition to strong state and local laws and ordinances prohibiting removal of the species could lead a reasonable person to conclude such species is inadequately protected under existing regulatory mechanisms.

3. DEPARTMENT EVALUATION FAILS TO NOTE THE FACT THAT THE PETITION IS INCOMPLETE

QuadState notes that the Department appears to have completely ignored the requirement of the California Code of Regulations that a petition to list a species under CESA provide information concerning the species population trends and abundance. Despite acknowledging that the "Petition does not present an estimate of western Joshua tree population size, nor does it provide evidence of a rangewide population trend," the Department nevertheless found that the Petition presented sufficient information on population trend and range. Department Evaluation at 2, 9.

Indeed, the Petition explicitly states that "[d]ue to the [Joshua tree's] patchy distribution within its range, highly variable population density…and lack of range-wide population surveys, a reliable estimate of Joshua tree population size is not available." Petition at 19. Moreover, the Petition notes that "impacts such as adult mortality and consequent population declines and range reductions may have a lag time before the presence is felt on the landscape." *Id*. at 20.

QuadState fails to understand how a Petition's provision of no data can result in a Department finding that sufficient data was provided.

4. STANDARD FOR LISTING UNDER CESA CANNOT BE BASED ON FUTURE DECLINE ALONE

The Petition includes dire warnings concerning the threat climate change poses to the western Joshua tree; however, the Petition also acknowledges that "[s]ince the end of the Pleistocene, the Joshua tree's distribution has been remarkably stable throughout the Holocene into the present day." Petition at 16-17. Despite the continued persistence of the species for tens of thousands of years, the Petition nevertheless predicts that the species will be extirpated at least from the JTNP by 2071 to 2099. *Id.* at 37. Among the studies relied upon by the Petition for this prediction is Cole et al. 2011. *Id.* at 68. However, it is notable that Cole et al. 2011 explains that the warming climate that occurred at the end of the Pleistocene and marking the beginning of the Holocene was the "most recent warming event of similar magnitude to that predicted for the near future." Cole et al. 2011 at 139. While that study indicated the species did not migrate as one might have expected, the species nevertheless has continued to persist, demonstrating its remarkable resilience.

Common logic would tell us that a species should not be listed on the sole basis that it may experience a future decline in range or distribution, particularly where no studies have demonstrated a downward population trend or reduction in abundance at a population level. Indeed, to date, the Commission has declined to list any species solely (or primarily) on the basis of future threats due to climate change. Doing so would open Pandora's box, allowing for the listing of innumerable plants and animal species that are not currently in danger of extinction nor likely to become so in the coming decades. QuadState believes a listing – or even a placement of a species – based on supposed future threats would be inconsistent with the Code.

QuadState suggests that the approach the Department adopted with respect to the American pika, mentioned briefly above and cited by the Petition, was precisely right. There, the Department did not recommend listing the species under CESA on the basis of future threats caused by climate change. Instead, the Department noted its belief that continued study and monitoring of the American pika would be "imperative" for the agency over the "next few decades" in order to "better assess the foreseeable future and the need for protections under CESA." 2013 Memorandum at 2.

This wait and watch closely approach suggested by the Department in connection with the status of the American pika under state law was prudent, thoughtful, and warranted. The Commission should decline to find the Petition warranted at this time and should, instead, adopt an approach wherein the species' trends and trajectory are closely monitored. The Commission may elect to initiate the CESA listing process at a later date due to the provision of new information and, of course, interested persons may submit new petitions to list at any time, which would trigger the petition review process.

5. CONCLUSION

In light of the foregoing, QuadState urges the Commission not to simply accept Petitioner's assertions regarding threats to the western Joshua tree and its habitats; rather, QuadState requests the Commission fulfill its legal obligation to evaluate the information in the Petition and other available information and determine whether the Petition's claims are accurate and credible.

Natural Resources Defense Council v. Fish & Game Com., 28 Cal. App. 4th 1104, 1119, 1125. The "may be warranted" finding described in Fish & Game Code § 2074.2 requires a determination that there is a "substantial possibility" that the petitioned action is warranted. *Id*. Based on the information provided in the Petition, there can be no rational determination of a substantial possibility that listing the western Joshua tree would be warranted at this time.

Very truly yours,

Paul S. Weiland
Nossaman LLP

cc: Charlton Bonham, Director, California Department of Fish and Wildlife
Gerald Hillier, Executive Director, QuadState Local Governments Authority

From: Quechan Historic Preservation
To: [redacted]
Cc: Wildlife Tribal Liaison
Subject: RE: Notification of Status Review for Western Joshua Tree
Date: Tuesday, November 17, 2020 1:45:04 PM

Warning: This email originated from outside of CDFW and should be treated with extra caution.

This email is to inform you that we do not wish to comment on this project. We defer to the more local Tribe(s) and support their decisions on the project.

From: [redacted]
Sent: Monday, November 16, 2020 11:49 AM
To: [redacted] Wildlife Tribal Liaison
Subject: Notification of Status Review for Western Joshua Tree

Dear Honorable Tribal Representative:

Please see the attached notification of a status review for western Joshua tree (*Yucca brevifolia*) under the California Endangered Species Act. A paper copy will follow via mail.

Thank you for your time.

Sincerely,

Jeb McKay Bjerke
Senior Environmental Scientist (Specialist)
Native Plant Program
California Department of Fish & Wildlife
Habitat Conservation Planning Branch
Mobile (916) 720-1232
https://www.wildlife.ca.gov/Conservation/Plants

From: Ryan Nordness
To: [redacted]
Cc: Wildlife Tribal Liaison; Jessica Mauck
Subject: RE: Notification of Status Review for Western Joshua Tree
Date: Tuesday, November 17, 2020 2:28:54 PM
Attachments: image[illegible].PNG

Warning: This email originated from outside of CDFW and should be treated with extra caution.

Hello Jeb,

Thank you for reaching out to the San Manuel Band of Mission Indians (SMBMI) regarding the petitioned status change of the Western Joshua Tree (Yucca brevifolia) to receive the same legal protections as endangered or threatened species. While the Western Joshua tree's protection is of concern to the SMBMI, there is some question on how tribal resources use the Western Joshua Tree and if that utility can continue.

Joshua Tree National Park (JTNP), in its efforts to protect and obscure tribal cultural resources from looting, uses Joshua trees in vertical and horizontal mulching. The mulch trees come from natural or unintentional felled Joshua trees. Would the use of Joshua trees in this manner be able to continue with this updated protection status? Does this change in protection for the State cascade into federal lands such as Joshua Tree National Park?

Respectfully,
Ryan Nordness

Ryan Nordness
CULTURAL RESOURCE ANALYST
O: (909) 864-8933 x50-2022
Internal: 50-2022
M: 909-838-4053
26569 Community Center Dr Highland CA 92346

copying it and notify the sender by reply e-mail so that the email address record can be corrected. Thank You

From: Tejeda, Jonathan@Parks
To: Wildlife Native Plants
Subject: Western Joshua Tree "Data"
Date: Monday, November 2, 2020 8:39:21 AM
Attachments: image001.png

Warning: This email originated from outside of CDFW and should be treated with extra caution.

To whom it may concern,

With much anticipation I have been personally following the review-related actions towards the protection initiatives of the Western Joshua tree.
I just wanted to inform California Department of Fish and Wildlife (Habitat Conservation Planning Branch) that California State Parks, The Great Basin District is planning on gathering a baseline "sample size" dataset of Joshua trees that exist within the district.
These research initiatives will commence this late winter/early spring.
Monitoring Joshua trees and its response to environmental factors is a proactive approach to creating effective conservation actions.

For more information please feel free to reach out directly, thank you for your time.

Jonathan Tejeda
Environmental Scientist – Great Basin District
15101 Lancaster Rd, Lancaster, CA 93536
Work Cell: (661) 201-9005

California Department of Parks and Recreation

02-003-2020-002

January 14, 2021

[VIA EMAIL TO [redacted]
California Department of Fish and Wildlife
Mr. Jeb Bjerke

Sacramento, California 944209

Re: Notification of Status Review for Western Joshua Tree

Dear Mr. Jeb Bjerke,

The Agua Caliente Band of Cahuilla Indians (ACBCI) appreciates your efforts to include the Tribal Historic Preservation Office (THPO) in the Status Review for Western Joshua Tree project. We have reviewed the documents and have the following comments:

> *At this time ACBCI has no comments, but please continue to provide our office with updates as the project progresses. Also, please inform our office if there are changes to the scope of this project.

Again, the Agua Caliente appreciates your interest in our cultural heritage. If you have questions or require additional information, please call me at (760)699-6907. You may also email me at ACBCI-THPO@aguacaliente.net.

Cordially,

Patricia Garcia-Plotkin

Pattie Garcia-Plotkin
Director
Tribal Historic Preservation Office
AGUA CALIENTE BAND
OF CAHUILLA INDIANS

Rincon Band of Luiseño Indians

CULTURAL RESOURCES DEPARTMENT

One Government Center Lane | Valley Center | CA 92082
(760) 749-1051 | Fax: (760) 749-8901 | rincon-nsn.gov

January 18, 2021

Sent via email: tribal.liaison@wildlife.ca.gov
California Department of Fish and Wildlife
Attn.: Nathan Voegeli, Tribal Liaison
P.O. Box 944209
Sacramento, CA 94244-2090

Re: Status Review for Western Joshua tree

Dear Mr. Voegeli,

This letter is written on behalf of the Rincon Band of Luiseño Indians ("Rincon Band" or "Band"), a federally recognized Indian Tribe and sovereign government. We have received your notification regarding the above status review of the western Joshua tree (*Yucca Brevifolia*) and we thank you for the opportunity to provide comments.

After review of the provided document and our internal information, the Band concurs with the California Department of Fish and Wildlife (Department) regarding the initiation of the designation of the western Joshua tree as a listed endangered or threatened species. Any measures to protect and preserve California biological species, which are also considered cultural resources, is supported by the Rincon Band.

The western Joshua tree habitat does not extend into Rincon's direct Traditional Use Area (TUA); however, maintaining this species is both peripherally and directly important to the Luiseño People for three primary reasons. First, diversity among animal and plant life is crucial to maintaining the environmental balance. Although it does not grow in our TUA, its place in its specific ecosystem supports the plants around it; those in turn support the plants that are in our TUA. Each depends on the other. Loss of this biodiversity, no matter how small it may seem, will ripple and cause more damage. While we do not know what effects the disappearance of the western Joshua tree would have on the ecosystem in our TUA, we do know that there would be a negative impact.

Second, the western Joshua tree population supports animals who are important to the Luiseños. During the time of creation, the First People were the animals, rocks, trees, stars, plants, and all living things. Animals such as the hummingbird, red-tailed hawk, coyote, and others important to continuing our culture, all utilize the western Joshua Tree as home and food as they travel throughout the land. Our stories and songs tell of the animals' exploits as they explored and learned of their lands. Today, the animals our People still rely on are sustained and diverse because of the sustenance the western Joshua tree provides to their species.

Thirdly, because of the interconnectedness of the western Joshua tree in the Cahuilla, Serrano, and other cultures to the north and east of the Luiseños, the relationships to others and the culture of our People has survived. Inland groups such as the Cahuilla and Mojave People to the east relied on trade and travel through different territories to obtain steatite and various tool stone, marine resource, and other items that were important to their cultures.

Conversely, the Luiseños traded and interacted with these tribes to obtain obsidian, clay, and other desert resources they needed. Embedded in these resources and within the TUA is Rincon's history, culture, and continuing traditional identity. Loss of the western Joshua tree would impact Luiseño culture.

The Rincon Band urges the Department to place the western Joshua tree on the endangered or threatened species list, affording the protection they need. We also ask that the Department of Fish and Wildlife review any developments that propose impacts to the species, enforcing more preservation and protection that has been implemented in the past. Finally, Rincon highly encourages the Department to work with researchers and biologists to study how to best preserve the western Joshua tree as a result of shifting environments from climate change.

If you have additional questions or concerns, please do not hesitate to contact our office at your convenience at (760) 297-2635. Thank you for the opportunity to protect and preserve our cultural assets.

Sincerely,

Cheryl Madrigal
Tribal Historic Preservation Officer
Cultural Resources Manager

From:	Steve Vanderwall
To:	Wildlife Native Plants
Subject:	western Joshua tree
Date:	Sunday, January 31, 2021 8:59:11 PM

I'd like to make a specific comment about seed dispersal of Joshua tree. The way the tree moves over time and the way the species responds to climate change. Currently, it is misunderstood by many ecologists and resource managers. There is speculation that Joshua tree seeds were once dispersed by giant ground sloths and perhaps other species of extinct herbivores. This is critically important because if the primary dispersal agent is gone, then how will the species respond to climate change? The hypothesis was based on the fact that Joshua tree seeds and other parts of the plants have been found in the feces of the giant ground sloth. Obviously, since the sloth is extinct, this idea cannot be tested directly. But I reviewed the original data on which the hypothesis is based and found the evidence lacking. First, in the original publication describing the sloth feces, the seeds were all digested; no intact seeds were found. Second, examination of Joshua tree seeds shows that they have a very thin, fragile seed coat. Seeds that are adapted to be dispersed by frugivorous animals usually have a thick, hard seed coat. This is so the seeds survive digestion. Joshua trees do not appear to be dispersed by animals, living or extinct, that ingest the seeds and poop them out.

There is an alternative explanation. My colleagues and I have studied the dispersal of Joshua tree by scatter hoarding rodents. In short, rodents bury seeds in the ground as a means of storing them, and seeds that are not recovered germinate during the winter rains. This is a very effective means of seeds dispersal; there are usually many juvenile plants in most populations. But rodents generally only move plants a few hundred meters per generation. This is sufficient to move the species up or down slopes as climate changes but not great for moving plants long distances at the same elevation (across a plain). I've included citation to a couple relevant papers below. If you would like copies of these papers, please let me know. My motivation here is that you cannot effectively manage Joshua tree if you do not know how it responds geographically to climate change. Good luck.

Joshua tree seeds are dispersed by seed-caching rodents. 2006. Ecoscience 13:539-543.

Seed dispersal and seed fate in Joshua tree. 2012. Journal of Arid Environments 81:1-8.

Stephen Vander Wall, PhD
Department of Biology
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From: Michael Szarzynski
To: Wildlife Native Plants
Subject: Western Joshua Tree - Comments Victorville
Date: Thursday, February 11, 2021 10:48:32 AM
Attachments: image001.png

Warning: This email originated from outside of CDFW and should be treated with extra caution.

Regarding the Listing of the Western Joshua Tree as a Threatened Species under CESA during the Candidacy Period, the City of Victorville would like to offer the following comment.

In the event that the Species is Listed as Threatened and Conservation Strategies and Mitigation is developed to protect the Joshua Tree, we would like the Department to consider allowing for the development of a local Mitigation Program under DFW guidance to protect and manage the Species. We feel strongly that a local Conservation Program would be much more streamlined and just as effective at protecting the Western Joshua Tree. This could include such mitigation as best planning and design practices to avoid and protect the Tree in place within a proposed development as well as administering the local Taking of the Species if a Tree cannot be protected. Additionally, this could include a locally controlled Mitigation Bank to manage LMAD's and DFAD's where the Species could be relocated and protected, again keeping the local Joshua Trees within their local environmental in the case of a take.

Thank you for your consideration,
-Michael

And I understand these comments come shortly after the Jan. 31 date, however as mentioned in the DFW letter, we hope these comments would be evaluated.

CITY OF VICTORVILLE CALIFORNIA
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'Proudly Serving the City for 20 years'

October 15, 2021

Charlton H. Bonham
Director
California Department of Fish and Wildlife
P.O. Box 944209
Sacramento, CA 94244-2090

Via E-mail

Re: Western Joshua Tree - Population Size Evaluation for the Western Joshua Tree prepared by Western Ecosystems Technology, Inc.

Dear Director Bonham:

Enclosed please find a Report titled "Population Size Evaluation for the Western Joshua Tree" prepared by Western Ecosystems Technology (WEST), Inc. (WEST Report). The undersigned companies commissioned WEST to prepare its Report for two purposes. The first is to inform the Department's evaluation of the western Joshua tree (Joshua Tree) for the Status Review Report it will submit to the Fish and Game Commission (Commission) for its consideration of whether listing the species is, in fact, warranted under the California Endangered Species Act. The second is to add to the information base about the Joshua Tree to shape conservation efforts that will be needed regardless of whether the Commission lists the species.

The undersigned companies believe that the WEST Report provides the best available science regarding estimated Joshua Tree population abundance. These population abundance data and estimate were not available when the Commission determined that listing the species may be warranted in September 2020. The Report estimates a total of some 8.5 million Joshua Tree across a defined range of 3.7 million acres, with a 95% confidence interval. This means that even at the low end of the confidence interval, the estimate of the Joshua Tree population is nearly 6.5 million trees. And this is within a conservatively-drawn range which results in a substantial undercount of Joshua Tree. Such population abundance should provide some comfort for those concerned, as we are, about the Joshua Tree and committed to its conservation.

As you know, in October 2020, the Commission adopted a 2084 Rule authorizing incidental take of Joshua Tree by certain listed utility-scale solar projects in Kern and San Bernardino Counties. 14 Cal. Code Regs. (CCR) §749.10. One of the conditions for incidental take authorization was submission of a Joshua Tree Census Report based on robust transect surveys and other requirements specified in the 2084 Rule. 14 CCR §749.10(a)(4)(A). The regulation expressly recognized that one purpose of the data is to provide information for the Department's Status Review Report for the species. 14 CCR §749.10(a)(4)(A). The data from a number of Joshua Tree Census Reports were used by WEST for its Report. WEST will provide the Department with the underlying data from all of the data sets used in its Report in a format that is usable for the Department's own data and statistical analysis.

In addition to providing a Joshua Tree population estimate, the WEST Report also shows that nearly 50% of the lands comprising the range of the Joshua Tree are already protected by federal and state government ownership. We believe these landowners should give greater attention to the protection and conservation of the species, given their legal authorities and the extent of those lands.

The undersigned, in addition to supporting the development of the best available scientific estimate of the Joshua Tree population and its range, as reflected by the WEST Report, will continue outreach to other stakeholders, including environmental organizations, local governments, and other industry sectors to assemble available information about the Joshua Tree and seek to promote collaboration among those stakeholders and with the Department on approaches to better conserve the Joshua Tree.

Thank you for your consideration.

Erec DeVost
Senior Director, Land Entitlement
8minute Solar Energy

Devon Muto
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Chris Carr, Paul Hastings LLP
Navi Dhillon, Paul Hastings LLP

Encl.: Population Size Evaluation for the Western Joshua Tree, Western EcosystemsTechnology (WEST), Inc. (October 2021).

Population Size Evaluation for the Western Joshua Tree

Prepared for:

8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen

Prepared by:

WEST, Inc.
415 W. 17th Street
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October 14, 2021

Table of Contents

EXECUTIVE SUMMARY ii
INTRODUCTION 1
METHODS 2
Estimation of the Total Abundance of Western Joshua Trees within the Range 2
Table 1: Land ownership for protected areas 3
Assessment of the western Joshua tree boundary 3
RESULTS 5
Estimation of the total abundance of western Joshua tree within the range 5
Table 2: Project-level Summary of Two-Phase Survey Data 5
Table 3: Linear mixed modeling results for model of field survey densities as a function of digitized count densities. 6
Table 4: Distribution of 1000 5-acre plots across land cover classes 7
Table 5: Estimates of Joshua tree totals and densities by population of interest with standard errors and 95%-confidence intervals 8
Assessment of the western Joshua tree boundary 8
Table 6: Summary statistics for a sample of 500 plots within a buffered region inside and outside of the JT range. 9
DISCUSSION 10
REFERENCES 12
APPENDIX A: Statistical Estimator of the Total Number of Western Joshua Trees and Variance Estimator 13
APPENDIX B: Linear mixed model coefficients and variance components for height class models 16
Table B.1: Linear mixed modeling results for a model of field survey densities for the height class of less than or equal to 1m as a function of digitized count densities. 16
Table B.2: Linear mixed modeling results for a model of field survey densities for the height class between 1m and 5m as a function of digitized count densities. 16
Table B.3: Linear mixed modeling results for a model of field survey densities for the height class of greater than or equal to 5m as a function of digitized count densities. 16

EXECUTIVE SUMMARY

Spatially-balanced sampling within census tracts and throughout the western Joshua tree range was used to obtain randomly selected five-acre plots where Joshua tree counts were obtained from digitized imagery and from available field data. The relationship between digitized densities and field densities was quantified with a linear mixed model which was then applied in a model-assisted estimator to obtain an estimate of the total western Joshua trees across the defined range. We estimated a total of 8,534,484 Joshua trees (95%-confidence interval: 6,456,782 – 10,612,187) across the western Joshua tree range. Applying the total area of the western Joshua tree range of 3,724,080 acres, we obtain an estimate of western Joshua tree density of 2.29 Joshua trees per acre (95%-confidence interval: 1.73 – 2.85).

INTRODUCTION

In response to a Listing Petition by the Center for Biological Diversity (CBD), the California Department of Fish and Wildlife (CDFW) is reviewing the status of the western Joshua tree (*Yucca brevifolia*) as Threatened under the California Endangered Species Act (CESA; CBD 2019) to determine if listing the species as threatened is warranted. A key piece of information to the western Joshua tree population status is the approximate population size and density. Information on population size and distribution is enhanced by the recent review by Heritage Consultants (2021) where they reviewed other recent listings and compared the occurrence records of those species and western Joshua tree.

Publicly available Joshua tree census data is extremely limited. However, field census data is available from a selection of relatively large (thousands of acres) areas that have been considered for solar energy development and were available for use by the authors. The protocols utilized for the field efforts provide detailed measures of density information as well as tree size distribution. However, the census tract areas may not be representative of western Joshua tree density across the range given that the sites were not selected randomly. Therefore, a two-stage analytical method was developed where we first digitized individual western Joshua trees from aerial imagery and then developed a model to adjust these "digitized densities" given information from densities obtained with western Joshua tree field surveys ("field densities"). Counts from digitized imagery may be susceptible to measurement error such as undercounting of Joshua trees from smaller height class or misclassification of similar yucca species, so comparison to field survey counts provides an adjustment for these sources of error. In our approach, five-acre plots were placed at randomly-selected points within each census tract, and plot-level field densities were compared to digitized densities within each plot. The samples of plots from census tracts were used to characterize the relationship between the digitized densities (the easily-obtained metric) and known field densities (the difficult-to-obtain metric). A random sample of plots across the Joshua tree range was used to overcome the non-random selection of census parcels. These independently (randomly) selected five-acre plots across the western Joshua tree range was used as the new sample of plots where all trees were counted, and then the relationship between the census-level density and photo-interpreted density was applied to obtain an estimate of the range-wide total number and density of western Joshua trees.

We developed estimates of population size and density by tree size class as well as an analysis of the sensitivity of the range boundary on total population size. Our approach was to compare the density from digitizing western Joshua trees from aerial imagery along a 5-km edge area within the boundary to a 5 km buffer just outside the boundary. This approach allowed us to estimate the minimum number of western Joshua trees that reside outside the boundary. We considered this a minimum because we used only digitized density, which is biased towards larger trees and only considered trees within 5-km of the range extent.

METHODS

Estimation of the Total Abundance of Western Joshua Trees within the Range

Eleven census tracts were used for analysis totaling 27,325 acres. A spatially balanced Halton Iterative Partition (HIP) sample of 100 points was selected within each census tract boundary, and 5-acre plots were centered on the selected points sequentially until plots began to overlap. We selected a point sample rather than a sample of plots from a finite sampling frame of predefined plots due to the irregular size of project boundaries. Plots that fell outside the boundary were clipped to the subset of area falling within the project boundary, and only digitized and field counts occurring within the project boundary were used to calculate plot-level density for analysis. We treated the data as a two-phase sample with digitized counts representing the first phase and field survey counts representing the second phase. The counts were transformed to densities by dividing by the plot area, and plots that overlapped the project boundary were clipped to the boundary.

We used the difference estimator (Breidt and Opsomer 2017) for the basic form of the estimate, and then applied the generalized regression (GREG) estimator of Montanari and Ranalli (2006) to estimate the number of Joshua trees in the range. For the set of two-phase samples taken within each project, field data densities were modeled with a linear mixed model as a function of the digitized Joshua tree densities with a random effect to account for correlation of plot-level densities within each project. An independent sample of 1000 5-acre plots within the current Joshua tree range boundary (produced by Cole et al. 2011) was drawn and digital counts from these sites were obtained. The relationship between the densities from digitized counts and densities from field surveys was estimated and then applied to the large sample of plots throughout the range to obtain a range-wide estimate of Joshua trees. Implicit assumptions of this analysis include that (1) census tracts are located in areas that are representative of conditions across the range and that (2) the plot-level relationships between digitized trees and ground-verified trees holds across the range.

Our sampling scenario differs from the classic setting where a first-phase sample to measure an inexpensive/accessible metric is augmented by a smaller, second-phase sample of correlated metrics that are more expensive to obtain. In our case, we had a large sample of plots across the sampling frame from which digitized counts (the easier-to-obtain metric) were obtained and an independent sample of plots within projects for which digitized counts and field data (the difficult-to-obtain metric) were available. Note that we did not weight the project-level density estimates thereby implicitly assuming that the densities observed in the set of 11 census tracts is representative of the distribution of densities across the western Joshua tree range.

We combined the two sources of data with the difference estimator. This estimator is calculated from the sum of two terms. The first term was obtained with a design-based estimate of digitized densities from the sample across the western Joshua tree range. The second term was estimated from the plot-level digitized densities and field densities from the project subsamples. This value estimates the bias in the digitized counts relative to the more accurate field counts and then applies a design-based extrapolation of that bias to the range level to correct the population estimate of digitized counts obtained in the first term. Because these two terms were obtained from independent data sets, the variance is computed as the sum of the variances of the two terms. HIP sampling was used for both the sample of points across the western Joshua tree range and the samples of points within each of the eleven projects, so we applied the neighborhood variance estimator to account for spatially balanced sampling. See Appendix A for more details on the estimator of the total number of trees and the variance estimator. We estimated total Joshua trees and Joshua tree density across the range, within each of the three size classes defined by CDFW, and for the set of protected areas (federal, state, and local governments and NGO, Table 1).

Table 1: Land ownership for protected areas (from U.S. Fish and Wildlife Service 2018).

Ownership	Acres	Percent of Total Western Joshua Tree Range
Federal		*47.71%*
Bureau of Land Management	841,220	22.59%
National Park Service	214,133	5.75%
Forest Service	133,770	3.59%
Department of Defense	17,243	0.46%
US Air Force	318,223	8.55%
US Department of Army	127,146	3.41%
US Department of Navy	120,144	3.23%
US Marine Corps	4,702	0.13%
State		
State of California	68,222	*1.86%*
Local		
County/City Government	928	*0.03%*
Total protected areas	1,845,731	49.60%

Assessment of the western Joshua tree boundary

In Task 1, we evaluate the density of Joshua trees within and outside the Joshua tree boundary. A 5-km buffer was extended inside and outside the current Joshua tree range boundary (Cole et al. 2011). The sampling frame was constructed by applying a 5km buffer outside the JT range and a 5km buffer inside the range. The area of the combined buffer totaled 3,785,296 acres. An equiprobable sample of 500 points was drawn from the frame with the Halton Iterative Partitioning sampling approach (HIP, Robertson et al. 2013) within the combined interior and exterior buffer. A 5-acre plot (Figure 1) was centered at each selected point, and Joshua trees were digitized within each plot using aerial imagery acquired from the National Agriculture Imagery Program (USDA NAIP 2018). Plots that fell outside the boundary were clipped to the subset of area falling within the JT range, and plot-level density was calculated as a function of the area of the plot within the range.

The density of Joshua trees inside and outside the boundary is compared to assess (1) whether the boundary excludes a substantial number of Joshua trees outside the defined range and (2) whether the density within the range near the boundary is so low as to warrant concern about extrapolation of interior Joshua tree densities to the edge of the range.

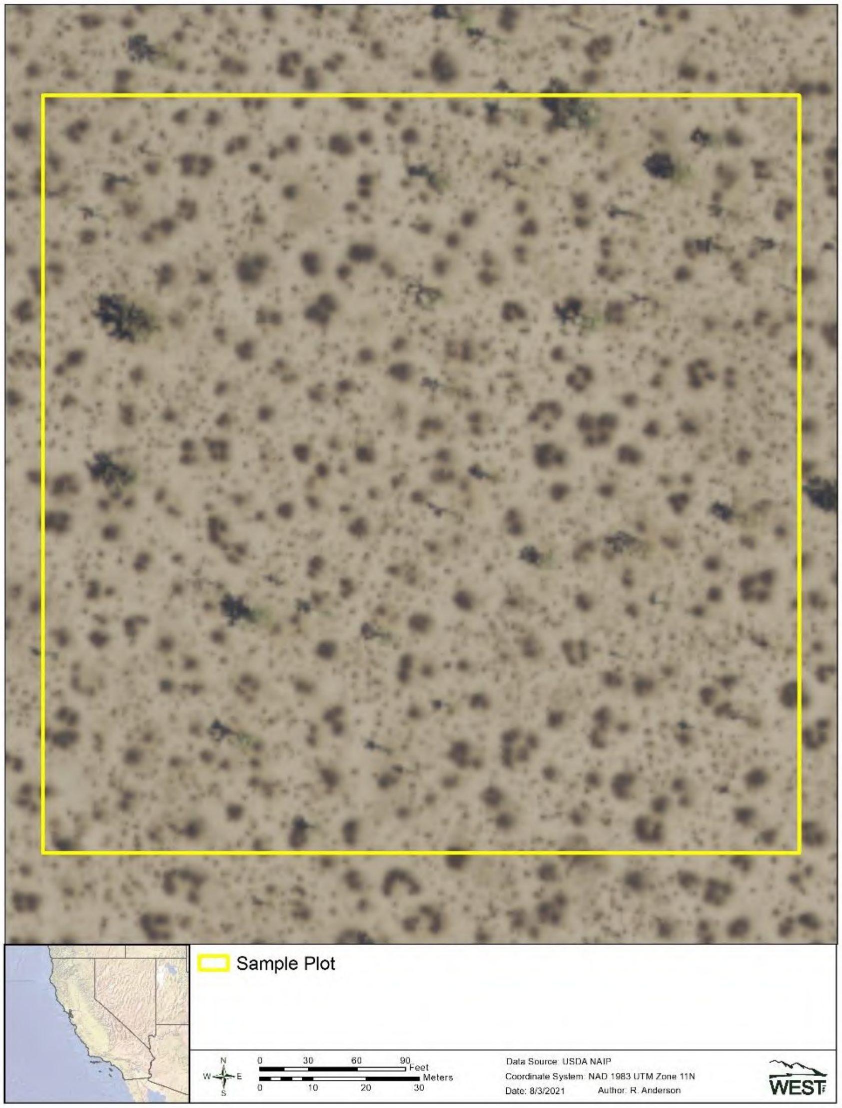

Figure 1: Sample 5-acre plot from digitized imagery used to obtain Joshua tree counts.

RESULTS

Estimation of the total abundance of western Joshua tree within the range

Data were obtained for 12 projects and formatted for analysis. For one of the projects, the number of trees observed in digital images (10) and from field surveys (2) were very small, so this project was dropped from the analysis. Data from four other projects were missing or incomplete for height class data, so these projects were not used in the estimation of western Joshua trees by height class. For the sample of non-overlapping plots in each of the remaining seven projects, digitized counts and field survey counts (Table 2) were obtained and plot-level densities were computed (Figure 2).

Table 2: Project-level Summary of Two-Phase Survey Data

Project	Area (Acres)		Number of Plots	Number of Joshua Trees		Joshua Tree Density	
	All	Sample		Digitized	Field	Digitized	Field
A	1466.35	232.89	51	566	1235	2.43	5.30
B	2373.51	264.35	56	178	665	0.67	2.52
C	8446.71	551.89	120	109	217	0.20	0.39
D	2181.22	250.30	54	58	289	0.23	1.15
E	661.46	86.22	20	45	137	0.52	1.59
F	768.53	120.00	26	13	84	0.11	0.70
G	5448.84	655.95	134	324	1829	0.49	2.79
H	625.95	39.83	8	19	93	0.48	2.33
I	1296.33	119.55	26	30	144	0.25	1.20
J	784.41	134.91	30	27	363	0.20	2.69
K	3271.25	161.80	38	21	89	0.13	0.55
Total	27324.56	2617.69	563	1390	5145	0.53	1.97

Linear mixed models were used to quantify the relationship between plot-level digitized densities and densities from field counts at 11 projects for the estimates of total trees (Table 3) and from 7 projects for the size class estimates (Appendix B). These models are then used to adjust the digitized counts for any undercounting relative to field survey counts. The sample of 1000 plots was digitized and observed plot-level densities were computed for estimating the total number of western Joshua trees in the range. The 1000 plots were spatially balanced across the western Joshua tree range and occurred roughly proportionally to the land cover classes occurring in that range (Table 4).

Table 3: Linear mixed modeling results for model of field survey densities as a function of digitized count densities.

Parameter	Estimate	Standard Error	df	t value	p value
(Intercept)	1.1449	0.2576	12.47	4.44	0.0007
Digitized density	1.4885	0.1266	358.97	11.76	<0.0001
Project variation	0.4426	-		-	-
Residual variation	8.4016	-		-	-

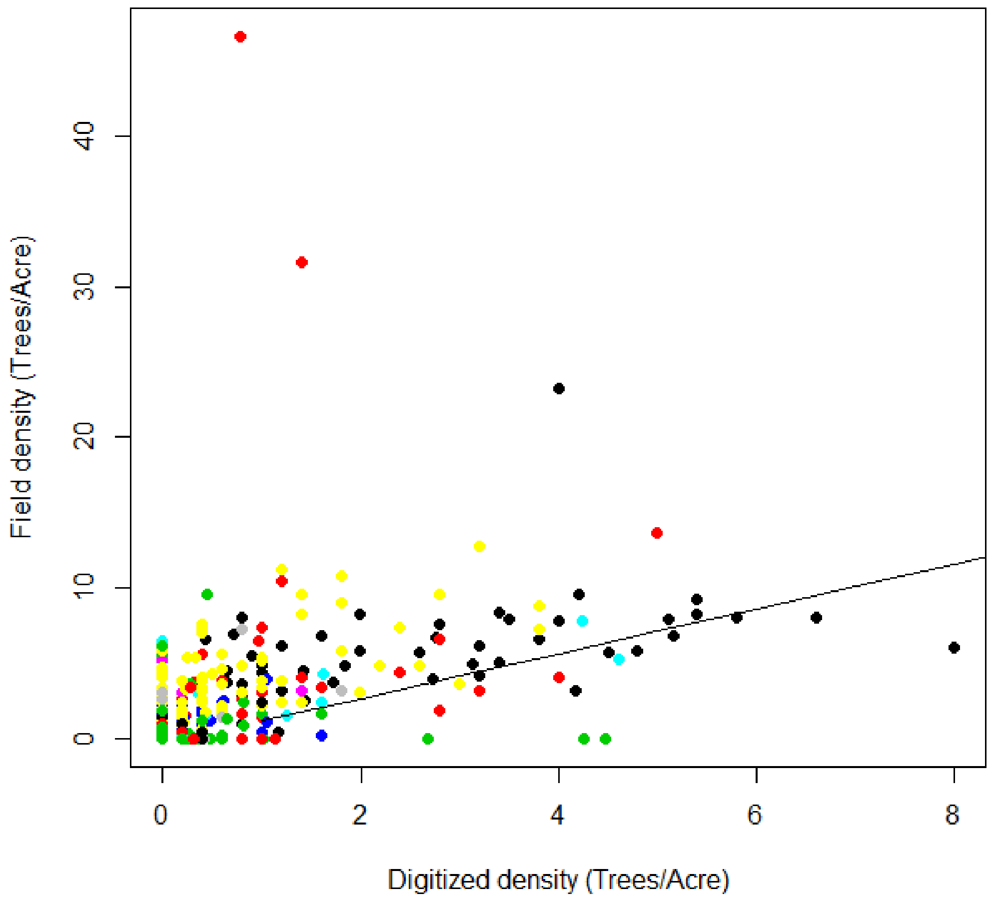

Figure 2: Plot-level field densities against digitized plot-level western Joshua tree for 5-acre plots within 11 census tracts with color coding by project.

Table 4: Distribution of 1000 5-acre plots across land cover classes

NLCD Land Cover Class	Number of Plots in Sample	Mean Digitized Density (JT/Acre)	Total Area in Range (Acres)	Percent Total Area in Range
Barren Land	39	0.13	140730.36	3.78%
Cultivated Crops	5	0.00	13688.12	0.37%
Deciduous Forest	0	-	15.56	0.00%
Developed, High Intensity	2	0.00	6273.58	0.17%
Developed, Low Intensity	21	0.26	73302.81	1.97%
Developed, Medium Intensity	10	0.04	37078.78	1.00%
Developed, Open Space	43	1.86	162231.24	4.36%
Emergent Herbaceous Wetlands	2	0.00	2620.52	0.07%
Evergreen Forest	9	0.16	28406.84	0.76%
Hay/Pasture	12	0.07	43034.38	1.16%
Herbaceous	60	0.89	247064.17	6.63%
Mixed Forest	1	0.00	1728.09	0.05%
Open Water	0	-	2163.23	0.06%
Shrub/Scrub	795	0.77	2962284.23	79.54%
Woody Wetlands	1	0.00	3458.33	0.09%

Applying the GREG estimator to the project data and the range sample, we obtain adjusted estimates for total Joshua trees for the entire western Joshua tree range, for protected areas (federal, state, and local governments and NGO) within the range, and for each of the three height classes (1m or less, 1-5 m, or at least 5m tall). We estimated a total of 8,534,484 Joshua trees (95%-confidence interval: 6,456,782 – 10,612,187) across the western Joshua tree range (Table 5). Note that this estimate pertains only to lands within the western Joshua tree boundary and does not include any trees within the 5km buffer outside the boundary (addressed in the next section) or trees that are more than 5km from that boundary.

The total area of the western Joshua tree range is 3,724,080 acres, which yields an estimate of western Joshua tree density of 2.29 Joshua trees per acre (Table 5, 95%-confidence interval: 1.73 – 2.85). A total of 356 plots occurred within the 1,314,765 total acres of protected lands occurring within the western Joshua tree range. The estimated number of trees within protected lands was calculated as 3,444,052 Joshua trees (95%-confidence interval: 2,444,147 – 4,443,958) with density computed as 2.62 Joshua trees per acre (95%-confidence interval: 1.86 – 3.38). Note that the density estimate in protected areas slightly exceeds that of the entire range, but the degree of overlap between the two confidence intervals indicates no significant difference between the two estimates at the $\alpha = 0.05$ level. Estimates of totals and densities for each of the three sizes classes are also provided, and precision of these estimates reflects the estimation of subpopulations with patchier distributions and more pronounced undercounting in digitized counts for the smaller size classes.

Table 5: Estimates of Joshua tree totals and densities by population of interest with standard errors and 95%-confidence intervals

Population for Estimation of Total Joshua Trees	Estimated Total	SE	95%-confidence interval	Estimated Density	SE	95%-confidence interval
Western JT range	8,534,484	1,060,053	(6,456,782; 10,612,187)	2.29	0.28	(1.73, 2.85)
Protected areas within western JT range	3,444,052	510,156	(2,444,147; 4,443,958)	2.62	0.39	(1.86, 3.38)
JT ≤ 1m	1,786,949	687,836	(438,790; 3,135,107)	0.48	0.18	(0.12, 0.84)
JT 1-5m	4,932,270	941,744	(3,086,452; 6,778,089)	1.32	0.25	(0.83, 1.82)
JT ≥ 5m	1,748,957	247,972	(1,262,932 2,234,982)	0.47	0.07	(0.34, 0.60)

In some cases, the number of digitized Joshua trees exceeded that recorded in the field surveys. This occurred in every project with the number of plots with larger digitized counts ranging from 1 to 22 and the total number of excess Joshua trees ranging from 1 to 65 per project. These cases may indicate false positive identification of another yucca species, *Yucca schidigera*, in areas where the two yucca species overlap.

Assessment of the western Joshua tree boundary

The Joshua tree range boundary is approximately 3,785,296 acres in size. The sampling exercise resulted in a sample of 288 plots in the buffer outside the western Joshua tree range and 212 plots within 5km inside the range (Figure 3). Digitized counts of Joshua trees within plots ranged from 0 to 64 trees. A total of 245 trees were counted in plots outside of the range and 254 trees were counted in the buffer within range (Table 6). Joshua tree counts were aggregated at the plot level, and design weights (the factor by which sample counts are extrapolated to the population) were calculated as the area of the buffer divided by the sample size of plots (3,785,296/500 = 7570.59).

Using the analysis functions in the *spsurvey* package (Kincaid et al. 2019) for spatially-balanced surveys, design-based estimators of the total number of trees and the density of trees per acre were applied to JT counts adjusted for the area of each plot. The standard errors for these estimates were obtained with the neighborhood variance estimator (Stevens and Olsen 2003, 2004) for spatially-balanced samples. The estimated total trees for the 5-km wide buffered area outside of the range was 370,945 (SE = 101,428) and the tree density was 0.17 trees per acre (SE = 0.05). For the 5-km wide buffer inside of the range boundary, the total number of trees was estimated to be 387,572 (SE = 73,621) with a density of 0.24 trees per acre (SE = 0.05). Assuming a normal distribution for the density estimates, a Z-test of the difference in Joshua tree density for plots inside and outside of the range provides no evidence of a substantial difference ($z = 1.06$, $p = 0.2875$). Note that the GREG estimator was not applied in this case because these Joshua trees are estimated outside the western Joshua tree range where relationships between digitized and field survey densities may not hold, especially for plots containing no Joshua trees.

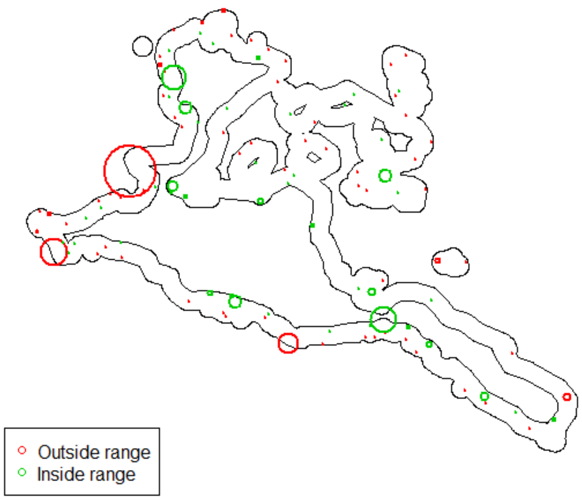

Figure 3: Observed Joshua tree counts for plots outside the range (red) and inside the range (green) with plotting symbol sizes proportional to the tree counts.

Table 6: Summary statistics for a sample of 500 plots within a buffered region inside and outside of the JT range.

Statistic	Buffered area outside Joshua tree range	Buffered area within Joshua tree range
Number of plots	288	212
Total JT counted	245	254
Mean number of trees per 5-acre plot	0.85	1.20
Estimated total trees (SE)	370,945 (101,428)	384,572 (73,621)
Estimated JT density per acre (SE)	0.17 (0.05)	0.24 (0.05)

DISCUSSION

In this analysis, the relationship between the densities of Joshua trees counted from digitized images and Joshua trees counted during field surveys at solar facilities is used to obtain a model-assisted estimate of the total number of western Joshua trees across the range, within and outside protected lands across the western Joshua tree range, and within each of three height classes identified by CDFW (2084 emergency rule). Note that landownership classes outside of governmental agencies and NGOs may also provide some level of protection from development. Assumptions of this analysis include (1) the relationships between digitized densities and field survey densities are representative of those relationships across the western Joshua tree range, (2) no Joshua trees were missed during field surveys or misidentified during digitized image reviews, and (3) the defined western Joshua tree range represents the full extent of the distribution.

Assumption 1 holds if census tracts are not located in areas that are substantially different from the overall range relative to size distribution or the relationship between digitized and field densities. For example, if relationships between digitized densities and field densities across and by height classes differ from that in the range, then the modeled relationships may be biased to some degree when applied range-wide. Note that the estimator used to estimate the total number incorporates a regression estimator which adds a constant to the estimated density (the intercept term in the regression equation) as well as multiplies the digitized density by a constant (the slope in the regression equation). Therefore, plots with no digitized Joshua trees are estimated as non-zero even in the case when field surveys also find no Joshua trees. The intercept term quantifies the overall additive relationship between digitized and field densities, but the predictions are likely less accurate on smaller spatial scales where the digitized and field densities may differ to a greater degree (in either direction). Therefore, the estimates of densities and totals at smaller spatial scales may be biased, but estimation is unbiased at the range scale. Inference for subpopulations (smaller areas or height classes, e.g.) is improved with models that reflect those subpopulations more directly.

We assume that field surveys are generally accurate due to the size and unique form of western Joshua trees. However, Joshua trees in the small height class were missed during some field surveys in areas of high Joshua tree density and areas where creosote is established (Devon Muto, personal communication). Therefore, detection error in the field counts may cause some underestimation of total Joshua trees and those in the smallest height class. Assumption 2 may be also impacted by overcounting in the digitized image review. In our data set, 45 of the 563 plots from census tracts had digitized counts that exceeded the field survey count. Differences in the plot-level counts ranged from 1 to 16 trees and totaled 130 trees out of 1,390 digitized trees (9%). In these cases, a different yucca species may have been identified by the digitizer and mistakenly counted as a western Joshua tree, or it could be due to spatial error in matching the digitized plot boundaries to the field data counts or some combination. The latter issue of spatial error in the two data sets would result in some undercounting and overcounting across the plots. The impact of misclassification bias is some overestimation of total trees and is likely restricted primarily to areas where the distributions of similar species overlap with western Joshua tree.

The buffer analysis provides some basis on which to assess the third assumption. The 5-km buffer outside the defined range represents an estimated 370,945 trees or about 4.3% of the estimated total number of western Joshua trees across the range. The results of the boundary analysis indicate that the overall density of western Joshua tree within a 5-km buffer inside (0.24, SE = 0.05) and outside (0.17, SE = 0.05) of the defined range is less than 1 tree per acre. The two highest counts (33 and 64) of western Joshua trees in the boundary analysis were found in plots outside of the western edge of the defined range. This might suggest that the western range boundary may omit some areas with substantial western Joshua tree density. Note also that the western Joshua tree range included some land cover types with no detected Joshua trees (Table 4). The definition of the western Joshua tree range could be refined to exclude developed areas or other areas where Joshua tree abundance may be artificially controlled or near zero.

REFERENCES

Cole, K.L., K. Ironside, J. Eischeid, G. Garfin, P.B. Duffy, and C. Toney. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications 21(1):137–149.

Kincaid, T. M., Olsen, A. R., and Weber, M. H. 2019. spsurvey: Spatial Survey Design and Analysis. R package version 4.1.0.

Lohr, S.L. 1999. Sampling: Design and Analysis. Duxbury Press: Pacific Grove, California.

McConville, K., B. Tang, G. Zhu, S. Cheung, and S. Li. 2018. mase: Model-Assisted Survey Estimation. R package version 0.1.2 https://cran.r-project.org/package=mase.

Montanari, G.E. and Ranalli, M.G., 2006. A mixed model-assisted regression estimator that uses variables employed at the design stage. Statistical methods and applications, 15(2), p.139.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Robertson, B.L., Brown, J.A., McDonald, T. and Jaksons, P. 2013. BAS: Balanced acceptance sampling of natural resources. Biometrics, 69(3), pp.776-784.

Robertson, B., McDonald, T., Price, C. and Brown, J., 2018. Halton iterative partitioning: spatially balanced sampling via partitioning. Environmental and Ecological Statistics, 25(3), pp.305-323.

Särndal, C.E., B. Swensson, and J. Wretman. 1992. Model Assisted Survey Sampling. Springer, New York.

St. Clair S.B. and J. Hoines. 2018. Reproductive ecology and stand structure of Joshua tree forests across climate gradients of the Mojave Desert. PLoS ONE 13(2): e0193248.

Stevens, D. L., and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. Environmetrics 14:594-610.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99(465):262-278.

US Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP). 2018. NAIP Imagery. USDA, Farm Service Agency (FSA), Washington, D.C. Accessed June 2021. Information online: https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/index

U.S. Fish and Wildlife Service. 2018. Joshua Tree Species Status Assessment. Dated July 20, 2018. 113 pp. + Appendices A–C.

APPENDIX A: Statistical Estimator of the Total Number of Western Joshua Trees and Variance Estimator

We apply the difference estimator (Breidt and Opsomer 2017) for the basic form of the estimate, and then apply the regression estimator of Montanari and Ranalli (2006) to inform the difference estimator. The difference estimator (Breidt and Opsomer 2017) for an estimate of the total is given by:

$$\hat{t}_{y,diff} = \sum_{k \epsilon U} m(x_k) \qquad \text{(Term 1)}$$
$$+ \sum_{k \epsilon s} \frac{y_k - m(x_k)}{\pi_k} \qquad \text{(Term 2)}$$

where *k* indexes the plot, U represents set of points in the entire western Joshua tree range, s represents the sampled points within U, x_k is the western Joshua tree plot density obtained from digitization in the k^{th} plot, y_k is the western Joshua tree plot density obtained from field surveys in the k^{th} plot, $m(x_k)$ is the prediction of y_k based on a model of x_k, and π_k is the inclusion probability for the k^{th} plot. The difference estimator provides a general form which can accommodate a wide range of models for $m(x_k)$.

In this application, let *k* index the sample of 1000 plots throughout the western Joshua tree range and let *k'* index the plots subsampled within each project, where projects are indexed by *j*. The model of $x_{k(j)}$used to estimate $y_{k(j)}$ is obtained from the linear mixed model of plot-level field count densities modeled as a function of plot-level digitized count densities and a random effect for Project to account for correlated densities among plots within the same project. The model is given as:

$$m(x_k) = \hat{y}_{k(j)} = \beta_0 + \beta_1 x_{k(j)} + a_j,$$

where β_0 is the intercept, β_1 is the coefficient of the digitized density, a_j is the random effect for the j^{th} project, and estimates are obtained with restricted maximum likelihood. Define s_R as the HIP sample of 1000 points from the western Joshua tree range, π_R as the inclusion probability from that sample, A_R as the total area of the range. We estimate the first term of the estimate, $\tau_{mx} = \sum_{k' \epsilon U} m(x_{k'})$ as:

$$\hat{\tau}_{mx} = \sum_{k' \epsilon s_R} \frac{m(x_{k'})}{\pi_R} = \sum_{k' \epsilon s_R} \frac{\hat{\beta}_0 + \hat{\beta}_1 x_{k'}}{\pi_R} = A_R \hat{\beta}_0 + \hat{\beta}_1 \tau_x$$

where $\tau_x = \sum_{k' \epsilon s_R} \frac{x_{k'}}{\pi_R}$ is the estimate of western Joshua trees across the range that would be obtained if the entire range was digitized. Note that in the range-wide sample we do not have clustering by projects and do not incorporate the random effect from $m(x_k)$.

The second term of the estimator $\hat{t}_{y,diff}$ is obtained from the project-level samples of plots. The values $y_{k(j)} - m(x_{k(j)})$ are obtained as conditional residuals from the linear mixed model. We estimate $\pi_{k(j)}$ as a function of the within-project inclusion probabilities from the HIP samples within each project and an adjustment for the proportion of the western Joshua tree range surveyed across all projects. Let n_j be the sample size of non-overlapping plots in project *j*, and let A_j be the total area of project *j*. We define $\pi_{k(j)}$ as $\pi_{k(j)} = \frac{n_j}{A_j} \times \frac{\sum_j A_j}{A_R}$. Note that the sum of the design weights (i.e. inverse inclusions probabilities) sums to the extent of the sampling frame indicating correct calculation:

$$\sum_j \sum_k \frac{1}{\pi_{k(j)}} = \sum_j \sum_k \frac{A_j A_R}{n_j \sum_j A_j} = \sum_j \frac{n_j A_j A_R}{n_j \sum_j A_j} = \frac{A_R}{\sum_j A_j} \sum_j A_j = A_R.$$

Therefore, we obtain the estimate of the total number of western Joshua trees in the range as:

$$\hat{t}_{y,diff} = \hat{\tau}_{mx} + \sum_{j \epsilon s} \sum_{k \epsilon s_j} \frac{y_{k(j)} - m(x_{k(j)})}{\pi_{k(j)}} \ .$$

The variance component for the first term of $\hat{t}_{y,diff}$ is derived as relative to two sources of variation, the design and the model. We denote the model as a function of the inclusion probability, π, for simplicity but note that the random variable for the design-based portion of the derivation is actually a latent Bernoulli variable indicating sample inclusion with probability π. Assuming design-unbiased estimators and model-based regression coefficients, the variance is calculated as:

$$\begin{aligned}
Var(\hat{\tau}_{mx}) &= Var_\beta E_\pi(\hat{\tau}_{mx}|\beta) + E_\beta Var_\pi(\hat{\tau}_{mx}|\beta) \\
&= Var_\beta E_\pi\left(A_R\hat{\beta}_0 + \hat{\beta}_1\hat{\tau}_x|\beta\right) + E_\beta Var_\pi\left(A_R\hat{\beta}_0 + \hat{\beta}_1\hat{\tau}_x|\beta\right) \\
&= Var_\beta\left(A_R\hat{\beta}_0 + \hat{\beta}_1\tau_x\right) + E_\beta\left(\hat{\beta}_1^2 Var_\pi(\hat{\tau}_x)\right) \\
&= A_R^2\, Var_\beta\left(\hat{\beta}_0\right) + \tau_x^2 Var_\beta\left(\hat{\beta}_1\right) + A_R\tau_x cov\left(\hat{\beta}_0, \hat{\beta}_1\right) + Var_\pi(\hat{\tau}_x) * \left\{Var_\beta\left(\hat{\beta}_1\right) + \left[E\left(\hat{\beta}_1\right)\right]^2\right\}. \\
&\approx A_R^2\, Var_\beta\left(\hat{\beta}_0\right) + \tau_x^2 Var_\beta\left(\hat{\beta}_1\right) + A_R\tau_x cov\left(\hat{\beta}_0, \hat{\beta}_1\right) + Var_\pi(\hat{\tau}_x) * \left[Var_\beta\left(\hat{\beta}_1\right) + \hat{\beta}_1^2\right]
\end{aligned}$$

We assume spatial balance from the HIP sample and apply the neighborhood variance estimator (Stevens and Olsen 2003, 2004) to obtain the term $Var_\pi(\hat{\tau}_x)$.

We compute the variance of the second term as a design-based estimator of variance of the conditional residuals (Montanari and Ranalli 2006) but applying the neighborhood variance estimator (Stevens and Olsen 2003, 2004) to account for the spatially-balanced sample. We treat the projects as strata in the variance calculation to account for the spatially balanced sampling within each project but without assuming spatial balance across projects, which were not randomly selected. Because the samples on which the two terms of the estimator are based were independently drawn, we treat the two terms as independent and obtain the variance of the estimator $\hat{t}_{y,diff}$ as a sum of the two variance terms:

$$Var(\hat{t}_{y,diff}) \approx A_R^2 \, Var_\beta(\hat{\beta}_0) + \tau_x^2 Var_\beta(\hat{\beta}_1) + A_R \tau_x cov(\hat{\beta}_0, \hat{\beta}_1) + Var_\pi(\hat{\tau}_x) * \left[Var_\beta(\hat{\beta}_1) + \hat{\beta}_1^2\right] + Var_{\pi_{k(j)}}\left(y_{k(j)} - m(x_{k(j)})\right),$$

where $Var_\pi(\hat{\tau}_x)$ is the neighborhood variance estimator of the estimate of total digitized trees from the project HIP samples treating projects as strata and $Var_{\pi_{k(j)}}\left(y_{k(j)} - m(x_{k(j)})\right)$ is the neighborhood variance estimator of the conditional residuals from the range HIP sample.

APPENDIX B: Linear mixed model coefficients and variance components for height class models

Table B.1: Linear mixed modeling results for a model of field survey densities for the height class of less than or equal to 1m as a function of digitized count densities.

Parameter	Estimate	Standard Error	df	t value	p value
(Intercept)	0.5011	0.1795	6.09	2.79	0.0310
Digitized density	0.3904	0.0578	375.93	6.76	<0.0001
Project variation	0.1853	-		-	-
Residual variation	1.4835	-		-	-

Table B.2: Linear mixed modeling results for a model of field survey densities for the height class between 1m and 5m as a function of digitized count densities.

Parameter	Estimate	Standard Error	df	t value	p value
(Intercept)	0.7701	0.2397	7.07	3.21	0.0146
Digitized density	0.9450	0.0927	311.60	10.20	<0.0001
Project variation	0.2976	-		-	-
Residual variation	3.9398	-		-	-

Table B.3: Linear mixed modeling results for a model of field survey densities for the height class of greater than or equal to 5m as a function of digitized count densities.

Parameter	Estimate	Standard Error	df	t value	p value
(Intercept)	-0.0062	0.0654	6.05	-0.09	0.9280
Digitized density	0.1503	0.0130	449.31	11.58	<0.0001
Project variation	0.0279	-		-	-
Residual variation	0.0718	-		-	-

December 17, 2021

Charlton H. Bonham
Director
California Department of Fish and Wildlife
P.O. Box 944209
Sacramento, CA 94244-2090

Via E-mail

Re: Western Joshua Tree – Supplemental Report Regarding Population Abundance Refinement and Data Needs for Population Trend for the Western Joshua Tree prepared by Western Ecosystems Technology, Inc.

Dear Director Bonham:

On October 15, 2021, the undersigned companies provided the Department with a Report titled "Population Size Evaluation for the Western Joshua Tree," prepared by Western Ecosystems Technology (WEST), Inc. (WEST Report). The undersigned companies commissioned WEST to prepare the Report for two reasons: (1) to inform the Department's evaluation of the western Joshua tree (Joshua Tree) for the Status Review Report it will submit to the Fish and Game Commission (Commission) for its consideration of whether listing the species is, in fact, warranted under the California Endangered Species Act (CESA); and (2) to add to the information base about the Joshua Tree to shape conservation efforts that will be needed regardless of whether the Commission lists the species.

After submitting the WEST Report to the Department, the undersigned companies asked WEST to refine its analysis in further service of these twin goals. WEST, in response, adjusted its population abundance estimate to account for recent fires and conducted an additional technical review of the available scientific literature on the Joshua Tree which are discussed in its "Supplemental Report Regarding Population Abundance Refinement and Data Needs for Population Trend for the Western Joshua Tree" (Supplemental Report). WEST's Supplemental Report is provided for the Department's consideration.

The Supplemental Report contains WEST's analysis of the impacts of fire events on Joshua Tree abundance. This was necessary because none of the data sets upon which WEST's prior population abundance estimate was based had experienced fire since at least 1915 (the earliest fires were recorded). The Supplemental Report estimates that fire events impacted 2% of the species population over the past 10 years, and 8% over the past 100 years. The undersigned companies believe that this analysis shows that previous fire events have had, at most, a minimal impact on the Joshua Tree population across the species' southern range. And it remains the case that, as stated in WEST's initial report, there are estimated to be more than 8 million Joshua Trees within a conservatively estimated range of 3.7 million acres.

In addition, the Supplemental Report provides a Literature Review Synopsis, setting forth WEST's review of the available scientific literature on (1) possible covariates related to the species' distribution and (2) the species' population structure and trend. This Synopsis makes clear that although climate change is expected to impact Joshua Tree habitat and abundance in the future, there are significant uncertainties and data gaps in the literature which make it difficult to predict the timing and extent of that impact. For instance, the literature does not contain any determination of the Joshua Tree's vital rates (i.e., survival and recruitment), nor any studies that conducted a Population Viability Analysis, a common and essential tool for evaluating population dynamics or estimating extinction probabilities. Similarly, there do not appear to be any studies that estimate the Joshua Tree's population growth rate (positive or negative), another essential metric for determining the population trend for the species. After scouring the relevant scientific literature, WEST concluded that the data needed to derive a population growth rate and conduct a proper Population Viability Analysis do not yet exist. The absence of a statistically valid population trend for the Joshua Tree precludes the formulation of a properly informed assessment of whether listing it is warranted. Under the present circumstances, such information would be necessary for the Commission to lawfully determine that the Joshua Tree is likely to become an endangered species (i.e., in serious danger of becoming extinct throughout all, or a significant portion, of its range) in the foreseeable future in the absence of the special protection and management efforts required by CESA. *See* Fish & Game Code §§ 2062, 2067.

Fortunately, a statistically valid population trend for the Joshua Tree can be developed in 1-5 years using conventional survey (data collection) and modeling methods; it appears that trend could also be derived by inferring the species' demographics (age structure) from genomic data. In the New Year, the undersigned companies look forward to working assiduously with the Department, federal landowners, the U.S. Fish and Wildlife Service and stakeholders to enhance the protection and conservation of the Joshua Tree throughout its range. Moreover, the undersigned companies will continue to work to bring additional solar energy projects online to achieve the greenhouse gas emissions reductions needed to mitigate what the scientific literature recognizes as the primary threat to the Joshua Tree – climate change.

Thank you for your consideration.

Erec DeVost
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8minute Solar Energy

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Encl.: Supplemental Report Regarding Population Abundance Refinement and Data Needs for Population Trend for the Western Joshua Tree prepared by Western Ecosystems Technology, Inc. (Dec. 17, 2021).

Supplemental Report Regarding Population Abundance Refinement and Data Needs for Population Trend for the Western Joshua Tree

Prepared for:

8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen

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Table of Contents

INTRODUCTION 1

LANDOWNERSHIP IN RANGE 1

IMPACTS OF FIRE EVENTS ON WESTERN JOSHUA TREE ESTIMATES OF ABUNDANCE 1

LITERATURE REVIEW SYNOPSIS: Fire Impacts and Efforts to Assess Joshua Tree Trend 6

REFERENCES 9

List of Tables

Table 1. Landownership in the southern and northern ranges of western Joshua tree. 1

Table 2: Estimates of total western Joshua trees in the southern range assuming zero density at previously burned areas for a range of time frames. 6

List of Figures

Figure 1. Historic fire perimeter data (CAL FIRE 2020) by year categories with the southern range of western Joshua tree. 3

Figure 2. Historic fire perimeter data (2011-2020, CAL FIRE 2020) with the protected lands from the USGS Protected Areas Database (USGS 2021). 4

Figure 3. Historic fire perimeter data (1878 – 2020, CAL FIRE 2020) with the protected lands from the USGS Protected Areas Database (USGS 2021). 5

INTRODUCTION

This material supplements the report entitled "Population Size Evaluation for the Western Joshua Tree" (WEST 2021). In that report, we developed estimates of population size and density by tree size class as well as an analysis of the sensitivity of the range boundary on total population size. The material included in this supplement provides 1) land ownership acreage calculations for the northern and southern ranges, 2) additional mapping and calculations of on fire impacts within the southern range historically, and 3) a synopsis of the literature on fire impacts and efforts to assess Joshua tree trend.

LANDOWNERSHIP IN RANGE

Using the "Protected Areas Database' (USGS 2021), we calculated the percentage of both the northern and southern ranges of western Joshua tree by landownership (Table 1). Roughly 32% of the southern range for western Joshua trees is owned by the federal government, which provides opportunities and mechanisms for additional protection and management. Nearly 85% of the northern range for the species is owned by the federal government, which also affords opportunities for identification and protection.

Table 1. Landownership in the southern and northern ranges of western Joshua tree.

	Northern Range		Southern Range	
Owner Type	**Acres**	**% composition**	**Acres**	**% composition**
Federal	1,682,529	84.8	1,191,939	32.0
Local Government	32,059	1.6	4,540	0.1
Non-Governmental Organization	143	0.0	21,085	0.6
State	11,856	0.6	94,742	2.5
private/other	257,779	13.0	2,411,774	64.8
Total	**1,984,365**		**3,724,080**	

IMPACTS OF FIRE EVENTS ON WESTERN JOSHUA TREE ESTIMATES OF ABUNDANCE

Historic fire perimeter data (CAL FIRE 2020) for the southern range of the western Joshua tree were used to assess the possible impact of fires on the estimate of abundance obtained by WEST (2021) (Figures 1, 2, 3). The database contained information from multiple agencies on timber fires of 10 acres or more, brush fires of 30 acres or more, and grass fires of 300 acres or more. Fires impacting areas of at least 10 acres were recorded by the US Forest Service since 1950. Fires occurred in the sample of 1000 five-acre plots throughout the southern Joshua tree range between 1915 and 2016. No fires occurred in the sampled plots between 2017 and 2020.

We examined the potential impact of previous fires on the estimate of western Joshua tree abundance obtained by WEST. Joshua tree abundance and density were computed with a difference estimator (Breidt and Opsomer 2017) that employed a generalized regression estimator (Montanari and Ranalli 2006) from a linear mixed model. The linear mixed model used to adjust the digitized counts was based on subsamples of plots within projects that had been previously censused by field crews. None of these plots occurred on previously burned areas based on the CAL FIRE data set. Therefore, we could not adjust the regression equation to include a fire covariate. We calculated the proportion of each plot impacted by fire for each of the 1000 five-acre plots across the southern range. Assuming that a plot impacted by fire within a specific time frame contained no Joshua trees, we extrapolated the densities to only the acreage unaffected by fire in each plot within the specified time frame. We examined time frames of 10, 25, 50, 75, and 100 years. For example, the estimated density for a plot impacted by fire in 1950 would be applied to the unburned proportion of the plot for the 10-, 25- and 50-year fire adjustments but applied to the entire plot for 75- and 100-year fire adjustments.

Using the proportion of each randomly selected plot that had been burned in fires within specified time frames, the proportion of the southern range impacted by fire was estimated as 2% for fires occurring within the previous 10 years and up to 8% for fires in the previous 100 years. Accounting for fire history in the southern Joshua tree range (Table 2) resulted in estimates of Joshua tree abundance that ranged from 8,176,117 to 8,466,864 total Joshua trees. The abundance estimates were 67,620 to 358,367 individuals lower than the original estimate of Joshua tree abundance (no adjustment). Therefore, the assumption of zero Joshua tree density in previously burned areas results in estimates of total western Joshua trees in the southern range of over 8 million Joshua trees.

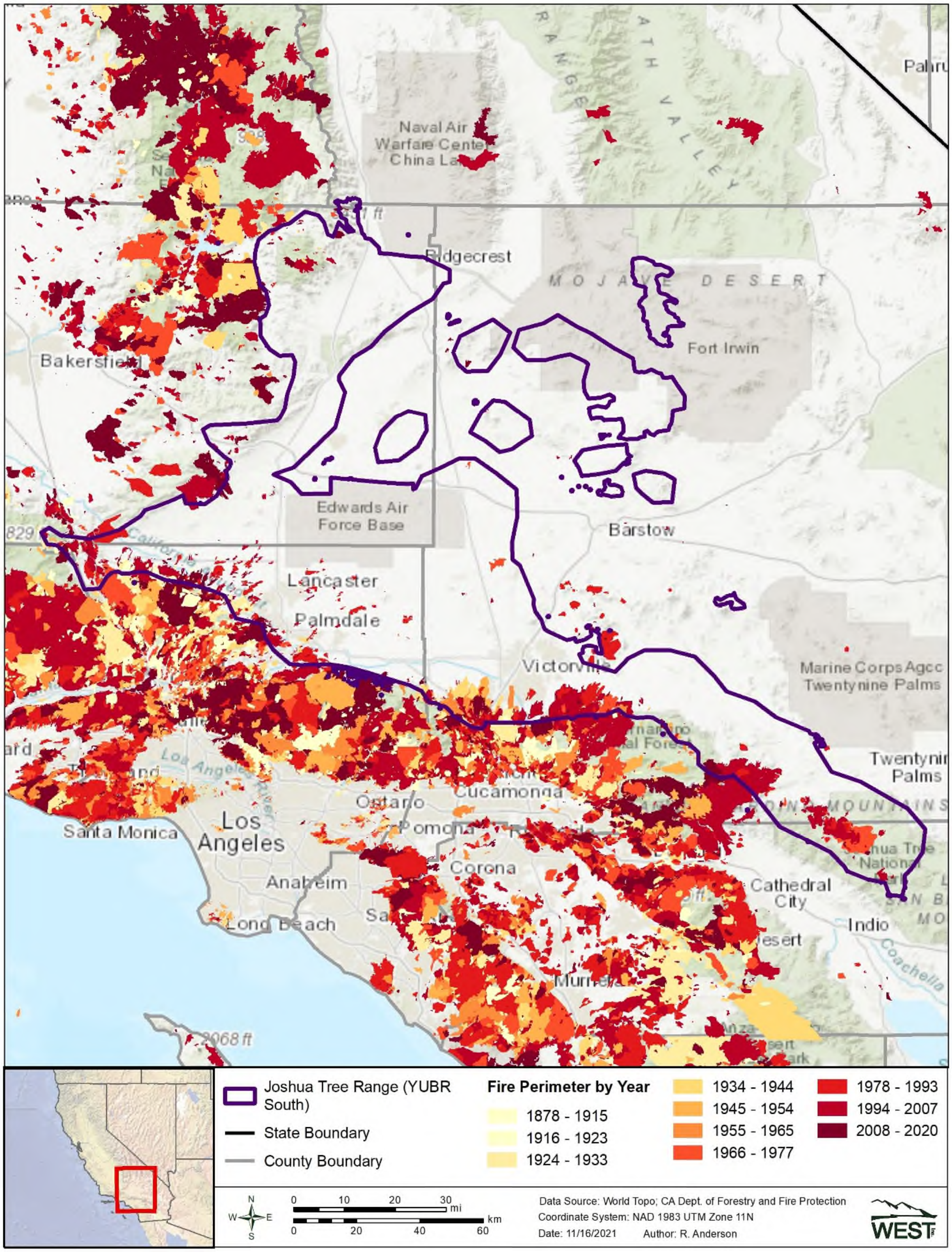

Figure 1. Historic fire perimeter data (CAL FIRE 2020) by year categories with the southern range of western Joshua tree.

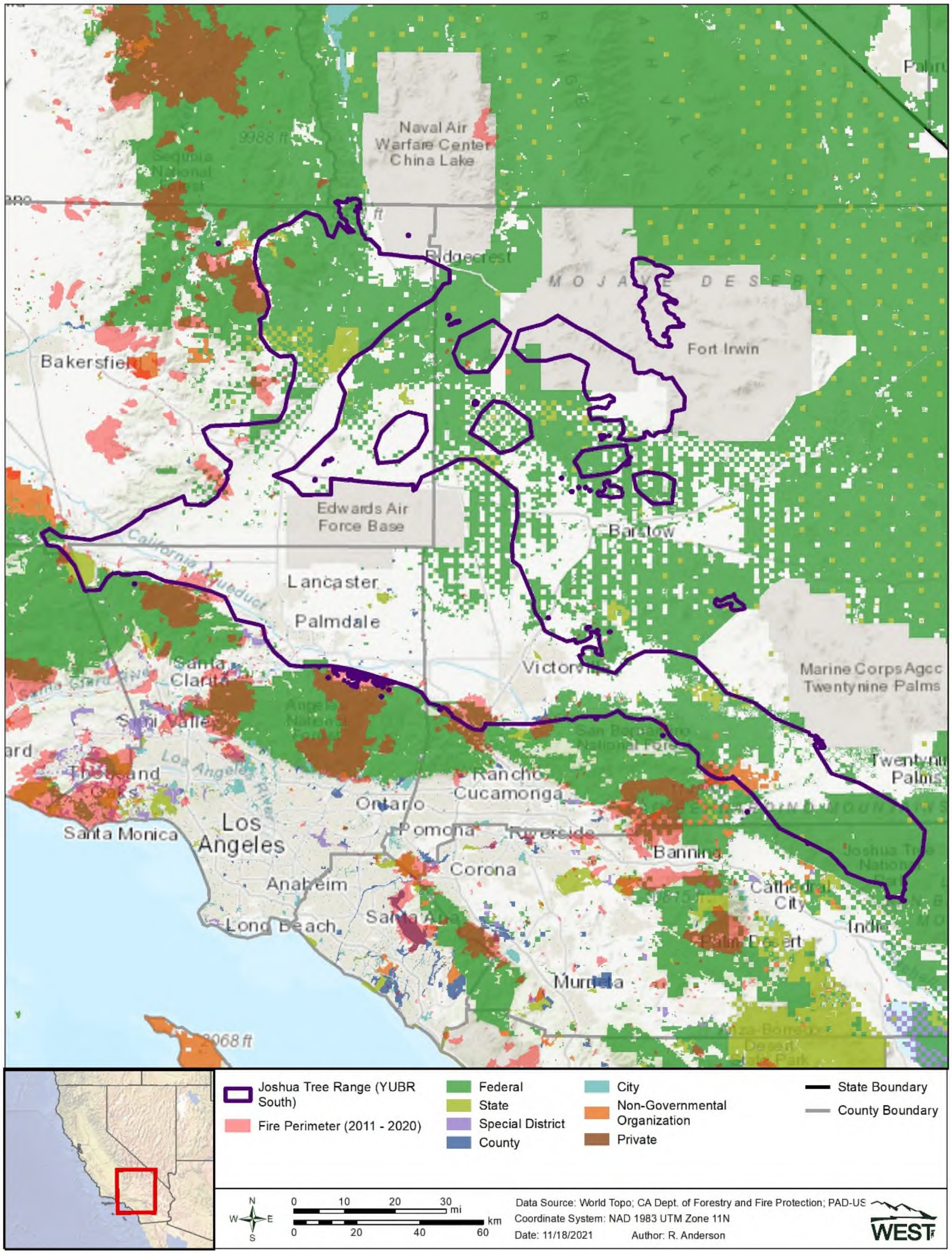

Figure 2. Historic fire perimeter data (2011-2020, CAL FIRE 2020) with the protected lands from the USGS Protected Areas Database (USGS 2021).

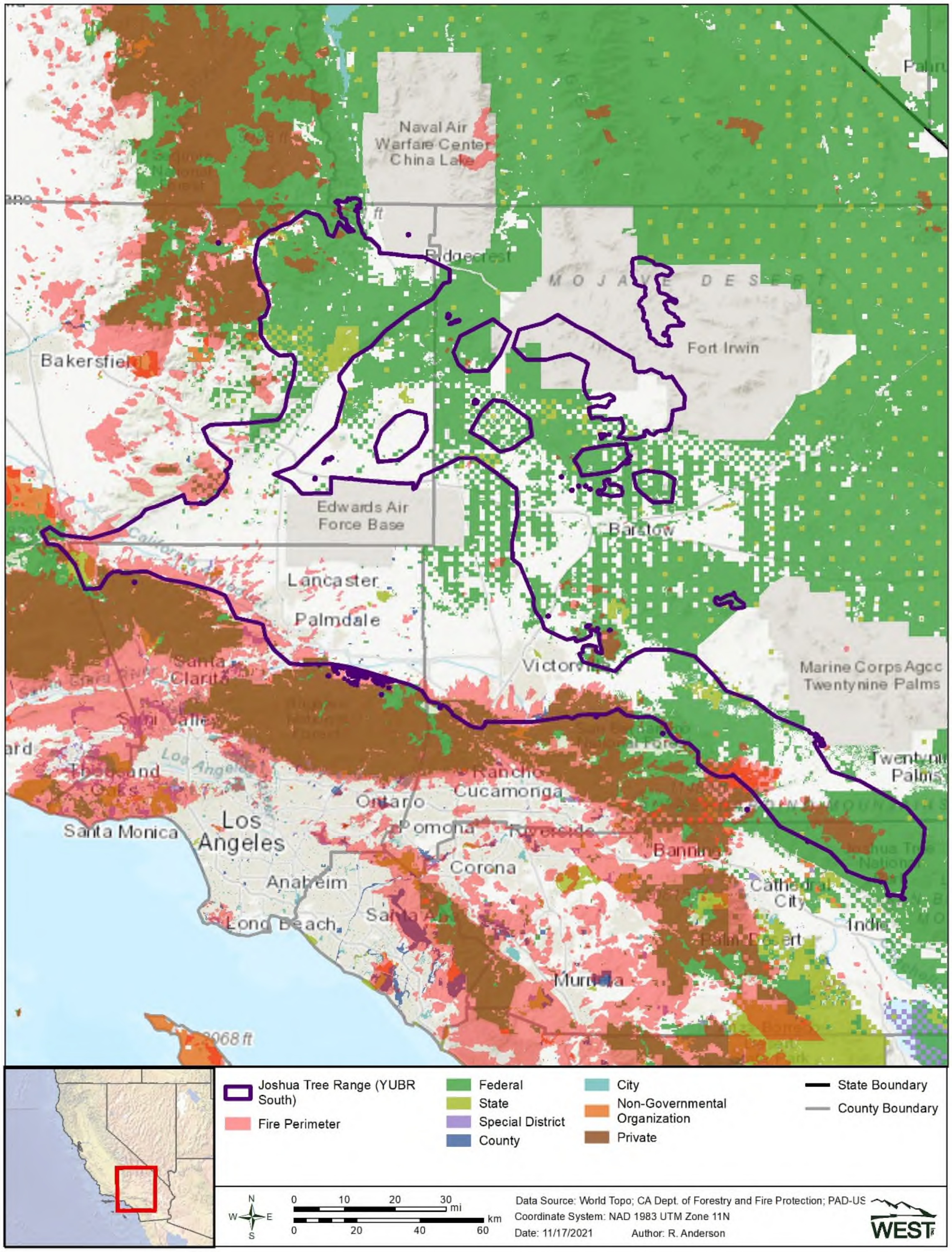

Figure 3. Historic fire perimeter data (1878 – 2020, CAL FIRE 2020) with the protected lands from the USGS Protected Areas Database (USGS 2021).

Table 2: Estimates of total western Joshua trees in the southern range assuming zero density at previously burned areas for a range of time frames.

Number of years of fire history	Number of plots (out of 1000) with any burn area within previous years	Proportion of the southern JT range burned within previous years	Estimated total JTs	SE of total estimate
No adjustment	-	-	8,534,484	1,060,053
10	18	0.02	8,466,864	1,007,262
25	63	0.05	8,305,290	975,080
50	88	0.08	8,212,715	956,776
75	89	0.08	8,207,933	955,833
100	99	0.08	8,176,117	949,568

LITERATURE REVIEW SYNOPSIS: Fire Impacts and Efforts to Assess Joshua Tree Trend

Relevant peer-reviewed literature was evaluated with respect to the impacts of fire and efforts to assess Joshua tree population trend (which, as explained below, have been limited to species distribution models including predictions of the impact of climate change on the forecasted distribution of the western Joshua tree population in the southern range).

Impacts of Fire. When fire occurs, species richness and composition in Joshua tree communities are impacted (Abella et al. 2020, DeFalco et al. 2010). Joshua trees in burned areas are more susceptible to herbivory, seedlings lack nurse plants to provide protection (DeFalco et al. 2010), and long-term nutrient availability declines (Fuentes Ramirez 2015). Pollination and fruit production are resistant to fire exposure (Lybbert and St. Clair 2017), and resprouting after fire was observed (Abella et al. 2020, Esque et al. 2015, Loik et al. 2000).

We found that, over the past 10 years, fires occurred on an estimated total of 2% of land on the southern range for western Joshua trees, while fires over the last 100 years impacted an estimated total of 8% of the southern range for the species. Our previous estimate of the total number of western Joshua trees in the southern range (WEST 2021) did not account for areas affected by fire. The field data from project censuses used to model the adjustment to digitized densities did not include any burned areas. We accounted for previous fires by conservatively assuming that any burned area would contain no Joshua trees. Using the range sample, we calculated the proportion of each randomly selected plot burned within the past 10, 25, 50, 75, and 100 years and adjusted the extrapolation to only the unburned area of the southern range for each time frame. After accounting for previous fires, our estimate of total western Joshua trees throughout the southern range nevertheless exceeded 8 million Joshua trees.

Trend Assessments to Date. Our literature review found several studies that used niche models to suggest that there is potential for decline in Joshua tree population size and range due to the predicted future climate based on climate change models (Barrows and Murphy-Mariscal 2012, Cole et al. 2011, Sweet et al. 2019). These niche models are correlative studies that assume changes in the future Joshua tree distribution based on the current distribution of the species and the predicted future environment given climate change projections. USFWS (2018) used scenario planning to avoid spurious conclusions that can occur with niche modeling of species with patchy or unknown distributions.

However, we did not find any studies that used vital rates (i.e., survival and recruitment) to conduct population viability analyses (PVAs), a common tool used to evaluate population dynamics and estimate extinction probabilities (Morris and Doak 2002). Similarly, we did not find any studies that estimated population growth rate (positive or negative) or predicted future population size. We also searched the literature for vital rates, which are necessary for conducting PVAs (Caswell 2001). The USFWS (2018) species status assessment notes uncertainties in estimates of pollinator status, number of reproductive individuals, survival and recruitment rates of seedlings and juvenile, adult survival, the age/size distribution, and population density for the southern range. Joshua Tree National Park does not yet have long-term monitoring data to inform these data gaps (Gonzalez 2019). We found estimates of survival for pre-productive life stages (Esque et al. 2015) and in burned and unburned areas (DeFalco et al. 2010) and estimates of spatial recruitment (Sweet et al. 2019), but we did not find sufficient documentation of recruitment rates or data needed to derive those vital rates. Therefore, our literature review suggests that there has not been an empirical study to show that Joshua tree populations are declining, and furthermore, the data necessary to demonstrate population decline have not been collected.

Models predicting the extent of Joshua tree range through the end of the century focused on various ranges and used distributional data from different time frames. Dole et al. (2003) and Cole et al. (2011) focused on the entire Joshua tree range for both species and based distributional assumptions on data collected in the early 1980’s (Dole et al. 2003) and between 1962 and 2003 (Cole et al. 2011). Habitat within Joshua Tree National Park (JTNP) was examined with data collected in 2000 (Barrows and Murphy-Mariscal 2012) and in 2016-17 (Sweet et al. 2019). These distributional data were collected over a wide range of conditions. Prolonged drought periods occurred in the Mojave Desert in 1942 - 1975 and 1999 through at least 2006, while a relatively wet period occurred from 1976 through 1998 (Hereford et al. 2006). Since 2006, record-breaking droughts have occurred in California between 2007 and 2009 (California Department of Water Resources 2010) and from 2012 to 2016 (Ullrich et al. 2018).

While Joshua trees are protected in JTNP, the park represents the southernmost point of the southern range of the western Joshua tree. Nevertheless, “considerable” recruitment was observed in JTNP in 2000 (Barrows and Murphy-Mariscal 2012) and more recently in 2016-17 (Sweet et al. 2019). These authors also found evidence of current recruitment at locations modeled as future refugia where Joshua trees will persist through the end of the century, identifying specific locations for potential local-scale conservation. Managing refugia with weed control and restoration (Barrows and Murphy-Mariscal 2012) provide methods to minimize stressors (such as grass fires and competition with invasive species) and conserve the species for the next 50 years or more (Sweet et al. 2019). Roughly 32% of the southern range for western Joshua trees is owned by the federal government, which provides opportunities and mechanisms for additional protection and management. Nearly 85% of the northern range for the species is owned by the federal government, which also affords opportunities for identification and protection of potential refugia. Reducing CO_2 emissions on a regional to global level is an important mitigation strategy for protecting Joshua tree range (Sweet et al. 2019).

REFERENCES

Abella, S. R., D. M. Gentilcore, and L. P. Chiquoine. 2020. Resilience and alternative stable states after desert wildfires. Ecological Monographs 00(00):e01432. 10.1002/ecm.1432.

Barrows, C. W. and Murphy-Mariscal, M. L., 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: how scale impacts predictions. Biological Conservation, 152, pp.29-36.

Breidt, F. J. and J. D. Opsomer. 2017. Model-Assisted Survey Estimation with Modern Prediction Techniques. Statistical Science 32(2): 190-205.

California Department of Forestry and Fire Protection (CAL FIRE). 2020. Fire Perimeters through 2020. October 26, 2021. Available online: https://frap.fire.ca.gov/mapping/gis-data/

California Department of Water Resources. 2010. California's Drought of 2007–2009: An Overview. 128 pp. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Water-Basics/Drought/Files/Resources/California-Drought-of-200709.pdf

Caswell, H. 2001. Matrix Population Models: Construction, Analysis, and Interpretation. Sinauer associates, Inc, Sunderland, Massachusetts, USA.

Cole, K.L., Ironside, K., Eischeid, J., Garfin, G., Duffy, P.B. and Toney, C., 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications, 21(1), pp.137-149.

DeFalco, L.A., T.C. Esque, S.J. Scoles-Sciulla, and J. Rodgers. 2010. Desert wildfire and severe drought diminish survivorship of the long-lived Joshua tree (Yucca brevifolia; Agavaceae). American Journal of Botany 97(2):243–250.

Dole, K. P., Loik, M. E. and Sloan, L. C., 2003. The relative importance of climate change and the physiological effects of CO2 on freezing tolerance for the future distribution of Yucca brevifolia. Global and Planetary Change, 36(1-2), pp.137-146.

Esque, T. C., P. A. Medica, D. F. Shryock, L. A. DeFalco, R. H. Webb, and R. B. Hunter. 2015. Direct and Indirect Effects of Environmental Variability on Growth and Survivorship of Pre-reproductive Joshua Trees, Yucca Brevifolia Engelm. (Agavaceae). American Journal of Botany 102(1): 85-91.

Fuentes Ramirez, A. H. 2015. Flammable deserts: understanding the impacts of fire on southwestern desert ecosystems of USA. Graduate Theses and Dissertations. 14340. Available online: https://lib.dr.iastate.edu/etd/14340

Gonzalez, P. 2019. Anthropogenic Climate Change in Joshua Tree National Park, California, USA. National Park Service, Berkeley, CA.

Hereford, R., Webb, R.H. and Longpre, C.I., 2006. Precipitation history and ecosystem response to multidecadal precipitation variability in the Mojave Desert region, 1893–2001. Journal of Arid Environments, 67, pp.13-34.

Loik, M. E., T. E. Huxman, E. P. Hamerlynck, and S. D. Smith. 2000. Low temperature tolerance and cold acclimation for seedlings of three Mojave Desert Yucca species exposed to elevated CO2. Journal of Arid Environments 46:43-56.

Lybbert, A. H., and S. B. St. Clair. 2017. Wildfire and floral herbivory alter reproduction and pollinator mutualisms of Yuccas and Yucca moths. Journal of Plant Ecology. Volume 10(5):851-858.

Montanari, G. E. and M. G. Ranalli. 2006. A Mixed Model-Assisted Regression Estimator That Uses Variables Employed at the Design Stage. Statistical methods and applications 15(2): 139.

Morris, W. F., and D. F. Doak. 2002. Quantitative Conservation Biology: Theory and Practice of Population Viability Analyses. Sinauer associates, Inc, Sunderland, Massachusetts, USA.

Sweet, L. C., Green, T., Heintz, J. G., Frakes, N., Graver, N., Rangitsch, J. S., Rodgers, J. E., Heacox, S. and Barrows, C. W. 2019. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. Ecosphere, 10(6), p.e02763.

Ullrich, P.A., Xu, Z., Rhoades, A.M., Dettinger, M.D., Mount, J.F., Jones, A.D. and Vahmani, P., 2018. California's drought of the future: A midcentury recreation of the exceptional conditions of 2012–2017. Earth's future, 6(11), pp.1568-1587.

US Fish and Wildlife Service (USFWS). 2018. Joshua Tree Species Status Assessment. October 23, 2018. 113 pp. + Appendices A–C.

US Geological Service (USGS) Protected Areas Database of the United States (PAD-US). 2021. Protected Areas Database of the United States. Version 2.1. Accessed November 2021. Available online: https://usgs.gov/gapanalysis/PAD-US/

Western EcoSystems Technology Inc. (WEST) 2021. Population Size Evaluation for the Western Joshua Tree. Technical Report prepared for: 8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen. WEST, Inc., 415 W. 17th Street, Suite 200, Cheyenne, WY 82001. Dated: October 14, 2021.

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January 29, 2021

VIA E-MAIL NATIVEPLANTS@WILDLIFE.CA.GOV

California Department of Fish and Wildlife
Habitat Conservation Planning Branch
Attn: Native Plant Program
P.O. Box 944209
Sacramento, CA 94244-2090

Re: **Informational Submittal on the Petition to List the Western Joshua Tree (*Yucca brevifolia*) as Threatened Under the California Endangered Species Act**

Dear Sir or Madam:

The Town of Yucca Valley (Town) submits this comment letter in response to the notice issued by California Department of Fish and Wildlife (CDFW) pursuant to Fish and Game Code section 2074.4 to solicit data and comments regarding the proposed listing of the western Joshua tree (*Yucca brevifolia*) as a threatened or endangered species under the California Endangered Species Act (Fish & Game Code § 2050 *et seq.*) (CESA).

The Town appreciates the chance to submit comments and to work with CDFW throughout the status review process.

The Joshua tree is abundant within the Morongo Basin and is found throughout the Town on all property types (including developed and undeveloped property) and within all planning zones. As a result, the Town has been involved in land use management, planning, and permitting with respect to the Joshua tree since incorporation in 1991. Many property owners within the Town have Joshua trees on their property that periodically need to be pruned or removed in order to prevent potential property damage or injury to persons or animals that may result from a dead tree or falling limbs. Because of the prevalence of the Joshua tree within the Town, listing the Joshua tree as a threatened or endangered species will impact the Town of Yucca Valley and its residents more than any other city in the state.

Due to the abundance of the Joshua tree within the Town and the role the Town may play in future management and protection of the tree, the Town is a key stakeholder and will be an essential resource for CDFW in its review process. Specifically, the Town joins with the County of San Bernardino in its request[1] to participate or contribute in the following ways:

- To provide CDFW with recommendations for experts to consider for the peer review panel.
- To be given the opportunity to review a draft of the status report to provide comments or feedback based on the Town's experience in desert land management, landscape rehabilitation, and planning.
- To submit independent scientific data or reports, under 14 CCR § 670.1(h), in a timely manner to assist CDFW.
- To engage with CDFW and other stakeholders in developing alternative, non-regulatory approaches for managing and protecting the western Joshua tree.

In evaluating whether the western Joshua tree is threatened with extinction absent the special protection of CESA, the Town joins with the County of San Bernardino and urges CDFW to review and consider the prior efforts of the United States Fish and Wildlife Service (USFWS) which engaged in a similar review of the species under the federal Endangered Species Act and ultimately determined that listing was not warranted. As was noted by the County in its recent letter[2] to CDFW:

> USFWS carefully assessed the best scientific and commercial information available on the past, present and future threats to the western Joshua tree, and evaluated the potential stressors to the species, including climate change and other factors being considered by CDFW, to conclude that western Joshua tree was not in danger of becoming extinct within the foreseeable future. The 2018 study published by USFWS, provides that threats to individual

[1] See January 28, 2021 letter from the County of San Bernardino to the California Department of Fish and Wildlife regarding "Informational Submittal on the Petition to List the Western Joshua Tree (Yucca brevifolia) as Threatened Under the California Endangered Species Act" ("County Letter").
[2] See County Letter.

> Joshua trees are not likely influencing population resiliency on a population or species scale since there is no evidence to indicate any recent population size reductions or range contractions over the past 40 years, based on distribution mapping and limited demographic studies that indicate recruitment is occurring. USFWS further concluded that most of habitat of the western Joshua tree is federally managed by NPS and other federal agencies, and that further protections under the federal Endangered Species Act were not warranted.

The Town appreciates the opportunity to submit this information and looks forward to working with CDFW moving forward.

Sincerely yours,

Thomas D. Jex
Yucca Valley Town Attorney

TDJ/tg
cc: Charlton Bonham, Director, California Department of Fish and Wildlife

The California Department of Fish and Wildlife's Science Institute was tasked by the CDFW Native Plant Program with coordinating an independent scientific peer review of Western Joshua tree (*Yucca brevifolia)* from December 27, 2021, to January 25, 2022. This document includes information about the peer reviewer selection process, background information on each reviewer, and a high-level summary of input received across reviewers.

Independent Peer Reviewer Selection Process

The following steps were taken by the Science Institute to identify independent scientific peer reviewers for the Western Joshua Tree (WJT) status review draft:

1. Established selection criteria for selection of independent peer reviewers:
    a. Reputable and verifiable scientific track record
    b. Reputable and verifiable expertise in field related to conservation and/or life history of WJT
    c. Unbiased (no vested interest/personal gain of any kind related to listing outcome) and independent from CDFW and WJT related decision-making
2. Conducted a scientific literature search for studies relevant to WJT
3. Performed a high-level review of WJT relevant studies, followed by in depth review of those studies most relevant to reproduction, climate change, wildfire, and habitat suitability
4. Researched author backgrounds and developed a spreadsheet with information on authors and their expertise and relevant publications
5. Also evaluated a list of suggested reviewers in a letter submitted by the County of Bernardino to Chad Dibble, dated April 28, 2021.
    a. Investigated suggested reviewers' backgrounds
    b. Carefully reviewed the list according to the independent peer review criteria
    c. One peer reviewer from this list was chosen according to the above listed criteria
6. Established initial list of candidate reviewers to contact
7. Contacted eight candidate reviewers to assess availability
8. Selected five finalist reviewers by availability and invited their review within a 4-week period from December 27, 2021, to January 25, 2022.
9. Received all five reviews by January 25, 2022.
10. Shared review documents with Native Plant Program on January 26, 2022.
11. Assembled reviewer input summary by main themes (sent February 4, 2022).

Peer Reviewer Background

- **Dr. Cameron Barrows**, Emeritus, University of California Riverside, cbarrows@ucr.edu
  - *Relevant Expertise:* Climate change effects on Joshua Trees
  - *Relevant Publications:*
  - 2014 Biodiv Cons - WJT Climate Monitoring
- **Dr. Erica Fleishman,** Director, Oregon Climate Change Research Institute Professor, College of Earth, Ocean, and Atmospheric Sciences, erica.fleishman@oregonstate.edu
  - *Relevant Expertise:* Conservation of biodiversity, ecological responses to environmental change, management of natural resources in western US, remote sensing applications to conservation and ecological modeling.
  - *Relevant Publications: 2011*Top 40 priorities for science to inform US conservation and management policy, full publication list
- **Dr. Tim Krantz**, Professor and Chair, Environmental Studies Program, University of Redlands, tim_krantz@redlands.edu
  - *Relevant Expertise:* Botany, Endangered species of the San Bernadino Mountains, environmental impact on species, renewable energy systems.
  - *Relevant Publications:* Supervised 2021 Student undergraduate honors thesis on Wildfire Impacts on WJT
- **Dr. Lynn Sweet**, Research Ecologist, University of California, Riverside, lynn.sweet@ucr.edu
  - *Relevant Expertise:* WJT distribution models
  - *Relevant Publications*:
  - 2019 Ecosphere - Distribution models
- **Dr. Jeremy Yoder**, Assistant Professor of Biology, California State University, Northridge, jeremy.yoder@csun.edu
  - *Relevant Expertise:* WJT coevolution, obligate mutualism of Yucca moth and WJT, ecology, evolution and the population genomics of local adaptation, genetic variation of WJT, species' adaptation capacity.
  - *Relevant Publications*: 2013 Gene flow effects in WJT varieties and pollinators; 2008 Joshua Tree/Yucca moth coevolution and divergence mutualism; 2009 host specificity and reproductive success of yucca moths relevant to WJT gene flow; 2009 Divergence in an obligate mutualism is not explained by divergent climatic factors; other.

High-Level Summary of Input Received Across Reviewers

Contents

Status Review as Thorough State of Knowledge about WJT 1
Endangered/Threatened Status Recommendation 3
Uncertainty of Climate Change Effects on WJT 5
Abundance and Trends of Demographic Health of WJT 8
Factors Affecting Survival and Reproduction - Species Distribution Model.................... 9
Wildfire Effects on WJT – Combined with Climate Change...12
Other Threats...14
Management Recommendations and Recovery Measures 14

Status Review as Thorough State of Knowledge about WJT

<u>Barrows:</u> "Overall, the report is **comprehensive, delving into the relevant aspects of this species ecology.**"

<u>Fleishman:</u> "The status review is **intended to reflect the best scientific information available** (see, e.g., line 310). In some cases, **the status review appears to include a more comprehensive selection of the scientific information available**—a subset of which, **as suggested by the review itself, may not be highly** reliable. The review would be more accessible to a diverse audience if it synthesized the best information and, if necessary, simply referenced other sources of information. **I underscore synthesized because some sections of the status review are presented as summaries of the literature (whether high-quality or variable) rather than as syntheses**."

"Throughout the review, **the concept of habitat is misrepresented**. Despite common misuse, habitat is not synonymous with location, vegetation type, or land-cover type. Instead, habitat is a species-specific construct. It encompasses the space within which a species (or other taxonomic entity) lives or can live and the abiotic and biotic elements in that space that generally are required for survival and persistence. The quality and configuration of a species' habitat affect its population dynamics and relations with other species and its connectivity, usually defined as the probability that genes or individuals move among patches of the species' habitat. **Representation of the concept of habitat matters because at both the California and federal levels, most species-specific mitigation plans focus on acquiring areas that appear to function as**

habitat for the species or increasing the quality of the species' habitat. Descriptions and quantifications of habitat that fully reflect existing knowledge about the manner in which a given species interacts with its abiotic and biotic environment **increase the feasibility of identifying the factors that limit survival and reproduction, the actions most likely to increase the species' survival and reproduction, and metrics of success**. Moreover, habitat is suitable by definition. *Suitable habitat* is redundant, and *unsuitable habitat* is an oxymoron."

Krantz: "The California Department of Fish and Wildlife (the Department) Draft Status Review provides **a comprehensive and detailed description of the biology of the WJT** (pages 5-29), **its habitat and ecological parameters** (pp. 30-37), **its abundance/range and population trends** (pp. 38-49), and **endangerment factors** (pp. 50-85)."

"The Status Review provides **an excellent synopsis of the taxonomy and biology of the WJT**."

Small: "In all, however, **the review**, listing hundreds of citations, and text of more than 100 pages **was useful in documenting the available science and areas needed for further research**."

Yoder: "Having considered the draft Status Review in full, **I am impressed by the thoroughness with which it enumerates the state of our knowledge about western Joshua tree's habitat requirements and current population extent, and pleased to see that it cites the latest available data on the trees' demographic status and the threats faced by the species.** However, **I am left with multiple concerns** about the Status Review as it stands, and **these may undermine the validity of its final recommendation.**

Most substantively, although the draft Status Review details threats arising from changing climate, increasing frequency and extent of wildfires, and ongoing habitat losses to development**, it does not substantially address how these threats may interact to rapidly endanger the survival of western Joshua tree throughout its range** — and the CESA specifically notes that threats to a species may act in combination, per the California Code of Regulations, tit.14, sect. 670.1, subd. 3709 (i)(1)(A). This oversight is, perhaps, related to a second issue, that **uncertainty in expected threats is consistently interpreted in a manner that minimizes those threats, particularly in the way that the text addresses uncertainties in habitat losses predicted by species distribution models**. Finally, I note several places in which the **draft Status Review misses ways in which available data provide answers to questions posed elsewhere in the text**."

Endangered/Threatened– Southern YUBR - ESU Status Recommendation

<u>Barrows:</u> "As requested, I will go through each point individually below, however, overall**, it reads as an argument for not listing this species as threatened or endangered, not as an objective analysis of the existing data, and as a result is flawed, suffering from repeated confirmation bias.** Whether or not listing Joshua trees as threatened or endangered under the CESA will do anything to ensure that this species will not go extinct is a point I can argue, but **whether or not Joshua trees are at risk of being extirpated from most of their current range, based on the available data, is quite clear."**

"**This document continually refers to climate change as if it is a future threat, something to deal with sometime in the future. It is here now and has been for decades. We can see the impacts on Joshua trees throughout their range.** This is irresponsible. **The only argument to be made is whether a CESU listing will alter that threat. I will argue that it will, if done with science and flexibility**. It will **increase public awareness** and quit this misinformation of climate change only being a future threat (tell that to the drought-stricken southwest, flooding in the east and northwest, wildfires in the northwest, and sea-level rises along coastlines). Additionally, and specific to Joshua trees**, it could fund research to identify climate refugia and genetic diversity within each population.** With that information climate refugia that represent distinct genetic trajectories would be provided the highest levels of protection, while solar development could then be focused on those regions where the populations have been evolutionarily extinct for many years."

Fleishman: "**On the basis of the best scientific information available, I agree with the recommendation of the California Department of Fish and Game (Department) that listing western Joshua tree as a threatened species is not warranted.** As detailed below, however, **I believe that some elements of the Department's assessment are unclear, may be misleading, or could be strengthened**."

<u>Krantz:</u> "The Petition states that the WJT warrants listing as a Threatened species throughout its range in California; **but requests the Department consider listing the southern population (YUBR South) as "ecologically significant units", as opposed to the northern extension of WJT (YUBR North)**—generally the range of WJT from Inyo County, northward into Nevada and the Great Basin Floristic Province (Page 10-11, Lines 498-508 and Figure 3: Joshua Tree Range in California). As we will see in the discussion of endangerment factors, **the levels of threat from land development, energy projects, wildfires and climate change are generally greater in the YUBR South range than the YUBR North range, thus warranting separate consideration of the appropriateness of listing under the CESA**."

“It is clear that the Western Joshua Tree **does not meet the definition of an Endangered species in accordance with the CESA**.”

“**The question before the Department and the focus of this Status Review is whether the WJT meets the definition of a Threatened species**, a species “that, although not presently threatened with extinction, is **likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA]**.”
“In this Status Review, the foreseeable future is considered to be the 21st century, or through the year 2100. Furthermore, the focus of this Peer Review is on whether the **southern extent of the populations of WJT (YUBR South) should be listed as Threatened “ecologically significant units**” unto themselves. **The conclusion of this Peer Review is that such a designation is appropriate because the YUBR South populations are subject to much greater threats than the northern WJT populations (YUBR North).** The facts and research presented in this Status Review demonstrate that **the potential for the YUBR South populations to become Endangered over a significant portion of their range (the YUBR South range) within the foreseeable future is very real.** The primary threats to the YUBR South populations of WJT are three-fold:
• Climate change
• Urbanization and land development
• and Wildfires”

“Thus, we find that **the Southern WJT populations are faced with a triple cumulative threat: their lowermost populations are already functionally extinct due to climate change;** even if they could disperse toward higher, more equable climate, they **are blocked by sprawling development across their middle elevations**; and finally, the **remaining high ground along the south edge of the YUBR range is being consumed by wildfire and will be biologically non-functional for the foreseeable future and beyond.** Together, **these three impacts represent significant adverse cumulative impacts to the YUBR South populations *throughout their range.*** Referring back to the definition of an Endangered species: one “which is in serious danger of becoming extinct throughout all, or a significant portion, of its range;” **I find that the data and studies presented in this Status Review do, indeed, support a finding that the YUBR South population of WJT meets the definition of a Threatened species:** one that, “although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA].””

Yoder: “Overall, I **concur with the conclusion of the draft Status Review that the size and extent of current western Joshua tree populations is sufficient that it**

would be inappropriate to recommend a designation of "endangered" under the CESA; western Joshua tree is not at this time "in serious danger of becoming extinct throughout all or a significant portion of its range," per the language of the Fish and Game Code, sect. 2062. **However, I am not convinced that the available evidence supports a recommendation against designating the species as "threatened." Current threats to western Joshua trees in California, considered in combination, mean that the species has very real potential to "become an endangered species in the foreseeable future**" (again, per Fish and Game Code, sect. 2067)."

"In conclusion, it is undoubtably the case, as the draft Status Review concludes, that western Joshua tree currently remains widespread and abundant. However, **I do not feel that the draft reflects a full assessment of the risk that this species "is likely to become an endangered species in the foreseeable future"** as specified for assigning "threatened" status under the CESA (Fish and Game Code, sect. 2067.) **As currently written, the draft Status Review interprets uncertainty in predicted threats in the most optimistic light, misses ways in which available data can answer questions that it poses, and does not seriously consider the joint effects of the interlocking threats to western Joshua tree."**

Uncertainty of Climate Change Effects on WJT

Barrows: "This is an argument repeated throughout the document. The Department's argument being that **yes, climate change is a threat to this species but because you can't quantify the impact range-wide, you discount this threat**. Joshua trees have been studied with respect to climate change more than any other species in western North America. **Every study has pointed to the same conclusion, that higher aridity constrains or eliminates recruitment. There is no controversy here, there is no wiggle room to say that the "jury is still out".** The Sweet et al. (2019) paper demonstrates that both through state-of-the-art modeling and through empirical data. I am happy to acknowledge that models can be suspect when not validated, but **this study did the validation and showed that everywhere the model indicated incrementally unsuitable habitat there was no recruitment. The adult trees looked fine, but without recruitment the stands were evolutionarily extinct.** The Cole et al (2011) analysis was much coarser but showed that this was not an isolated phenomenon."

"Line 227: "*Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species, and substantially lowers the threat of extinction within the foreseeable future."* This appears to be the Department's primary, continually repeated, defense for their conclusion that Joshua trees do not warrant any additional state protection**. It would be true if the threats**

were spatially constrained, but climate change is an existential threat, unconstrained by area, and so whether Joshua trees are currently abundant and widespread is a meaningless argument. Climate change is and will continue to impact all Joshua trees throughout their range. Many are already "evolutionarily extinct" populations of only mature adults, with no successful recruitment. Others will be unless we do something."

<u>**Krantz:**</u> "**Record high summer temperatures in recent years are already being measured in the lower elevations of the WJT range and increasing temperatures and overall reductions in precipitation will lessen recruitment of WJTs in those areas**. For WJTs to "newly appear" to the north and in higher elevation areas implies that there would be some means of long-distance dispersal."

"**The models all indicate a contraction of WJT range from lower elevation slopes, where extreme summer high temperatures and increasing drought will cause those areas to become locally extinct,** toward higher elevation or northerly areas characterized by cooler temperatures and more precipitation. The Status Review is correct, however, in qualifying that "**the species is unlikely to naturally colonize these areas in the foreseeable future," because of its inability to disperse such long distances over inhospitable terrain, given the species' short dispersal range** (~30m, op.cit. under Biology of the WJT)."

"**It will be virtually impossible for WJT in the southern populations to disperse over these relatively few decades to the northern YUBR populations to adjust to climate change.** As far as Southern YUBR plants are concerned, **dispersal to newly suitable habitat in the YUBR North range is not possible**. They will have to **disperse/migrate to the higher elevation, cooler, moister habitats of the slopes along the southern edge of the YUBR South range, which we will see below, is also impossible**. In fact, the lower elevation populations of southern WJT are already **experiencing very low reproduction rates** and those individuals are not maturing to achieve mature flowering plant status, as illustrated in Figure 4 of the Status Review. Furthermore, **there is evidence that the obligate pollinator, *T. synthetica,* may already be declining or absent from the lower elevation WJT populations, implying that these areas cannot sexually reproduce** (Harrower and Gilbert 2018) and, therefore, **cannot produce viable seeds for dispersal.** The **lower elevation portions of YUBR South should already be considered ecologically and functionally extinct."**

<u>**Small:**</u> "**The Department appears on the one hand to take seriously the threat of climate change and the many published studies detailing species distribution models that predict reductions in suitable habitat for the species**. **However, on the other hand, there is doubt cast on what the meaning is of these predictions, without an effective framework for evaluating such modeling.** The **reason** that the

predictions of habitat loss (by the six models summarized) are discounted appears to be 1) **the associated uncertainty in the models themselves** (e.g. in model accuracy where there are differences in actual distribution differ from predictions, or criticisms of the data used), and 2) **uncertainty about the species response.** To this reviewer, there would seem to be less uncertainty about some substantial reduction in habitat in the foreseeable future, **as predicted by all six models, and likely others, indicating strong predicted exposure to climate change**. The uncertainty surrounding species response, or what this means for reductions in species abundance or range indicates sensitivity, or response to climate change. These need to be considered along with adaptive capacity, and the latter two may be questions that remain more unclear. However, **several lines of evidence were presented that indicate sensitivity to e.g. decadal droughts, for populations of the species that are found to be unsustainable or declining in various parts of the range.** This would seem to be in contrast to the assertion that unsuitable conditions over longer timescales, towards the end of century would not be predicted to impact the range of the species. **I found one of the main foundations of the argument, the paleoecological evidence that the species may take thousands of years to respond to a rapid change in climate to be poorly substantiated, as explained, although paleoecology is not my area of expertise**. It is true that there are some changes to vegetation that are not as linear as expected over the short term (for example, Abella et al. 2019), and this may be especially true in regions that are diverse topographically and with strong effects of insolation, soil moisture, texture and depth, etc., as well as with high exposure (due to low cloud cover and low humidity) to a highly variable short-term climate. **This does not mean that long-term exposure and trends in increased warmth and decreased moisture availability will not impact vegetation over the long-term.**

<u>Yoder:</u> "The observation by WEST Inc that **population density is lower in the southern range extent is in fact an early indication of climate-change impacts**. **Climate change** that has occurred since pre-industrial times **is expected to impact species at the warmest and driest parts of their ranges first, and reduced population density would be one sign of such an impact.**"

"*Line 1938:* The statement here (repeated at line 2110 and line 3757) <u>that the</u> **Department lacks data on the effects of climate change on the demography of western Joshua tree populations is contradicted by the extensive discussion later in the text of not one but two studies,** by Barrows and Murphy-Mariscal (2012) and by Sweet *et al.* (2019), which use SDM methods informed by demographic data; and **it further misses data on threats to juvenile Joshua trees that are highly likely to be exacerbated by changing climate**. Most notably: findings by Esque *et al.* (2015) that establishment of Joshua tree seedlings may peak in rare years of higher than average rainfall, and that their survivorship is heavily reduced by herbivory in drought years. **If climate change reduces the frequency of wet years and makes droughts both more frequent and longer, this study clearly indicates that seedlings will be less**

likely to establish and then less likely to survive to reproductive age as a result of climate change."

Abundance and Trends of Demographic Health of WJT

Barrows: "**Population trends,** using those populations that continue to have successful recruitment as the baseline for populations that are not already evolutionarily extinct, **show a distinct tread downward**. **So why conclude Joshua trees do not require some additional level of protection?**"

"Having a "comprehensive random field sample" has never been the criteria for action. Using the best available science is that criteria. **Using the best available science, there is no controversy here, there is no wiggle room to say that the "jury is still out"."**

"Line 1795: "*Species with large ranges therefore tend to be less vulnerable to extinction from disturbances, environmental changes, random events, and other threats than species with more limited ranges (Purvis et al. 2000, Harris and Pimm 2007, Gaston and Fuller 2009, Pimm et al. 2014, Leão et al. 2014, Newbold et al. 2018, Silva et al. 2019, Enquist et al. 2019, Staude et al. 2020)."* **Less vulnerable does not mean that larger populations are not vulnerable. None of those citations refer to populations impacted by existential threats such as climate change**."

Krantz: "**Lower elevation areas of the WJT range are already exhibiting lower absolute cover and reduced seedling germination and recruitment**." "Thus, when one re-examines the range of YUBR South as illustrated in Figure 4, one can see that **fully half of the total YUBR South distribution may already be functionally extinct**—that is, non-reproductive at rates that can sustain the population in those areas in the "foreseeable future" (the 21st century)."

Small: In all, there is apparently **a lack of systematic demographic data range-wide, although a meta-analysis could have been used to summarize these findings** more effectively from the many small demographic studies described in text form. These need to be contextualized with respect to the position within the range, and this was difficult to properly contextualize as presented.

Yoder: "This section of the draft text considers key indicators of the "demographic health" of western Joshua tree populations: the density of tree populations, in terms of total individuals per space, and more importantly the density of juvenile-sized trees. As noted elsewhere in the text (especially lines 2025-2027) Joshua trees are long-lived, so a population may have substantial density of larger trees, but ultimately fail if seedlings do not survive to replace those larger, older trees as they die. This factor means that

data on the frequency of Joshua tree seedlings is critical for assessing the viability of populations in the foreseeable future, but because seedlings are small and frequently sheltered by nurse plants, they are much more difficult to survey than mature Joshua trees."

"**The summation of long-term monitoring studies here seems to me to miss important overall trends.** Multiple cited studies find population declines or lack of new recruitment in monitoring plots at relatively southern sites (Victorville, in the Comanor and Clark study; Saddleback Butte and Joshua Tree National Park, in the Cornett studies cited; other sites in the National Park in the DeFalco study**). The text here correctly notes that this is limited data, but none of the direct studies discussed appear to have found substantial recruitment of juvenile trees into the populations being monitored**."

"Line 2035: The statement that **the Department lacks data showing that western Joshua tree populations are experiencing "delayed local extinction"** — in which populations of established adult trees are failing to recruit new seedlings — is **contradicted by the earlier discussion of demographic studies** showing that, at multiple sites in the Mojave, juvenile Joshua trees are sufficiently rare to be consistent with population declines. **Such a demographic population decline is a "delayed local extinction" in a long-lived species such as western Joshua tree.**

Factors Affecting Survival and Reproduction - Species Distribution Model

Barrows: "Line 2212: "*how well their model accurately predicts the current distribution of Joshua tree, which calls into serious question the modeling methods used and therefore the accuracy of model predictions*." This statement is a "red herring" and underlines the confirmation bias the Department has used in developing their conclusion**. If the data indicate a conclusion that is at odds with what the Department wants, then challenge the accuracy of that data with no background or support as to why it should be questioned. Or use the best available science.** Use science that has done what all science must do, undergo rigorous peer review. **Show us where peer reviewed science is in disagreement, don't just question inconvenient truths**."

"*Line 2313:* "*Continuation of western Joshua tree recruitment in areas of JTNP that Sweet et al. (2019) modeled as no longer containing suitable climate demonstrates that a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species*." Another red herring. Rather that focus on the high level of congruence between the model and the patterns of recruitment on the ground, the Department has chosen to question the conclusions since they are not 100% accurate (they were closer to 95% accurate). **The reality is that +70% of the Joshua trees within the park are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia. As aridity increases those refugia will incrementally become less and less suitable for the long-term sustainability of this species.”**

Krantz: “A key biological factor for the WJT is its obligate pollination mutualism with the yucca moth, *Tegeticula synthetica* (Page 19, Lines 719-730). **The yucca moth and WJT are co-evolved to the degree that the WJT is dependent on the moth for sexual reproduction and the moth is dependent on the WJT for its own reproduction**.”

“Thus, the **environmental limits of the yucca moth have a direct bearing on the sexual reproduction of the WJT, and the lower elevation limitations for the moth—most likely reflecting a high temperature threshold and/or low soil moisture tolerance—may indicate that these low elevation WJT populations are already no longer viable and will, with increasing temperatures resultant to climate change, become locally extinct**.”

“**Although asexual reproduction does occur in WJTs, particularly after fires and/or at higher elevations, sexual reproduction is essential for maintenance of genetic diversity of the species.** Little is known about the life history or survival of yucca moths regarding their survival (or not) after fires, their environmental tolerances to extreme temperatures or moisture, or of their capabilities of locating host plants and dispersal in highly fragmented habitats, such as urbanized, low density WJT habitat in the YUBR South range. **These potential endangerment factors relative to the *T. synthetica* moth are not addressed in the Status Review**.”

“Other biological **factors that are of critical importance in consideration of the endangerment** of the WJT are summarized herein:
• **Seed dispersal is very limited**: average seed dispersal is ~30m (Lines 805-825)
• **Seed germination requires periods of cooler, moist conditions for several years** following mast seeding events.
• After germination takes place, **seedlings require long periods of time, perhaps as much as 30-50 years, to reach reproductive maturity**.”

“These three biological factors all conspire to create a cumulative adverse impact on WJT health and viability in the face of the impacts of climate change: 1) that **WJT seed dispersal is extremely limited and that dispersal to more northerly or higher elevation potential habitat will not keep pace with increasingly extreme high temperatures and drought**; 2) the conditions of **higher temperatures and drought at lower elevation WJT locations will adversely impact seed germination**; and 3) the **time from germination to reproductive maturity will be very slow, especially given**

the likelihood of increasingly severe heat and drought episodes, and the increasing frequency and severity of fires in the higher elevation populations. Thus, just based on these biological requirements alone (not considering the impacts of land development in the middle elevation populations of the YUBR South range), **we can expect the continuing loss of sexual reproduction in the lower and upper elevation populations of WJT; and an inability of WJT to adapt to these environmental extremes by dispersal to more northerly or higher elevation potential habitat."**

Yoder: "This section of the text addresses the prospects for substantial habitat loss and population decline within the "foreseeable future" timeline established earlier in the text, particularly due to climate change. Noted here, as elsewhere, is the correct assessment that western Joshua tree is currently widespread and abundant relative to standards for considering a species endangered (lines 1815-1841). Most relevant here is the IUCN criterion (E), **"a quantitative analysis demonstrating probability of extinction". One such quantitative analysis is a *species distribution model*, or SDM**, which the text correctly describes as identifying suitable climate for a species based on known geographic locations at which the species currently occurs, then identifying the spatial extent of similar climate under projected future climate-change scenarios. Throughout this section, the **text emphasizes uncertainties inherent in SDM construction and the predictions derived from SDMs, but these uncertainties are consistently described in terms of their possibility to overestimate risk, never the possibility that they may *underestimate* risk."**

"*Line 2241-2279:* **Discussion of the SDM study of mature and seedling western Joshua trees in Joshua Tree National Park** by Barrows and Murphy-Mariscal (2012) **assumes the high end of the range of uncertainty in the authors' projections. They find that up to 10%** of the current habitat within the park will remain suitable by the end of the century, **but it may be as little as 2%.** This result must also be viewed in light of the results of the study by Sweet *et al*. (2019) discussed immediately following this work — **that later work notes the risks to wildfire in the small climate refugia identified within the park**."

"*Line 2327:* **The finding by Sweet *et al*. (2019),** that Joshua tree populations in study sites within future climate refugia are more demographically healthy (i.e., have higher density of juvenile trees) than populations outside of climate refugia **is as close to demonstrating a demographic effect of climate change as anything short of long-term survey data tracking population declines over the rest of this century. It is particularly relevant because** the region examined, Joshua Tree National Park, **lies at the southern edge of the species range, where impacts of climate change are expected to manifest first.**"

"**Line 2368: It is not entirely true that species distribution models cannot account for the "resilience" of "an abundant and widespread species."** A widespread species necessarily occupies a wider range of habitats, and SDMs are fundamentally designed to account for variation in the habitats across which a species occurs. A rare, narrowly endemic species will occupy a narrower range of conditions, and an SDM would be more likely to find that its current range would become uninhabitable under climate change as a result. **If a species occupies a wide range of climate conditions and those conditions remain present in the future, an SDM should show that the species will retain its extensive existing range; but this is not what we see for SDM studies of western Joshua tree."**

"*Lines 2352-2373:* **Discussion of the limitations to SDM projections of habitat losses under climate change misses a key factor in evaluating SDM studies of Joshua tree: the species is in many respects an excellent candidate for SDM methods**. Species distribution models gain power as they incorporate larger and larger sets of validated observations of a species' presence or absence from the landscape. Joshua tree, as the most visible member of most plant communities in which it occurs, is exceptionally well observed. **Studies of Joshua trees using SDM methods routinely incorporate thousands of observations** — **Sweet *et al.* (2019) had 11,142 "presence" data-points in their most spatially extensive model. There certainly remain limitations on these data sets, but they are in many respects the ideal applications for SDM methods."**

Wildfire Effects on WJT – Combined with Climate Change

<u>Krantz: </u>"**The Status Review examines three primary factors affecting the survival and reproduction of the WJT: climate change, [land] development and other human activities, and wildfire. Other factors, including invasive plants, herbivory and predation, and human use and vandalism are not considered to be significant endangerment factors unto themselves** and are not discussed further in this Peer Review."

"Wildfire, although a defining component in many of California's ecosystems, is a relatively rare phenomenon in the Mojave Desert, but **fire frequency and intensity has increased dramatically in recent decades, especially in the period from 2001-2020**, as illustrated in *Figure 9: Fires within the California Range of Western Joshua Tree, 1900-2020* (CALFIRE 2021) of the Status Review."

"**The size, intensity and frequency of fires in the YUBR South range are the result of higher fuel loads in the higher elevation portions of the species' range and increasing drought and higher summer temperatures—characteristics of climate change**. The GIS study completed by Krantz et al. (unpublished, 2021), using the same CALFIRE database as cited in Figure 9, above, estimated that between 1980-2019 a total area of 950km2 of WJT habitat was burned within the YUBR South range, representing approximately 8% of total WJT habitat, but as much as 12.9% of YUBR South distribution. Wildfire impacts on YUBR habitat are severe."

"**Smaller WJT plants (<0.5m) are almost entirely killed by fire, but even taller, mature trees are largely killed above ground.** These may sprout vegetatively after fires, but these sprouts may take 30-50 years before reaching sexual maturity and producing flowers."

"With increasing fire frequency and intensity, vegetative sprouts of WJTs are largely eliminated from these areas if the subsequent fire occurs before the sprouts are more than 2-2.5m high—the height at which Southern WJTs first flower (Rowlands, 1978). **Fires eliminate seed stock in the soils and remove potential nursery plants, further reducing the potential for flowering, seed production and seed germination for the "foreseeable future"—the end of this century.** Finally, studies cited in the Status Review indicate that **the yucca moth, upon which the WJT is dependent for pollination, is already rare at these higher elevations of the WJT range** (Harrower and Gilbert 2018**). With the elimination of flowering YUBR plants for 50+ years (before vegetative sprouts will flower again), these areas are essentially lost for their requisite pollinators."**

Yoder: A substantial missed opportunity in the draft Status Review is serious consideration of the joint risks posed by climate change and the increasing frequency of wildfire in the Mojave, driven by the establishment of invasive fire-tolerant grasses. The Review correctly identifies the dramatic increase in burned area over recent decades (Figures 9 and 10) but does not systematically compare this to projected future refugia."

"*Line 2819:* As noted here, smaller trees are more likely to be killed in wildfires; this means that increasing frequency and severity of wildfires is a foreseeable risk to the demographic health of Joshua tree populations."

"*Lines 3854-3867:* **The consideration here of the combined effects of threats to Joshua tree, particularly the joint impacts of climate change and increased wildfire frequency and severity, is really insufficient in considering their joint power.** An example of how fire risk might be weighed in concert with climate change is the work by Sweet *et al.* (2019), which compares the extent of recent fires in Joshua Tree National Park to the extent of projected suitable habitat at the end of the century, and finds that up to 50% of the projected climate refuge area within the park has been burned. **If western Joshua tree does indeed suffer predicted habitat losses as great as projected by even somewhat optimistic SDM studies, the remaining populations will be dramatically more vulnerable to stochastic losses, such as wildfires.** It is unlikely that a single fire could substantially damage the survivability of currently extant Joshua tree populations, but **losses on the scale of the Cima Dome**

fire could represent a large fraction of the populations remaining in climate refugia by the end of this century."

Other Threats

Krantz: "**Land development in the form of clearing the land for agriculture, housing and urban development, or energy projects represents a direct and permanent loss of WJT habitat.** Most land development in the Mojave Desert region occurs on private land in the YUBR South range." "If one considers the incorporated cities within the YUBR South range as developed habitat within the foreseeable future, then a total habitat loss of 654.56 mi2 should be considered extirpated and functionally extinct. Fifteen renewable energy projects were granted §2084 take exemptions during the hearings to establish the WJT as a candidate species for listing under the CESA. **According to an analysis done by the USFWS using U.S. Environmental Protection Agency Integrated Climate and Land Use Scenarios projections, between 22% and 42% of the habitat within the southern part of western Joshua tree's range may be lost by the year 2095 due to urban growth and renewable energy development**. (Lines 2641-2645)."

Management Recommendations and Recovery Measures

Krantz: "If the Department finds that the WJT does not warrant protection as a Threatened species under the CESA, then other regulatory and recovery measures shall be necessary to ensure that the species does not become a Threatened species. **The Department lists a range of management recommendations and recovery measures (Lines 4056-4088). A few of these measures are practical and may be implemented, while many are vague, impractical and unenforceable**."

"**The WJT Conservation Plan should include detailed protocols for environmental assessment and mitigation of proposed projects that have the potential to impact WJTs.**"

"**Dedicate State funds toward acquisition and protection of otherwise unprotected high-value WJT habitat**."

"In this circumstance, **it is my recommendation that the Department sanction the WJT in its YUBR South distribution as a Regulated species, like regulated game or fish animals**."

“If, however, **the State designated the Southern WJT as a Regulated species**, similar to other game and fish animals (§2116 *et seq.* of the Fish and Game Code), then **CEQA review or at least regulatory review would be required, and permits would be necessary for removal of WJT plants on impacted properties. By this means, projects that have the potential to adversely impact WJTs would have to consider avoidance of WJTs to the extent possible and mitigation of impacts to WJTs in the case that Joshua trees cannot be avoided**.”

“Regarding mitigation for removal of WJT, **the trees may be successfully transplanted**.”

“**For this practice to be effective, it is essential that the State designate the WJT as a regulated species**. Otherwise, if left to the individual county and city municipalities, the southern WJT would have only inconsistent standards for environmental review and mitigation. **Standardized environmental assessment and mitigation measures may be included in the WJT Conservation Plan recommendations**, described in #2 above. The WJT Conservation Plan may also **identify conserved areas for translocation of Joshua trees in anticipation of climate change**, such as the Pioneertown Preserve. The Pioneertown Preserve is a 25,500-acre natural preserve managed by The Wildlands Conservancy. The area was burned during the Sawtooth Complex Fire in 2006 and native WJT woodland habitat has been very slow to recover. **Translocation from lower elevation sites** in the cities of Yucca Valley and Joshua Tree to the Pioneertown Preserve would facilitate WJT recovery from the fire, as well as **help with climate adaptation by moving plants to higher elevations. Such translocation sites would require long-term management for fire and fuel modification, non-native grass and fuels management around the base of the trees, and irrigation maintenance until such trees are reestablished. Other potential “climate refugia” may be identified in the Conservation Plan on State, Federal or private lands across the WJT range.”**

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

Date: December 27th, 2021

Dr. Cameron Barrows
Center for Conservation Biology at University of California, Riverside
UCR Palm Desert
75080 Frank Sinatra Drive
Palm Desert, CA 92211
cbarrows@ucr.edu

SUBJECT: STATUS REVIEW OF WESTERN JOSHUA TREE; CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW

Dear Dr. Barrows:

Thank you for agreeing to serve as a scientific peer reviewer for the California Department of Fish and Wildlife's (Department) Status Review of western Joshua tree (*Yucca brevifolia* Engelm.) (Status Review). A copy of the Status Review, dated December 2021, is enclosed for your use in the review. The Department seeks your expert analysis and input regarding the scientific validity of the Status Review, and its assessment and conclusions regarding the status of western Joshua tree in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information, the Department's related assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA), and the Department's overall conclusions. **The Department would appreciate receiving your peer review input on or before January 25, 2022**.

The Department seeks your scientific peer review as part of formal proceedings pending before the California Fish and Game Commission (Commission) under CESA. The Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened (Fish & G. Code, § 2070). The Department serves in an advisory capacity during CESA listing proceedings, charged by the Fish and Game Code to evaluate the status of the species based on the best scientific information available to the Department and make recommendations to the Commission, including if CESA listing is warranted (Fish & G. Code, § 2074.6).

The Commission received the petition to list western Joshua tree under CESA on October 21, 2019. On October 9, 2020, the Commission published findings regarding its

acceptance of the petition for consideration, and formally designated western Joshua tree as a candidate for listing as threatened under CESA. As a candidate species, western Joshua tree currently receives the same protections under CESA as threatened and endangered species. Formal acceptance of the petition triggered the Department's initiation of this Status Review, which will inform the Commission's decision on whether listing the species is warranted.

The draft Status Review forwarded to you today reflects the Department's effort to identify and analyze the best scientific information available regarding the status of western Joshua tree in California. The Department's preliminary recommendation on whether CESA listing is warranted for the species may be found in the draft Status Review. We underscore, however, that scientific peer review plays a critical role in the Department's analysis and effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code. Our analysis and expected recommendation to the Commission may change or be modified following your input. For your reference, under CESA an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion of its range due to one of more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code § 2067).

We ask you to focus your peer review on the best scientific information available regarding the status of western Joshua tree in California. Your peer review of the science and analysis regarding the population status and the threat categories prescribed in CESA's implementing regulations are particularly important (Cal. Code Regs., tit. 14, § 670.1(i)(1)(A); i.e., present or threatened modification or destruction of the species' habitat, overexploitation, predation, competition, disease, or other natural occurrences or human-related activities), as well as your opinion on whether the body of information and reasonable conclusions drawn from the information indicate that western Joshua tree is at serious risk of becoming extinct throughout all or a significant portion of its range in California (i.e. the species is endangered), or whether the species is likely to become so in the foreseeable future in the absence of CESA protection (i.e. threatened).

Please note that currently, the Department releases this Status Review solely to you as part of the peer review process, it is not yet public. However, your review will be appended to the final Status Review which will be released to the public upon receipt by the Commission. We ask that you please keep the Department's Status Review and your review of it confidential until the final Status Review is received by the Commission.

For ease of review and for accessibility by the public, the Department requests that you please submit your comments in list form by report page and line number. Please submit your comments electronically to me via email at Christina.Sloop@wildlife.ca.gov. For questions, I can be reached via email or by phone at (916) 261-1159. If there is anything the Department can do to facilitate your review, please let me know. Following receipt and consideration of peer review comments, the Department will prepare and submit its final Status Review report and related recommendation to the Commission. After at least a 30-day public review period, the Commission will consider the petition, the Department's Status Review, related recommendations including peer review comments, and public testimony during a regularly scheduled Commission meeting prior to making their decision.

Thank you again for your contribution to the Status Review effort and the important input it contributes to the CESA listing process.

Sincerely,

Christina Sloop, Science Advisor & Science Institute Lead
California Department of Fish and Wildlife

Enclosure

ec: California Department of Fish and Wildlife

Isabel Baer, Program Manager
Native Plant Program
Habitat Conservation Planning Branch
[redacted]

Jeb Bjerke, Senior Environmental Scientist (Specialist)
Native Plant Program
Habitat Conservation Planning Branch
[redacted]

12/28/2021

Christina Sloop, PhD
CDFW Science Advisor & Science Institute Lead
California Department of Fish and Wildlife

Dr. Sloop,

Thank you for the opportunity to review and assess the Department's recommendations regarding the status of western Joshua trees. Overall, the report is comprehensive, delving into the relevant aspects of this species ecology. As requested, I will go through each point individually below, however, overall, it reads as an argument for not listing this species as threatened or endangered, not as an objective analysis of the existing data, and as a result is flawed, suffering from repeated confirmation bias. Whether or not listing Joshua trees as threatened or endangered under the CESA will do anything to ensure that this species will not go extinct is a point I can argue, but whether of not Joshua trees are at risk of being extirpated from most of their current range, based on the available data, is quite clear.

Line 209-214: "Predicted loss of areas of 20th century suitable climate conditions for western Joshua tree could result in an overall reduction in recruitment or increase in adult tree mortality, but the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts on existing populations that are severe enough to threaten to eliminate the species from a significant portion of its range by the end of the 21st century."

This is an argument repeated throughout the document. The Department's argument being that yes, climate change is a threat to this species but because you can't quantify the impact range-wide, you discount this threat. Joshua trees have been studied with respect to climate change more than any other species in western North America. Every study has pointed to the same conclusion, that higher aridity constrains or eliminates recruitment. There is no controversy here, there is no wiggle room to say that the "jury is still out". The Sweet et al. (2019) paper demonstrates that both through state-of-the-art modeling and through empirical data. I am happy to acknowledge that models can be suspect when not validated, but this study did the validation and showed that everywhere the model indicated incrementally unsuitable habitat there was no recruitment. The adult trees looked fine, but without recruitment the stands were evolutionarily extinct. The Cole et al (2011) analysis was much coarser but showed that this was not an isolated phenomenon.

Line 227: "Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species, and substantially lowers the threat of extinction within the foreseeable future."

This appears to be the Department's primary, continually repeated, defense for their conclusion that Joshua trees do not warrant any additional state protection. It would be true if the threats were spatially constrained, but climate change is an existential threat, unconstrained by area, and so whether Joshua trees are currently abundant and widespread is a meaningless argument.

Climate change is and will continue to impact all Joshua trees throughout their range. Many are already "evolutionarily extinct" populations of only mature adults, with no successful recruitment. Others will be unless we do something.

Line 1301: "Figure 5: Average Deviation of Annual Precipitation in the Mojave Desert Region"

Here the Department failed to include the most recent two decades of precipitation data which show the most significant and long-lasting drought, including three years of severe drought, over the past century. The best way to portray drought severity is with the SPI, (Standard Precipitation Index). Not including the last two decades is irresponsible and demonstrates the bias in presenting or emphasizing only those data that support a no additional protection needed conclusion.

Line 1473: "Population trends can be an important predictor for extinction risk (O'Grady et al. 2004)."

OK. Population trends, using those populations that continue to have successful recruitment as the baseline for populations that are not already evolutionarily extinct, show a distinct tread downward. So why conclude Joshua trees do not require some additional level of protection?

Line 1795: "Species with large ranges therefore tend to be less vulnerable to extinction from disturbances, environmental changes, random events, and other threats than species with more limited ranges (Purvis et al. 2000, Harris and Pimm 2007, Gaston and Fuller 2009, Pimm et al. 2014, Leão et al. 2014, Newbold et al. 2018, Silva et al. 2019, Enquist et al. 2019, Staude et al. 2020)."

Less vulnerable does not mean that larger populations are not vulnerable. None of those citations refer to populations impacted by existential threats such as climate change.

Line 1875: "Studies indicate that by the end of the 21st century California's climate will be considerably warmer than it is today, precipitation will become more variable, droughts will become more frequent, heavy precipitation events will become more intense, more winter precipitation will fall as rain instead of snow, snowpack will melt earlier in the year, and snowpack will be diminished (Leung et al. 2004, Hayhoe et al. 2004, Mote et 53 al. 2005, Knowles et al. 2006, Garfin et al. 2013, Bedsworth et al. 2018, He et al. 2018)."

This document continually refers to climate change as if it is a future threat, something to deal with sometime in the future. It is here now and has been for decades. We can see the impacts on Joshua trees throughout their range. This is irresponsible. The only argument to be made is whether a CESU listing will alter that threat. I will argue that it will, if done with science and flexibility. It will increase public awareness and quit this misinformation of climate change only being a future threat (tell that to the drought-stricken southwest, flooding in the east and northwest, wildfires in the northwest, and sea-level rises along coastlines). Additionally, and specific to Joshua trees, it could fund research to identify climate refugia and genetic diversity within each population. With that information climate refugia that represent distinct genetic trajectories would be provided the highest levels of protection, while solar development could then be focused on those regions where the populations have been evolutionarily extinct for many years.

Line 1990: “the Department does not possess a 1990 comprehensive random field sample of western Joshua tree demographic information in 1991 California”

Having a “comprehensive random field sample” has never been the criteria for action. Using the best available science is that criteria. Using the best available science, there is no controversy here, there is no wiggle room to say that the “jury is still out”.

Line 2212: “how well their model accurately predicts the current distribution of Joshua tree, which calls into serious question the modeling methods used and therefore the accuracy of model predictions.”

This statement is a “red herring” and underlines the confirmation bias the Department has used in developing their conclusion. If the data indicate a conclusion that is at odds with what the Department wants, then challenge the accuracy of that data with no background or support as to why it should be questioned. Or use the best available science. Use science that has done what all science must do, undergo rigorous peer review. Show us where peer reviewed science is in disagreement, don’t just question inconvenient truths.

Line 2313: “Continuation of western Joshua tree recruitment in areas of JTNP that Sweet et al. (2019) modeled as no longer containing suitable climate demonstrates that a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species.”

Another red herring. Rather that focus on the high level of congruence between the model and the patterns of recruitment on the ground, the Department has chosen to question the conclusions since they are not 100% accurate (they were closer to 95% accurate). The reality is that +70% of the Joshua trees within the park are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia. As aridity increases those refugia will incrementally become less and less suitable for the long-term sustainability of this species.

Line 2485: “but the Department does not have information indicating that western Joshua trees in the affected areas will likely die, or that populations are likely to cease reproducing or be no longer sustainable at the end of the 21st century”

Yes, the department does have that information. Just use the best available science.

Cameron Barrows

Cameron Barrows, PhD
Emeritus
University of California Riverside

Peer Review Comments from Dr. Cameron Barrows on the western Joshua tree (*Yucca brevifolia*) Status Review and California Department of Fish and Wildlife Responses

Note: Comments not associated with specific line numbers by the peer reviewer have "N/A" in the Line column.

Line	Reviewer Comment	Department Response
N/A	Thank you for the opportunity to review and assess the Department's recommendations regarding the status of western Joshua trees. Overall, the report is comprehensive, delving into the relevant aspects of this species ecology. As requested, I will go through each point individually below, however, overall, it reads as an argument for not listing this species as threatened or endangered, not as an objective analysis of the existing data, and as a result is flawed, suffering from repeated confirmation bias. Whether or not listing Joshua trees as threatened or endangered under the CESA will do anything to ensure that this species will not go extinct is a point I can argue, but whether or not Joshua trees are at risk of being extirpated from most of their current range, based on the available data, is quite clear.	The Department has addressed multiple specific examples brought up by peer reviewers regarding uncertainty of scientific results being interpreted in a manner that minimizes those threats, and in response has included additional text to address the possibility that the severity of some threats may have been underestimated. The Department also added a paragraph in the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat to discuss uncertainty regarding the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review.

Line	Reviewer Comment	Department Response
209-214	"Predicted loss of areas of 20th century suitable climate conditions for western Joshua tree could result in an overall reduction in recruitment or increase in adult tree mortality, but the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts on existing populations that are severe enough to threaten to eliminate the species from a significant portion of its range by the end of the 21st century." This is an argument repeated throughout the document. The Department's argument being that yes, climate change is a threat to this species but because you can't quantify the impact range-wide, you discount this threat. Joshua trees have been studied with respect to climate change more than any other species in western North America. Every study has pointed to the same conclusion, that higher aridity constrains or eliminates recruitment. There is no controversy here, there is no wiggle room to say that the "jury is still out". The Sweet et al. (2019) paper demonstrates that both through state-of-the-art modeling and through empirical data. I am happy to acknowledge that models can be suspect when not validated, but this study did the validation and showed that everywhere the model indicated incrementally unsuitable habitat there was no recruitment. The adult trees looked fine, but without recruitment the stands were evolutionarily extinct. The Cole et al (2011) analysis was much coarser but showed that this was not an isolated phenomenon.	The Climate Change section discusses the high exposure of western Joshua tree to climate change, at length, and goes on to discuss the possibility that this climate exposure will have demographic effects, concluding that they are likely to result in population declines. Population declines are cause for substantial concern, but they do not mean that western Joshua tree will be in serious danger of becoming extinct in a significant portion of its range by the end of the 21st century. The reviewer mischaracterizes the results presented by Sweet et al. (2019). While both Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Barrows and Murphy-Mariscal (2012) incorporated demographic data by comparing a binary map product for adult trees with another for juvenile trees, which was useful in suggesting that a demographic link with climate change is present, but it is not an actual correlation. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of "High Recruiting" and "Low Recruiting" macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Both of these studies also examined the same area: Joshua Tree National Park, which is a small portion of western Joshua Tree's total range.

Line	Reviewer Comment	Department Response
277	"Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species, and substantially lowers the threat of extinction within the foreseeable future." This appears to be the Department's primary, continually repeated, defense for their conclusion that Joshua trees do not warrant any additional state protection. It would be true if the threats were spatially constrained, but climate change is an existential threat, unconstrained by area, and so whether Joshua trees are currently abundant and widespread is a meaningless argument. Climate change is and will continue to impact all Joshua trees throughout their range. Many are already "evolutionarily extinct" populations of only mature adults, with no successful recruitment. Others will be unless we do something.	While all of the studies assessed by the Department come to similar conclusions that the areas with climate conditions that supported western Joshua tree during the 20th century are expected to contract substantially by the end of the 21st century, the negative effects are not expected to affect the range of the species evenly and a goal of both Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) was to identify areas of refugia. The Department does not agree that the abundance and widespread nature of western Joshua tree is meaningless when considering the extent to which it may be affected by climate change.
1301	"Figure 5: Average Deviation of Annual Precipitation in the Mojave Desert Region" Here the Department failed to include the most recent two decades of precipitation data which show the most significant and long-lasting drought, including three years of severe drought, over the past century. The best way to portray drought severity is with the SPI, (Standard Precipitation Index). Not including the last two decades is irresponsible and demonstrates the bias in presenting or emphasizing only those data that support a no additional protection needed conclusion.	The Department did not produce this figure, which was reproduced in the Status Review to illustrate multi-decadal precipitation patterns in the Mojave Desert region. To address the lack of data from the last 2 decades the Department added a reference to a 2021 study by Khatri-Chhetri et al. to the Precipitation and Climate Change sections of the Status Review to state that the Mojave Desert region has experienced more frequent and severe drought conditions in recent years.

Line	Reviewer Comment	Department Response
1473	"Population trends can be an important predictor for extinction risk (O'Grady et al. 2004)." OK. Population trends, using those populations that continue to have successful recruitment as the baseline for populations that are not already evolutionarily extinct, show a distinct tread downward. So why conclude Joshua trees do not require some additional level of protection?	As discussed and illustrated in the Demographic Information section of the Status Review, the Department has evidence of recent recruitment at many populations throughout the range of the species, and demographic information from some populations appear consistent with negative population trends. As discussed in the Management Recommendations and Recovery Measures section, the Department also recognizes the value of additional protections for the species, however the purpose of this Status Review is to make a recommendation regarding whether western Joshua tree is likely to be in serious danger of becoming extinct in all or a significant portion of its range in the foreseeable future.
1795	"Species with large ranges therefore tend to be less vulnerable to extinction from disturbances, environmental changes, random events, and other threats than species with more limited ranges (Purvis et al. 2000, Harris and Pimm 2007, Gaston and Fuller 2009, Pimm et al. 2014, Leão et al. 2014, Newbold et al. 2018, Silva et al. 2019, Enquist et al. 2019, Staude et al. 2020)." Less vulnerable does not mean that larger populations are not vulnerable. None of those citations refer to populations impacted by existential threats such as climate change.	The Status Review does not claim that larger populations are not vulnerable to extinction. The most recent article cited for this sentence in the Status Review is Staude et al. (2020), which is a global review of risk of local extinction that discusses climate change specifically and includes several citations. As stated in the Staude et al. (2020) article, empirical evidence for climate-driven global plant extinctions in recent centuries is very limited. However, the article acknowledges the increasing importance of climate change as a driver of plant extinctions.

Line	Reviewer Comment	Department Response
1875	“Studies indicate that by the end of the 21st century California’s climate will be considerably warmer than it is today, precipitation will become more variable, droughts will become more frequent, heavy precipitation events will become more intense, more winter precipitation will fall as rain instead of snow, snowpack will melt earlier in the year, and snowpack will be diminished (Leung et al. 2004, Hayhoe et al. 2004, Mote et 53 al. 2005, Knowles et al. 2006, Garfin et al. 2013, Bedsworth et al. 2018, He et al. 2018).” This document continually refers to climate change as if it is a future threat, something to deal with sometime in the future. It is here now and has been for decades. We can see the impacts on Joshua trees throughout their range. This is irresponsible. The only argument to be made is whether a CESU listing will alter that threat. I will argue that it will, if done with science and flexibility. It will increase public awareness and quit this misinformation of climate change only being a future threat (tell that to the drought-stricken southwest, flooding in the east and northwest, wildfires in the northwest, and sea-level rises along coastlines). Additionally, and specific to Joshua trees, it could fund research to identify climate refugia and genetic diversity within each population. With that information climate refugia that represent distinct genetic trajectories would be provided the highest levels of protection, while solar development could then be focused on those regions where the populations have been evolutionarily extinct for many years.	The first sentence of the Climate Change Direct Impacts section of the Status Review states that “The climatic conditions across western Joshua tree’s range have already changed and will continue to change as a result of ongoing global carbon emissions.” A primary purpose of this Status Review is to make a recommendation on the condition of western Joshua tree in the foreseeable future, which is defined in the Status Review to be the year 2100, and discussions in the Climate Change section therefore focus on that future. A discussion of climate conditions in the recent past to the present is provided in the Climate, Hydrology and Other Factors section of the Status Review, which serves as baseline for the comparison with future conditions provided here. Added a sentence to the Protection Afforded by Listing section of the Status Review to state that CESA listing of western Joshua tree could also increase public awareness of the conservation needs of the species and California desert ecosystems, and could lead to an increased interest in scientific research on the species.

Line	Reviewer Comment	Department Response
1990	"the Department does not possess a 1990 comprehensive random field sample of western Joshua tree demographic information in 1991 California" Having a "comprehensive random field sample" has never been the criteria for action. Using the best available science is that criteria. Using the best available science, there is no controversy here, there is no wiggle room to say that the "jury is still out".	A comprehensive random field sample is not a criteria for determining listing; this sentence was intended to highlight that the limitations of currently available demographic information limits the Department's ability to determine western Joshua tree's sensitivity to climate change. This sentence has been revised to be more specific and state that such a sample could be used to correlate declines in recruitment with areas most severely affected by climate warming that has already occurred, and the sentence now includes a reference to the work of Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019).
2212	"how well their model accurately predicts the current distribution of Joshua tree, which calls into serious question the modeling methods used and therefore the accuracy of model predictions." This statement is a "red herring" and underlines the confirmation bias the Department has used in developing their conclusion. If the data indicate a conclusion that is at odds with what the Department wants, then challenge the accuracy of that data with no background or support as to why it should be questioned. Or use the best available science. Use science that has done what all science must do, undergo rigorous peer review. Show us where peer reviewed science is in disagreement, don't just question inconvenient truths.	Species distribution models have many limitations that are well acknowledged by the scientific community in peer-reviewed scientific literature. For these reasons, species distribution models should be credible, transparent, reproducible, and evaluated carefully to be used effectively for decision-making (Sofaer et al. 2019, Lee-Yaw et al. 2021). Performing checks of model predictions is a common best practice for species distribution modeling efforts (see cited sources above) and pointing out this significant shortcoming in this very early species distribution modeling effort that also addressed 75 other plant species using the same methods is a valid criticism. Despite limitations, however, the Department clearly acknowledges the usefulness of species distribution models in the Status Review, concluding that western Joshua tree will experience a high level of exposure to climate change. The text was revised to remove the word serious from the sentence.

Line	Reviewer Comment	Department Response
2313	“Continuation of western Joshua tree recruitment in areas of JTNP that Sweet et al. (2019) modeled as no longer containing suitable climate demonstrates that a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species.” Another red herring. Rather that focus on the high level of congruence between the model and the patterns of recruitment on the ground, the Department has chosen to question the conclusions since they are not 100% accurate (they were closer to 95% accurate). The reality is that +70% of the Joshua trees within the park are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia. As aridity increases those refugia will incrementally become less and less suitable for the long-term sustainability of this species.	The reviewer did not provide data or cite a source for the claim that “+70% of the Joshua trees within the park are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia.” While both Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Barrows and Murphy-Mariscal (2012) incorporated demographic data by comparing a binary map product for adult trees with another for juvenile trees, which was useful in suggesting that a demographic link with climate change is present, but it is not an actual correlation. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of “High Recruiting” and “Low Recruiting” macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Both of these studies also examined the same area: Joshua Tree National Park, which is a small portion of western Joshua Tree’s total range. Sentence revised to add the modifier “, at least in the short term” at the end, and made it clear that the statement was in reference to the areas that Sweet et al. (2019) modeled as no longer containing suitable climate during the 1981–2010 climate period.

Line	Reviewer Comment	Department Response
2485	“but the Department does not have information indicating that western Joshua trees in the affected areas will likely die, or that populations are likely to cease reproducing or be no longer sustainable at the end of the 21st century” Yes, the department does have that information. Just use the best available science.	Sentence revised to include additional reasoning in response to this and other peer-reviewer comments. The Department also added a paragraph in the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat to discuss uncertainty regarding the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review.

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Date: December 27th, 2021

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SUBJECT: STATUS REVIEW OF WESTERN JOSHUA TREE; CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW

Dear Dr. Fleishman:

Thank you for agreeing to serve as a scientific peer reviewer for the California Department of Fish and Wildlife's (Department) Status Review of western Joshua tree (*Yucca brevifolia* Engelm.) (Status Review). A copy of the Status Review, dated December 2021, is enclosed for your use in the review. The Department seeks your expert analysis and input regarding the scientific validity of the Status Review, and its assessment and conclusions regarding the status of western Joshua tree in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information, the Department's related assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA), and the Department's overall conclusions. **The Department would appreciate receiving your peer review input on or before January 25, 2022**.

The Department seeks your scientific peer review as part of formal proceedings pending before the California Fish and Game Commission (Commission) under CESA. The Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened (Fish & G. Code, § 2070). The Department serves in an advisory capacity during CESA listing proceedings, charged by the Fish and Game Code to evaluate the status of the species based on the best scientific information available to the Department and make recommendations to the Commission, including if CESA listing is warranted (Fish & G. Code, § 2074.6).

The Commission received the petition to list western Joshua tree under CESA on October 21, 2019. On October 9, 2020, the Commission published findings regarding its

acceptance of the petition for consideration, and formally designated western Joshua tree as a candidate for listing as threatened under CESA. As a candidate species, western Joshua tree currently receives the same protections under CESA as threatened and endangered species. Formal acceptance of the petition triggered the Department's initiation of this Status Review, which will inform the Commission's decision on whether listing the species is warranted.

The draft Status Review forwarded to you today reflects the Department's effort to identify and analyze the best scientific information available regarding the status of western Joshua tree in California. The Department's preliminary recommendation on whether CESA listing is warranted for the species may be found in the draft Status Review. We underscore, however, that scientific peer review plays a critical role in the Department's analysis and effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code. Our analysis and expected recommendation to the Commission may change or be modified following your input. For your reference, under CESA an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion of its range due to one of more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code § 2067).

We ask you to focus your peer review on the best scientific information available regarding the status of western Joshua tree in California. Your peer review of the science and analysis regarding the population status and the threat categories prescribed in CESA's implementing regulations are particularly important (Cal. Code Regs., tit. 14, § 670.1(i)(1)(A); i.e., present or threatened modification or destruction of the species' habitat, overexploitation, predation, competition, disease, or other natural occurrences or human-related activities), as well as your opinion on whether the body of information and reasonable conclusions drawn from the information indicate that western Joshua tree is at serious risk of becoming extinct throughout all or a significant portion of its range in California (i.e. the species is endangered), or whether the species is likely to become so in the foreseeable future in the absence of CESA protection (i.e. threatened).

Please note that currently, the Department releases this Status Review solely to you as part of the peer review process, it is not yet public. However, your review will be appended to the final Status Review which will be released to the public upon receipt by the Commission. We ask that you please keep the Department's Status Review and your review of it confidential until the final Status Review is received by the Commission.

For ease of review and for accessibility by the public, the Department requests that you please submit your comments in list form by report page and line number. Please submit your comments electronically to me via email at Christina.Sloop@wildlife.ca.gov. For questions, I can be reached via email or by phone at (916) 261-1159. If there is anything the Department can do to facilitate your review, please let me know. Following receipt and consideration of peer review comments, the Department will prepare and submit its final Status Review report and related recommendation to the Commission. After at least a 30-day public review period, the Commission will consider the petition, the Department's Status Review, related recommendations including peer review comments, and public testimony during a regularly scheduled Commission meeting prior to making their decision.

Thank you again for your contribution to the Status Review effort and the important input it contributes to the CESA listing process.

Sincerely,

Christina Sloop, Science Advisor & Science Institute Lead
California Department of Fish and Wildlife

Enclosure

ec: California Department of Fish and Wildlife

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15 January 2022

Dear Colleagues,

Thank you for the opportunity to provide a scientific peer review of *Status review of western Joshua tree (*Yucca brevifolia*)*. On the basis of the best scientific information available, I agree with the recommendation of the California Department of Fish and Game (Department) that listing western Joshua tree as a threatened species is not warranted. As detailed below, however, I believe that some elements of the Department's assessment are unclear, may be misleading, or could be strengthened.

The status review is intended to reflect the best scientific information available (see, e.g., line 310). In some cases, the status review appears to include a more comprehensive selection of the scientific information available—a subset of which, as suggested by the review itself, may not be highly reliable. The review would be more accessible to a diverse audience if it synthesized the best information and, if necessary, simply referenced other sources of information. I underscore *synthesized* because some sections of the status review are presented as summaries of the literature (whether high-quality or variable) rather than as syntheses. As one of many possible illustrations, the section on seed dispersal (768) would convey the best scientific information more effectively if it synthesized the species that are known to disperse seeds and the known dispersal distances. Instead, the section describes the methods and results of published studies sequentially, leaving it to readers to extract the primary inferences. As another illustration, the geology and soil section could begin with a statement that water availability likely limits survival and reproduction of Joshua trees, and therefore the water-retention capacity of the soil in a given area is relevant to the persistence of the species. The conclusions of some sections (e.g., 1064) could form the basis for such syntheses, much like introductions to high-quality, peer-reviewed scientific publications.

Throughout the review, the concept of habitat is misrepresented. Despite common misuse, *habitat* is not synonymous with location, vegetation type, or land-cover type. Instead, habitat is a species-specific construct. It encompasses the space within which a species (or other taxonomic entity) lives or can live and the abiotic and biotic elements in that space that generally are required for survival and persistence. The quality and configuration of a species' habitat affect its population dynamics and relations with other species and its connectivity, usually defined as the probability that genes or individuals move among patches of the species' habitat. Representation of the concept of habitat matters because at both the California and federal levels, most species-specific mitigation plans focus on acquiring areas that appear to function as habitat for the species or increasing the quality of the species' habitat. Descriptions and quantifications of habitat that fully reflect existing knowledge about the manner in which a given species interacts with its abiotic and biotic environment increase the feasibility of identifying the factors that limit survival and reproduction, the actions most likely to increase the species' survival and reproduction, and metrics of success. Moreover, habitat is suitable by definition. *Suitable habitat* is redundant, and *unsuitable habita*t is an oxymoron.

There is some inconsistency with respect to topics for which background is provided, and the rationale for more or less explanation is unclear. For example, aspects of plant physiology are defined (e.g., lines 387-401, 414-417), and diapause is explained briefly (750), but recruitment (e.g., 1539) and the El Niño–Southern Oscillation and the Pacific Decadal Oscillation (1281) are not.

The numbers below reference line numbers in the pdf of the review.

185. The Mojave and Great Basin are deserts. Therefore, by definition, any vegetation (not habitat; see above) in these ecosystems is desert vegetation, and it is redundant to state that precipitation in these areas is low.

188. "obligate pollinating moth" implies that the moth must pollinate to survive, which is not correct. It would be more accurate to say that sexual reproduction of western Joshua trees appears to require pollination by this species of moth.

204. Remove "as refugia," given that the climate tolerances of the species are not well understood.

208. Change "climate disruption," which is not objective, to "climate change".

Lines 222–238 largely are redundant with the previous paragraph.

It is true that the likely effects of climate change on the species (230-232) are not well understood. As a result, stating that climate change is the greatest threat to the species (199) seems inconsistent with the evidence and with the subsequent caveats.

413. It would be helpful to provide the context about taxonomic criteria for legal protection at the start of this section rather than later in the section.

471. Note here that genetic distinctiveness was based on analysis of single nucleotide polymorphisms. Royer et al. (2016) hypothesized that selection in an intergrade zone operates on style length via the reproductive success of *Tegeticula synthetica* and *T. antithetica*; the paragraph does not clearly link information at lines 464-468 to this hypothesis. It also should be noted that although Smith et al. (2021) inferred that coevolution with *Tegeticula* might sustain taxonomic distinctiveness of Joshua trees, it likely was not the ultimate cause of divergence.

502-505 and beyond. The petition may abbreviate the species name, but this is distracting in the status review. When not quoting the petition, please simply refer to the southern and northern populations.

544. Cline should not be in quotation marks.

551. I very much hope that this project will improve scientific understanding. However, the cited work is the equivalent of a public relations piece on the project, and should be deleted.

554. Range and distribution are differentiated here, but the subsequent discussion sometimes confounds the two.

593-596. Distribution or range?

606. This is somewhat ambiguous. Do you mean that over time, understanding of the species' distribution has improved, or that understanding of the temporal trajectory of the species' distribution has improved?

615-618. The URL at line 4309 no longer is linked to the vegetation map. However, I found the map by searching on "Vegetation – Mojave Desert for DRECP." I cannot easily find the reference to 95% accuracy. Note here that the California Native Plant Society's description of the *Yucca brevifolia* vegetation alliance includes the membership (classification) rule that cover of *Yucca brevifolia* is even and ≥1%. Additionally, it is not clear whether the 95% accuracy refers to where the alliance is present or absent (binary) or whether it's a reference to the accuracy of the percent cover classifications. Is line 617 implying that absolute percent cover is estimated and then aggregated into classes? It it is unclear how figure 4 was derived, or whether and how the accuracy of the derived map was evaluated. Furthermore, at line 620, it is unclear whether there are areas within the range of western Joshua tree in which vegetation was not mapped.

621. The information is cover, not density.

623. These are cover classes, not absolute cover.

623-639. Why is this not in the range section rather than the distribution section?

628. Line 683 correctly notes that occurrence records from individuals without scientific training can be erroneous. This is all the more reason to fully describe the unpublished process used to estimate the range of western Joshua trees. For instance, how were observations deemed erroneous?

629. This description of methods is insufficient to facilitate replication. Additionally, dates of observations in other sources (e.g., herbarium records) may differ considerably, and may not reflect current distribution accurately. The analysis mentioned at line 637 is not detailed. Moreover, a mapping exercise is not necessarily synonymous with an analysis.

631. Do you mean the extent of the presumed range of the species, rather than the map? The map includes areas that are outside the species' range.

634. Do some records include buffer distances, or were buffers added during the mapping process? If no buffers were used, why is this statement necessary?

640. This is confusing. I think you mean that the range is larger than the distribution. Again, the relevance of discussion of buffers is unclear if data were not buffered, and why 0.2 km versus any other distance? (Also, 643 should be “data are”, not “data is”).

650. So what? Is the area of a particular state a criterion for listing?

658. Quite confusing here whether the references are to range or distribution.

662. There is an abrupt shift here from range to distribution.

671. It would be helpful to indicate the breadth of spatial extents included in these occurrences, given that an occurrence could be an individual or a stand. Furthermore, the implication is unclear. Is this an estimate of the number of populations of the species, or an estimate of the number of potential records in the California Natural Diversity Database?

673, 689. The fact that the number of documented occurrences of western Joshua trees is greater than that of many other species that are tracked within the California Natural Diversity Database does not necessarily provide information about the status of western Joshua trees. For example, Joshua trees are easy to detect and relatively easy to identify. The same cannot be said for many of the other plant species that are tracked.

695. Does this mean that flowering occurs relatively early in the season (and move lines 707-710 here to provide context for early versus late season) as opposed to relatively late in the season? Or does it mean that during cold and dry years, flowering occurs and happens to be early, as opposed to not occurring? Also, what seasons correspond to a wet or dry year? For example, is this a reference to flowering in the spring following a wet winter? Could a wet summer followed by a dry winter prompt flowering?

711. Comparing height and age is confusing without data on heights at different ages; explain here the extent to which age can be inferred from height. Comparing height and latitude is confusing without data on heights at different latitudes.

720. All species are unique. Here I think you mean that western Joshua trees primarily are pollinated by *T. synthetica*; they also can be pollinated by *T. antithetica*.

734. Why is this mouth part “special”? Delete that word.

739. Stigmas are not restricted to western Joshua trees. Rephrase.

746. The definition of a mutualism is that both species benefit—rephrase.

762. Do you mean that transfer of pollen is limiting? Meaning of “greater sexual reproduction” is unclear. Do you mean that the proportion of sexual to asexual reproduction is greater?

764. Spell out Joshua Tree National Park. The authors may be familiar with this acronym, and the acronym is defined in a separate section of the document, but many readers won’t be familiar

with it. The reference to detection of *T. synthetica* is accurate, but the implication that the moths do not occur in certain locations may be misleading given the duration and methods of the work by Harrower and Gilbert (2018).

778-779. And still may be important today, and still may occur today.

884. Please simply reference “seedling establishment.” If establishment, then successful. If no establishment, then not successful. The same comment is applicable elsewhere in the document, and to other concepts, such as recruitment (successful recruitment is redundant), e.g., lines 911, 923, 927, 1961; I suggest that you search on “successful” to identify all instances.

898. What does “satiate predation” mean, and is this is reference to mast years?

902. dispersed “in the wild”—as opposed to where?

932. These plants can’t really avoid anything—rephrase to “must not be consumed”

937. Is how much greater of a likelihood known?

943. Restate to “Many plants with which Joshua trees co-occur”

971. Restate to “a greater likelihood of survival,” and indicate how much greater.

981. “carefully controlling”—as opposed to recklessly controlling? Just say “controlling”.

992. Plants cannot be frugal. However, they may be able to survive with limited water.

1019. What age would that be?

1087. The relevance of this section is unclear. I would hope that anyone trying to identify Joshua trees would use a field guide rather than this report. Would the section be better placed with discussion of potentially erroneous occurrence records?

1091. Co-occurrence by definition refers to the same location

1116. Habitat that may be essential to the continued existence of the species usually is referenced with respect to critical habitat in the regulatory sense. There is no geographic information here. It is not possible that all locations where the species occurs are essential; if that was the case, the species should be listed. Habitat can’t be located where the species occurs—that’s circular—wherever the species occurs is habitat. Natural communities should not be confused with habitat given that habitat refers to the suite of biotic and abiotic attributes necessary for survival and reproduction, and it is unlikely that Joshua trees are dependent on all of the species with which they co-occur.

1141. Combine with 1132.

1143. Remove this sentence, which is confusing and redundant with the material above.

1149. This is redundant with material above (551).

1161. These are not habitats.

1163. What is meant by visually dominant? What is meant by other species being “more dominant”? Is this a reference to percent cover?

1165. This sentence is quite confusing.

1181. Explain the difference in microhabitat among the cardinal directions.

1184. The dominant plant species should be listed in taxonomic rather than alphabetical order. Scientific name and common name generally refer to species rather than alliances—do you mean that these are the dominant species in the alliances, or that these are the names of the alliances? Especially with the inclusion of the *Yucca brevifolia* alliance, which of course supports Joshua trees, the caption might be more accurate as “Vegetation alliances in which Joshua trees occur or may occur,” or something similar.

1203, 1205. If in the Mojave and Great Basin then the landforms and mountains are desert by definition; remove “desert”.

1206. “may be”, or “are”?

1237. Does this mean “climate in the Mojave and southwestern Great Basin,” or something similar?

1239. Is this a reference to climate at a given point in time, given that climate also varies as a function of topography and latitude?

1243. It is worthwhile to discuss the fact that average climate may be associated with the physical condition, distributions, or population dynamics of many species, but extreme climate may be equally if not more relevant. For example, see the following.

Germain SJ and Lutz JA. 2020. Climate extremes may be more important than climate means when predicting species range shifts. Climatic Change 163:579–598.

Siegmund JF, Sanders TGM, Heinrich I, van der Maaten E, Simard S, Helle G and Donner RV. 2016. Meteorological drivers of extremes in daily stem radius variations of beech, oak, and pine in northeastern Germany: an event coincidence analysis. Frontiers in Plant Science 7:733. doi: 10.3389/fpls.2016.00733.

Stewart SB et al. 2021. Climate extreme variables generated using monthly time-series data improve predicted distributions of plant species. Ecography 44:626–639.

Zimmermann NE, Yoccoz NG, Edwards TC Jr, Meier ES, Thuiller W, Guisan A, Schmatz DR and Pearman PB. 2009. Climatic extremes improve predictions of spatial patterns of tree species. Proceedings of the National Academy of Sciences of the United States of America 106(Supplement 2):19723–19728.

1248. Change “it is unlikely” to “are not”

1268. Especially given that these citations do not include climate data from the past 20 years, I’m puzzled by why the authors of the status review did not compile climate data for the region from, say, the National Centers for Environmental Information or PRISM.

1277. As written, the sentence implies that the article’s authors completed their identification sometime during the past 108 years.

1283. This section is not entirely clear, and may be confusing El Niño and La Niña with the weather patterns they sometimes produce. In essence, El Niño and La Niña are defined by sea surface temperatures, and those temperatures may or may not result in anomalously wet or dry conditions across the Mojave. See https://www.climate.gov/news-features/featured-images/how-el-ni%C3%B1o-and-la-ni%C3%B1a-affect-winter-jet-stream-and-us-climate

1308. Required for what life history elements? Germination, growth, survival, reproduction? Might precipitation requirements vary throughout the life cycle?

1310. What is meant by “extent of other plants”?

1317. This statement is somewhat misleading. Climate water deficit does not quantify slope and aspect, for example, although it may be affected by slope and aspect.

1343. The difference between averages and extremes is quite relevant here and likely should go beyond the simple mention of duration of high temperatures (1339).

1363. Provide some context here relating “elevated” to the concentrations of carbon dioxide projected under different scenarios by the Intergovernmental Panel on Climate Change or something similar.

1366. Recognize here that acclimation affects tolerances of many organisms to many extremes.

1373. Abundance and density are not synonyms. The section seems to use the concepts interchangeably, however.

1386. Is the intent here to imply that percent cover (which is not the same as abundance or density) of western Joshua trees is below a given threshold in some areas, but may be lower elsewhere?

1409. This is another section that would benefit from reorganization. Why not begin with a statement about the range of densities that have been estimated in the field, and then provide additional detail about whether the estimates were across extensive or limited areas?

1425. Data “were”, not “was”

1445. When did these wildfires occur?

1448. What was that resolution of these images? Were the estimates evaluated against ground data—how was 95% confidence estimated? Not enough information is provided here to support replication of the work.

1471. Just “demographic information” One obviously cannot infer on the basis of unavailable information

1479. What do you mean by concerted population growth? Concerted doesn’t seem like the correct word here.

1483. Range and abundance often are correlated, but not necessarily. I’m not convinced that a change in range can be interpreted as a change in abundance (1489).

1497. But maybe could estimate percentage of habitat as of some year that was developed

1510, 1517, 1527. To what years does “historical” refer? What were the sources and resolution of the images?

1552. This is confusing. How large were the plots? What type of data were collected in the 1970s? I’m skeptical that it’s not possible to make any type of comparison.

1554. Again a couple of synthetic sentences about trend would be quite useful rather than only summarizing a series of individual monitoring programs. The section seems to imply that across the species’ range, trends are not uniform, which would not be surprising.

1562. How many is several?

1587. If there is “significant doubt,” then why include the work in a review of the “best scientific information available”?

1607. Change “is” to “are” (data are)

1612. However, one could use simulation modeling to estimate the level of recruitment needed to sustain a population of a given size for a given period of time.

1623. Seems like height measurements, not censuses. Census refers to an accounting of all individuals.

1648. Here, summarize what reasonably can be inferred about persistence on the basis of multiple sources of information on height distributions. It is difficult for readers to synthesize the inferences from many summaries of individual articles or data-collection efforts. Perhaps move the paragraph starting at line 1751.

1703. Standardizing the range of values on the x-axes for figures 6, 7, and 8 would facilitate easier comparison.

1721. What was the source and resolution of the images?

1748. What aspect is being referenced here?

1801. Abundant populations can mean many populations, which is confusing. What you seem to mean here, and is clearer in the next sentence, is populations with a high number of individuals.

1807. Do you mean high-quality habitat? Habitat is favorable by definition.

1820-1821. These are odd definitions of redundancy and representation. If they were included in the USFWS documents, they should be removed from the status review. Redundancy usually refers to function; for example, if many co-occurring bee species pollinate a given plant, there is some functional redundancy. Representation generally refers to a sample of natural variability rather than adaptive capacity.

1849. All of this is true. Nevertheless, some native and non-native species are likely to benefit from projected changes in climate, and this fact should be acknowledged. It is disingenuous to imply that climate change is a threat in all cases.

1868. True, but not just "in the Department's possession," which sounds rather odd. Few scientific teams or individual scientists have made credible projections of climate change beyond 2100.

1880. This is too broad of a statement, and as written is not true. Nor is it necessary—whether California is more or less affected by climate variability than other states is irrelevant to the status of Joshua trees. Also, be careful not to imply that all winter storms are caused by atmospheric rivers, although it is true that the strongest storms tend to be from atmospheric rivers. See, for example, https://climate.nasa.gov/news/2409/study-atmospheric-river-storms-can-reduce-sierra-snow/.

1890. Explain the range of values. I'm guessing it reflects different scenarios of emissions of greenhouse gases, but should be clarified.

1899. Yes, but the point should again be made here, or at 1892, that even if precipitation totals are consistent or increase somewhat, higher temperatures and more precipitation falling as rain than as snow may decrease water availability, especially during summer.

1910. True, but the number of ignitions may or may not be related to the size or intensity of wildfires.

1915. And ongoing emissions of other greenhouse gases (not restricted to carbon dioxide).

1916, 1922, 1923, etc. As applicable, explicitly related these assumptions to other sections of the document.

1944. What was the magnitude of warming?

1955. Climate is only one component of habitat. Soil type, presence of other species of plants and animals, and land use also affect likelihood of colonization.

1968. Assuming that survival of seedlings does not increase.

1993. Explain why – link to other sections of the document as applicable.

2016. Explain why one might expect increases in atmospheric concentrations of carbon dioxide to affect temperature stress. Also, line 2055 seems to offer evidence to the contrary.

2028. These areas don't just appear to be occupied, they are occupied. As noted, the species may or may not persist in that location in the future.

2042. If Joshua trees could not survive and reproduce in these areas, then the areas were not habitat.

2045-2052. Some redundancy here.

2064. The description of species distribution models could be updated and strengthened. For example, the description does not address the necessary data on response variables or trade-offs among different types of response-variable data (e.g., abundance, presence-absence, presence-only). The description also seems to imply that the environmental variables entered into such models are restricted to climate data, whereas ideally one would include spatial data layers on a larger set of abiotic or biotic variables hypothesized to have a major effect on distribution. By extension, this section seems to imply, perhaps inadvertently, that a small set of climate variables are the primary factors that limit or predict species distributions. Some of these points are addressed at lines 2352-2374, but not all. Furthermore, those caveats should be presented at the start of the section so readers have the caveats in their mind while learning about species distribution models for Joshua trees.

2355. It would be more accurate to note that species distribution models are limited by the availability of spatially continuous data on variables of interest; by the capacity of the scientific community to make accurate measurements or projections of certain variables (e.g., projections of temperature generally are more feasible than projections of wind speed); and by the feasibility and reliability of downscaling or aggregating data to a common spatial and temporal resolution.

2077. This sentence would benefit from clarification. If one wishes to identify areas where climate may change, there is no need to use a species distribution model. Additionally, it is preferable to use temporally matched data on species distributions and climate.

2106-2112. It would be more accurate and streamlined to say that climate models suggest a shift in the potential range of the species, but effects on population dynamics, or current populations, are unknown (as recognized at line 2424).

2110. Change to "data that show"

2116. It would be more accurate to say "information currently is insufficient to conclude" whether climate change is likely to threaten the species. The current texts suggests, perhaps inadvertently, that with more information, a conclusion that the species is threatened would be likely. At line 2119, change "yet" to "currently".

2126. The spatial resolution of climate variables is not necessarily an indication of the reliability of an analysis. Similarly, the most informative temporal resolution varies among species, locations, and analysis objectives.

2128. "endured" is not the best word choice here given that it implies hardship. Also, the twentieth century is not representative of the species' evolutionary history.

2130. What is meant by "effectiveness"? Also, in and of itself, comparing multiple models does not render an analysis reliable.

2132. Change to "how climate is correlated with". These are not mechanistic models. Also, "relied on" is unclear. Are you trying to say that those variables were included in the models, or that among the variables included in the models, these were the most strongly correlated with the species' current distribution?

2135. What is the difference between temperature and a temperature event?

2142. Meaning that June drought and summer thunderstorms are not conducive to establishment and persistence of the species?

2157. What do you mean by "concordant demographic data"? It also would be good to mention that the uncertainty of model outputs increases when projected values of predictor variables are outside the range used to build the model.

2159. Change "that" to "whether"

2164. Within the species' current range, yes? Does "historically" mean "twentieth century"?

2168. This is not clear. Do you mean that relative changes in precipitation were smaller than relative changes in temperature, or that correlations between precipitation and current presences were weaker than correlations between temperature and current presences?

2175. This sentence is difficult to follow. Also, isn't warming a component of climate? Climate shifting after warming sounds odd. Additionally, it seems worthwhile to note that these models generally do not account for climate heterogeneity in complex terrain, such as mountains. Long-distance dispersal may not always be necessary to track climate.

2183. Clarify whether the work examined climate as forced by doubled carbon dioxide concentrations. Physiological responses to carbon dioxide per se may differ from responses to greenhouse gas-driven climate change.

2185. What was the 30-year period?

2193, 2209. If the Department has serious questions about methods or assumptions, why include a description of the analysis in a status review that is intended to reflect the best science available? It would be more informative to synthesize, rather than sequentially summarize, the model outputs for which the Department has reasonably high confidence (e.g., an expansion of the paragraph at lines 2470-2489, but not nine pages that amounts to summaries of the literature, including articles that likely would not be classified as the best science available). If you're trying to signal that you're aware of other work, then why not say something to the effect of "Others also have modeled the potential future range of Joshua tree on the basis of climate, but uncertainty in those outputs is high given poor fit to the species' current distribution or lack of model validation"?

2252. If including details about projected changes in temperature, then include details about projected changes in precipitation.

2278. Above, lack of model validation was criticized strongly. Again, why detail this article if the Department does not have confidence in the outputs?

2286. Instead of explaining that Maxent is software, explain the major assumptions on which it is based. Also, either explain percent contribution and permutation importance, or summarize the results without using these terms. But again, if input values were not reported (2295), why is the work being included in the status review?

2346. This statement is misleading. These studies suggest that recruitment is decreasing in areas in which temperatures are increasing. There may be a mechanistic link, but other mechanisms also are possible.

2350. This is incorrect. Such data would substantially improve ability to evaluate the predictive capacity of these models.

2399. True, but all models are highly sensitive to the data used for their construction.

2510. As a result of climate change in general.

2402. Again, "endured" is not the correct word.

2453. If confidence in this output is low—and I agree that it is low—why calculate the index, or include it in a report that aims to present the best science available?

2522. Does *Prodoxus* sp. parasitize Joshua trees? That is implied at line 2988, but not made explicit in either location.

2554. This statement is incorrect. Reduction of the contiguity of habitat indeed results in fragmentation. However, fragmentation can occur independent of changes in habitat area. See work by Fahrig and others on this topic.

2538-2559. Note, too, that some native species benefit from human activities or from creation of edges. As one of many examples, in arid ecosystems, residential and agricultural irrigation may benefit some native species. Joshua trees may not benefit from irrigation, but this paragraph is not specific to Joshua trees.

2579. Just “habitat” (delete “suitable”)

2601. Extensive experience with management of Department of Defense lands leads me to question the unreferenced statement that military activities are likely to lead to modification and destruction of habitat for Joshua trees. Native species tend to be conserved much more effectively on Department of Defense lands than on lands under other public jurisdictions.

2616. Dry conditions are not identified in Figure 5, although they may be illustrated in Figure 5.

2621. A need cannot be disrupted. Fulfillment of a need may be disrupted.

2622. Change to “or as adults”. “Flight phase” doesn’t make sense.

2632-2634. Protection of habitat can be distinct from protection of individuals. My guess is that the development projects also would take habitat, but as written, the text references removal of individuals.

2687. How is severity being defined here?

2715. Moreover, livestock grazing and use of off-road vehicles, which can be extensive in the Mojave, generally are associated with expansion of non-native invasive grasses. Also see Curtis, C.A., and B.A. Bradley. 2015. Invasive Plant Science and Management 8:341–352 and Bradley, B.A., C.A. Curtis, and J.C. Chambers. 2016. Bromus response to climate and projected changes with climate change. Pages 257–274 in M.J. Germino, J.S. Chambers, and C.S. Brown, editors. Exotic brome-grasses in arid and semiarid ecosystems of the western US. Springer, Zurich.

2765. Correct that the Great Basin is a cold desert. How is that relevant here?

2772. The distribution and density of cheatgrass in the Great Basin also fluctuates considerably as a function of amount and timing of precipitation.

2778. This is a statement about fire size rather than likelihood of fire per se.

2827-2844. Please synthesize.

2878. This is not entirely true. Probability of fire is related to aridity, but aridity can increase even if precipitation amounts increase.

2882, 2886. Okay, but not all invasive species increase fire likelihood appreciably.

2911. Non-native is not synonymous with invasive. Native plants can be invasive, and not all non-native plants are invasive. This seems to be recognized starting at line 2939, but is not noted explicitly.

2918. I assume you mean either changes to the natural fire frequency or simply changes in fire frequency. The latter is preferable given that fire frequency generally is quite variable.

2921, 2963. Use of “habitat” here is incorrect.

2996. Remove “yet,” which implies that an effect will be found in the future.

2084, 3085. Why are these terms in quotation marks? Either explain the terms or remove the quotation marks.

3102. This section describes petitions for listing, not protections under the law.

3461. It is not immediately clear how this section relates to its headers, “Existing management” and “Regulatory status and legal protections”. An explanation at the top of the section would be helpful.

3513. “found extensively” isn’t quite correct. It seems more accurate to say that most of the known range of the species is under federal jurisdiction.

3530. Refugium (singular), not refugia (plural).

3751. Correct the tense here.

3755. Do you mean that the area will decline? “areas . . . will decline” is unclear.

3791, 3803. Just “habitat” (delete “suitable”)

3793. What about lands on which use of off-road vehicles is permitted or common, even if not permitted?

3863. Revise to avoid the implication that large fires favor vegetation growth. The latter may be true in the case of non-native invasive bromes, but I don’t think that’s what you meant.

3858. This statement seems inconsistent with 3781 and many statements throughout the document that the future demography of western Joshua trees cannot be projected with any appreciable degree of certainty.

4057. Completion of a conservation plan is a component of a preliminary conservation strategy (4045)? Is the intended emphasis here the partnerships rather than the conservation plan per se?

4066. I think you mean “implement disincentives”

4071. This component must be accompanied by integration of scientific research into management. Knowledge in and of itself will not conserve the species.

Thank you again for the opportunity to provide a scientific peer review of the status review. Please contact me if you would like to discuss any aspect of the review.

Sincerely,

Erica Fleishman

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Peer Review Comments from Dr. Erica Fleishman on the western Joshua tree (*Yucca brevifolia*) Status Review and California Department of Fish and Wildlife Responses

Note: Comments not associated with specific line numbers by the peer reviewer have "N/A" in the Line column.

Line	Reviewer Comment	Department Response
N/A	Thank you for the opportunity to provide a scientific peer review of Status review of western Joshua tree (*Yucca brevifolia*). On the basis of the best scientific information available, I agree with the recommendation of the California Department of Fish and Game (Department) that listing western Joshua tree as a threatened species is not warranted. As detailed below, however, I believe that some elements of the Department's assessment are unclear, may be misleading, or could be strengthened.	Responses to specific comments on elements identified by the reviewer as unclear, possibly misleading, or that could be strengthened are provided below.
N/A	The status review is intended to reflect the best scientific information available (see, e.g., line 310). In some cases, the status review appears to include a more comprehensive selection of the scientific information available—a subset of which, as suggested by the review itself, may not be highly reliable. The review would be more accessible to a diverse audience if it synthesized the best information and, if necessary, simply referenced other sources of information. I underscore synthesized because some sections of the status review are presented as summaries of the literature (whether high-quality or variable) rather than as syntheses. As one of many possible illustrations, the section on seed dispersal (768) would convey the best scientific information more effectively if it synthesized the species that are known to disperse seeds and the known dispersal distances. Instead, the section describes the methods and results of published studies sequentially, leaving it to readers to extract the primary inferences. As another illustration, the geology and soil section could begin with a statement that water availability likely limits survival and reproduction of Joshua trees, and therefore the water-retention capacity of the soil in a given area is relevant to the persistence of the species. The conclusions of some sections (e.g., 1064) could form the basis for such syntheses, much like introductions to high-quality, peer-reviewed scientific publications.	Additional synthesis text added near the beginnings of the Seed Dispersal and Geology and Soils sections of the Status Review per the reviewer's suggestion. The Status Review includes syntheses of information where appropriate, but also includes summaries of the literature when that is important because some of the details of the methods may be relevant to the study conclusions (such as the species and location of the work). The section on seed dispersal includes more detail because some of the information has been important for Department functions related to CESA including environmental review and permitting.

Line	Reviewer Comment	Department Response
N/A	Throughout the review, the concept of habitat is misrepresented. Despite common misuse, habitat is not synonymous with location, vegetation type, or land-cover type. Instead, habitat is a species-specific construct. It encompasses the space within which a species (or other taxonomic entity) lives or can live and the abiotic and biotic elements in that space that generally are required for survival and persistence. The quality and configuration of a species' habitat affect its population dynamics and relations with other species and its connectivity, usually defined as the probability that genes or individuals move among patches of the species' habitat. Representation of the concept of habitat matters because at both the California and federal levels, most species-specific mitigation plans focus on acquiring areas that appear to function as habitat for the species or increasing the quality of the species' habitat. Descriptions and quantifications of habitat that fully reflect existing knowledge about the manner in which a given species interacts with its abiotic and biotic environment increase the feasibility of identifying the factors that limit survival and reproduction, the actions most likely to increase the species' survival and reproduction, and metrics of success. Moreover, habitat is suitable by definition. Suitable habitat is redundant, and unsuitable habitat is an oxymoron.	The document was searched for the word habitat and text updated where necessary.
N/A	There is some inconsistency with respect to topics for which background is provided, and the rationale for more or less explanation is unclear. For example, aspects of plant physiology are defined (e.g., lines 387-401, 414-417), and diapause is explained briefly (750), but recruitment (e.g., 1539) and the El Niño–Southern Oscillation and the Pacific Decadal Oscillation (1281) are not.	Additional background added for the two examples identified by the reviewer: Added a definition of recruitment to the Establishment section of the Status Review and added background that El Niño, La Niña, and Pacific Decadal Oscillation are sea surface temperature conditions.

Line	Reviewer Comment	Department Response
185	The Mojave and Great Basin are deserts. Therefore, by definition, any vegetation (not habitat; see above) in these ecosystems is desert vegetation, and it is redundant to state that precipitation in these areas is low.	The word “habitat” was replaced to address another comment from this reviewer. Low precipitation is a characteristic of deserts, but this sentence describes fluctuations between wetter and drier conditions, so it is important context to initially state that precipitation is low so wetter and drier conditions can be put into context. The words “is low” were retained because they occupy little space and may help inform readers who are less familiar with the characteristics of deserts.
188	“obligate pollinating moth” implies that the moth must pollinate to survive, which is not correct. It would be more accurate to say that sexual reproduction of western Joshua trees appears to require pollination by this species of moth.	Text updated per suggestion
204	Remove “as refugia,” given that the climate tolerances of the species are not well understood.	Text updated per suggestion
208	Change “climate disruption,” which is not objective, to “climate change”.	Text updated per suggestion
222-238	Lines 222–238 largely are redundant with the previous paragraph.	This is a summary of the primary reasoning in the executive summary and the document, and therefore must reference the key topics already discussed.
199, 230-232	It is true that the likely effects of climate change on the species (230-232) are not well understood. As a result, stating that climate change is the greatest threat to the species (199) seems inconsistent with the evidence and with the subsequent caveats.	Removed statement per suggestion

Line	Reviewer Comment	Department Response
413	It would be helpful to provide the context about taxonomic criteria for legal protection at the start of this section rather than later in the section.	Moved the paragraph about taxonomic criteria for legal protection to the beginning of the section per suggestion
471	Note here that genetic distinctiveness was based on analysis of single nucleotide polymorphisms. Royer et al. (2016) hypothesized that selection in an intergrade zone operates on style length via the reproductive success of Tegeticula synthetica and T. antithetica; the paragraph does not clearly link information at lines 464-468 to this hypothesis. It also should be noted that although Smith et al. (2021) inferred that coevolution with Tegeticula might sustain taxonomic distinctiveness of Joshua trees, it likely was not the ultimate cause of divergence.	Added note on Royer et al. (2016) methods being based on analysis of single nucleotide polymorphisms. No additional changes were made in response to this comment because hybridization is not a threat to western Joshua tree and the selection pressures influencing the taxonomic distinctiveness of western and eastern Joshua tree are not important for the conclusions of the Status Review.
502-505 and beyond	The petition may abbreviate the species name, but this is distracting in the status review. When not quoting the petition, please simply refer to the southern and northern populations.	Text updated per suggestion
544	Cline should not be in quotation marks.	Text updated per suggestion
551	I very much hope that this project will improve scientific understanding. However, the cited work is the equivalent of a public relations piece on the project, and should be deleted.	Text updated per suggestion
554	Range and distribution are differentiated here, but the subsequent discussion sometimes confounds the two	Text checked and clarified per suggestion
593-596	Distribution or range?	Text changed to range per suggestion
606	This is somewhat ambiguous. Do you mean that over time, understanding of the species' distribution has improved, or that understanding of the temporal trajectory of the species' distribution has improved?	Text clarified per suggestion

Line	Reviewer Comment	Department Response
615-618	The URL at line 4309 no longer is linked to the vegetation map. However, I found the map by searching on "Vegetation – Mojave Desert for DRECP." I cannot easily find the reference to 95% accuracy. Note here that the California Native Plant Society's description of the Yucca brevifolia vegetation alliance includes the membership (classification) rule that cover of Yucca brevifolia is even and ≥1%. Additionally, it is not clear whether the 95% accuracy refers to where the alliance is present or absent (binary) or whether it's a reference to the accuracy of the percent cover classifications. Is line 617 implying that absolute percent cover is estimated and then aggregated into classes? It it is unclear how figure 4 was derived, or whether and how the accuracy of the derived map was evaluated. Furthermore, at line 620, it is unclear whether there are areas within the range of western Joshua tree in which vegetation was not mapped.	Text updated to address reviewer comments, and clarify techniques and mapping methodology. Broken links updated.
621	The information is cover, not density.	Text updated per suggestion
623	These are cover classes, not absolute cover.	Text updated per suggestion
623-639	Why is this not in the range section rather than the distribution section?	This section discusses how distribution information was used to develop the range information shown in Figures 2 and 3. Text was added to the Range section stating that the range shown in Figures 2 and 3 was developed using distribution information as described in the Current Distribution section. The Range section is intended to be more general and the Current Distribution section is intended to contain more detailed and specific information.
628	Line 683 correctly notes that occurrence records from individuals without scientific training can be erroneous. This is all the more reason to fully describe the unpublished process used to estimate the range of western Joshua trees. For instance, how were observations deemed erroneous?	Added a sentence describing how observations were deemed erroneous and noted that the information used for mapping is publicly available.

Line	Reviewer Comment	Department Response
629	This description of methods is insufficient to facilitate replication. Additionally, dates of observations in other sources (e.g., herbarium records) may differ considerably, and may not reflect current distribution accurately. The analysis mentioned at line 637 is not detailed. Moreover, a mapping exercise is not necessarily synonymous with an analysis.	Added a sentence describing how observations were deemed erroneous and noted that the information used for mapping is publicly available. Added text stating that some observations used to produce the range map may be old. Changed the word “analysis” to “exercise” per suggestion.
631	Do you mean the extent of the presumed range of the species, rather than the map? The map includes areas that are outside the species’ range.	Text updated per suggestion
634	Do some records include buffer distances, or were buffers added during the mapping process? If no buffers were used, why is this statement necessary?	Text updated to make it clear that buffers were used
640	This is confusing. I think you mean that the range is larger than the distribution. Again, the relevance of discussion of buffers is unclear if data were not buffered, and why 0.2 km versus any other distance? (Also, 643 should be “data are”, not “data is”).	Text updated to clarify that the area of range is larger than area of distribution. The 0.2 km distance was selected by the GIS analyst who performed these calculations based on prior experience with similar mapping exercises. Changed “data is” to “data are” per suggestion.
650	So what? Is the area of a particular state a criterion for listing?	The area of occupied habitat is important for assessing extinction risk. Areas represented as numbers of unit area are sometimes difficult to conceptualize. This sentence is meant to provide a more accessible and easy-to-conceptualize description of the area occupied by the species.
658	Quite confusing here whether the references are to range or distribution.	Text updated to be more consistent with the terms range and distribution; however, the sources of information citied in this section may not follow the same conventions as the Status Review.

Line	Reviewer Comment	Department Response
662	There is an abrupt shift here from range to distribution.	Previous section discusses how available information on distribution contributed to the range map provided in the Status Review. The subjects are not considered to be different enough to warrant an additional subheading.
671	It would be helpful to indicate the breadth of spatial extents included in these occurrences, given that an occurrence could be an individual or a stand. Furthermore, the implication is unclear. Is this an estimate of the number of populations of the species, or an estimate of the number of potential records in the California Natural Diversity Database?	Text updated to clarify that separate element occurrences within the California Natural Diversity Database need to be separated by at least ¼ mile, and that this is in reference to the number of separate element occurrences.
673, 689	The fact that the number of documented occurrences of western Joshua trees is greater than that of many other species that are tracked within the California Natural Diversity Database does not necessarily provide information about the status of western Joshua trees. For example, Joshua trees are easy to detect and relatively easy to identify. The same cannot be said for many of the other plant species that are tracked.	This information will be retained because it is informative to disclose how western Joshua tree compares with all other CNDDB-tracked plant species, because the current abundance and distribution of populations are important predictors of extinction risk. An implication of this comment is that the CNDDB would have a much larger number of element occurrences for the other plant species tracked in the database if they were as easy to detect as western Joshua tree. While it is true to an extent, most species tracked in the database are truly rare, and it is highly unlikely that hundreds of undiscovered occurrences are present. A caveat was added that the highest number of occurrences for a plant currently tracked by the Department in the CNDDB was for comparison.

Line	Reviewer Comment	Department Response
695	Does this mean that flowering occurs relatively early in the season (and move lines 707-710 here to provide context for early versus late season) as opposed to relatively late in the season? Or does it mean that during cold and dry years, flowering occurs and happens to be early, as opposed to not occurring? Also, what seasons correspond to a wet or dry year? For example, is this a reference to flowering in the spring following a wet winter? Could a wet summer followed by a dry winter prompt flowering?	Discussion of flowering months moved up per comment. Added text to clarify that the conditions that lead to flowering are not well known.
711	Comparing height and age is confusing without data on heights at different ages; explain here the extent to which age can be inferred from height. Comparing height and latitude is confusing without data on heights at different latitudes.	Added a reference to the Growth and Longevity section of the Status Review where information on the relationship between plant height and age is discussed. There may be information on plant height at different latitudes within references cited in the Status Review, but that information was not considered to be important enough to include in the Status Review. The Department included information on height to first branching in the section referenced here because that information was available in Rowlands (1978) and branching is an indication of reproductive maturity, which may be important for understanding the demographics of the species.
720	All species are unique. Here I think you mean that western Joshua trees primarily are pollinated by T. synthetica; they also can be pollinated by T. antithetica.	Text updated for clarity
734	Why is this mouth part “special”? Delete that word.	Text updated per suggestion
739	Stigmas are not restricted to western Joshua trees. Rephrase.	Text updated per suggestion
746	The definition of a mutualism is that both species benefit—rephrase.	Text updated per suggestion. Definition of mutualism added earlier in the section.

Line	Reviewer Comment	Department Response
762	Do you mean that transfer of pollen is limiting? Meaning of “greater sexual reproduction” is unclear. Do you mean that the proportion of sexual to asexual reproduction is greater?	The reference suggests that transfer of pollen could limit seed production. Text updated, and mention of greater sexual reproduction was removed.
764	Spell out Joshua Tree National Park. The authors may be familiar with this acronym, and the acronym is defined in a separate section of the document, but many readers won’t be familiar with it. The reference to detection of T. synthetica is accurate, but the implication that the moths do not occur in certain locations may be misleading given the duration and methods of the work by Harrower and Gilbert (2018).	JTNP abbreviation removed per suggestion. Changed to an in-line citation to emphasize that these results were from only one study.
778-779	And still may be important today, and still may occur today.	Text updated per suggestion
884	Please simply reference “seedling establishment.” If establishment, then successful. If no establishment, then not successful. The same comment is applicable elsewhere in the document, and to other concepts, such as recruitment (successful recruitment is redundant), e.g., lines 911, 923, 927, 1961; I suggest that you search on “successful” to identify all instances.	Text updated per suggestion
898	What does “satiate predation” mean, and is this is reference to mast years?	Text updated per suggestion
902	dispersed “in the wild”—as opposed to where?	Text updated per suggestion
932	These plants can’t really avoid anything—rephrase to “must not be consumed”	Text updated per suggestion
937	Is how much greater of a likelihood known?	Text updated to illustrate how much greater the likelihood is based on the study
943	Restate to “Many plants with which Joshua trees co-occur”	Text updated per suggestion
971	Restate to “a greater likelihood of survival,” and indicate how much greater.	Text updated per suggestion, however the source does not clearly describe how much greater this chance of survival is, so this information is not provided.
981	“carefully controlling”—as opposed to recklessly controlling? Just say “controlling”.	Text updated per suggestion
992	Plants cannot be frugal. However, they may be able to survive with limited water.	Text updated per suggestion

Line	Reviewer Comment	Department Response
1019	What age would that be?	Text updated with the age of approximately three years
1087	The relevance of this section is unclear. I would hope that anyone trying to identify Joshua trees would use a field guide rather than this report. Would the section be better placed with discussion of potentially erroneous occurrence records?	If someone was unfamiliar with the desert flora, they may wonder how easy it would be to mis-identify western Joshua Tree and how physically distinct it is from eastern Joshua tree given that the two species have not always been recognized as distinct entities. A reference to this section was also added to the section of the Status Review that discusses misidentifications of the species submitted to databases such as iNaturalist.
1091	Co-occurrence by definition refers to the same location	Text updated per suggestion
1116	Habitat that may be essential to the continued existence of the species usually is referenced with respect to critical habitat in the regulatory sense. There is no geographic information here. It is not possible that all locations where the species occurs are essential; if that was the case, the species should be listed. Habitat can't be located where the species occurs—that's circular— wherever the species occurs is habitat. Natural communities should not be confused with habitat given that habitat refers to the suite of biotic and abiotic attributes necessary for survival and reproduction, and it is unlikely that Joshua trees are dependent on all of the species with which they co-occur.	Department's preliminary identification of the habitat that may be essential to the continued existence of western Joshua tree updated in response to suggestion.
1141	Combine with 1132.	Text updated per suggestion
1143	Remove this sentence, which is confusing and redundant with the material above.	Sentence removed
1149	This is redundant with material above (551)	Redundant material removed and text edited.
1161	These are not habitats.	Exchanged the word "habitats" with "communities"
1163	What is meant by visually dominant? What is meant by other species being "more dominant"? Is this a reference to percent cover?	Text updated for clarity per suggestion

Line	Reviewer Comment	Department Response
1165	This sentence is quite confusing.	Reduced and combined sentences for clarity
1181	Explain the difference in microhabitat among the cardinal directions.	The cited study does not provide information on differences in conditions between the cardinal directions but did suggest that microclimates are important. Updated the text to refer to microclimates.
1184	The dominant plant species should be listed in taxonomic rather than alphabetical order. Scientific name and common name generally refer to species rather than alliances—do you mean that these are the dominant species in the alliances, or that these are the names of the alliances? Especially with the inclusion of the Yucca brevifolia alliance, which of course supports Joshua trees, the caption might be more accurate as "Vegetation alliances in which Joshua trees occur or may occur," or something similar.	Table revised to list vegetation alliances in a more taxonomic order (of vegetation community), first by primary lifeform, then alphabetical by alliance scientific name.
1203, 1205	If in the Mojave and Great Basin then the landforms and mountains are desert by definition; remove "desert".	Text updated per suggestion
1206	"may be", or "are"?	May be. Text retained.
1237	Does this mean "climate in the Mojave and southwestern Great Basin," or something similar?	Text updated per suggestion
1239	Is this a reference to climate at a given point in time, given that climate also varies as a function of topography and latitude?	Climate is the long term pattern of weather in an area, and therefore this is not intended to refer to a specific point in time. While latitude and topography also affect climate, this is intended to mean that local climate is most affected by elevation. Added the word "topography" and the word "local" to help clarify.

Line	Reviewer Comment	Department Response
1243	It is worthwhile to discuss the fact that average climate may be associated with the physical condition, distributions, or population dynamics of many species, but extreme climate may be equally if not more relevant. For example, see the following. Germain SJ and Lutz JA. 2020. Climate extremes may be more important than climate means when predicting species range shifts. Climatic Change 163:579–598. Siegmund JF, Sanders TGM, Heinrich I, van der Maaten E, Simard S, Helle G and Donner RV. 2016. Meteorological drivers of extremes in daily stem radius variations of beech, oak, and pine in northeastern Germany: an event coincidence analysis. Frontiers in Plant Science 7:733. doi: 10.3389/fpls.2016.00733. Stewart SB et al. 2021. Climate extreme variables generated using monthly time-series data improve predicted distributions of plant species. Ecography 44:626–639. Zimmermann NE, Yoccoz NG, Edwards TC Jr, Meier ES, Thuiller W, Guisan A, Schmatz DR and Pearman PB. 2009. Climatic extremes improve predictions of spatial patterns of tree species. Proceedings of the National Academy of Sciences of the United States of America 106(Supplement 2):19723–19728.	Information and associated citations added per suggestion
1248	Change “it is unlikely” to “are not”	Text updated per suggestion

Line	Reviewer Comment	Department Response
1268	Especially given that these citations do not include climate data from the past 20 years, I'm puzzled by why the authors of the status review did not compile climate data for the region from, say, the National Centers for Environmental Information or PRISM.	It would be a significant analysis beyond the scope of compiling existing information to re-compile precipitation data from the ~50 weather stations across the Mojave Desert and Great Basin similar to what was done by the reference that was cited to create a new figure. Added a reference to a 2021 study by Khatri-Chhetri et al. to the Precipitation and Climate Change Sections to state that the Mojave Desert region is experiencing more frequent and severe drought conditions in recent years.
1277	As written, the sentence implies that the article's authors completed their identification sometime during the past 108 years.	Text updated per suggestion
1283	This section is not entirely clear, and may be confusing El Niño and La Niña with the weather patterns they sometimes produce. In essence, El Niño and La Niña are defined by sea surface temperatures, and those temperatures may or may not result in anomalously wet or dry conditions across the Mojave. See https://www.climate.gov/news-features/featured-images/howel-ni%C3%B1o-and-la-ni%C3%B1a-affect-winter-jet-stream-and-us-climate	Revised the text to be clearer about El Niño and La Niña sea surface temperatures and the weather patterns that they sometimes produce.
1308	Required for what life history elements? Germination, growth, survival, reproduction? Might precipitation requirements vary throughout the life cycle?	Text updated per suggestion
1310	What is meant by "extent of other plants"?	Text updated to "cover of other plants"
1317	This statement is somewhat misleading. Climate water deficit does not quantify slope and aspect, for example, although it may be affected by slope and aspect.	Text updated per suggestion
1343	The difference between averages and extremes is quite relevant here and likely should go beyond the simple mention of duration of high temperatures (1339).	Text updated per suggestion to emphasize the possible effects of high temperature extremes

Line	Reviewer Comment	Department Response
1363	Provide some context here relating “elevated” to the concentrations of carbon dioxide projected under different scenarios by the Intergovernmental Panel on Climate Change or something similar.	Text updated per suggestion
1366	Recognize here that acclimation affects tolerances of many organisms to many extremes.	Text updated per suggestion
1373	Abundance and density are not synonyms. The section seems to use the concepts interchangeably, however.	A definition of both abundance and density was added. Abundance is defined as the number of individuals that are present, and density is the number of individuals that are present per unit of area.
1386	Is the intent here to imply that percent cover (which is not the same as abundance or density) of western Joshua trees is below a given threshold in some areas, but may be lower elsewhere?	Text updated for clarity per comment
1409	This is another section that would benefit from reorganization. Why not begin with a statement about the range of densities that have been estimated in the field, and then provide additional detail about whether the estimates were across extensive or limited areas?	Information on the range of localized population densities added to the first sentence of the paragraph to introduce and summarize the information presented, but the information on specific local densities was not removed because it may be informative.
1425	Data “were”, not “was	Text updated per suggestion
1445	When did these wildfires occur?	Text updated to “within the previous 100 years”
1448	What was that resolution of these images? Were the estimates evaluated against ground data—how was 95% confidence estimated? Not enough information is provided here to support replication of the work.	Text updated to state that the resolution of imagery is not known, no ground truthing was conducted, and cite the statistical methods used for stratified random sampling.
1471	Just “demographic information” One obviously cannot infer on the basis of unavailable information	Text updated per suggestion
1479	What do you mean by concerted population growth? Concerted doesn’t seem like the correct word here.	Removed the word “concerted” which was from the cited source

Line	Reviewer Comment	Department Response
1483	Range and abundance often are correlated, but not necessarily. I'm not convinced that a change in range can be interpreted as a change in abundance (1489).	Text updated per suggestion
1497	But maybe could estimate percentage of habitat as of some year that was developed	A rough estimate of 30 percent habitat loss is provided later in the paragraph.
1510, 1517, 1527	To what years does "historical" refer? What were the sources and resolution of the images?	The Department does not have a precise year that it considers to be the beginning of European settlement of the Mojave but added the phrase "during and before the 19th century". Added the general dates of the aerial images examined (mid 20th century) and added another citation to the source (it is cited earlier in the paragraph).
1552	This is confusing. How large were the plots? What type of data were collected in the 1970s? I'm skeptical that it's not possible to make any type of comparison.	This information is not in the Department's possession. Based on personal communication with National Park Service staff serious attempts were made to make comparisons but it was not possible.
1554	Again a couple of synthetic sentences about trend would be quite useful rather than only summarizing a series of individual monitoring programs. The section seems to imply that across the species' range, trends are not uniform, which would not be surprising	Added a synthetic sentence to the opening paragraph per suggestion
1562	How many is several?	The researcher may have established plots that the Department is not aware of. Deleted the word "several".
1587	If there is "significant doubt," then why include the work in a review of the "best scientific information available"?	This source was submitted to the Department by Edwards Air Force Base during a call for information, and therefore the Department has analyzed it and included it for transparency.
1607	Change "is" to "are" (data are)	Text updated per suggestion

Line	Reviewer Comment	Department Response
1612	However, one could use simulation modeling to estimate the level of recruitment needed to sustain a population of a given size for a given period of time.	The Department does not currently have any data from simulation modeling or any other methods to estimate the level of recruitment needed to sustain a population of western Joshua tree at a given size for a given period of time.
1623	Seems like height measurements, not censuses. Census refers to an accounting of all individuals.	Changed “censuses” to “surveys”
1648	Here, summarize what reasonably can be inferred about persistence on the basis of multiple sources of information on height distributions. It is difficult for readers to synthesize the inferences from many summaries of individual articles or data-collection efforts. Perhaps move the paragraph starting at line 1751.	Moved paragraph up per suggestion
1703	Standardizing the range of values on the x-axes for figures 6, 7, and 8 would facilitate easier comparison	Comment noted. The Department will address this if possible within time constraints.
1721	What was the source and resolution of the images?	The source reports that imagery was from the National Agriculture Imagery Program and the resolution was not reported. Text updated.
1748	What aspect is being referenced here?	This is speculative. We don’t know what aspect of life history may have been disrupted.
1801	Abundant populations can mean many populations, which is confusing. What you seem to mean here, and is clearer in the next sentence, is populations with a high number of individuals.	A definition of abundance was added in the Abundance section of the Status Review. Text updated for clarity per suggestion.
1807	Do you mean high-quality habitat? Habitat is favorable by definition.	Texted updated to “more suitable locations”

Line	Reviewer Comment	Department Response
1820-1821	These are odd definitions of redundancy and representation. If they were included in the USFWS documents, they should be removed from the status review. Redundancy usually refers to function; for example, if many co-occurring bee species pollinate a given plant, there is some functional redundancy. Representation generally refers to a sample of natural variability rather than adaptive capacity.	Added a citation for the definition of those terms as they are used by the U.S. Fish and Wildlife Service.
1849	All of this is true. Nevertheless, some native and non-native species are likely to benefit from projected changes in climate, and this fact should be acknowledged. It is disingenuous to imply that climate change is a threat in all cases	Text updated to acknowledge that projected changes in climate may benefit some species.
1868	True, but not just “in the Department’s possession,” which sounds rather odd. Few scientific teams or individual scientists have made credible projections of climate change beyond 2100.	Text updated per suggestions
1880	This is too broad of a statement, and as written is not true. Nor is it necessary—whether California is more or less affected by climate variability than other states is irrelevant to the status of Joshua trees. Also, be careful not to imply that all winter storms are caused by atmospheric rivers, although it is true that the strongest storms tend to be from atmospheric rivers. See, for example, https://climate.nasa.gov/news/2409/study-atmospheric-river-stormscan-reduce-sierra-snow/.	Text updated per suggestions
1890	Explain the range of values. I’m guessing it reflects different scenarios of emissions of greenhouse gases, but should be clarified.	Text updated per suggestion
1899	Yes, but the point should again be made here, or at 1892, that even if precipitation totals are consistent or increase somewhat, higher temperatures and more precipitation falling as rain than as snow may decrease water availability, especially during summer.	Text updated per suggestion
1910	True, but the number of ignitions may or may not be related to the size or intensity of wildfires.	Text updated per suggestion
1915	And ongoing emissions of other greenhouse gases (not restricted to carbon dioxide).	Text updated per suggestion

Line	Reviewer Comment	Department Response
1916, 1922, 1923, etc.	As applicable, explicitly related these assumptions to other sections of the document.	Added references to other sections of the Status Review.
1944	What was the magnitude of warming?	Text updated with magnitude of warming per suggestion
1955	Climate is only one component of habitat. Soil type, presence of other species of plants and animals, and land use also affect likelihood of colonization.	Text updated per suggestion
1968	Assuming that survival of seedlings does not increase.	Text updated per suggestion
1993	Explain why – link to other sections of the document as applicable.	Text updated per suggestion
2016	Explain why one might expect increases in atmospheric concentrations of carbon dioxide to affect temperature stress. Also, line 2055 seems to offer evidence to the contrary.	Added brief explanatory text. Line 2055 is about low temperature stress, not high temperature stress.
2028	These areas don't just appear to be occupied, they are occupied. As noted, the species may or may not persist in that location in the future.	Text updated per suggestion
2042	If Joshua trees could not survive and reproduce in these areas, then the areas were not habitat.	"habitats" changed to "areas"
2045-2052	Some redundancy here.	Reorganized portions of this section to reduce redundancy.

Line	Reviewer Comment	Department Response
2064	The description of species distribution models could be updated and strengthened. For example, the description does not address the necessary data on response variables or trade-offs among different types of response-variable data (e.g., abundance, presence-absence, presence only). The description also seems to imply that the environmental variables entered into such models are restricted to climate data, whereas ideally one would include spatial data layers on a larger set of abiotic or biotic variables hypothesized to have a major effect on distribution. By extension, this section seems to imply, perhaps inadvertently, that a small set of climate variables are the primary factors that limit or predict species distributions. Some of these points are addressed at lines 2352-2374, but not all. Furthermore, those caveats should be presented at the start of the section so readers have the caveats in their mind while learning about species distribution models for Joshua trees.	Description updated per reviewer suggestions. This is complex subject matter for many readers of this document. We consider it better to first present basic information about species distribution models, then reference the limitations of the models without going into detail, and then discuss the results of the models that have been conducted for Joshua tree, with the more thorough discussion of the limitations of models at the end. This allows readers unfamiliar with models and their results to read about them first, before being presented with a complex critique of the models which are themselves also complex.
2355	It would be more accurate to note that species distribution models are limited by the availability of spatially continuous data on variables of interest; by the capacity of the scientific community to make accurate measurements or projections of certain variables (e.g., projections of temperature generally are more feasible than projections of wind speed); and by the feasibility and reliability of downscaling or aggregating data to a common spatial and temporal resolution.	Text updated per suggestion
2077	This sentence would benefit from clarification. If one wishes to identify areas where climate may change, there is no need to use a species distribution model. Additionally, it is preferable to use temporally matched data on species distributions and climate.	Sentence clarified per suggestion. Added mention of temporally matched data on species distributions and climate to the opening paragraph of this section.
2106-2112	It would be more accurate and streamlined to say that climate models suggest a shift in the potential range of the species, but effects on population dynamics, or current populations, are unknown (as recognized at line 2424).	Text updated per suggestion.
2110	Change to “data that show”	Text removed in response to previous comment

Line	Reviewer Comment	Department Response
2116	It would be more accurate to say “information currently is insufficient to conclude” whether climate change is likely to threaten the species. The current texts suggests, perhaps inadvertently, that with more information, a conclusion that the species is threatened would be likely. At line 2119, change “yet” to “currently”.	Text updated per suggestion.
2126	The spatial resolution of climate variables is not necessarily an indication of the reliability of an analysis. Similarly, the most informative temporal resolution varies among species, locations, and analysis objectives.	While it is not necessarily an indication of the reliability of an analysis, higher resolution is more likely to identify smaller areas of climate refugia. Removed the word “because” in the sentence in response to this comment, to make the logic of the sentence less causal while retaining the descriptive information. Added mention of temporally matched data on species distributions and climate to the opening paragraph of this section.
2128	“endured” is not the best word choice here given that it implies hardship. Also, the twentieth century is not representative of the species’ evolutionary history.	Changed “endured” to “experienced”. Added text stating that the 20th century is not representative of the species’ evolutionary history in a paragraph later in the section.
2130	What is meant by “effectiveness”? Also, in and of itself, comparing multiple models does not render an analysis reliable.	Changed “effectiveness” to “results” and changed the beginning of the sentence in response to previous comment.
2132	Change to “how climate is correlated with”. These are not mechanistic models. Also, “relied on” is unclear. Are you trying to say that those variables were included in the models, or that among the variables included in the models, these were the most strongly correlated with the species’ current distribution?	Text updated per suggestion. The source implies that among the variables included in the models, these were the most strongly correlated with the species’ current distribution, but the source does not say this directly, so the text was changed to just that these variables were “included”.
2135	What is the difference between temperature and a temperature event?	Deleted the word “event.”

Line	Reviewer Comment	Department Response
2142	Meaning that June drought and summer thunderstorms are not conducive to establishment and persistence of the species?	Revised the sentence to better match the source.
2157	What do you mean by “concordant demographic data”? It also would be good to mention that the uncertainty of model outputs increases when projected values of predictor variables are outside the range used to build the model.	Revised the sentence to remove the word “concordant,” and added sentence near the end of this section with suggested text.
2159	Change “that” to “whether”	Text updated per suggestion.
2164	Within the species’ current range, yes? Does “historically” mean “twentieth century”?	Text updated per suggestion.
2168	This is not clear. Do you mean that relative changes in precipitation were smaller than relative changes in temperature, or that correlations between precipitation and current presences were weaker than correlations between temperature and current presences?	This statement was from the abstract of the paper, but there is little information in the paper itself to justify or explain the statement. Sentence removed.
2175	This sentence is difficult to follow. Also, isn’t warming a component of climate? Climate shifting after warming sounds odd. Additionally, it seems worthwhile to note that these models generally do not account for climate heterogeneity in complex terrain, such as mountains. Long-distance dispersal may not always be necessary to track climate.	Text updated per suggestions. Added sentence near the end of this section with suggested text.
2183	Clarify whether the work examined climate as forced by doubled carbon dioxide concentrations. Physiological responses to carbon dioxide per se may differ from responses to greenhouse gas-driven climate change.	Text updated per suggestion.
2185	What was the 30-year period?	This information was not provided by the information source. Added a note to the text to say this.

Line	Reviewer Comment	Department Response
2193, 2209	If the Department has serious questions about methods or assumptions, why include a description of the analysis in a status review that is intended to reflect the best science available? It would be more informative to synthesize, rather than sequentially summarize, the model outputs for which the Department has reasonably high confidence (e.g., an expansion of the paragraph at lines 2470-2489, but not nine pages that amounts to summaries of the literature, including articles that likely would not be classified as the best science available). If you're trying to signal that you're aware of other work, then why not say something to the effect of "Others also have modeled the potential future range of Joshua tree on the basis of climate, but uncertainty in those outputs is high given poor fit to the species' current distribution or lack of model validation"?	Because climate change is one of the primary threats to the species, and species distribution models are a primary way of evaluating the possible effects of that threat, the Department thinks it is important to summarize all available species distribution modeling efforts for this Status Review. Information in early modeling efforts can still be useful and contribute to our understanding of the future distribution of western Joshua tree, and therefore still constitutes a portion of the best available science. Added additional subheadings to this section to help with organization and to break up this long section of the document.
2252	If including details about projected changes in temperature, then include details about projected changes in precipitation.	Added detail about different precipitation scenarios evaluated in the models.
2278	Above, lack of model validation was criticized strongly. Again, why detail this article if the Department does not have confidence in the outputs?	Addressed in above comment for lines 2193, 2209
2286	Instead of explaining that Maxent is software, explain the major assumptions on which it is based. Also, either explain percent contribution and permutation importance, or summarize the results without using these terms. But again, if input values were not reported (2295), why is the work being included in the status review?	Added text explaining the major assumptions on which Maxent is based. Deleting text regarding percent contribution and permutation importance because they are not reported by source author, and uncertainty in model performance is discussed more generally under the Limitations of Models section of the Status review, to better organize the long Species Distribution Models section.
2346	This statement is misleading. These studies suggest that recruitment is decreasing in areas in which temperatures are increasing. There may be a mechanistic link, but other mechanisms also are possible	Text updated per suggestion to suggest that evidence would be of a correlation.

Line	Reviewer Comment	Department Response
2350	This is incorrect. Such data would substantially improve ability to evaluate the predictive capacity of these models.	Text updated per suggestion
2399	True, but all models are highly sensitive to the data used for their construction	Text updated per suggestion to state that all species distribution models are sensitive to the climate data they are based on.
2510	As a result of climate change in general.	Text updated per suggestion
2402	Again, “endured” is not the correct word.	Text changed from “endured” to “experienced.”
2453	If confidence in this output is low—and I agree that it is low—why calculate the index, or include it in a report that aims to present the best science available?	Addressed in above comment for lines 2193, 2209. Text updated to provide more information on the meaning of a low confidence score.
2522	Does Prodoxus sp. parasitize Joshua trees? That is implied at line 2988, but not made explicit in either location.	Text updated per suggestion
2554	This statement is incorrect. Reduction of the contiguity of habitat indeed results in fragmentation. However, fragmentation can occur independent of changes in habitat area. See work by Fahrig and others on this topic.	Updated text per suggestion. Added citations to work by Fahrig and others, and work with opposing views by Fletcher and others in the following sentence, and replaced the word “can” with “may” in that sentence.
2538-2559	Note, too, that some native species benefit from human activities or from creation of edges. As one of many examples, in arid ecosystems, residential and agricultural irrigation may benefit some native species. Joshua trees may not benefit from irrigation, but this paragraph is not specific to Joshua trees	Added sentence regarding possibility of positive benefits.
2579	Just “habitat” (delete “suitable”)	Text updated per suggestion

Line	Reviewer Comment	Department Response
2601	Extensive experience with management of Department of Defense lands leads me to question the unreferenced statement that military activities are likely to lead to modification and destruction of habitat for Joshua trees. Native species tend to be conserved much more effectively on Department of Defense lands than on lands under other public jurisdictions.	Off road vehicle use alone is a modification of habitat, and there is a high likelihood of at least some construction or expansion of existing facilities (such as roads) on BLM and DOD lands by the year 2100. Two sentences in this paragraph already acknowledge that development on these lands may be limited. Minor revisions to the text were made for clarity and in response to reviewer comment.
2616	Dry conditions are not identified in Figure 5, although they may be illustrated in Figure 5.	Changed “identified” to “illustrated”.
2621	A need cannot be disrupted. Fulfillment of a need may be disrupted	Text updated per suggestion
2622	Change to “or as adults”. “Flight phase” doesn’t make sense.	Text updated per suggestion
2632-2634	Protection of habitat can be distinct from protection of individuals. My guess is that the development projects also would take habitat, but as written, the text references removal of individuals.	Text updated to include mention of protecting individuals
2687	How is severity being defined here?	Removed the word “severe.”
2715	Moreover, livestock grazing and use of off-road vehicles, which can be extensive in the Mojave, generally are associated with expansion of non-native invasive grasses. Also see Curtis, C.A., and B.A. Bradley. 2015. Invasive Plant Science and Management 8:341–352 and Bradley, B.A., C.A. Curtis, and J.C. Chambers. 2016. Bromus response to climate and projected changes with climate change. Pages 257–274 in M.J. Germino, J.S. Chambers, and C.S. Brown, editors. Exotic brome-grasses in arid and semiarid ecosystems of the western US. Springer, Zurich.	Added sentence regarding livestock grazing and use of off-road vehicles. Added reference to suggested citation in the Climate Change Indirect Effects section of the Status Review.
2765	Correct that the Great Basin is a cold desert. How is that relevant here?	Cold desert province is mentioned here to contrast with Mojave Desert which is a warm desert province mentioned further down in the paragraph.

Line	Reviewer Comment	Department Response
2772	The distribution and density of cheatgrass in the Great Basin also fluctuates considerably as a function of amount and timing of precipitation.	Made revisions in response to reviewer comment and moved a general sentence about invasive grass species fluctuating with precipitation to the first paragraph of this section.
2778	This is a statement about fire size rather than likelihood of fire per se.	Text updated per comment
2827-2844	Please synthesize.	Condensed some text in this section.
2878	This is not entirely true. Probability of fire is related to aridity, but aridity can increase even if precipitation amounts increase.	Changed the word “drive” in this sentence to the word “affect.”
2882, 2886	Okay, but not all invasive species increase fire likelihood appreciably.	Clarified that the sentence is referring to invasive species that contribute to wildfire risk
2911	Non-native is not synonymous with invasive. Native plants can be invasive, and not all non-native plants are invasive. This seems to be recognized starting at line 2939, but is not noted explicitly.	Added an explanation about non-native and invasive species.
2918	I assume you mean either changes to the natural fire frequency or simply changes in fire frequency. The latter is preferable given that fire frequency generally is quite variable.	Deleted the word “natural”
2921, 2963	Use of “habitat” here is incorrect.	Replaced with “characteristics of the location”
2996	Remove “yet,” which implies that an effect will be found in the future.	Text updated per comment
3084, 3085	Why are these terms in quotation marks? Either explain the terms or remove the quotation marks.	Quotation marks removed
3102.	This section describes petitions for listing, not protections under the law.	This section is titled “Regulatory Status and Legal Protections”. Added an introductory sentence to indicate that western Joshua tree has no federal protections under the federal ESA.
3461	It is not immediately clear how this section relates to its headers, “Existing management” and “Regulatory status and legal protections”. An explanation at the top of the section would be helpful.	Added an introduction at the beginning of the section.

Line	Reviewer Comment	Department Response
3513	"found extensively" isn't quite correct. It seems more accurate to say that most of the known range of the species is under federal jurisdiction.	Text updated per suggestion
3530	Refugium (singular), not refugia (plural).	Text updated per suggestion
3751	Correct the tense here.	Changed "cannot be" to "is not"
3755	Do you mean that the area will decline? "areas . . . will decline" is unclear.	Text updated per suggestion
3791, 3803	Just "habitat" (delete "suitable")	Text updated per suggestion
3793	What about lands on which use of off-road vehicles is permitted or common, even if not permitted?	Habitat modification and destruction will occur in those areas as well, but it will not primarily be in those areas, and most off-road vehicle use is within the vicinity of roads that are used for access or to load and unload off-road vehicles.
3863	Revise to avoid the implication that large fires favor vegetation growth. The latter may be true in the case of non-native invasive bromes, but I don't think that's what you meant.	Added the word negative in two places to clarify.
3858	This statement seems inconsistent with 3781 and many statements throughout the document that the future demography of western Joshua trees cannot be projected with any appreciable degree of certainty.	Changed "is expected to" to "may".
4057	Completion of a conservation plan is a component of a preliminary conservation strategy (4045)? Is the intended emphasis here the partnerships rather than the conservation plan per se?	There is redundancy with the opening paragraph, but including it as a bullet point emphasizes it, and other reviewers have found the bullet point to be important.
4066	I think you mean "implement disincentives"	Text updated per suggestion
4071	This component must be accompanied by integration of scientific research into management. Knowledge in and of itself will not conserve the species.	Text updated per suggestion

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Date: December 27th, 2021

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SUBJECT: STATUS REVIEW OF WESTERN JOSHUA TREE; CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW

Dear Dr. Krantz:

Thank you for agreeing to serve as a scientific peer reviewer for the California Department of Fish and Wildlife's (Department) Status Review of western Joshua tree (*Yucca brevifolia* Engelm.) (Status Review). A copy of the Status Review, dated December 2021, is enclosed for your use in the review. The Department seeks your expert analysis and input regarding the scientific validity of the Status Review, and its assessment and conclusions regarding the status of western Joshua tree in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information, the Department's related assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA), and the Department's overall conclusions. **The Department would appreciate receiving your peer review input on or before January 25, 2022**.

The Department seeks your scientific peer review as part of formal proceedings pending before the California Fish and Game Commission (Commission) under CESA. The Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened (Fish & G. Code, § 2070). The Department serves in an advisory capacity during CESA listing proceedings, charged by the Fish and Game Code to evaluate the status of the species based on the best scientific information available to the Department and make recommendations to the Commission, including if CESA listing is warranted (Fish & G. Code, § 2074.6).

The Commission received the petition to list western Joshua tree under CESA on

October 21, 2019. On October 9, 2020, the Commission published findings regarding its acceptance of the petition for consideration, and formally designated western Joshua tree as a candidate for listing as threatened under CESA. As a candidate species, western Joshua tree currently receives the same protections under CESA as threatened and endangered species. Formal acceptance of the petition triggered the Department's initiation of this Status Review, which will inform the Commission's decision on whether listing the species is warranted.

The draft Status Review forwarded to you today reflects the Department's effort to identify and analyze the best scientific information available regarding the status of western Joshua tree in California. The Department's preliminary recommendation on whether CESA listing is warranted for the species may be found in the draft Status Review. We underscore, however, that scientific peer review plays a critical role in the Department's analysis and effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code. Our analysis and expected recommendation to the Commission may change or be modified following your input. For your reference, under CESA an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion of its range due to one of more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code § 2067).

We ask you to focus your peer review on the best scientific information available regarding the status of western Joshua tree in California. Your peer review of the science and analysis regarding the population status and the threat categories prescribed in CESA's implementing regulations are particularly important (Cal. Code Regs., tit. 14, § 670.1(i)(1)(A); i.e., present or threatened modification or destruction of the species' habitat, overexploitation, predation, competition, disease, or other natural occurrences or human-related activities), as well as your opinion on whether the body of information and reasonable conclusions drawn from the information indicate that western Joshua tree is at serious risk of becoming extinct throughout all or a significant portion of its range in California (i.e. the species is endangered), or whether the species is likely to become so in the foreseeable future in the absence of CESA protection (i.e. threatened).

Please note that currently, the Department releases this Status Review solely to you as part of the peer review process, it is not yet public. However, your review will be appended to the final Status Review which will be released to the public upon receipt by the Commission. We ask that you please keep the Department's Status Review and your review of it confidential until the final Status Review is received by the Commission.

For ease of review and for accessibility by the public, the Department requests that you please submit your comments in list form by report page and line number. Please submit your comments electronically to me via email at Christina.Sloop@wildlife.ca.gov. For questions, I can be reached via email or by phone at (916) 261-1159. If there is anything the Department can do to facilitate your review, please let me know. Following receipt and consideration of peer review comments, the Department will prepare and submit its final Status Review report and related recommendation to the Commission. After at least a 30-day public review period, the Commission will consider the petition, the Department's Status Review, related recommendations including peer review comments, and public testimony during a regularly scheduled Commission meeting prior to making their decision.

Thank you again for your contribution to the Status Review effort and the important input it contributes to the CESA listing process.

Sincerely,

Christina Sloop, Science Advisor & Science Institute Lead
California Department of Fish and Wildlife

Enclosure

ec: California Department of Fish and Wildlife

Isabel Baer, Program Manager
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Native Plant Program
Habitat Conservation Planning Branch

UNIVERSITY OF Redlands
CENTER FOR ENVIRONMENTAL STUDIES

January 15, 2022

Subject: Peer Review of the California Department of Fish and Wildlife
Status Review of Western Joshua Tree

To Whom It May Concern:

Thank you for this opportunity to provide these peer review comments relative to the Draft Status Review of the Petition to List the Western Joshua Tree (WJT) as a Threatened species under the auspices of the California Endangered Species Act (CESA).

The primary purpose of the Status Review is to evaluate the appropriateness of listing the WJT as a Threatened species. According to the CESA, "An endangered species under CESA is one 'which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease' (Fish & G. Code, § 2062). A threatened species under CESA is one 'that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]' (*Id.*, § 2067). A species' range for CESA purposes is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com*. (2007) 156 Cal.App.4th 1535, 1551). (Lines 3710-3719)

Given the extent of the range of WJT (10,160 km^2 (3,920 mi^2) to 13,880 km^2 (5,360 mi^2), Lines 1382-1385), and the distribution of WJT within that range (3.1 million and 4.9 million adult western Joshua trees in California, Lines 1459-1465), the designation of WJT as an Endangered species, according to the definition under the CESA, is inappropriate at his time. The appropriateness of listing the WJT as a Threatened species, however, requires further definition of what is meant by the "foreseeable future". As described in the Status Review, the "foreseeable future" with regard to the Threatened species definition is considered to be the 21st century, or by the year 2100.

The California Department of Fish and Wildlife (the Department) Draft Status Review provides a comprehensive and detailed description of the biology of the WJT (pages 5-29), its habitat and ecological parameters (pp. 30-37), its abundance/range and population trends (pp. 38-49), and endangerment factors (pp. 50-85).

These comments address each of these topics as they are presented in the Draft Status Review, with numeric line citations and quotations for reference, as necessary. Finally, I will review the Department's conclusions and recommendations for the Petitioned Action, with my own suggestions as to the appropriateness or not of listing the WJT as a Threatened species under CESA.

<u>Biology of the WJT</u>

The Status Review provides an excellent synopsis of the taxonomy and biology of the WJT. For this peer review, I will limit my comments and analysis to the WJT—

Yucca brevifolia—as opposed to the Eastern Joshua Tree, *Yucca jaegeriana.* (Page 9, Lines 452-457).

The Petition states that the WJT warrants listing as a Threatened species throughout its range in California; but requests the Department consider listing the southern population (YUBR South) as "ecologically significant units", as opposed to the northern extension of WJT (YUBR North)—generally the range of WJT from Inyo County, northward into Nevada and the Great Basin Floristic Province (Page 10-11, Lines 498-508 and Figure 3: Joshua Tree Range in California). As we will see in the discussion of endangerment factors, the levels of threat from land development, energy projects, wildfires and climate change are generally greater in the YUBR South range than the YUBR North range, thus warranting separate consideration of the appropriateness of listing under the CESA.

A key biological factor for the WJT is its obligate pollination mutualism with the yucca moth, *Tegeticula synthetica* (Page 19, Lines 719-730). The yucca moth and WJT are co-evolved to the degree that the WJT is dependent on the moth for sexual reproduction and the moth is dependent on the WJT for its own reproduction. Thus, it is not surprising that, "greater sexual reproduction tends to occur in areas with more *T. synthetica* moths (Harrower and Gilbert 2018). Within the vicinity of JTNP, *T. synthetica* moths were found at elevations ranging from 1,049 m (3,442 ft) to 2,076 m (6,811 ft), but not at the lowest elevation study site that had western Joshua trees at 1,004 m (3,294 ft) or the highest elevation study site with western Joshua trees at 2,212 m (7,257 ft) (Harrower and Gilbert 2018)." (Page 20, Lines 761-767)

Thus, the environmental limits of the yucca moth have a direct bearing on the sexual reproduction of the WJT, and the lower elevation limitations for the moth—most likely reflecting a high temperature threshold and/or low soil moisture tolerance—may indicate that these low elevation WJT populations are already no longer viable and will, with increasing temperatures resultant to climate change, become locally extinct.

Once fertilization of the WJT flowers has occurred and the moth larvae mature, they "fall to the ground below the tree, burrow into the ground, create a cocoon, and enter a period of suspended development called diapause (Pellmyr 2003). Yucca moth larvae are likely able to remain in diapause for several years before pupating into moths; the environmental or other cues that trigger this pupation are currently unknown (Riley 1892, Pellmyr 2003)" (Page 20, Lines 749-753).

Although asexual reproduction does occur in WJTs, particularly after fires and/or at higher elevations, sexual reproduction is essential for maintenance of genetic diversity of the species. Little is known about the life history or survival of yucca moths regarding their survival (or not) after fires, their environmental tolerances to extreme temperatures or moisture, or of their capabilities of locating host plants and dispersal in highly fragmented habitats, such as urbanized, low density WJT habitat in the YUBR South range. These potential endangerment factors relative to the *T. synthetica* moth are not addressed in the Status Review.

Other biological factors that are of critical importance in consideration of the endangerment of the WJT are summarized herein:

- Seed dispersal is very limited: average seed dispersal is ~30m (Lines 805-825)
- Seed germination requires periods of cooler, moist conditions for several years following mast seeding events. "After burial of seeds, several successive years of sufficiently wet and/or cool conditions are likely required to ensure that seeds germinate, and that seedlings reach a sufficiently large size (perhaps at least 25 cm) before the arrival of a period of hotter and/or drier conditions. This period of several successive years of sufficiently wet and/or

cool conditions must occur relatively soon after a mast seeding event, because western Joshua tree seeds do not remain viable in the soil for long periods of time." (Lines 1077-1085)

- After germination takes place, seedlings require long periods of time, perhaps as much as 30-50 years, to reach reproductive maturity. "After a seedling has become established, it must survive a long period of time (perhaps 30-50+ years) to reach reproductive maturity. A minimum rate of recruitment is necessary to keep populations from declining (Wiegand et al. 2004)." (Lines 1083-1086)

These three biological factors all conspire to create a cumulative adverse impact on WJT health and viability in the face of the impacts of climate change: 1) that WJT seed dispersal is extremely limited and that dispersal to more northerly or higher elevation potential habitat will not keep pace with increasingly extreme high temperatures and drought; 2) the conditions of higher temperatures and drought at lower elevation WJT locations will adversely impact seed germination; and 3) the time from germination to reproductive maturity will be very slow, especially given the likelihood of increasingly severe heat and drought episodes, and the increasing frequency and severity of fires in the higher elevation populations.

Thus, just based on these biological requirements alone (not considering the impacts of land development in the middle elevation populations of the YUBR South range), we can expect the continuing loss of sexual reproduction in the lower and upper elevation populations of WJT; and an inability of WJT to adapt to these environmental extremes by dispersal to more northerly or higher elevation potential habitat.

WJT Habitat, Range and Ecological Parameters

The Status Review describes the pre-historic range of WJT: "Fossil evidence indicates that Joshua tree was more widespread during the late Pleistocene period (22,000 to 13,000 years before present) than it is today, with its range at that time extending south of its present range farther into southern California and Arizona, and likely also into northwestern Mexico (Rowlands 1978, Holmgren et al. 2010, Cole et al. 2011, Smith et al. 2011). The apparent reduction in Joshua tree range from the late Pleistocene period to modern times suggests the population trend of Joshua tree across its entire range has been in decline." (Lines 1483-1488)

The contraction of WJT range in post-Pleistocene times has seen some expansion of WJTs to the north and into the Great Basin, and into higher elevation habitats on the southeastern Sierra Nevada slopes and the northern slopes of the Transverse Mountains and Little San Bernardino Mountains (Joshua Tree National Park). These transmigrations of the species have taken place over several thousands of years.

The Status Review states in its Executive Summary that, "Predicted suitable habitat for western Joshua tree based on 20th century climate conditions will likely remain in some areas at the end of the 21st century as refugia, and newly appear to the north and in higher elevation areas, although western Joshua tree is unlikely to colonize areas with newly suitable climate conditions quickly." (Lines 202-206)

Record high summer temperatures in recent years are already being measured in the lower elevations of the WJT range and increasing temperatures and overall reductions in precipitation will lessen recruitment of WJTs in those areas. For WJTs to "newly appear" to the north and in higher elevation areas implies that there would be some means of long-distance dispersal. During Pleistocene times, with much more temperate conditions than present, WJTs were dispersed over significant distances by giant ground sloths (Lines 857-878), whereas dispersal distances by desert packrats and other rodents is measured in meters and would be ineffective for WJTs to adjust to rapid climate change.

This Peer Review finds that the total range estimate of 10,160 km^2 (3,920 mi^2) to 13,880 km^2 (5,360 mi^2) for the WJT is reasonably accurate. Using the Department's WJT range map (Figure 4. Joshua Tree Absolute Cover), one can readily see that the higher WJT cover estimates (>1-5% and >5%) are all in the upper elevation range of the species, extending from the southeast Sierra Nevada slopes, the extreme western edge of the Mojave Desert west of Palmdale-Lancaster (where there is some supplemental precipitation through the Tehachapi Pass), and along the north aspect slopes of the San Gabriel, San Bernardino and Little San Bernardino Mountains.

Lower elevation areas of the WJT range are already exhibiting lower absolute cover and reduced seedling germination and recruitment. As the Status Review summarizes:

Declines due to reduced seedling recruitment will likely be most severe in areas of western Joshua tree's range that are already near the thermal and water stress tolerance limits for recruitment, such as at hotter, low-elevation areas. (Lines 1970-1972)

The compounding endangerment factors of climate change are described further by the Department: "The climatic conditions across western Joshua tree's range have already changed and will continue to change as a result of ongoing global carbon emissions. The Department expects that the direct effects of climate change (e.g., increased temperatures and decreased total water availability locally) will likely contribute to a decline in populations of [WJT] within California through the end of the 21st century… The primary reasons for the decline of populations of [WJT} within California may be the incremental contribution of climate change to high intensity and longer duration droughts, coupled with extreme high temperatures during summer months, which may have direct physiological effects on [WJT] plants. These effects of climate change will likely reduce [WJT] seedling recruitment, and to a lesser extent also increase adult [WJT] mortality, leading to population declines as recruitment does not keep pace with mortality. Climate change may also contribute to the decline of populations of [WJT] via other more indirect mechanisms, including increased impacts from small mammals during drought, reduced growth due to lack of low winter temperatures, increases in fire activity, or effects on pollinating moths…" (Lines 1914-1930).

Furthermore, "There may be a time delay between the time when an area becomes no longer suitable for a species (crossing an extinction threshold) and when that species is no longer present, (Tilman et al. 1994, Kuussaari et al. 2009, van Mantgem et al. 2009, Svenning and Sandel 2013, Figueiredo et al. 2019). Extinction processes often occur with a time delay and populations living close to their extinction threshold might survive for long periods of time despite local extinction being inevitable (Hanski and Ovaskainen 2002, Lindborg and Eriksson 2004, Helm et al. 2006, Vellend et al. 2006, Malanson 2008, Cronk 2016). Because western Joshua tree is a long-lived species, adults could persist for decades or longer in areas that are no longer suitable for recruitment, or recruitment may continue, but at rates that are ultimately insufficient to maintain the species. Although these areas may appear occupied, the presence of western Joshua tree may merely represent a delayed local extinction. (Lines 2018-2029)

Thus, when one re-examines the range of YUBR South as illustrated in Figure 4, one can see that fully half of the total YUBR South distribution may already be functionally extinct—that is, non-reproductive at rates that can sustain the population in those areas in the "foreseeable future" (the 21st century).

Endangerment Factors

The Status Review examines three primary factors affecting the survival and reproduction of the WJT: climate change, [land] development and other human activities, and wildfire. Other factors, including invasive plants, herbivory and predation, and human use and vandalism are not considered to be significant endangerment factors unto themselves and are not discussed further in this Peer Review.

Climate—

The potential impacts of climate change have been described in the previous section of this peer review. Several climate models are presented in the Status Review: Thompson et al. 1998, Shafer et al. 2001, Dole et al. 2003, Cole et al. 2011, Barrows and Murphy-Mariscal 2012, and Sweet et al. 2019. The first four models evaluate both Eastern and Western Joshua Tree species; and the last two are focused on WJT population models for JTNP and vicinity.

The Status Review summarizes the models' findings: "The species distribution modeling efforts that have been conducted for Joshua tree suggest that climate change could cause substantial reductions in areas with 20th century suitable climate conditions for the species at the southern parts of western Joshua tree's range, including within JTNP. These species distribution modeling efforts also suggest that substantial additional areas of 20th century suitable climate conditions may become available for western Joshua tree to the north, particularly in Nevada (outside of the scope of CESA) but also in some parts of eastern California, although **the species is unlikely to naturally colonize these areas in the foreseeable future.**" [Bold highlight added by the Peer Reviewer]

The models all indicate a contraction of WJT range from lower elevation slopes, where extreme summer high temperatures and increasing drought will cause those areas to become locally extinct, toward higher elevation or northerly areas characterized by cooler temperatures and more precipitation. The Status Review is correct, however, in qualifying that "the species is unlikely to naturally colonize these areas in the foreseeable future," because of its inability to disperse such long distances over inhospitable terrain, given the species' short dispersal range (~30m, op.cit. under Biology of the WJT).

Land Development—

Land development in the form of clearing the land for agriculture, housing and urban development, or energy projects represents a direct and permanent loss of WJT habitat. Most land development in the Mojave Desert region occurs on private land in the YUBR South range.

The Status Review mentions large-scale clearing of land in the western Mojave Desert portion of the range for dry farming and agriculture during the early 1900s and how these areas have shown little or no WJT recruitment since those times. Much of that area has since been developed for housing and urban development in the cities of Palmdale and Lancaster.

The Status Review reports that, "Much of the recent western Joshua tree habitat modification and destruction has been the result of ongoing urban development, typically on private property within the general vicinity of existing developed areas. The USFWS (2019) reported that approximately 50% of the southern part of western Joshua tree's range (YUBR South) is on private property, 2% of the northern part of western Joshua tree's range (YUBR North) is on private property, with the remainder predominately on federal land. WEST Inc. (2021b) found a higher percentage of western Joshua tree's range on private property than the USFWS did, with approximately 65% of the southern range on private property…" (Lines 2562-2570)

An unpublished recent study conducted by a Geographic Information Systems (GIS) research group under my direction at the University of Redlands found that 420 mi^2/677 km^2 of WJT habitat within the cities of Palmdale, Lancaster, Yucca Valley, Joshua Tree, Twentynine Palms, Victorville, Hesperia, and Apple Valley were developed within those jurisdictions between 1984 to 2021 (Krantz et al. 2021). This analysis examined decadal aerial photo imagery, identifying developed areas within those jurisdictions, but it did not include isolated blocks of open space that may represent occupied WJT habitat. In fact, the remaining undeveloped blocks within these cities are so highly fragmented that they likely no longer represent ecologically viable habitat. Given the extremely short distance dispersibility of WJT seeds and isolation from potential yucca moth pollinators, these remaining patches of WJT habitat should be considered ecologically unviable and essentially extirpated.

Within the foreseeable future (the year 2100), if not already, the undeveloped areas of these incorporated cities should be considered functionally extinct. Most of the smaller fragments of extant habitat are already ecologically unviable and would, therefore, meet the definition of functionally extinct, as described in the previous section of this peer review.

City	Area (mi^2)
Palmdale	106.3
Lancaster	94.54
Victorville	74.01
Hesperia	72.78
Adelanto	52.88
Apple Valley	77.08
Joshua Tree	37.04
Yucca Valley	39.83
Barstow	41.34
Twenty-nine Palms	58.76
	654.56 mi^2

If one considers the incorporated cities within the YUBR South range as developed habitat within the foreseeable future, then a total habitat loss of 654.56 mi^2 should be considered extirpated and functionally extinct.

Fifteen renewable energy projects were granted §2084 take exemptions during the hearings to establish the WJT as a candidate species for listing under the CESA. According to an analysis done by the USFWS using U.S. Environmental Protection Agency Integrated Climate and Land Use Scenarios projections, between 22% and 42% of the habitat within the southern part of western Joshua tree's range may be lost by the year 2095 due to urban growth and renewable energy development. (Lines 2641-2645)

<u>Wildfire</u>

Wildfire, although a defining component in many of California's ecosystems, is a relatively rare phenomenon in the Mojave Desert, but fire frequency and intensity has increased dramatically in recent decades, especially in the period from 2001-2020, as illustrated in *Figure 9: Fires within the California Range of Western Joshua Tree, 1900-2020* (CALFIRE 2021) of the Status Review.

Within the WJT range, "Fire is unevenly distributed in the Mojave Desert, and fire occurrence tends to align with distinct precipitation regime boundaries, with most large and recurring fires occurring in areas that have a relatively high amount of precipitation in summer (Tagestad et al. 2016). Fuels tend to be more available, and fires tend to be more frequent and severe at higher-elevation areas of the Mojave Desert, and the availability of fuels and frequency of fires is somewhat lower at middle elevation areas, and still lower at the low elevation areas of the Mojave Desert (Brooks et al. 2018). (Lines 2683-2690)

The size, intensity and frequency of fires in the YUBR South range are the result of higher fuel loads in the higher elevation portions of the species' range and increasing drought and higher summer temperatures—characteristics of climate change. The GIS study completed by Krantz et al. (unpublished, 2021), using the same CALFIRE database as cited in Figure 9, above, estimated that between 1980-2019 a total area of 950km^2 of WJT habitat was burned within the YUBR South range, representing approximately 8% of total WJT habitat, but as much as 12.9% of YUBR South distribution.

Wildfire impacts on YUBR habitat are severe. As cited in the Status Review,

"Western Joshua tree populations are very slow to recover from fire. Minnich (1995) observed a 47 year chronological sequence of 13 burned Joshua tree woodland sites within JTNP that were similar, but that had burned at different times in the past. Minnich (1995) found that 64% to 95% of western Joshua tree stems were fatally damaged in all but one of the sample sites, and western Joshua tree cover and density remained low in burned sites compared with unburned sites, even 47 years after burning."

Smaller WJT plants (<0.5m) are almost entirely killed by fire, but even taller, mature trees are largely killed above ground. These may sprout vegetatively after fires, but these sprouts may take 30-50 years before reaching sexual maturity and producing flowers.

The Department summarizes the impacts of wildfire on the WJT as follows:

"Wildfire is a substantial threat to western Joshua tree and invasive plants contribute to that threat, but wildfire does not affect the entire range of the species evenly, does not necessarily burn through habitat in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. For these reasons, wildfire is likely to reduce the abundance of the species, but it is unlikely to result in a serious danger of elimination of the species throughout a significant portion of its range. Nevertheless, because western Joshua tree recruitment from seed is rare, and because the species takes a long time to reestablish in burned areas, wildfire causes long-lasting negative effects in burned areas. The Department expects that the impacts from continuing and increasing wildfire activity in the Mojave Desert and surrounding areas will cause ongoing gradual reductions in the size of at-risk populations of western Joshua tree within California, but the range of the species is unlikely to be affected by wildfire in the foreseeable future, because western Joshua tree is unlikely to be completely eliminated from affected areas due to its high abundance and widespread distribution." (Lines 2893-2907)

This conclusion fails to account for several factors. With increasing fire frequency and intensity, vegetative sprouts of WJTs are largely eliminated from these areas if the subsequent fire occurs before the sprouts are more than 2-2.5m high—the height at which Southern WJTs first flower (Rowlands, 1978). Fires eliminate seed stock in the soils and remove potential nursery plants, further reducing the potential for flowering, seed production and seed germination for the "foreseeable future"—the end of this century. Finally, studies cited in the Status Review indicate that the yucca moth, upon which the WJT is dependent for pollination, is already rare at these higher elevations of the WJT range (Harrower and Gilbert 2018). With the elimination of flowering YUBR plants for 50+ years (before vegetative sprouts will flower again), these areas are essentially lost for their requisite pollinators.

<u>Conclusions Regarding Listing the WJT as a Threatened or Endangered Species</u>

It is clear that the Western Joshua Tree does not meet the definition of an Endangered species in accordance with the CESA: a species "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range." The question before the Department and the focus of this Status Review is whether the WJT meets the definition of a Threatened species, a species "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA]." In this Status Review, the foreseeable future is considered to be the 21st century, or through the year 2100.

Furthermore, the focus of this Peer Review is on whether the southern extent of the populations of WJT (YUBR South) should be listed as Threatened "ecologically significant units" unto themselves. The conclusion of this Peer Review is that such a designation is appropriate because the YUBR South populations are subject to much greater threats than the northern WJT populations (YUBR North). The facts and research presented in this Status Review demonstrate that the potential for the YUBR South populations to become Endangered over a significant portion of their range (the YUBR South range) within the foreseeable future is very real.

The primary threats to the YUBR South populations of WJT are three-fold:

- Climate change
- Urbanization and land development
- and Wildfires

Each of these endangerment factors will be discussed briefly and summarized below.

<u>Climate Change</u>

The impacts of climate change are already manifest in the YUBR South populations, with higher summer temperatures and more extreme drought, particularly in the lower elevations of the YUBR South range. As stated in this Status Review, "climate change could cause substantial reductions in areas with 20th century suitable climate conditions for the species at the southern parts of western Joshua tree's range, including within JTNP."

As the climate models cited in this Review have found, the impacts of increasing heat and drought will be most severe at the lower elevations of the YUBR South range.

The Status Review goes on to state that, "These species distribution modeling efforts also suggest that substantial additional areas of 20th century suitable climate conditions may become available for western Joshua tree to the north, particularly in Nevada (outside of the scope of CESA) but also in some parts of eastern California, although the species is unlikely to naturally colonize these areas in the foreseeable future."

The Department is correct in noting that as the climate warms and low elevation areas of the WJT become uninhabitable for the species, other areas to the north and at higher elevations may develop suitable climate conditions; but the Department is also correct in stating that the species is unlikely to naturally colonize these areas in the foreseeable future (by the Year 2021) due to its very limited dispersibility (~30m).

It will be virtually impossible for WJT in the southern populations to disperse over these relatively few decades to the northern YUBR populations to adjust to climate change. As far as Southern YUBR plants are concerned, dispersal to newly suitable habitat in the YUBR North range is not possible. They will have to disperse/migrate to the higher elevation, cooler, moister habitats of the slopes along the southern edge of the YUBR South range, which we will see below, is also impossible.

In fact, the lower elevation populations of southern WJT are already experiencing very low reproduction rates and those individuals are not maturing to achieve mature flowering plant status, as illustrated in Figure 4 of the Status Review. Furthermore, there is evidence that the obligate pollinator, *T. synthetica,* may already be declining or absent from the lower elevation WJT populations, implying that these areas cannot sexually reproduce (Harrower and Gilbert 2018) and, therefore, cannot produce viable seeds for dispersal. The lower elevation portions of YUBR South should already be considered ecologically and functionally extinct.

To visualize the extent of the impact of climate change on the YUBR South metapopulation, the entire area shown as yellow on Figure 4 will be functionally extinct within the foreseeable future. Yes, there will be islands of refugia in the isolated mountains north of Barstow and northeast of Lancaster, but these islands will be reproductively and ecologically isolated to the extent that they are biologically doomed if current climate trends continue, as the climate models cited in the Status Review all predict.

Urbanization and Land Development

As described earlier in this Peer Review, urbanization and land development in the desert cities of the southern Mojave Desert represent an enormous and permanent conversion of WJT habitat. Development and fragmentation within the incorporated city limits alone represent more than 650 square miles of habitat loss. This does not include the clearing and destruction of the 15 large-scale renewable energy projects that were granted §2084 take exemptions during the hearings to establish the WJT as a candidate species for listing under the CESA, nor does it include the expansive developments of rural "ranchettes" and other associated developments in the unincorporated communities of Phelan, Oak Hills, Baldy Mesa, Lucerne Valley, and Pioneertown, to name just a few. (See attached Image of the Unincorporated Communities)

Most of this development, from the Palmdale-Lancaster area in the western portion of the YUBR South range, to the cities of Yucca Valley and Joshua Tree at the eastern limit of the YUBR South range, extends across the middle elevations of the southern WJT habitat. Remaining fragments of occupied habitat within these city limits are, once again, functionally extinct. That is, extant WJTs on these remaining patches are now totally isolated, unable to disperse to higher ground in the face of warming temperatures and increasing drought. This isolation is compounded by the fact that they require the presence of yucca moths for pollination and production of viable seeds; and even if pollination is successful, the dispersal of seeds across the fragmented urban landscapes becomes increasingly unlikely, if not impossible.

Furthermore, the development of the wide swath of the middle elevations across the southern flank of YUBR habitat effectively isolates the entire lower elevation populations from any chance of dispersal across the urban barrier to reach the cooler, moister suitable habitats in the face of climate change. This compounds the effective isolation of the lower elevation populations, reinforcing their functional extinction.

Wildfires

Finally, we have the fact of increasing frequency, size and severity of wildfires in the southern WJT range. As noted in the Status Review (see Figures 9 and 10), the area burned by wildfires has more than doubled in the last three decades in comparison with the previous 90 years. Most of those fires and the largest of them have occurred in the higher elevations of the YUBR South range.

For example, the Sawtooth Fire Complex near the community of Pioneertown (readily visible on Figure 9 in the southeast portion of the range), consumed 61,700 acres of high quality, high density WJT woodland habitat in 2006. Now, 15 years later, the area is still nearly devoid of WJT plants, with no mature Joshua trees in the burn area and very few vegetative sprouts. The area is essentially "dead" for many generations to come, with no flowering WJT plants. The lack of mature, flowering Joshua trees equates to no yucca moths. The absence of the flowering host plant will eliminate the yucca moths from the area for many moth generations, certainly for the "foreseeable future" through the Year 2100.

The WJT and yucca moth are obligate co-dependent species. This represents a significant and cumulative adverse impact, with very serious implications for WJT in wildfire areas. It means that these areas, even if they recover by vegetative reproduction from the fire, will remain without their obligate pollinators for many decades or even beyond 2100.

The fact that these wildfires are almost entirely in the higher elevations in the southernmost extent of the YUBR South range effectively removes the climate refugia that lower elevation populations will need, if they are capable of dispersal to these cooler, more hospitable habitats at all.

Final Peer Review Recommendation

Thus, we find that the Southern WJT populations are faced with a triple cumulative threat: their lowermost populations are already functionally extinct due to climate change; even if they could disperse toward higher, more equable climate, they are blocked by sprawling development across their middle elevations; and finally, the remaining high ground along the south edge of the YUBR range is being consumed by wildfire and will be biologically non-functional for the foreseeable future and beyond.

Together, these three impacts represent significant adverse cumulative impacts to the YUBR South populations ***throughout their range.*** Referring back to the definition of an Endangered species: one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range;" I find that the data and studies presented in this Status Review do, indeed, support a finding that the YUBR South population of WJT meets the definition of a Threatened species: one that, "although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA]."

Management Recommendations and Recovery Measures

If the Department finds that the WJT does not warrant protection as a Threatened species under the CESA, then other regulatory and recovery measures shall be necessary to ensure that the species does not become a Threatened species.

The Department lists a range of management recommendations and recovery measures (Lines 4056-4088). A few of these measures are practical and may be implemented, while many are vague, impractical and unenforceable. I will briefly review the recommendations below.

1) Continue efforts to drastically reduce greenhouse gas emissions. Of course!

2) Complete a western Joshua tree conservation plan in collaboration with partners and stakeholders. The WJT Conservation Plan should include detailed protocols for environmental assessment and mitigation of proposed projects that have the potential to impact WJTs.

3) Preserve western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia. Dedicate State funds toward acquisition and protection of otherwise unprotected high-value WJT habitat.

4) Minimize wildfire risk to western Joshua tree woodlands, particularly following one or more years of high precipitation, and particularly in areas with high recruitment and areas projected to be climate refugia.

Would this mean weed-whacking non-native flash fuels over hundreds of square miles? Impractical.

5) Manage fires aggressively to protect Joshua tree woodlands, particularly in areas with high recruitment and areas projected to be climate refugia. Not practical.

6) Implement ways to disincentivize destruction of western Joshua tree habitat, particularly in areas with high recruitment and areas projected to be climate refugia. What sort of "disincentives" are contemplated here? Not practical.

7) Implement state and/or local laws and regulations that limit unmitigated impacts to high quality western Joshua tree habitat. Not practical unless accompanied by enforceable, regulatory measures. In this circumstance, it is my recommendation that the Department sanction the WJT in its YUBR South distribution as a Regulated species, like regulated game or fish animals.

8) Continue scientific investigations into the biology, ecology and genetics of western Joshua tree and the species and habitats upon which it depends:

- o Collect and analyze range-wide demographic information to detect baseline population trends and identify populations that do not appear to be recruiting new individuals at sustainable levels.
- o Implement long-term range-wide direct population monitoring and vegetation monitoring with emphasis on leading and trailing edges and highest and lowest elevations of the species' range.
- o Produce and improve upon range-wide species distribution models for western Joshua tree.
- o Produce range-wide species distribution models for western Joshua tree's obligate pollinating moth.
- o Investigate the significance of multi-year and multi-decade climate variability patterns for western Joshua tree recruitment.
- o Investigate ways to control the spread and abundance of invasive plant species to reduce wildfire risk.
- o Investigate the feasibility, practicality, and risks of implementing assisted migration and translocation.

Of these last measures, all are necessary to provide basic baseline monitoring information for the WJT. Of particular importance would be to promote further investigations and biological research on the obligate pollinating moth, *Tegeticula synthetica*. The Status Review presents some basic information about the life history of the moths, but certain information pertinent to this Petition is lacking, such as: what are the temperature and moisture thresholds for the species? There is some indication that the moths are rare or absent at the lower and upper elevations of WJT. What are the limiting factors that determine its range? These are ***obligate***, co-dependent species. Therefore, the limiting environmental factors of one have direct consequences on the distribution of the other.

One of the more practical measures, not mentioned above, would be to require consideration of projects within the YUBR South range to undertake environmental impact assessments in accordance with the CEQA guidelines. The Status Review describes this alternative (Lines 4007-4019), but, without formal listing, there would be no requirement that projects analyze potential impacts to WJT.

If, however, the State designated the Southern WJT as a Regulated species, similar to other game and fish animals (§2116 *et seq.* of the Fish and Game Code), then CEQA review or at least regulatory review would be required, and permits would be necessary for removal of WJT plants on impacted properties. By this means, projects that have the potential to adversely impact WJTs would have to consider avoidance of WJTs to the extent possible and mitigation of impacts to WJTs in the case that Joshua trees cannot be avoided.

Regarding mitigation for removal of WJT, the trees may be successfully transplanted. San Bernardino County enacted a Joshua tree policy in the late 1980s that required developers to avoid the trees if possible, translocate them or make them available for translocation if necessary. During this time and through the 1990s, I worked with a landscape company, *NativeScapes*, transplanting Joshua trees using a 24-inch and

36-inch hydraulic tree spade. Joshua trees have a fibrous root system, like palm trees, and they can be excavated and placed in 36-inch or 48-inch boxes for re-location to protected areas on- or off-site. Trees as tall as 10-12 feet with moderate branching can be transplanted.

Once the trees are installed, larger trees must be tethered to stabilize the weight of the tree; and transplants must receive additional irrigation maintenance through the first two summer seasons until the fibrous root system is reestablished.

For this practice to be effective, it is essential that the State designate the WJT as a regulated species. Otherwise, if left to the individual county and city municipalities, the southern WJT would have only inconsistent standards for environmental review and mitigation. Standardized environmental assessment and mitigation measures may be included in the WJT Conservation Plan recommendations, described in #2 above.

The WJT Conservation Plan may also identify conserved areas for translocation of Joshua trees in anticipation of climate change, such as the Pioneertown Preserve. The Pioneertown Preserve is a 25,500-acre natural preserve managed by The Wildlands Conservancy. The area was burned during the Sawtooth Complex Fire in 2006 and native WJT woodland habitat has been very slow to recover. Translocation from lower elevation sites in the cities of Yucca Valley and Joshua Tree to the Pioneertown Preserve would facilitate WJT recovery from the fire, as well as help with climate adaptation by moving plants to higher elevations. Such translocation sites would require long-term management for fire and fuel modification, non-native grass and fuels management around the base of the trees, and irrigation maintenance until such trees are re-established.

Other potential "climate refugia" may be identified in the Conservation Plan on State, Federal or private lands across the WJT range.

This concludes my Peer Review comments on the Status Review of the Petition to List the Western Joshua Tree. Thank you again for the opportunity to provide these comments. If the Department has any further questions in these regards, please do not hesitate to reach out to me at the numbers/email below.

Sincerely,

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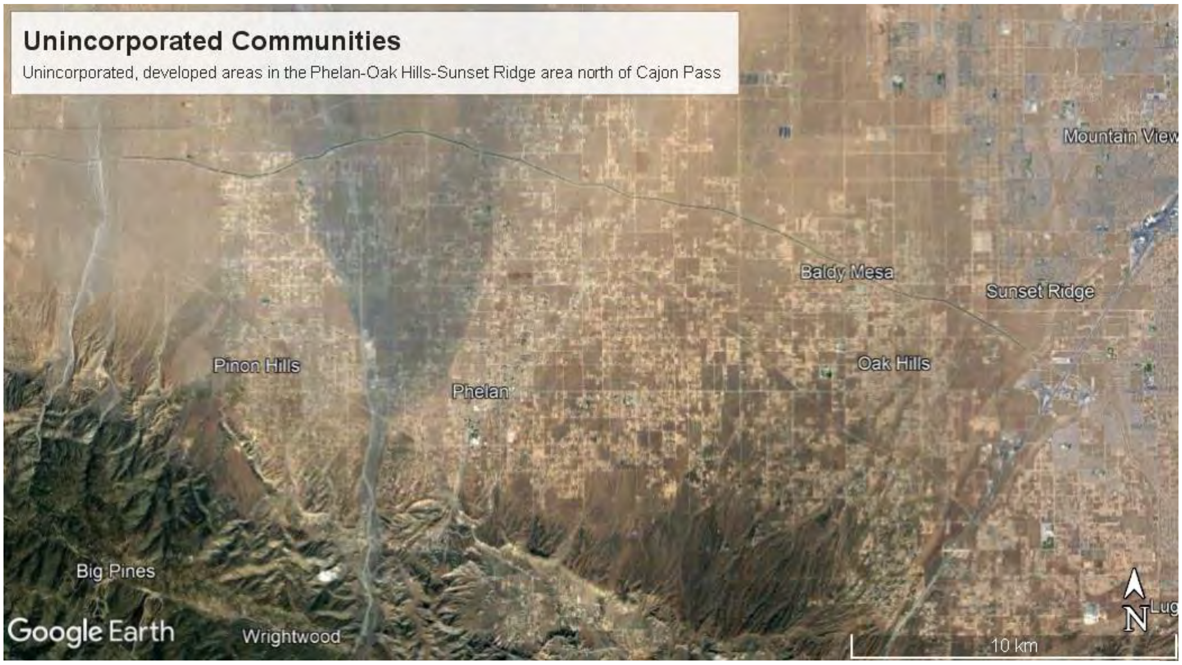

Figure: Unincorporated Communities in the Phelan-Baldy Mesa Area.

Note the extensive land clearance for small ranches and rural residential development. These communities are entirely within high density WJT woodland habitat. Estimated WJT habitat loss just within this image is approximately 300 km^2. The even more densely developed cities of Hesperia and Adelanto are immediately east of the image.

Peer Review Comments from Dr. Tim Krantz on the western Joshua tree (*Yucca brevifolia*) Status Review and California Department of Fish and Wildlife Responses

Note: Dr. Krantz quoted large sections of the Draft Status Review in his comments, and then responded to the quoted text. The Department did not reproduce the quoted text in this table unless it was needed for context. Comments not associated with specific line numbers by the peer reviewer have "N/A" in the Line column.

Line	Reviewer Comment	Department Response
539	As we will see in the discussion of endangerment factors, the levels of threat from land development, energy projects, wildfires and climate change are generally greater in the YUBR South range than the YUBR North range, thus warranting separate consideration of the appropriateness of listing under the CESA.	The Department recognizes that populations of western Joshua tree in the southern part of its range generally face more serious threats than populations in the northern part of its range, as described in the Factors Affecting the Ability to Survive and Reproduce section of the Status Review. Nevertheless, seriousness of threats is not a component of species concepts. As described in the Taxonomy section of the Status Review, the Department does not currently have evidence that would support the differentiation of southern and northern populations as separate and discrete evolutionary significant units that would qualify them as separate "species or subspecies" under CESA. Sentence added to the Taxonomy section of the Status Review about threats.

Line	Reviewer Comment	Department Response
2527	Thus, the environmental limits of the yucca moth have a direct bearing on the sexual reproduction of the WJT, and the lower elevation limitations for the moth—most likely reflecting a high temperature threshold and/or low soil moisture tolerance—may indicate that these low elevation WJT populations are already no longer viable and will, with increasing temperatures resultant to climate change, become locally extinct.	Lack of sexual reproduction reduces the ability of species to adapt, often reduces dispersal ability, and may present other serious challenges for population persistence, but it does not necessarily mean that a population of species that is capable of asexual reproduction will no longer be viable in the foreseeable future. The Department has very little information on the range of *T. synthetica*, however, any instance of non-clonal western Joshua tree recruitment is an indication that *T. synthetica* was present at the time the flower that produced the seed was pollinated. The potential for climate change to affect *T. synthetica* is discussed in the Climate Change Indirect Effects section of the status Review, and a discussion of the consequences of lack of sexual reproduction was added. Text also added to the Flowering, Pollination, and Fruit Production section.
2536, 2559	Although asexual reproduction does occur in WJTs, particularly after fires and/or at higher elevations, sexual reproduction is essential for maintenance of genetic diversity of the species. Little is known about the life history or survival of yucca moths regarding their survival (or not) after fires, their environmental tolerances to extreme temperatures or moisture, or of their capabilities of locating host plants and dispersal in highly fragmented habitats, such as urbanized, low density WJT habitat in the YUBR South range. These potential endangerment factors relative to the *T. synthetica* moth are not addressed in the Status Review.	Information on survival of yucca moths following fire is discussed in the Wildfire section of the Status Review, and although the information is for eastern Joshua tree, it is the best information available to the Department. *T. synthetica* environmental tolerances are discussed in the Climate Change Indirect Impacts section. The reviewer is correct that little is known about environmental tolerances of *T. synthetica,* but this lack of knowledge is not, in and of itself, a threat to western Joshua tree. We added a statement to the Development and other Human Activities section to acknowledge how little is known, but that fragmentation may have negative effects on the moth. We added a discussion of the possible effects of lack of sexual reproduction on western Joshua tree due to climate change effects on *T. synthetica*. Lack of sexual reproduction does not necessarily mean that a population of species that is capable of asexual reproduction will no longer be viable in the foreseeable future.

Line	Reviewer Comment	Department Response
623, 1914-1930, 1970-1972, 2018-2029	Lower elevation areas of the WJT range are already exhibiting lower absolute cover and reduced seedling germination and recruitment. (Lines 1970-1972) The compounding endangerment factors of climate change are described further by the Department (Lines 1914-1930) Furthermore, “There may be a time delay between the time when an area becomes no longer suitable for a species (crossing an extinction threshold) and when that species is no longer present, (Tilman et al. 1994, Kuussaari et al. 2009, van Mantgem et al. 2009, Svenning and Sandel 2013, Figueiredo et al. 2019). Extinction processes often occur with a time delay and populations living close to their extinction threshold might survive for long periods of time despite local extinction being inevitable (Hanski and Ovaskainen 2002, Lindborg and Eriksson 2004, Helm et al. 2006, Vellend et al. 2006, Malanson 2008, Cronk 2016). Because western Joshua tree is a long-lived species, adults could persist for decades or longer in areas that are no longer suitable for recruitment, or recruitment may continue, but at rates that are ultimately insufficient to maintain the species. Although these areas may appear occupied, the presence of western Joshua tree may merely represent a delayed local extinction. (Lines 2018-2029) Thus, when one re-examines the range of YUBR South as illustrated in Figure 4, one can see that fully half of the total YUBR South distribution may already be functionally extinct—that is, non-reproductive at rates that can sustain the population in those areas in the “foreseeable future” (the 21st century).	While the Department speculates that areas of western Joshua tree habitat could be subject to a delayed local extinction and acknowledges the possibility that this may occur by including the discussions referenced by the reviewer, the Department also states in the Status Review that local extinctions may be delayed for centuries or millennia, or that the species may be preserved as a relict from an earlier climate. The Department does not possess demographic information demonstrating that significant portions of the species range will be subject to a delayed local extinction in the foreseeable future.

Line	Reviewer Comment	Department Response
1519-1525	An unpublished recent study conducted by a Geographic Information Systems (GIS) research group under my direction at the University of Redlands found that 420 mi2/677 km2 of WJT habitat within the cities of Palmdale, Lancaster, Yucca Valley, Joshua Tree, Twentynine Palms, Victorville, Hesperia, and Apple Valley were developed within those jurisdictions between 1984 to 2021 (Krantz et al. 2021). This analysis examined decadal aerial photo imagery, identifying developed areas within those jurisdictions, but it did not include isolated blocks of open space that may represent occupied WJT habitat. In fact, the remaining undeveloped blocks within these cities are so highly fragmented that they likely no longer represent ecologically viable habitat. Given the extremely short distance dispersibility of WJT seeds and isolation from potential yucca moth pollinators, these remaining patches of WJT habitat should be considered ecologically unviable and essentially extirpated.	Text updated to include some of the details provided by the reviewer. The unpublished study cited by the reviewer was not provided to the Department, but an email from the reviewer was cited as a personal communication during preparation of the Status Review. The many effects of habitat modification and destruction including habitat fragmentation are discussed in the Development and other Human Activities section of the status review, however, the Department does not have information demonstrating that isolated blocks of habitat should be considered ecologically unviable and essentially extirpated. The Department does have information that suggests some populations near urban areas are declining (see Figure 8), but we don't know the cause of this decline and speculate in the Status Review that an important aspect of western Joshua tree life history may have been disrupted by environmental degradation related to urban and agricultural development.
1519-1525	Within the foreseeable future (the year 2100), if not already, the undeveloped areas of these incorporated cities should be considered functionally extinct. Most of the smaller fragments of extant habitat are already ecologically unviable and would, therefore, meet the definition of functionally extinct, as described in the previous section of this peer review.	See response to previous comment.
	If one considers the incorporated cities within the YUBR South range as developed habitat within the foreseeable future, then a total habitat loss of 654.56 mi2 should be considered extirpated and functionally extinct.	See response to previous comment.

Line	Reviewer Comment	Department Response
2810	The GIS study completed by Krantz et al. (unpublished, 2021), using the same CALFIRE database as cited in Figure 9, above, estimated that between 1980-2019 a total area of 950km2 of WJT habitat was burned within the YUBR South range, representing approximately 8% of total WJT habitat, but as much as 12.9% of YUBR South distribution.	Text updated with information from reviewer comment.
2819	Smaller WJT plants (<0.5m) are almost entirely killed by fire, but even taller, mature trees are largely killed above ground. These may sprout vegetatively after fires, but these sprouts may take 30-50 years before reaching sexual maturity and producing flowers.	Text updated with detail from DeFalco et al. 2010.
N/A	With increasing fire frequency and intensity, vegetative sprouts of WJTs are largely eliminated from these areas if the subsequent fire occurs before the sprouts are more than 2-2.5m high—the height at which Southern WJTs first flower (Rowlands, 1978). Fires eliminate seed stock in the soils and remove potential nursery plants, further reducing the potential for flowering, seed production and seed germination for the “foreseeable future”—the end of this century. Finally, studies cited in the Status Review indicate that the yucca moth, upon which the WJT is dependent for pollination, is already rare at these higher elevations of the WJT range (Harrower and Gilbert 2018). With the elimination of flowering YUBR plants for 50+ years (before vegetative sprouts will flower again), these areas are essentially lost for their requisite pollinators.	Added two sentences to the Wildfire section of the Status Review on indirect effects of wildfire on *T. synthetica*. Wildfire effects on juvenile trees, nurse plants, seeds in the soil, and the long-lasting nature of impacts are all already discussed in the Wildfire section of the Status Review. Wildfire is a substantial threat to western Joshua tree but wildfire does not affect the entire range of the species evenly, does not necessarily burn through habitat in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. Also, see the results of Lybbert and St. Clair (2016).

Line	Reviewer Comment	Department Response
N/A	Furthermore, the focus of this Peer Review is on whether the southern extent of the populations of WJT (YUBR South) should be listed as Threatened "ecologically significant units" unto themselves. The conclusion of this Peer Review is that such a designation is appropriate because the YUBR South populations are subject to much greater threats than the northern WJT populations (YUBR North). The facts and research presented in this Status Review demonstrate that the potential for the YUBR South populations to become Endangered over a significant portion of their range (the YUBR South range) within the foreseeable future is very real. The primary threats to the YUBR South populations of WJT are three-fold: • Climate change • Urbanization and land development • and Wildfires	See response to comment from reviewer regarding line 539. Seriousness of threats is not a component of species concepts.
N/A	It will be virtually impossible for WJT in the southern populations to disperse over these relatively few decades to the northern YUBR populations to adjust to climate change. As far as Southern YUBR plants are concerned, dispersal to newly suitable habitat in the YUBR North range is not possible. They will have to disperse/migrate to the higher elevation, cooler, moister habitats of the slopes along the southern edge of the YUBR South range, which we will see below, is also impossible.	The Status Review discusses and acknowledges that western Joshua tree has limited ability to disperse seed, and that it may take centuries or millennia for the species to naturally colonize areas of newly suitable climate. The Department's conclusions in the Status Review are not based on an assumption that any significant natural colonization will occur in the foreseeable future.

Line	Reviewer Comment	Department Response
N/A	To visualize the extent of the impact of climate change on the YUBR South metapopulation, the entire area shown as yellow on Figure 4 will be functionally extinct within the foreseeable future. Yes, there will be islands of refugia in the isolated mountains north of Barstow and northeast of Lancaster, but these islands will be reproductively and ecologically isolated to the extent that they are biologically doomed if current climate trends continue, as the climate models cited in the Status Review all predict.	The reviewer does not cite, and the Department does not possess any demographic or trend information to support the assertion that areas with >0-1% western Joshua tree cover will be functionally extinct within the foreseeable future. The Department does not possess information to conclude that reproductive and ecological isolation is necessarily a threat to species populations in the foreseeable future, even in the face of increasing threats.
N/A	Development and fragmentation within the incorporated city limits alone represent more than 650 square miles of habitat loss. This does not include the clearing and destruction of the 15 large-scale renewable energy projects that were granted §2084 take exemptions during the hearings to establish the WJT as a candidate species for listing under the CESA, nor does it include the expansive developments of rural "ranchettes" and other associated developments in the unincorporated communities of Phelan, Oak Hills, Baldy Mesa, Lucerne Valley, and Pioneertown, to name just a few. (See attached Image of the Unincorporated Communities)	Sentence added to the Development and Other Human Activities section of the Status Review regarding development within incorporated city limits and unincorporated areas.

Line	Reviewer Comment	Department Response
N/A	Most of this development, from the Palmdale-Lancaster area in the western portion of the YUBR South range, to the cities of Yucca Valley and Joshua Tree at the eastern limit of the YUBR South range, extends across the middle elevations of the southern WJT habitat. Remaining fragments of occupied habitat within these city limits are, once again, functionally extinct. That is, extant WJTs on these remaining patches are now totally isolated, unable to disperse to higher ground in the face of warming temperatures and increasing drought. This isolation is compounded by the fact that they require the presence of yucca moths for pollination and production of viable seeds; and even if pollination is successful, the dispersal of seeds across the fragmented urban landscapes becomes increasingly unlikely, if not impossible. Furthermore, the development of the wide swath of the middle elevations across the southern flank of YUBR habitat effectively isolates the entire lower elevation populations from any chance of dispersal across the urban barrier to reach the cooler, moister suitable habitats in the face of climate change. This compounds the effective isolation of the lower elevation populations, reinforcing their functional extinction.	See Department responses to previous similar reviewer comments. The Department recognizes that habitat loss and fragmentation will occur in the Development and Other Human Activities section of the Status Review. The Department's conclusions in the Status Review are not based on an assumption that any significant natural colonization will occur in the foreseeable future.

Line	Reviewer Comment	Department Response
N/A	Finally, we have the fact of increasing frequency, size and severity of wildfires in the southern WJT range. As noted in the Status Review (see Figures 9 and 10), the area burned by wildfires has more than doubled in the last three decades in comparison with the previous 90 years. Most of those fires and the largest of them have occurred in the higher elevations of the YUBR South range. For example, the Sawtooth Fire Complex near the community of Pioneertown (readily visible on Figure 9 in the southeast portion of the range), consumed 61,700 acres of high quality, high density WJT woodland habitat in 2006. Now, 15 years later, the area is still nearly devoid of WJT plants, with no mature Joshua trees in the burn area and very few vegetative sprouts. The area is essentially "dead" for many generations to come, with no flowering WJT plants. The lack of mature, flowering Joshua trees equates to no yucca moths. The absence of the flowering host plant will eliminate the yucca moths from the area for many moth generations, certainly for the "foreseeable future" through the Year 2100.	The Sawtooth Fire Complex is a large relatively recent wildfire that affected western Joshua tree, however the Status Review focuses discussion on the overall impact of wildfire across the species range, and therefore specific wildfires are not discussed individually. The effects of wildfire on adult and juvenile trees, nurse plants, seeds in the soil, and the long-lasting nature of impacts are all already discussed in the Wildfire section of the Status Review. Wildfire is a substantial threat to western Joshua tree but wildfire does not affect the entire range of the species evenly, does not necessarily burn through habitat in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. Also, see the results of Lybbert and St. Clair (2016).
N/A	The WJT and yucca moth are obligate co-dependent species. This represents a significant and cumulative adverse impact, with very serious implications for WJT in wildfire areas. It means that these areas, even if they recover by vegetative reproduction from the fire, will remain without their obligate pollinators for many decades or even beyond 2100.	A sentence was added to the Summary of Listing Factors section of the status review to acknowledge that the cumulative impacts of climate change, wildfire, and the direct and indirect effects of development and other human activities may also affect populations of *T. synthetica*, reducing western Joshua tree's ability to sexually reproduce. Also see Department responses to previous comments.

Line	Reviewer Comment	Department Response
N/A	The fact that these wildfires are almost entirely in the higher elevations in the southernmost extent of the YUBR South range effectively removes the climate refugia that lower elevation populations will need, if they are capable of dispersal to these cooler, more hospitable habitats at all.	Sentence added to the Wildfire section of the Status Review to state that high-elevation areas of the Mojave Desert likely have the highest probability of retaining 20th century suitable climate conditions for western Joshua tree, however, these areas also have a high probability of wildfire, which means that wildfire may disproportionately affect areas of climate refugia for the species.
N/A	Thus, we find that the Southern WJT populations are faced with a triple cumulative threat: their lowermost populations are already functionally extinct due to climate change; even if they could disperse toward higher, more equable climate, they are blocked by sprawling development across their middle elevations; and finally, the remaining high ground along the south edge of the YUBR range is being consumed by wildfire and will be biologically non-functional for the foreseeable future and beyond.	Added text to the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat section of the Status Review to include a general statement that the southern portion of the species range faces greater threats than the northern portion of the species range. Also see Department responses to previous comments.
N/A	Together, these three impacts represent significant adverse cumulative impacts to the YUBR South populations *throughout their range.* Referring back to the definition of an Endangered species: one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range;" I find that the data and studies presented in this Status Review do, indeed, support a finding that the YUBR South population of WJT meets the definition of a Threatened species: one that, "although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA]."	See response to comment from reviewer regarding line 539. Seriousness of threats is not a component of species concepts, and the Department does not possess information to support a conclusion that the southern portion of western Joshua tree's range can be considered a "species or subspecies" under CESA.

Line	Reviewer Comment	Department Response
4057	The WJT Conservation Plan should include detailed protocols for environmental assessment and mitigation of proposed projects that have the potential to impact WJTs.	Text updated with new bullet point per suggestion.
4059	Dedicate State funds toward acquisition and protection of otherwise unprotected high-value WJT habitat.	Text updated to state that long-term conservation of the species is likely beyond the scope of any one government, agency, or organization, and could require *funding and* legislation.
4061	Would this mean weed-whacking non-native flash fuels over hundreds of square miles? Impractical.	Revised text for clarity. While landscape-scale invasive species management is impractical with current technology and resources, smaller-scale vegetation management to minimize wildfire risk in western Joshua tree woodland is already being implemented by Joshua Tree National Park, and the Department recently issued a scientific, educational, or management permit covering western Joshua tree for a project to remove non-native plants from large parcels to reduce wildfire risk.
4064	Not practical.	Revised text to “Manage *active* fires aggressively…” for clarity. Full fire suppression is currently the policy of Joshua Tree National Park.
4066	What sort of “disincentives” are contemplated here? Not practical.	As stated in the Management Recommendations and Recovery Measures section of the Status Review, western Joshua tree faces serious challenges, and long-term conservation of the species is likely beyond the scope of any one government, agency, or organization, and could require funding and legislation. Disincentives could be implemented via legislation, and could take many forms, ranging from regulatory programs to financial incentives.
4069	Not practical unless accompanied by enforceable, regulatory measures.	Text updated per suggestion to include enforcement.

Line	Reviewer Comment	Department Response
4069	In this circumstance, it is my recommendation that the Department sanction the WJT in its YUBR South distribution as a Regulated species, like regulated game or fish animals.	The Fish and Game Commission is responsible for designating regulated species, not the Department. The Management Recommendations and Recovery Measures section of the Status Review already discusses implementation of disincentives and regulatory programs as recommended measures to protect western Joshua tree.
4071-4088	Of these last measures, all are necessary to provide basic baseline monitoring information for the WJT. Of particular importance would be to promote further investigations and biological research on the obligate pollinating moth, *Tegeticula synthetica*. The Status Review presents some basic information about the life history of the moths, but certain information pertinent to this Petition is lacking, such as: what are the temperature and moisture thresholds for the species? There is some indication that the moths are rare or absent at the lower and upper elevations of WJT. What are the limiting factors that determine its range? These are ***obligate***, co-dependent species. Therefore, the limiting environmental factors of one have direct consequences on the distribution of the other.	Text updated with bullet on investigating the life history, environmental tolerances, and distribution of *T. synthetica*.
4056-4088	One of the more practical measures, not mentioned above, would be to require consideration of projects within the YUBR South range to undertake environmental impact assessments in accordance with the CEQA guidelines. The Status Review describes this alternative (Lines 4007-4019), but, without formal listing, there would be no requirement that projects analyze potential impacts to WJT.	Impacts to western Joshua trees, alone, may not trigger the requirement for a lead agency to conduct an environmental review for a project under CEQA. Additionally, what is disclosed and mitigated under CEQA for unlisted species is largely determined by the lead agency. Changing this would require regulatory change or legislation, both of which are already mentioned in this section.

Line	Reviewer Comment	Department Response
N/A	If, however, the State designated the Southern WJT as a Regulated species, similar to other game and fish animals (§2116 *et seq.* of the Fish and Game Code), then CEQA review or at least regulatory review would be required, and permits would be necessary for removal of WJT plants on impacted properties. By this means, projects that have the potential to adversely impact WJTs would have to consider avoidance of WJTs to the extent possible and mitigation of impacts to WJTs in the case that Joshua trees cannot be avoided.	Changing section 2116 of the Fish and Game Code would require legislation which is already mentioned in this section.
4087	Regarding mitigation for removal of WJT, the trees may be successfully transplanted. San Bernardino County enacted a Joshua tree policy in the late 1980s that required developers to avoid the trees if possible, translocate them or make them available for translocation if necessary. During this time and through the 1990s, I worked with a landscape company, *NativeScapes*, transplanting Joshua trees using a 24-inch and 36-inch hydraulic tree spade. Joshua trees have a fibrous root system, like palm trees, and they can be excavated and placed in 36-inch or 48-inch boxes for re-location to protected areas on- or off-site. Trees as tall as 10-12 feet with moderate branching can be transplanted. Once the trees are installed, larger trees must be tethered to stabilize the weight of the tree; and transplants must receive additional irrigation maintenance through the first two summer seasons until the fibrous root system is reestablished.	Added a sentence with details from this comment in the Management Efforts Other section of the Status Review.

Line	Reviewer Comment	Department Response
4057, 4087	For this practice to be effective, it is essential that the State designate the WJT as a regulated species. Otherwise, if left to the individual county and city municipalities, the southern WJT would have only inconsistent standards for environmental review and mitigation. Standardized environmental assessment and mitigation measures may be included in the WJT Conservation Plan recommendations, described in #2 above.	Text updated with new bullet point per suggestion.
4057	The WJT Conservation Plan may also identify conserved areas for translocation of Joshua trees in anticipation of climate change, such as the Pioneertown Preserve. The Pioneertown Preserve is a 25,500-acre natural preserve managed by The Wildlands Conservancy. The area was burned during the Sawtooth Complex Fire in 2006 and native WJT woodland habitat has been very slow to recover. Translocation from lower elevation sites in the cities of Yucca Valley and Joshua Tree to the Pioneertown Preserve would facilitate WJT recovery from the fire, as well as help with climate adaptation by moving plants to higher elevations. Such translocation sites would require long-term management for fire and fuel modification, non-native grass and fuels management around the base of the trees, and irrigation maintenance until such trees are reestablished.	Text revised to include identification and management as well as preservation of western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia. Text revised to clarify that results from investigations into the feasibility, practicality, and risks of implementing assisted migration and translocation should be integrated into management and conservation actions.
4057	Other potential “climate refugia” may be identified in the Conservation Plan on State, Federal or private lands across the WJT range.	See response to previous comment.

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Science Institute
P.O. Box 944209
Sacramento, CA 94244-2090
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GAVIN NEWSOM, Governor
CHARLTON H. BONHAM, Director

Date: December 27th, 2021

Dr. Lynn Sweet
University of California, Riverside
UCR Palm Desert
75080 Frank Sinatra Drive
Palm Desert, CA 92211
lynn.sweet@ucr.edu

SUBJECT: STATUS REVIEW OF WESTERN JOSHUA TREE; CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW

Dear Dr. Sweet:

Thank you for agreeing to serve as a scientific peer reviewer for the California Department of Fish and Wildlife's (Department) Status Review of western Joshua tree (*Yucca brevifolia* Engelm.) (Status Review). A copy of the Status Review, dated December 2021, is enclosed for your use in the review. The Department seeks your expert analysis and input regarding the scientific validity of the Status Review, and its assessment and conclusions regarding the status of western Joshua tree in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information, the Department's related assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA), and the Department's overall conclusions. **The Department would appreciate receiving your peer review input on or before January 25, 2022**.

The Department seeks your scientific peer review as part of formal proceedings pending before the California Fish and Game Commission (Commission) under CESA. The Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened (Fish & G. Code, § 2070). The Department serves in an advisory capacity during CESA listing proceedings, charged by the Fish and Game Code to evaluate the status of the species based on the best scientific information available to the Department and make recommendations to the Commission, including if CESA listing is warranted (Fish & G. Code, § 2074.6).

The Commission received the petition to list western Joshua tree under CESA on October 21, 2019. On October 9, 2020, the Commission published findings regarding its

acceptance of the petition for consideration, and formally designated western Joshua tree as a candidate for listing as threatened under CESA. As a candidate species, western Joshua tree currently receives the same protections under CESA as threatened and endangered species. Formal acceptance of the petition triggered the Department's initiation of this Status Review, which will inform the Commission's decision on whether listing the species is warranted.

The draft Status Review forwarded to you today reflects the Department's effort to identify and analyze the best scientific information available regarding the status of western Joshua tree in California. The Department's preliminary recommendation on whether CESA listing is warranted for the species may be found in the draft Status Review. We underscore, however, that scientific peer review plays a critical role in the Department's analysis and effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code. Our analysis and expected recommendation to the Commission may change or be modified following your input. For your reference, under CESA an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion of its range due to one of more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code § 2067).

We ask you to focus your peer review on the best scientific information available regarding the status of western Joshua tree in California. Your peer review of the science and analysis regarding the population status and the threat categories prescribed in CESA's implementing regulations are particularly important (Cal. Code Regs., tit. 14, § 670.1(i)(1)(A); i.e., present or threatened modification or destruction of the species' habitat, overexploitation, predation, competition, disease, or other natural occurrences or human-related activities), as well as your opinion on whether the body of information and reasonable conclusions drawn from the information indicate that western Joshua tree is at serious risk of becoming extinct throughout all or a significant portion of its range in California (i.e. the species is endangered), or whether the species is likely to become so in the foreseeable future in the absence of CESA protection (i.e. threatened).

Please note that currently, the Department releases this Status Review solely to you as part of the peer review process, it is not yet public. However, your review will be appended to the final Status Review which will be released to the public upon receipt by the Commission. We ask that you please keep the Department's Status Review and your review of it confidential until the final Status Review is received by the Commission.

For ease of review and for accessibility by the public, the Department requests that you please submit your comments in list form by report page and line number. Please submit your comments electronically to me via email at Christina.Sloop@wildlife.ca.gov. For questions, I can be reached via email or by phone at (916) 261-1159. If there is anything the Department can do to facilitate your review, please let me know. Following receipt and consideration of peer review comments, the Department will prepare and submit its final Status Review report and related recommendation to the Commission. After at least a 30-day public review period, the Commission will consider the petition, the Department's Status Review, related recommendations including peer review comments, and public testimony during a regularly scheduled Commission meeting prior to making their decision.

Thank you again for your contribution to the Status Review effort and the important input it contributes to the CESA listing process.

Sincerely,

Christina Sloop, Science Advisor & Science Institute Lead
California Department of Fish and Wildlife

Enclosure

ec: California Department of Fish and Wildlife

Isabel Baer, Program Manager
Native Plant Program
Habitat Conservation Planning Branch
[redacted]

Jeb Bjerke, Senior Environmental Scientist (Specialist)
Native Plant Program
Habitat Conservation Planning Branch
[redacted]

Christina Sloop, Science Advisor & Science Institute Lead
California Department of Fish and Wildlife

RE: Peer Review, STATUS REVIEW OF WESTERN JOSHUA TREE; CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

January 25, 2022

To the Department:

I appreciate the Department's statement that the combined threats to the western Joshua tree are cause for substantial concern (line 3980, Summary). The findings that the species is widespread and abundant in some areas are both supported by evidence presented. The Department appears on the one hand to take seriously the threat of climate change and the many published studies detailing species distribution models that predict reductions in suitable habitat for the species. However, on the other hand, there is doubt cast on what the meaning is of these predictions, without an effective framework for evaluating such modeling.

The reason that the predictions of habitat loss (by the six models summarized) are discounted appears to be 1) the associated uncertainty in the models themselves (e.g. in model accuracy where there are differences in actual distribution differ from predictions, or criticisms of the data used), and 2) uncertainty about the species response. To this reviewer, there would seem to be less uncertainty about some substantial reduction in habitat in the foreseeable future, as predicted by all six models, and likely others, indicating strong predicted exposure to climate change. The uncertainty surrounding species response, or what this means for reductions in species abundance or range indicates sensitivity, or response to climate change. These need to be considered along with adaptive capacity, and the latter two may be questions that remain more unclear. However, several lines of evidence were presented that indicate sensitivity to e.g. decadal droughts, for populations of the species that are found to be unsustainable or declining in various parts of the range. This would seem to be in contrast to the assertion that unsuitable conditions over longer timescales, towards the end of century would not be predicted to impact the range of the species. I found one of the main foundations of the argument, the paleoecological evidence that the species may take thousands of years to respond to a rapid change in climate to be poorly substantiated, as explained, although paleoecology is not my area of expertise. It is true that there are some changes to vegetation that are not as linear as expected over the short term (for example, Abella et al. 2019), and this may be especially true in regions that are diverse topographically and with strong effects of insolation, soil moisture, texture and depth, etc., as well as with high exposure (due to low cloud cover and low humidity) to a highly variable short-term climate. This does not mean that long-term exposure and trends in increased warmth and decreased moisture availability will not impact vegetation over the long-term.

In all, there is apparently a lack of systematic demographic data range-wide, although a meta-analysis could have been used to summarize these findings more effectively from the many small demographic studies described in text form. These need to be contextualized with respect to the position within the range, and this was difficult to properly contextualized as presented. In all, however, the review, listing hundreds of citations, and text of more than 100 pages was useful in documenting the available science and areas needed for further research.

Thank you for considering my specific comments, below.

Sincerely,

Lynn Sweet, PhD
Research Ecologist, University of California, Riverside

Major Issue:
Please indicate why the following was not included:
Thomas, K.A., Guertin, P.P., and Gass, L., 2012, Plant distributions in the southwestern United States; a scenario assessment of the modern-day and future distribution ranges of 166 species: U.S. Geological Survey Open-File Report 2012–1020, 83 p. and 166-page appendix, available at http://pubs.usgs.gov/of/2012/1020/.
https://pubs.usgs.gov/of/2012/1020/
https://pubs.usgs.gov/of/2012/1020/of2012-1020_appendix_b/

Minor Issues by Line Number:

Line 195: Decline due "in part" to, lest it conflict with following sentence. I'm not aware of a study that has weighed all factors in a relative sense, including climate change, fire, habitat destruction and the impacts of invasive species together, other than this Review.

Line 368: Please clarify if this regarding "Yucca species"; it's not clear as written.

Line 374: This is an interesting note, but I find it to be speculative in the reference cited. This reference cited is a study on the Eastern tree in southwestern Utah. Although this study was primarily on blackbrush, they excavated a pit and noted the presence of a Joshua tree root 11m away; this was not conclusively tied to the individual measured, however, and could have been from an undetected Joshua tree seedling that was nearer by. For this reason, it would be important to add that while not impossible, there is no reason to think that this rooting radius is typical, and this may be relevant to protection measures. It's surprising that there is no better reference for rooting depth. At the very least, a description of what is seen here, which has been in the public domain, demonstrating what is seen along roadsides would be helpful to the reader:

https://commons.wikimedia.org/wiki/File:Joshua_tree_(Yucca_brevifolia)_roots;_Covington_Flat.jpg

Line 379-380: May be more common. I don't see evidence presented here to make this generalization. This is currently under study at Joshua Tree National Park.

Line 409: Because these numbers are relevant to the demographic information later stated to be needed, a citation is necessary here.

Line 423: Earliest known, to whom? Please qualify that this is a statement about European settler accounts of the species, and there may be extensive Traditional Ecological Knowledge of the species that may not be recorded in a way accessible to this reviewer.

Line 470: To the degree I am familiar with both species, but as an ecologist and not a taxonomist, I concur with Smith et al. 2021 that they are distinct and it is therefore appropriate to treat this species separately.

Line 637: Due to this method and the patchy distribution, this does represent the range as looking larger than it is, as you state in line 642. I believe there are more errors of commission here than omission per the range, due to the stature of the tree.

Line 640-655: This all is highly speculative and while somewhat helpful to bookend the possibilities, detracts in its apparent precision (reporting decimals to the hundredth?).

Line 672: While this could be, if accurate, a compelling illustration of the relatively large range of the species spatially and number of stands of trees, a reader unfamiliar with how these EA's are counted would be hard pressed to understand how the Department came to this conclusion. Please provide detail the qualifications of a locality to be counted as an EA.

Line 766: Please note that this was a short-term study. We don't have evidence that moths are never found at these locations and although it is a significant trend and could indicate declines in pollination at these sites, this is likely a phenomenon that shifts in space and time year-to-year.

Line 803: I believe the name has changed to California scrub jay.

Line 805 (paragraph): Agreed that the evidence is that rodents are a primary mode of dispersal, not wind, and within short distances. Second-caching is speculative and implies that territories would be extended in a linear manner further away.

Line 882: Germination and viability are different. It might be advantageous to mention this difference here for the reader to be clear. Out of the seeds formed, as mentioned earlier, many are consumed by larvae. Thus from the seeds formed within the fruit not all are viable and I would assume without descriptions that studies have used only the apparently viable seeds that are black in color. This is also important for a full life cycle assessment as it affects # effective genets that result from the fruit. Either way evidence is that both are fairly high. It's important to state whether this is out of selected viable seed. Kew: https://data.kew.org/sid/SidServlet?ID=24500&Num=DN5 88% germination.

Line 922: Establishment-stage bottlenecks for long-lived species are not unusual, as it takes very few successful seedlings to maintain communities of sparse and long-lived individuals. However, this also means that demography should be closely monitored. As suggested by studies on other species (e.g. oaks (Tyler et al. 2006 Quart Rev Bio ; Kwit et al 2004), conservation should focus on early stages prior to significant declines.

Line 946: Cite Loik et al.
Loik, M.E., Onge, C.D.S. and Rogers, J., 2000. Post-Fire Recruitment of Yucca brevifolia and Yucca schidigera in. *Open-file Report*, *2000*(62), p.79.
Also, I have not seen a study definitively documenting this in natural systems (Brittingham and Walker looked at the Eastern tree. Many Joshua tree stands lack both extensive blackbrush and creosotebush, My impression is that there are many more species that act as nurse plants, including bunchgrasses, and occasionally juniper, or other sheltered sites including rocks and cacti.

Line 963: The paper referenced states Yucca Flat in Nevada as the location of the study.

Line 990: Leaf blades per plant? I suggest this be clarified as per growing tip.

Line 998 and paragraph: While there is certainly variability in growth rates range-wide, rates within a smaller region are likely more uniform, so that relative heights of trees within a smaller regions ought to be more comparable when using this as a proxy for age.

Line 1039: The term "refugial" with respect to climate suggests suitable, or steady climate conditions with regard to the species environmental niche. I'm not sure it is used here to mean this unless the author means specifically all areas the species grows currently.

Line 1085: Statement about minimum rate without specification very generic as to be not very useful here.

Line 1182: It is critical to note whether this mutualism appears to be required for germination and growth. Because these seeds are grown in sterilized conditions, I would assume that not for the former, but for restoration and to denote overall vulnerability, please state any evidence as to whether this is required for the trees to survive to reproductive age. The study cited may be the only study on this topic, and therefore the information is lacking.

1210: If the author does not mean to say that Joshua trees occur on dunes, then please rephrase. I am not familiar with that area, but I have never seen Joshua trees on active dunes, or sand fields. Here is must be meant that these are stabilized sand features that are supporting permanent vegetation?

Line 1230: Please note the scale they are indicating that these factors were not important, and relative to what. For instance, pH would certainly exclude the Joshua tree from some habitats globally, but I assume here this is *relative* to other factors, on a *regional* scale?

Line 1258: I disagree; these plants are likely much more shallow-rooted than similar-stature dicot trees and especially phreatophytes, which may be classically described as "deep rooted." Please provide the citation with evidence that the roots may be characterized as deep.

Line 1268: Relatively high precipitation for a desert or arid scrub system.

Line 1308: Characterized as using the C3 photosynthetic pathway, this would be typical. However, since the trees are evergreen (where many desert plants are drought deciduous) the trees are losing water, and likely summer water prevents further water loss by decreasing soil evaporation and plant transpiration.

Line 1438 (section): The Sweet et al. 2019 peer-reviewed published study data is the same as cited here as Frakes 2017, after quality checks during analysis for publication. Although only summarized, unfortunately in the paper they are published as average densities on 14 300 x 300m plots within Joshua Tree National Park and one adjacent parcel in California. Quoting Sweet and others, page 7: "The total number of live Joshua trees per macroplot ranged from 48 to 562 trees per 9 ha (5.3-62.4 trees/ha). To be clear, the data used for this peer-reviewed published study is the same as that cited here as personal communication provided by Frakes et al. 2017, after quality control.

Line 1461: Confidence reported here appears to indicate the variation between plots (aka similar to precision), NOT the true confidence in the estimate (aka accuracy), which would have to be field verified. Please modify this phrase to indicate what this confidence refers to.

Line 1475: Please note the period of time for which this decline is relevant. Note also any evidence of pre-settlement influence on Joshua tree patterns.

Line 1519-1524: This is a qualitative statement that is directly contradicted by the evidence presented in the last paragraph (Line 1504) stating that some portion of the apparent habitat of the tree had been lost to development. To say that this has not impacted the "range" of the tree is being arbitrary about the definition of "range" as the scale of the term in the usage here is not defined. If defined as the maximum area of a polygon simply drawn from the outermost individuals, the loss of any individual at the range edge therefore impacts the range of the species. Thus it is unclear at what scale the Department is setting the threshold for significant range loss, and this statement is not supported.

Line 1538-1594: Direct population monitoring. While none of these is a complete analysis, taken together, there is noted either no recruitment over time spans of one to several decades, or declines in more studies: Comanor and Clark 2000 for Victorville; Comanor and

Clark 2000 for JTNP; Cornett 2016; Cornett 2020, and Cornett 2009, 2012 and 2014 JTNP; DeFalco et al. 2010; Gilliland et al 2006. Whereas only one study mentioned any population increase (Cornett 2013). This was presented in a long section and this reviewer found it difficult to put this information together and into context.

Line 1584: Agreed on this point. I do not have access to the report cited here, however as described, there is no way to possibly definitively identify changes in range or density using the different methodologies in different years. To boot, it is highly unlikely that this magnitude of change has occurred, and if so, would need to be field verified.

Line 1667: Any trends in population size should be with reference to the population's specific locality with respect to the range edge. Northern populations may be expected to be increasing. Southern or dry edge populations may be decreasing. As reported, this reviewer is not able to discern the meaning of all of this information in the time allotted and it should be summarized by geographic locality, source of information, and trend.

Line 1640 paragraph, Line 1714 and 1775: Esque et al. is a study by highly respected scientists, however, I do not have access to the paper, and no numbers are reported here. As stated in this review, demographic patterns may differ among areas of the species range and especially between two species. It seems that the data are being combined for consideration across localities, quoting lines 1652-1654, "aggregated among sampling locations within the range of both the western Joshua tree and eastern Joshua tree." Thus, I'm not sure why as a reviewer I can accept a broad statement indicating population stability based on the information solely presented here, to characterize entire Park Service units together. I would venture to guess that these authors placed those plots across spatial/environmental gradients exactly to study these differences. It could be that I misunderstand the statements here. Please clarify.

Line 1779: I believe a formal meta-analysis of effects detected and associated uncertainty is necessary to make a definitive statement here. I agree that there is a lack of range-wide data that is standardized and thorough enough to model population trends thoroughly. However many of the trends reported here are troubling in terms of population sustainability in some areas of the range.

Line 1812: Whether these climate variations occurred at the same temporal scale as is predicted for anthropogenic climate change in the industrial age, however, is relevant to this discussion. If there is evidence that these past changes are comparable, temporally or spatially as what climate scientists predict will occur, please state that here.

Line 1886: Cite Gonzalez et al. 2018 Env. Research Letters.

Line 1906: There is uncertainty with respect to the future climate scenarios; however, the way this is written incorrectly characterizes the prediction of an increase in precipitation in the region as the "current" model, which is misleading to the non-specialist reader. The simulations in the citation, Allen and Luptowitz do not represent all "current" climate models (as far as the CMIP5); only the subset that those authors chose that best simulate

the observed El Nino, as I understand it, the CESM and GFDL from CMIP5. Looking at a range of scenarios from the CMIP5, Gonzalez 2019 (Anthropogenic Climate Change in Joshua Tree National Park, California, USA. US National Park Service) stated that half of the models predict increased precipitation and half predict a decrease for Joshua Tree National park, while thirty three predict an increase of 4.6 C in temperature, which would lead to an increase in aridity regardless. I appreciate the work of Allen and colleague, I'm simply pointing out that this is not all current scenarios, and among them there is much discussion due to the difference in effects on jet stream and storm tracks based by the scenario, the discussion of which is outside of my expertise.
If the range and uncertainty of the predictions for the region are not going to be presented in a standardized manner here (see Neelin et al. 2013 J Climate), I would be satisfied if a qualifier is added here, "According to *some* current climate models," as many suggest warmer and drier, and it is to be determined which are in fact more accurate.

Line 1933: Agreed.

Line 1944: I do not know if this has been substantiated, and whether this precision is justified.

Line 1960-1972: Agreed, this seems supported by the evidence.

Line 2025: Agreed that this is a possibility based on other scientific studies.

Line 2065: I don't think this is intentional, however, this description of species distribution models seems odd, and implies that scientists performing these techniques modify variables or data manually and may detract from the perception of their objectivity unnecessarily. Perhaps there is a better description indicating that we "project" the species model on to new given conditions, e.g. those associated with future climates, as produced by climatologists. Try Franklin or Elith for better plain-terms descriptions.

Line 2080: This is the concept of sensitivity. Exposure is defined by the change in conditions experienced; sensitivity is the impact it may have on organisms, as defined by its biology and ecological relationships. See Dawson et al. 2011. Science.

Line 2123: It is unfortunate that this is the only range-wide study available, and it is significantly impacted by the inclusion of two species in the model, one of which is not being assessed here. Many efforts are currently underway by several entities to map the species distribution and model future distribution, mindfully and using data from the species separately. Relevant and not cited here is the model of Thomas et al. 2012 USGS (see above for reference) that shows substantial declines, and has updated information over Cole et al., which relied heavily on old, spatially-coarse and geo-referenced data, much of which was digitized from maps manually.

Line 2135-2144: There are some inherent limitations in the ability to infer biology using species and habitat distribution modeling because of the difficulty in isolating the effect of any one variable using these techniques without accounting for colinearity statistically. In other words, climate variables are often highly correlated, and assessing them independently requires further analysis. Inferring these relationships is more appropriate for models based on mechanistic understanding of species tolerances as opposed to correlations.

Line 2156: SDM's can certainly be improved by carefully choosing and vetting data inputs, variable choice, and even using advanced techniques as necessary, this statement is quite dismissive, if this is the only way to predict the threat of future climate change to the species. Predictions are always associated with a range of uncertainty. Invoking physics, Dr. Prescod-Weinstein (2021) explains that every scenario is possible, but each is associated with a probability. Here, if there is no acceptable probability defined, relying on models that have been peer-reviewed by the expert scientific community is probably the most reliable way to make predictions about changes in species ranges. The last 20 years have seen, as you state, at least 6 models of this species, each building upon the last to better use for each study aim. To dismiss this route of analysis on the basis of each shortcoming is shortsighted.

Line 2315: I see this is an interpretation of Sweet et al. 2019. The difference between the two first models, for the historic 30 year periods, are based on the suitability using a historic or observed downscaled hydrologic gridded datasets from Flint and Flint as cited. The differences in temperature and precipitation between each of the climate datasets used is found within Table 3. As you can see, the 1981-2010 time stamp is the only time for which there was an increase in precipitation within the variable dataset from the historic period of 1951-1980 to that time period. In other words, the model is then projecting suitable area for the Joshua tree across space with an increase in precipitation and an increase in temperature, which resulted in a lower listed suitable area. As stated in this Review, climate is variable on shorter time periods especially in the Mojave Desert, and this variability has an impact on extrapolated estimates from measurement stations, especially in a topographically-complex and measurement-poor region (see Heintzman et al. 2022 J App Met and Clim), as you point out later in Line 2396. If the climate dataset as gridded accurately represents the climatic landscape during the second time step, this may support the proposal that the tree is able to weather shorter-term changes in climate, as the Department asserts. This time stamp was included to be fully transparent, using all time steps available. However, all future scenarios under MIROC listed show an increase in both min and max temperature, decreases in precipitation, and aridity (climatic water deficit), all of which demonstrate that this would reduce suitable habitat, which is logical and consistent with all other models. This would happen over a longer-term period, which is more likely to have consistent impacts on the species than changes from one 30 year period to the next.

Line 2317: This was an oversight, I am happy to provide these data. I thought I had sent it, but I must have not, I do apologize. To answer the criticism here, any difference in the abundance of where seedlings may occur, similar to the Department's summary of the Barrows seedling habitat model, indicates a possible shift in where trees will occur into the future. I can confirm that the areas outside of refugia demonstrated demographic histogram patterns much more like those deemed stable or declining in previous sections than low recruiting plots. These are the same plots cited as Frakes et al 2017 in this Review.

Line 2419: Sweet et al. reported an AUC for the model, which is often used as an indication of the sensitivity and specificity of the model. It should be listed here.

Line 2425: Again this refers to the sensitivity to the climate change exposure, consider citing Dawson et al. 2011 Science and utilizing this terminology.

Line 2989: However, given upward trend indicated, if larger and larger areas burn, that may have some impact that could start to shift the ability of populations to be sustainable long term and lead to range contraction eventually, as is stated later. I would put a slightly higher emphasis on this perhaps than the department, but agree that it would not be the sole factor in range decreases.

Line 3054: Small, but important and relevant to early seedling stages, which is relevant to restoration.

Peer Review Comments from Dr. Lynn Sweet on the western Joshua tree (*Yucca brevifolia*) Status Review and California Department of Fish and Wildlife Responses

Note: Comments not associated with specific line numbers by the peer reviewer have "N/A" in the Line column.

Line	Reviewer Comment	Department Response
N/A	The Department appears on the one hand to take seriously the threat of climate change and the many published studies detailing species distribution models that predict reductions in suitable habitat for the species. However, on the other hand, there is doubt cast on what the meaning is of these predictions, without an effective framework for evaluating such modeling.	The Department reviewed and added a citation to Sofaer et al. (2019) which provides an effective framework for evaluating the species distribution modeling efforts presented in the Status Review. As described in the Status Review, the loss of 20th century suitable climate conditions for western Joshua tree from some areas is expected to have negative effects on populations in the affected areas, but the Department does not have information indicating that western Joshua trees in the affected areas will likely die, or that populations are likely to cease reproducing or be no longer sustainable at the end of the 21st century.
N/A	The reason that the predictions of habitat loss (by the six models summarized) are discounted appears to be 1) the associated uncertainty in the models themselves (e.g. in model accuracy where there are differences in actual distribution differ from predictions, or criticisms of the data used), and 2) uncertainty about the species response. To this reviewer, there would seem to be less uncertainty about some substantial reduction in habitat in the foreseeable future, as predicted by all six models, and likely others, indicating strong predicted exposure to climate change. The uncertainty surrounding species response, or what this means for reductions in species abundance or range indicates sensitivity, or response to climate change. These need to be considered along with adaptive capacity, and the latter two may be questions that remain more unclear.	As stated in the Status Review, the degree to which climate change will affect western Joshua tree populations will depend on both the magnitude of climate change and the species' resilience to a changing climate. The Department acknowledges that species distribution modeling efforts produced for the species so far suggest that climate change will generally have negative effects on much of the current southern range of the species. The Department agrees that the response of the species to the effects of climate change is a greater uncertainty than whether or not climate change will affect large portions of the species range.

Line	Reviewer Comment	Department Response
N/A	However, several lines of evidence were presented that indicate sensitivity to e.g. decadal droughts, for populations of the species that are found to be unsustainable or declining in various parts of the range. This would seem to be in contrast to the assertion that unsuitable conditions over longer timescales, towards the end of century would not be predicted to impact the range of the species.	Information available to the Department regarding the negative effects of droughts on population abundance have been presented in the Status Review, however the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts on existing populations that are severe enough to threaten to eliminate the species from a significant portion of its range by the end of the 21st century.
N/A	I found one of the main foundations of the argument, the paleoecological evidence that the species may take thousands of years to respond to a rapid change in climate to be poorly substantiated, as explained, although paleoecology is not my area of expertise.	Additional information from Cole et al. (2011) on this range shift was added to the Climate Change Direct Effects section of the Status Review.
N/A	It is true that there are some changes to vegetation that are not as linear as expected over the short term (for example, Abella et al. 2019), and this may be especially true in regions that are diverse topographically and with strong effects of insolation, soil moisture, texture and depth, etc., as well as with high exposure (due to low cloud cover and low humidity) to a highly variable short-term climate. This does not mean that long-term exposure and trends in increased warmth and decreased moisture availability will not impact vegetation over the long-term.	The Abella et al. 2019 source cited by the reviewer may be Abella, S.R., R.J. Guida, C.L. Roberts, C.M. Norman, and J.S. Holland. 2019. Persistence and turnover in desert plant communities during a 37-yr period of land use and climate change. Ecological Monographs 89:e01390. Comment noted.

Line	Reviewer Comment	Department Response
N/A	In all, there is apparently a lack of systematic demographic data range-wide, although a meta-analysis could have been used to summarize these findings more effectively from the many small demographic studies described in text form. These need to be contextualized with respect to the position within the range, and this was difficult to properly contextualized as presented.	A subsection summarizing available demographic information was added at the end of the Demographic Information section of the Status Review. The Department agrees that there is a lack of systematic range-wide demographic data, which would be very useful for assessing the population trend of the species. Demographic data was to be compiled from available sources.
N/A	Please indicate why the following was not included: Thomas, K.A., Guertin, P.P., and Gass, L., 2012, Plant distributions in the southwestern United States; a scenario assessment of the modern-day and future distribution ranges of 166 species: U.S. Geological Survey Open-File Report 2012–1020, 83 p. and 166-page appendix, available at http://pubs.usgs.gov/of/2012/1020/. https://pubs.usgs.gov/of/2012/1020/ https://pubs.usgs.gov/of/2012/1020/of2012-1020_appendix_b/	Document reviewed, cited, and a discussion of it was added to the Species Distribution Models section of the Status Review.
195	Decline due “in part” to, lest it conflict with following sentence. I’m not aware of a study that has weighed all factors in a relative sense, including climate change, fire, habitat destruction and the impacts of invasive species together, other than this Review.	Added “largely” to the sentence because habitat modification and destruction in a broad sense that includes wildfire is considered to be the largest source of habitat loss and population decline, as discussed primarily in the Inferred Long-term Trends section of the Status Review.
368	Please clarify if this regarding “Yucca species”; it’s not clear as written.	Text updated per suggestion.

Line	Reviewer Comment	Department Response
374	This is an interesting note, but I find it to be speculative in the reference cited. This reference cited is a study on the Eastern tree in southwestern Utah. Although this study was primarily on blackbrush, they excavated a pit and noted the presence of a Joshua tree root 11m away; this was not conclusively tied to the individual measured, however, and could have been from an undetected Joshua tree seedling that was nearer by. For this reason, it would be important to add that while not impossible, there is no reason to think that this rooting radius is typical, and this may be relevant to protection measures. It's surprising that there is no better reference for rooting depth. At the very least, a description of what is seen here, which has been in the public domain, demonstrating what is seen along roadsides would be helpful to the reader: https://commons.wikimedia.org/wiki/File:Joshua_tree_(Yucca_brevifolia)_roots;_Covington_Flat.jpg	Sentence edited to state that underground roots of eastern Joshua tree were observed 11 m (36 ft) away from *what appeared to be* the aboveground portion of the plant by Bowns (1973).
379-380	May be more common. I don't see evidence presented here to make this generalization. This is currently under study at Joshua Tree National Park.	Added citation to Rowlands (1978) to justify this sentence.
409	Because these numbers are relevant to the demographic information later stated to be needed, a citation is necessary here.	Added citation to Borchert (2021).
423	Earliest known, to whom? Please qualify that this is a statement about European settler accounts of the species, and there may be extensive Traditional Ecological Knowledge of the species that may not be recorded in a way accessible to this reviewer.	Text updated per suggestion.
470	To the degree I am familiar with both species, but as an ecologist and not a taxonomist, I concur with Smith et al. 2021 that they are distinct and it is therefore appropriate to treat this species separately.	Comment noted

Line	Reviewer Comment	Department Response
637	Due to this method and the patchy distribution, this does represent the range as looking larger than it is, as you state in line 642. I believe there are more errors of commission here than omission per the range, due to the stature of the tree.	Text in this section has been updated for clarity in response to this and other peer review comments.
640-655	This all is highly speculative and while somewhat helpful to bookend the possibilities, detracts in its apparent precision (reporting decimals to the hundredth?).	The 0.2 km distance was selected by the GIS analyst who performed these calculations based on prior experience with producing similar map products. The decimals to the hundredth is a function of converting km to mi. The Department also wishes to be as transparent as possible regarding assumptions, because these range area estimates are also used for abundance estimates.
672	While this could be, if accurate, a compelling illustration of the relatively large range of the species spatially and number of stands of trees, a reader unfamiliar with how these EA's are counted would be hard pressed to understand how the Department came to this conclusion. Please provide detail the qualifications of a locality to be counted as an EA.	Text updated with details of CNDDB mapping methodology.
766	Please note that this was a short-term study. We don't have evidence that moths are never found at these locations and although it is a significant trend and could indicate declines in pollination at these sites, this is likely a phenomenon that shifts in space and time year-to-year.	Added a sentence to clarify that these results were from one short-term study conducted within one continuous western Joshua tree population.
803	I believe the name has changed to California scrub jay.	Text updated per suggestion
805	Agreed that the evidence is that rodents are a primary mode of dispersal, not wind, and within short distances. Second-caching is speculative and implies that territories would be extended in a linear manner further away.	Evidence of secondary caching was observed by Vander Wall et al. (2006) and is therefore not speculative. The text is speculative regarding maximum dispersal distance- making it clear what this additive distance is based on: "Assuming seeds are sometimes re-cached in the same direction away from the source tree".

Line	Reviewer Comment	Department Response
882	Germination and viability are different. It might be advantageous to mention this difference here for the reader to be clear. Out of the seeds formed, as mentioned earlier, many are consumed by larvae. Thus from the seeds formed within the fruit not all are viable and I would assume without descriptions that studies have used only the apparently viable seeds that are black in color. This is also important for a full life cycle assessment as it affects # effective genets that result from the fruit. Either way evidence is that both are fairly high. It's important to state whether this is out of selected viable seed. Kew: https://data.kew.org/sid/SidServlet?ID=24500&Num=DN5 88% germination.	Text updated to clarify that seed viability is the ability of a seed to germinate, and to mention that seeds used for studies were likely selected for apparent viability.
922	Establishment-stage bottlenecks for long-lived species are not unusual, as it takes very few successful seedlings to maintain communities of sparse and long-lived individuals. However, this also means that demography should be closely monitored. As suggested by studies on other species (e.g. oaks (Tyler et al. 2006 Quart Rev Bio ; Kwit et al 2004), conservation should focus on early stages prior to significant declines.	Sources provided by the reviewer were reviewed. According to Kwit et al. 2004, conservation efforts of long-lived slow-growing trees should focus on protecting established reproductive individuals as well as juveniles. The Management Recommendations section of the Status Review already includes "Identify, preserve, and manage western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia."
946	Cite Loik et al. Loik, M.E., Onge, C.D.S. and Rogers, J., 2000. Post-Fire Recruitment of Yucca brevifolia and Yucca schidigera in. *Open-file Report*, *2000*(62), p.79. Also, I have not seen a study definitively documenting this in natural systems (Brittingham and Walker looked at the Eastern tree. Many Joshua tree stands lack both extensive blackbrush and creosotebush, My impression is that there are many more species that act as nurse plants, including bunchgrasses, and occasionally juniper, or other sheltered sites including rocks and cacti.	Added citation per suggestion. The text already says that "Many plants in Joshua tree habitat… can act as nurse plants…" so the sentence is already acknowledging that these are just two examples. The paragraph also indicates the information is for Joshua tree and not specific to western Joshua tree.

Line	Reviewer Comment	Department Response
963	The paper referenced states Yucca Flat in Nevada as the location of the study.	Text updated per suggestion.
990	Leaf blades per plant? I suggest this be clarified as per growing tip	Text updated per suggestion.
998	While there is certainly variability in growth rates range-wide, rates within a smaller region are likely more uniform, so that relative heights of trees within a smaller regions ought to be more comparable when using this as a proxy for age.	Text updated per suggestion. A reference to the Demographic Information section of the Status Review was added later in this paragraph.
1039	The term “refugial” with respect to climate suggests suitable, or steady climate conditions with regard to the species environmental niche. I’m not sure it is used here to mean this unless the author means specifically all areas the species grows currently.	Removed “and refugial” from the sentence.
1085	Statement about minimum rate without specification very generic as to be not very useful here.	Revised sentence to state that this rate for western Joshua tree is not known.
1182	It is critical to note whether this mutualism appears to be required for germination and growth. Because these seeds are grown in sterilized conditions, I would assume that not for the former, but for restoration and to denote overall vulnerability, please state any evidence as to whether this is required for the trees to survive to reproductive age. The study cited may be the only study on this topic, and therefore the information is lacking.	Added a statement that it is not known whether mycorrhizal associations are required for western Joshua tree recruitment.
1210	If the author does not mean to say that Joshua trees occur on dunes, then please rephrase. I am not familiar with that area, but I have never seen Joshua trees on active dunes, or sand fields. Here is must be meant that these are stabilized sand features that are supporting permanent vegetation?	This information is from the cited source.
1230	Please note the scale they are indicating that these factors were not important, and relative to what. For instance, pH would certainly exclude the Joshua tree from some habitats globally, but I assume here this is *relative* to other factors, on a *regional* scale?	Text updated to make it clear that the statement was for within the study area near Riverside, California.

Line	Reviewer Comment	Department Response
1258	I disagree; these plants are likely much more shallow-rooted than similar stature dicot trees and especially phreatophytes, which may be classically described as “deep rooted.” Please provide the citation with evidence that the roots may be characterized as deep.	Changed text to “extensive” roots instead of “deep” per Gucker 2006. Citations for root structure are in the Species Description section of the Status Review.
1268	Relatively high precipitation for a desert or arid scrub system.	It is unclear what the reviewer is commenting on here.
1308	Characterized as using the C3 photosynthetic pathway, this would be typical. However, since the trees are evergreen (where many desert plants are drought deciduous) the trees are losing water, and likely summer water prevents further water loss by decreasing soil evaporation and plant transpiration.	Updated text to remove an assumption of reliance, and only state that western Joshua trees in the western Mojave Desert receive a greater proportion of their annual precipitation in the winter.
1438	The Sweet et al. 2019 peer-reviewed published study data is the same as cited here as Frakes 2017, after quality checks during analysis for publication. Although only summarized, unfortunately in the paper they are published as average densities on 14 300 x 300m plots within Joshua Tree National Park and one adjacent parcel in California. Quoting Sweet and others, page 7: “The total number of live Joshua trees per macroplot ranged from 48 to 562 trees per 9 ha (5.3-62.4 trees/ha). To be clear, the data used for this peer-reviewed published study is the same as that cited here as personal communication provided by Frakes et al. 2017, after quality control.	Text updated to reference Sweet et al. 2019, and density values changed.
1461	Confidence reported here appears to indicate the variation between plots (aka similar to precision), NOT the true confidence in the estimate (aka accuracy), which would have to be field verified. Please modify this phrase to indicate what this confidence refers to.	Text updated to state 95% statistical confidence based on the methods in Elzinga et al. (1998).

Line	Reviewer Comment	Department Response
1475	Please note the period of time for which this decline is relevant. Note also any evidence of pre-settlement influence on Joshua tree patterns.	The Department does not have a precise year that it considers to be the beginning of European settlement of the Mojave but added the phrase “during and before the 19th century”. Also added a sentence that says “Available information on Joshua trees population trends prior to European settlement is provided in the following section.”
1519-1524	This is a qualitative statement that is directly contradicted by the evidence presented in the last paragraph (Line 1504) stating that some portion of the apparent habitat of the tree had been lost to development. To say that this has not impacted the “range” of the tree is being arbitrary about the definition of “range” as the scale of the term in the usage here is not defined. If defined as the maximum area of a polygon simply drawn from the outermost individuals, the loss of any individual at the range edge therefore impacts the range of the species. Thus it is unclear at what scale the Department is setting the threshold for significant range loss, and this statement is not supported.	Added some clarifying words to further distinguish the two sentences that the Reviewer finds contradictory. Range is defined as “the general geographical area in which an organism occurs” in the Range and Distribution section of the Status Review, which also states: “Range is largely independent of species abundance, because population declines within an area do not necessarily change the overall geographical area in which an organism occurs.” This definition of range is reiterated parenthetically here in response to the reviewer comment. “Significant range” is a subjective term that should be evaluated on a case-by-case basis based upon all relevant information, and was evaluated for western Joshua tree based on the information presented in the Status Review. The Department also added a paragraph in the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat to discuss uncertainty regarding the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review.

Line	Reviewer Comment	Department Response
1538-1594	Direct population monitoring. While none of these is a complete analysis, taken together, there is noted either no recruitment over time spans of one to several decades, or declines in more studies: Comanor and Clark 2000 for Victorville; Comanor and Clark 2000 for JTNP; Cornett 2016; Cornett 2020, and Cornett 2009, 2012 and 2014 JTNP; DeFalco et al. 2010; Gilliland et al 2006. Whereas only one study mentioned any population increase (Cornett 2013). This was presented in a long section and this reviewer found it difficult to put this information together and into context.	Added a sentence to the first paragraph of this section to summarize. Also added more information on the limitations of the available direct population monitoring efforts.
1584	Agreed on this point. I do not have access to the report cited here, however as described, there is no way to possibly definitively identify changes in range or density using the different methodologies in different years. To boot, it is highly unlikely that this magnitude of change has occurred, and if so, would need to be field verified.	Comment noted
1667	Any trends in population size should be with reference to the population's specific locality with respect to the range edge. Northern populations may be expected to be increasing. Southern or dry edge populations may be decreasing. As reported, this reviewer is not able to discern the meaning of all of this information in the time allotted and it should be summarized by geographic locality, source of information, and trend.	A subsection summarizing available demographic information was added at the end of the Demographic Information section of the Status Review. As stated in the Status Review, there does not appear to be a uniform range-wide trend.

Line	Reviewer Comment	Department Response
1714, 1775	Esque et al. is a study by highly respected scientists, however, I do not have access to the paper, and no numbers are reported here. As stated in this review, demographic patterns may differ among areas of the species range and especially between two species. It seems that the data are being combined for consideration across localities, quoting lines 1652-1654, “aggregated among sampling locations within the range of both the western Joshua tree and eastern Joshua tree.” Thus, I’m not sure why as a reviewer I can accept a broad statement indicating population stability based on the information solely presented here, to characterize entire Park Service units together. I would venture to guess that these authors placed those plots across spatial/environmental gradients exactly to study these differences. It could be that I misunderstand the statements here. Please clarify.	Esque et al. (2010) is a publicly available document, and the report does not isolate height data on western Joshua tree and eastern Joshua tree and does not isolate data by National Park Service Unit. The Department agrees that additional analysis of data used for this study would be useful, but the Department doesn’t have access to this data. The Department is simply reporting the demographic data that is available. Minor revisions to text were made for clarity.
1779	I believe a formal meta-analysis of effects detected and associated uncertainty is necessary to make a definitive statement here. I agree that there is a lack of range-wide data that is standardized and thorough enough to model population trends thoroughly. However many of the trends reported here are troubling in terms of population sustainability in some areas of the range.	A formal meta-analysis is beyond the scope of this Status Review. The Status Review acknowledges that some populations may decline, but current information taken together suggests that the species is not likely to disappear from a significant portion of its range in the foreseeable future.
1812	Whether these climate variations occurred at the same temporal scale as is predicted for anthropogenic climate change in the industrial age, however, is relevant to this discussion. If there is evidence that these past changes are comparable, temporally or spatially as what climate scientists predict will occur, please state that here.	Added reference to discussions of previous climate variations in the Inferred Long-term Trends section of the Status Review.

Line	Reviewer Comment	Department Response
1886	Cite Gonzalez et al. 2018 Env. Research Letters	This paper is about the relative impact of climate change within and outside of U.S. National Park Service lands and it is not specific to the Southwestern U.S. or the areas where Joshua trees occur. Joshua trees also occur both within and outside of National Park Service lands, making this paper not very relevant for a discussion of regional, direct, or indirect effects of climate change on the species.

Line	Reviewer Comment	Department Response
1906	There is uncertainty with respect to the future climate scenarios; however, the way this is written incorrectly characterizes the prediction of an increase in precipitation in the region as the “current” model, which is misleading to the non-specialist reader. The simulations in the citation, Allen and Luptowitz do not represent all “current” climate models (as far as the CMIP5); only the subset that those authors chose that best simulate the observed El Nino, as I understand it, the CESM and GFDL from CMIP5. Looking at a range of scenarios from the CMIP5, Gonzalez 2019 (Anthropogenic Climate Change in Joshua Tree National Park, California, USA. US National Park Service) stated that half of the models predict increased precipitation and half predict a decrease for Joshua Tree National park, while thirty three predict an increase of 4.6 C in temperature, which would lead to an increase in aridity regardless. I appreciate the work of Allen and colleague, I’m simply pointing out that this is not all current scenarios, and among them there is much discussion due to the difference in effects on jet stream and storm tracks based by the scenario, the discussion of which is outside of my expertise. If the range and uncertainty of the predictions for the region are not going to be presented in a standardized manner here (see Neelin et al. 2013 J Climate), I would be satisfied if a qualifier is added here, “According to *some* current climate models,” as many suggest warmer and drier, and it is to be determined which are in fact more accurate.	Changed the word “current” to “some” per reviewer suggestion. Added a sentence and reference to Gonzalez (2019) earlier in this paragraph for a statement regarding half of models projecting increased precipitation and half projecting decreased precipitation in Joshua Tree National Park.
1933	Agreed.	Comment noted
1944	I do not know if this has been substantiated, and whether this precision is justified.	Another peer reviewer requested more detail on this statement, not less, and therefore additional information from Cole et al (2011) regarding the magnitude of warming was added to the Status Review here.

Line	Reviewer Comment	Department Response
1960-1972	Agreed, this seems supported by the evidence.	Comment noted
2025	Agreed that this is a possibility based on other scientific studies.	Comment noted
2065	I don't think this is intentional, however, this description of species distribution models seems odd, and implies that scientists performing these techniques modify variables or data manually and may detract from the perception of their objectivity unnecessarily. Perhaps there is a better description indicating that we "project" the species model on to new given conditions, e.g. those associated with future climates, as produced by climatologists. Try Franklin or Elith for better plain-terms descriptions.	Made revisions to this sentence to clarify, and removed the word "modifying" in response to the reviewer's concern.
2080	This is the concept of sensitivity. Exposure is defined by the change in conditions experienced; sensitivity is the impact it may have on organisms, as defined by its biology and ecological relationships. See Dawson et al. 2011. Science.	Introduced the terms exposure and sensitivity in this sentence. Added citation to Dawson et al. (2011).
2123	It is unfortunate that this is the only range-wide study available, and it is significantly impacted by the inclusion of two species in the model, one of which is not being assessed here. Many efforts are currently underway by several entities to map the species distribution and model future distribution, mindfully and using data from the species separately. Relevant and not cited here is the model of Thomas et al. 2012 USGS (see above for reference) that shows substantial declines, and has updated information over Cole et al., which relied heavily on old, spatially-coarse and geo-referenced data, much of which was digitized from maps manually.	Added a discussion of Thomas et al. (2012) near the end of this section.

Line	Reviewer Comment	Department Response
2135-2144	There are some inherent limitations in the ability to infer biology using species and habitat distribution modeling because of the difficulty in isolating the effect of any one variable using these techniques without accounting for colinearity statistically. In other words, climate variables are often highly correlated, and assessing them independently requires further analysis. Inferring these relationships is more appropriate for models based on mechanistic understanding of species tolerances as opposed to correlations.	Updated text to recognize that models should be used with caution until tested with independent verification. Additional edits were made to this section in response to comments from other reviewers. Added citation to Lee-Yaw et al. (2021).
2156	SDM's can certainly be improved by carefully choosing and vetting data inputs, variable choice, and even using advanced techniques as necessary, this statement is quite dismissive, if this is the only way to predict the threat of future climate change to the species. Predictions are always associated with a range of uncertainty. Invoking physics, Dr. Prescod-Weinstein (2021) explains that every scenario is possible, but each is associated with a probability. Here, if there is no acceptable probability defined, relying on models that have been peer-reviewed by the expert scientific community is probably the most reliable way to make predictions about changes in species ranges. The last 20 years have seen, as you state, at least 6 models of this species, each building upon the last to better use for each study aim. To dismiss this route of analysis on the basis of each shortcoming is shortsighted.	Removed much of the end of this sentence to avoid the implication that species distribution models cannot be useful.

Line	Reviewer Comment	Department Response
2315	I see this is an interpretation of Sweet et al. 2019. The difference between the two first models, for the historic 30 year periods, are based on the suitability using a historic or observed downscaled hydrologic gridded datasets from Flint and Flint as cited. The differences in temperature and precipitation between each of the climate datasets used is found within Table 3. As you can see, the 1981-2010 time stamp is the only time for which there was an increase in precipitation within the variable dataset from the historic period of 1951-1980 to that time period. In other words, the model is then projecting suitable area for the Joshua tree across space with an increase in precipitation and an increase in temperature, which resulted in a lower listed suitable area. As stated in this Review, climate is variable on shorter time periods especially in the Mojave Desert, and this variability has an impact on extrapolated estimates from measurement stations, especially in a topographically-complex and measurement-poor region (see Heintzman et al. 2022 J App Met and Clim), as you point out later in Line 2396. If the climate dataset as gridded accurately represents the climatic landscape during the second time step, this may support the proposal that the tree is able to weather shorter-term changes in climate, as the Department asserts. This time stamp was included to be fully transparent, using all time steps available. However, all future scenarios under MIROC listed show an increase in both min and max temperature, decreases in precipitation, and aridity (climatic water deficit), all of which demonstrate that this would reduce suitable habitat, which is logical and consistent with all other models. This would happen over a longer-term period, which is more likely to have consistent impacts on the species than changes from one 30 year period to the next.	Comment noted, and the Department points out later in this section that it may not be appropriate to use averages of narrow (30 to 40 year) timeframes to represent the climate conditions and climate variability that is suitable for western Joshua tree. Text also updated in response to reviewer comment to acknowledge that "…a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species, *at least in the short term*."

Line	Reviewer Comment	Department Response
2317	This was an oversight, I am happy to provide these data. I thought I had sent it, but I must have not, I do apologize. To answer the criticism here, any difference in the abundance of where seedlings may occur, similar to the Department's summary of the Barrows seedling habitat model, indicates a possible shift in where trees will occur into the future. I can confirm that the areas outside of refugia demonstrated demographic histogram patterns much more like those deemed stable or declining in previous sections than low recruiting plots. These are the same plots cited as Frakes et al 2017 in this Review.	Data were not provided to the Department with the reviewer's comments and therefore could not be included in this Status Review in time for completion, however comment indicates that demographic data used may be comparable with that reported by St. Clair and Hoines (2018) and illustrated in Figure 6 of the Status Review.
2419	Sweet et al. reported an AUC for the model, which is often used as an indication of the sensitivity and specificity of the model. It should be listed here.	Reporting performance values under various metrics for the different models is likely too much detail for this report, however a citation to Sweet et al. 2019 was added to this section to indicate that performance of model results was evaluated with a single metric, like Cole et al. (2011) and Thomas et al. (2012). Added a sentence to indicate that Barrows and Murphy-Mariscal (2012) used two metrics to evaluate model performance.
2425	Again this refers to the sensitivity to the climate change exposure, consider citing Dawson et al. 2011 Science and utilizing this terminology.	Included additional use of the terms sensitivity and exposure in the Status Review per reviewer comment.
2989	However, given upward trend indicated, if larger and larger areas burn, that may have some impact that could start to shift the ability of populations to be sustainable long term and lead to range contraction eventually, as is stated later. I would put a slightly higher emphasis on this perhaps than the department, but agree that it would not be the sole factor in range decreases.	Comment probably intended for line 2889 or 2898. Edited text in the Summary of Wildfire Threat section to state that wildfire may negatively impact the species distribution.
3054	Small, but important and relevant to early seedling stages, which is relevant to restoration.	Added sentence to acknowledge that the early seedling stage is a vulnerable one. Added the word "overall" to the last sentence in this section to emphasize that the threat is evaluated in context of the entire species.

Date: December 27th, 2021

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SUBJECT: STATUS REVIEW OF WESTERN JOSHUA TREE; CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE, PEER REVIEW

Dear Dr. Yoder:

Thank you for agreeing to serve as a scientific peer reviewer for the California Department of Fish and Wildlife's (Department) Status Review of western Joshua tree (*Yucca brevifolia* Engelm.) (Status Review). A copy of the Status Review, dated December 2021, is enclosed for your use in the review. The Department seeks your expert analysis and input regarding the scientific validity of the Status Review, and its assessment and conclusions regarding the status of western Joshua tree in California based on the best scientific information currently available. The Department is interested in and respectfully requests that you focus your peer review effort on the body of relevant scientific information, the Department's related assessment of the required population and life history elements prescribed in the California Endangered Species Act (CESA), and the Department's overall conclusions. **The Department would appreciate receiving your peer review input on or before January 25, 2022**.

The Department seeks your scientific peer review as part of formal proceedings pending before the California Fish and Game Commission (Commission) under CESA. The Commission is a constitutionally established entity distinct from the Department, exercising exclusive statutory authority under CESA to list species as endangered or threatened (Fish & G. Code, § 2070). The Department serves in an advisory capacity during CESA listing proceedings, charged by the Fish and Game Code to evaluate the status of the species based on the best scientific information available to the Department and make recommendations to the Commission, including if CESA listing is warranted (Fish & G. Code, § 2074.6).

The Commission received the petition to list western Joshua tree under CESA on

October 21, 2019. On October 9, 2020, the Commission published findings regarding its acceptance of the petition for consideration, and formally designated western Joshua tree as a candidate for listing as threatened under CESA. As a candidate species, western Joshua tree currently receives the same protections under CESA as threatened and endangered species. Formal acceptance of the petition triggered the Department's initiation of this Status Review, which will inform the Commission's decision on whether listing the species is warranted.

The draft Status Review forwarded to you today reflects the Department's effort to identify and analyze the best scientific information available regarding the status of western Joshua tree in California. The Department's preliminary recommendation on whether CESA listing is warranted for the species may be found in the draft Status Review. We underscore, however, that scientific peer review plays a critical role in the Department's analysis and effort to develop and finalize its recommendation to the Commission as required by the Fish and Game Code. Our analysis and expected recommendation to the Commission may change or be modified following your input. For your reference, under CESA an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion of its range due to one of more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code § 2067).

We ask you to focus your peer review on the best scientific information available regarding the status of western Joshua tree in California. Your peer review of the science and analysis regarding the population status and the threat categories prescribed in CESA's implementing regulations are particularly important (Cal. Code Regs., tit. 14, § 670.1(i)(1)(A); i.e., present or threatened modification or destruction of the species' habitat, overexploitation, predation, competition, disease, or other natural occurrences or human-related activities), as well as your opinion on whether the body of information and reasonable conclusions drawn from the information indicate that western Joshua tree is at serious risk of becoming extinct throughout all or a significant portion of its range in California (i.e. the species is endangered), or whether the species is likely to become so in the foreseeable future in the absence of CESA protection (i.e. threatened).

Please note that currently, the Department releases this Status Review solely to you as part of the peer review process, it is not yet public. However, your review will be appended to the final Status Review which will be released to the public upon receipt by the Commission. We ask that you please keep the Department's Status Review and your review of it confidential until the final Status Review is received by the Commission.

For ease of review and for accessibility by the public, the Department requests that you please submit your comments in list form by report page and line number. Please submit your comments electronically to me via email at Christina.Sloop@wildlife.ca.gov. For questions, I can be reached via email or by phone at (916) 261-1159. If there is anything the Department can do to facilitate your review, please let me know. Following receipt and consideration of peer review comments, the Department will prepare and submit its final Status Review report and related recommendation to the Commission. After at least a 30-day public review period, the Commission will consider the petition, the Department's Status Review, related recommendations including peer review comments, and public testimony during a regularly scheduled Commission meeting prior to making their decision.

Thank you again for your contribution to the Status Review effort and the important input it contributes to the CESA listing process.

Sincerely,

Christina Sloop, Science Advisor & Science Institute Lead
California Department of Fish and Wildlife

Enclosure

ec: California Department of Fish and Wildlife

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CSUN | CALIFORNIA STATE UNIVERSITY NORTHRIDGE

January 25, 2022

Christina Sloop, Science Advisor & Science Institute Lead
California Department of Fish and Wildlife
PO Box 944209
Sacramento, CA 94244-2090

Dear Ms. Sloop,

Thank you for your request that I provide a peer review of the draft Status Review of western Joshua tree (*Yucca brevifolia*), considering this iconic California native plant for protection under the California Endangered Species Act. I was happy to review the Department's written assessment of western Joshua tree's population status and the risk posed by "present or threatened modification or destruction of the species' habitat" and "other natural occurrences or human-related activities." I believe I am well prepared to provide this review, having contributed substantially to studies of Joshua tree, including ecological studies, species distribution modeling, and population genetics (Godsoe *et al.* 2008, 2009; Smith *et al.* 2009; Yoder *et al.* 2013; see References list, appended), and as a collaborator in the ongoing Joshua Tree Genome Project (joshuatreegenome.org), using genomic and experimental data to examine the trees' adaptation to extreme desert climates and specialized pollinators.

Having considered the draft Status Review in full, I am impressed by the thoroughness with which it enumerates the state of our knowledge about western Joshua tree's habitat requirements and current population extent, and pleased to see that it cites the latest available data on the trees' demographic status and the threats faced by the species. However, I am left with multiple concerns about the Status Review as it stands, and these may undermine the validity of its final recommendation. Most substantively, although the draft Status Review details threats arising from changing climate, increasing frequency and extent of wildfires, and ongoing habitat losses to development, it does not substantially address how these threats may interact to rapidly endanger the survival of western Joshua tree throughout its range — and the CESA specifically notes that threats to a species may act in combination, per the California Code of Regulations, tit. 14, sect. 670.1, subd. 3709 (i)(1)(A). This oversight is, perhaps, related to a second issue, that uncertainty in expected threats is consistently interpreted in a manner that minimizes those threats, particularly in the way that the text addresses uncertainties in habitat losses predicted by species distribution models. Finally, I note several places in which the draft Status Review misses ways in which available data provide answers to questions posed elsewhere in the text.

Overall, I concur with the conclusion of the draft Status Review that the size and extent of current western Joshua tree populations is sufficient that it would be inappropriate to recommend

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a designation of “endangered” under the CESA; western Joshua tree is not at this time “in serious danger of becoming extinct throughout all or a significant portion of its range,” per the language of the Fish and Game Code, sect. 2062. **However, I am not convinced that the available evidence supports a recommendation against designating the species as “threatened.”** Current threats to western Joshua trees in California, considered in combination, mean that the species has very real potential to “become an endangered species in the foreseeable future” (again, per Fish and Game Code, sect. 2067).

Below, I provide comments of specific points in the draft Status Review with which I have concerns, following the line numbering in the draft document. Full bibliographic information for external sources I cite in these comments follows in the appended References list.

ABUNDANCE AND TRENDS IN CALIFORNIA

This section of the draft text considers key indicators of the “demographic health” of western Joshua tree populations: the density of tree populations, in terms of total individuals per space, and more importantly the density of juvenile-sized trees. As noted elsewhere in the text (especially lines 2025-2027) Joshua trees are long-lived, so a population may have substantial density of larger trees, but ultimately fail if seedlings do not survive to replace those larger, older trees as they die. This factor means that data on the frequency of Joshua tree seedlings is critical for assessing the viability of populations in the foreseeable future, but because seedlings are small and frequently sheltered by nurse plants, they are much more difficult to survey than mature Joshua trees.

Line 1402: The observation by WEST Inc that population density is lower in the southern range extent is in fact an early indication of climate-change impacts. Climate change that has occurred since pre-industrial times is expected to impact species at the warmest and driest parts of their ranges first, and reduced population density would be one sign of such an impact.

Lines 1538-1598: The summation of long-term monitoring studies here seems to me to miss important overall trends. Multiple cited studies find population declines or lack of new recruitment in monitoring plots at relatively southern sites (Victorville, in the Comanor and Clark study; Saddleback Butte and Joshua Tree National Park, in the Cornett studies cited; other sites in the National Park in the DeFalco study). The text here correctly notes that this is limited data, but none of the direct studies discussed appear to have found substantial recruitment of juvenile trees into the populations being monitored.

Lines 1630-1632: The discussion here of limitations to existing population demographic data is correct to note the difficulty in surveying the abundance of Joshua tree seedlings, given their small size and their typical need of a sheltering nurse plant (discussed earlier in the text). However, the conclusion here appears to be that this should be read solely as a risk of *underestimating* the presence of seedlings; whereas it can just as easily mean that population demographic profiles with no data on seedling abundance will be unable to distinguish populations with no seedlings from populations that have them in abundance. The demographic data discussed in the text following this point should be understood in that light.

Lines 1686-1720: The consideration here of demographic surveys by St Clair and Hoynes, published in 2018, correctly notes that this dataset is consistent with demographic declines. However, it is not correctly weighed against the older data published by Esque *et al*. in 2010. Esque *et al*. aggregate data from National Parks properties across the Mojave, while St Clair and Hoynes report data specifically from sites in Joshua Tree National Park. Given that the St Clair and Hoynes data are both more recent and more clearly attributable to specific populations, the balance of the evidence here is that populations in JTNP are declining. (This is consistent with results from modeling-based studies, discussed later in the text.)

Figures 6, 7, and 8: The demographic profiles displayed in these figures do not appear to be consistent with their descriptions in the text. (Notably, the histogram attributed to St. Clair and Hoynes in Figure 7 shows strong representation of trees in the smallest size class, consistent with good demographic health; while Figure 6 shows a striking lack of trees in the smallest class despite being described as "what would be expected for a sustainable or increasing population" on line 1665.) Regardless, two of the three demographic datasets presented here as figures are consistent with recent poor recruitment of juvenile Joshua trees, and these are specifically linked to sites in the southern part of the range — again, a potential early sign of impacts from warming climate.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

This section of the text addresses the prospects for substantial habitat loss and population decline within the "foreseeable future" timeline established earlier in the text, particularly due to climate change. Noted here, as elsewhere, is the correct assessment that western Joshua tree is currently widespread and abundant relative to standards for considering a species endangered (lines 1815-1841). Most relevant here is the IUCN criterion (E), "a quantitative analysis demonstrating probability of extinction". One such quantitative analysis is a *species distribution model*, or SDM, which the text correctly describes as identifying suitable climate for a species based on known geographic locations at which the species currently occurs, then identifying the spatial extent of similar climate under projected future climate-change scenarios. Throughout this section, the text emphasizes uncertainties inherent in SDM construction and the predictions derived from SDMs, but these uncertainties are consistently described in terms of their possibility to overestimate risk, never the possibility that they may *underestimate* risk.

Line 1938: The statement here (repeated at line 2110 and line 3757) that the Department lacks data on the effects of climate change on the demography of western Joshua tree populations is contradicted by the extensive discussion later in the text of not one but two studies, by Barrows and Murphy-Mariscal (2012) and by Sweet *et al.* (2019), which use SDM methods informed by demographic data; and it further misses data on threats to juvenile Joshua trees that are highly likely to be exacerbated by changing climate. Most notably: findings by Esque *et al.* (2015) that establishment of Joshua tree seedlings may peak in rare years of higher than average rainfall, and that their survivorship is heavily reduced by herbivory in drought years. If climate change reduces the frequency of wet years and makes droughts both more frequent and longer, this study clearly indicates that seedlings will be less likely to establish and then less likely to survive to reproductive age as a result of climate change.

Line 2035: The statement that the Department lacks data showing that western Joshua tree populations are experiencing "delayed local extinction" — in which populations of established adult trees are failing to recruit new seedlings — is contradicted by the earlier discussion of demographic studies showing that, at multiple sites in the Mojave, juvenile Joshua trees are sufficiently rare to be consistent with population declines. Such a demographic population decline is a "delayed local extinction" in a long-lived species such as western Joshua tree.

Lines 2145-2161: The discussion of uncertainties in the SDM study by Cole *et al.* (2011) fails to acknowledge that these uncertainties cut two ways. Yes, it is possible the model may overestimate losses of suitable habitat by the end of the century; but by the same token the model may *underestimate* losses of suitable habitat. The model only considers climate, and cannot address reductions in population growth within regions that may remain suitable for mature trees but too harsh for seedlings to survive. Moreover, it makes deliberately optimistic assumptions about the trees' natural capacity for migration (Cole *et al.* 2011, page 145), the limitations of which are discussed earlier in the text. Thus, the dramatic estimate that only 10% of the current range may remain suitable by the end of this century is still in some respects a best-case scenario.

Lines 2214-2240: Discussion here of the SDM study by Dole *et al.* (2003) appears to misunderstand the degree to which the top-line estimate of a 9% reduction in total suitable habitat relies on Joshua trees migrating to track suitable climates. Even under the modeled scenario in which elevated CO_2 allows the trees to tolerate colder conditions, Dole *et al.* project that 71% of the current range will become unsuitable ("... 29% of cells from the current prediction remaining occupied", Dole et al 2003, page 142).

Line 2241-2279: Discussion of the SDM study of mature and seedling western Joshua trees in Joshua Tree National Park by Barrows and Murphy-Mariscal (2012) assumes the high end of the range of uncertainty in the authors' projections. They find that up to 10% of the current habitat within the park will remain suitable by the end of the century, but it may be as little as 2%. This result must also be viewed in light of the results of the study by Sweet *et al*. (2019) discussed immediately following this work — that later work notes the risks to wildfire in the small climate refugia identified within the park.

Line 2327: The finding by Sweet *et al*. (2019), that Joshua tree populations in study sites within future climate refugia are more demographically healthy (i.e., have higher density of juvenile trees) than populations outside of climate refugia is as close to demonstrating a demographic effect of climate change as anything short of long-term survey data tracking population declines over the rest of this century. It is particularly relevant because the region examined, Joshua Tree

National Park, lies at the southern edge of the species range, where impacts of climate change are expected to manifest first.

Line 2368: It is not entirely true that species distribution models cannot account for the "resilience" of "an abundant and widespread species." A widespread species necessarily occupies a wider range of habitats, and SDMs are fundamentally designed to account for variation in the habitats across which a species occurs. A rare, narrowly endemic species will occupy a narrower range of conditions, and an SDM would be more likely to find that its current range would become uninhabitable under climate change as a result. If a species occupies a wide range of climate conditions and those conditions remain present in the future, an SDM should show that the species will retain its extensive existing range; but this is not what we see for SDM studies of western Joshua tree.

Lines 2352-2373: Discussion of the limitations to SDM projections of habitat losses under climate change misses a key factor in evaluating SDM studies of Joshua tree: the species is in many respects an excellent candidate for SDM methods. Species distribution models gain power as they incorporate larger and larger sets of validated observations of a species' presence or absence from the landscape. Joshua tree, as the most visible member of most plant communities in which it occurs, is exceptionally well observed. Studies of Joshua trees using SDM methods routinely incorporate thousands of observations — Sweet *et al.* (2019) had 11,142 "presence" data-points in their most spatially extensive model. There certainly remain limitations on these data sets, but they are in many respects the ideal applications for SDM methods.

WILDFIRE

A substantial missed opportunity in the draft Status Review is serious consideration of the joint risks posed by climate change and the increasing frequency of wildfire in the Mojave, driven by the establishment of invasive fire-tolerant grasses. The Review correctly identifies the dramatic increase in burned area over recent decades (Figures 9 and 10), but does not systematically compare this to projected future refugia.

Line 2819: As noted here, smaller trees are more likely to be killed in wildfires; this means that increasing frequency and severity of wildfires is a foreseeable risk to the demographic health of Joshua tree populations.

Lines 2851-2859: Discussion of this study showing recovery of reproduction in a population of eastern Joshua trees after a burn is somewhat misleading, because it is impossible to assess flowering or fruit set in populations with no surviving trees after a burn — so the data is, by necessity, showing recovery of reproduction in populations that were less severely burned.

Lines 2893-2907: Notably unmentioned in this section is the Cima Dome fire of 2020, perhaps because it impacted eastern Joshua tree. That event burned over 43,000 acres in Mojave National Preserve, a probable climate refuge, killing 1.3 million Joshua trees in the estimation of National Parks Service staff (NPS 2020). The Cima Dome fire demonstrates how rapidly a "stochastic" event can impact even a dense, demographically healthy population, and subsequent recovery efforts emphasize the substantial resources required to restore a Joshua tree population afterward.

Lines 3854-3867: The consideration here of the combined effects of threats to Joshua tree, particularly the joint impacts of climate change and increased wildfire frequency and severity, is really insufficient in considering their joint power. An example of how fire risk might be weighed in concert with climate change is the work by Sweet *et al.* (2019), which compares the extent of recent fires in Joshua Tree National Park to the extent of projected suitable habitat at the end of the century, and finds that up to 50% of the projected climate refuge area within the park has been burned. If western Joshua tree does indeed suffer predicted habitat losses as great as projected by even somewhat optimistic SDM studies, the remaining populations will be dramatically more vulnerable to stochastic losses, such as wildfires. It is unlikely that a single fire could substantially damage the survivability of currently extant Joshua tree populations, but losses on the scale of the Cima Dome fire could represent a large fraction of the populations remaining in climate refugia by the end of this century.

In conclusion, it is undoubtably the case, as the draft Status Review concludes, that western Joshua tree currently remains widespread and abundant. However, I do not feel that the draft reflects a full assessment of the risk that this species "is likely to become an endangered species in the foreseeable future" as specified for assigning "threatened" status under the CESA (Fish and Game Code, sect. 2067.) As currently written, the draft Status Review interprets uncertainty in predicted threats in the most optimistic light, misses ways in which available data can answer questions that it poses, and does not seriously consider the joint effects of the interlocking threats to western Joshua tree.

Yours sincerely,

Jeremy B. Yoder
Assistant Professor of Biology

REFERENCES

Barrows CW, ML Murphy-Marisical. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions. *Biological Conservation*. 152:29-36. doi: 10.1016/j.biocon.2012.03.028

Cole KL, K Ironside, J Eidschied, G Garfin, PB Duffy, and C Toney. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. *Ecological Applications*. 21:137–149. doi: 10.1890/09-1800.1

Dole KP, ME Loik, and LC Sloan. 2003. The relative importance of climate change and the physiological effects of CO2 on freezing tolerance for the future distribution of *Yucca brevifolia*. *Global and Planetary Change* 36: 137–146. doi: 10.1016/S0921-8181(02)00179-0

Esque TC, PA Medica, DF Shryock, LA DeFalco, RH Webb, and RB Hunter. 2015. Direct and indirect effects of environmental variability on growth and survivorship of pre-reproductive Joshua trees, *Yucca brevifolia*, Engelm. (Agavaceae). *American Journal of Botany*. 102(1):85-91. doi: 10.3732/ajb.1400257

Godsoe W, **JB Yoder**, CI Smith, and O Pellmyr. 2008. Coevolution and divergence in the Joshua tree/yucca moth mutualism. *American Naturalist* 171(6): 816-23. doi: 10.1086/587757

Godsoe WK, E Strand, T Esque, CI Smith, **JB Yoder**, and O Pelmyr. 2009. Divergence in an obligate mutualism is not explained by divergent climatic factors. *New Phytologist* 183(3): 589-99. doi: 10.1111/j.1469-8137.2009.02942.x

National Parks Service. 2020. Dome Fire. nps.gov/moja/learn/nature/dome-fire.htm. Accessed 25 January 2021.

Smith CI, CS Drummond, WKW Godsoe, **JB Yoder**, and O Pellmyr. 2009. Host specificity and reproductive success of yucca moths (*Tegeticula* spp. Lepidoptera: Prodoxidae) mirror patterns of gene flow between host plant varieties of Joshua tree (*Yucca brevifolia*: Agavaceae). *Molecular Ecology*. 18(24): 5218-29. doi: 10.1111/j.1365-294X.2009.04428.x

Sweet LC, T Green, JGC Heintz, N FRakes, N Graver, JS Rangitsch, JE Rodgers, S Heacox, and CW Barrows. 2019. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. *Ecosphere*. 10(6):e02763. doi: 10.1002/ecs2.2763

Yoder JB, CI Smith, DJ Rowley, WKW Godsoe, CS Drummond, and O Pellmyr. 2013. Effects of gene flow on phenotype matching between two varieties of Joshua tree (*Yucca brevifolia*; Agavaceae) and their pollinators *Journal of Evolutionary Biology*. **26**(6): 1220-33. doi: 10.1111/jeb.12134

Peer Review Comments from Dr. Jeremy Yoder on the western Joshua tree (*Yucca brevifolia*) Status Review and California Department of Fish and Wildlife Responses

Note: Comments not associated with specific line numbers by the peer reviewer have "N/A" in the Line column.

Line	Reviewer Comment	Department Response
N/A	Most substantively, although the draft Status Review details threats arising from changing climate, increasing frequency and extent of wildfires, and ongoing habitat losses to development, it does not substantially address how these threats may interact to rapidly endanger the survival of western Joshua tree throughout its range — and the CESA specifically notes that threats to a species may act in combination, per the California Code of Regulations, tit. 14, sect. 670.1, subd. 3709 (i)(1)(A).	The Department has little information on the degree to which threats may interact to rapidly endanger the survival of western Joshua tree throughout its range, but cumulative effects are discussed generally in the Summary of Listing Factors section of the Status Review, and cumulative threats are addressed throughout the Status Review when such information is available. In response to the reviewer's comment, the "Indirect Effects" section of the Status Review under Climate Change was renamed "Indirect and Cumulative Effects". A new paragraph discussing aspects of work by Sweet et al. (2019) regarding how climate change and historic wildfire may interact has been added to the renamed section. Additional sentences were also added to the Status Review to identify interconnected threats of development and other human activities and invasive plants and wildfire.
N/A	This oversight is, perhaps, related to a second issue, that uncertainty in expected threats is consistently interpreted in a manner that minimizes those threats, particularly in the way that the text addresses uncertainties in habitat losses predicted by species distribution models.	A goal of the Status Review is to discuss the range of possibilities that may occur. A sentence was added to the Species Distribution Models section to acknowledge that the negative effects of western Joshua tree exposure to climate change within the foreseeable future could perhaps be very severe, resulting in a loss of significant range, or perhaps they will be less severe, resulting in lowered abundance without significant range loss. As discussed in the Status Review in detail, species distribution models can be useful, but they have significant inherent limitations, and exposure to climate change does not necessarily mean that there will be a loss of range. Specific comments from the reviewer related to this topic are addressed below.

Line	Reviewer Comment	Department Response
N/A	However, I am not convinced that the available evidence supports a recommendation against designating the species as “threatened.” Current threats to western Joshua trees in California, considered in combination, mean that the species has very real potential to “become an endangered species in the foreseeable future” (again, per Fish and Game Code, sect. 2067).	See response to previous comment.
1402	The observation by WEST Inc that population density is lower in the southern range extent is in fact an early indication of climate-change impacts. Climate change that has occurred since pre-industrial times is expected to impact species at the warmest and driest parts of their ranges first, and reduced population density would be one sign of such an impact.	The text in the Status Review regarding the WEST Inc study was misleading as written and therefore was misunderstood by the reviewer. The text has been revised for clarity. The information from WEST Inc is therefore not evidence of the point being made by the reviewer here. WEST Inc did not compare the northern and southern portions of the species range and examined the entire perimeter of the portion of the species range analyzed (not just lower elevation and/or lower latitude areas of the range perimeter, but higher elevation and higher latitude areas as well). To the reviewer’s point, it is noted in the Species Distribution Models section of the status review that lower recruitment in marginal habitats subject to climate change may be a sign that climatic warming is negatively influencing recruitment.
1538-1598	The summation of long-term monitoring studies here seems to me to miss important overall trends. Multiple cited studies find population declines or lack of new recruitment in monitoring plots at relatively southern sites (Victorville, in the Comanor and Clark study; Saddleback Butte and Joshua Tree National Park, in the Cornett studies cited; other sites in the National Park in the DeFalco study). The text here correctly notes that this is limited data, but none of the direct studies discussed appear to have found substantial recruitment of juvenile trees into the populations being monitored.	Text in the opening paragraph of this section revised to state that “little recruitment in plots has been observed”. A reference to the Demographic Information section was added for more information on recruitment trends.

Line	Reviewer Comment	Department Response
1630-1632	The discussion here of limitations to existing population demographic data is correct to note the difficulty in surveying the abundance of Joshua tree seedlings, given their small size and their typical need of a sheltering nurse plant (discussed earlier in the text). However, the conclusion here appears to be that this should be read solely as a risk of *underestimating* the presence of seedlings; whereas it can just as easily mean that population demographic profiles with no data on seedling abundance will be unable to distinguish populations with no seedlings from populations that have them in abundance. The demographic data discussed in the text following this point should be understood in that light.	Added a sentence to further clarify that it is difficult to detect both periods of high seedling establishment and periods where little or no seedling establishment is taking place. Added similar text later in this section when discussing specific figures.
1686-1720	The consideration here of demographic surveys by St Clair and Hoynes, published in 2018, correctly notes that this dataset is consistent with demographic declines. However, it is not correctly weighed against the older data published by Esque *et al*. in 2010. Esque *et al*. aggregate data from National Parks properties across the Mojave, while St Clair and Hoynes report data specifically from sites in Joshua Tree National Park. Given that the St Clair and Hoynes data are both more recent and more clearly attributable to specific populations, the balance of the evidence here is that populations in JTNP are declining. (This is consistent with results from modeling-based studies, discussed later in the text.)	The purpose of this section is to present the known (but limited) demographic information on the species, and Joshua Tree National Park is not being evaluated specifically. Nevertheless, a reference to the St. Clair and Hoines (2018) data was added in the section discussing the Esque 2010 data, and some additional detail on the St. Clair and Hoines (2018) data in Joshua Tree National Park was also added.

Line	Reviewer Comment	Department Response
1703-1712	Figures 6, 7, and 8: The demographic profiles displayed in these figures do not appear to be consistent with their descriptions in the text. (Notably, the histogram attributed to St. Clair and Hoynes in Figure 7 shows strong representation of trees in the smallest size class, consistent with good demographic health; while Figure 6 shows a striking lack of trees in the smallest class despite being described as “what would be expected for a sustainable or increasing population” on line 1665.) Regardless, two of the three demographic datasets presented here as figures are consistent with recent poor recruitment of juvenile Joshua trees, and these are specifically linked to sites in the southern part of the range — again, a potential early sign of impacts from warming climate.	Added additional text to emphasize that the relative amounts of shorter to taller plants is important in assessing whether the current number of taller plants can be replaced. Also added text discussing the smallest height class in Figure 6, and comparing height classes in Figure 7. While there are examples of recent poor recruitment at the southern portion of the species range, there are also examples of relatively high recruitment in the southern portion of the species range, and as described in the Life History section of the Status Review, recruitment for the species is episodic.
1787	Factors affecting the ability to survive and reproduce: Throughout this section, the text emphasizes uncertainties inherent in SDM construction and the predictions derived from SDMs, but these uncertainties are consistently described in terms of their possibility to overestimate risk, never the possibility that they may *underestimate* risk.	The text does little to suggest that models are overestimating or underestimating risk and the reviewer does not cite any specific examples to address. A sentence was added near the beginning of this section to address this comment generally by pointing out that uncertainty in species distribution modeling results could mean that a species exposure to climate change is either higher or lower than models predict.

Line	Reviewer Comment	Department Response
1938	The statement here (repeated at line 2110 and line 3757) that the Department lacks data on the effects of climate change on the demography of western Joshua tree populations is contradicted by the extensive discussion later in the text of not one but two studies, by Barrows and Murphy-Mariscal (2012) and by Sweet *et al.* (2019), which use SDM methods informed by demographic data; and it further misses data on threats to juvenile Joshua trees that are highly likely to be exacerbated by changing climate. Most notably: findings by Esque *et al.* (2015) that establishment of Joshua tree seedlings may peak in rare years of higher than average rainfall, and that their survivorship is heavily reduced by herbivory in drought years. If climate change reduces the frequency of wet years and makes droughts both more frequent and longer, this study clearly indicates that seedlings will be less likely to establish and then less likely to survive to reproductive age as a result of climate change.	While Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Barrows and Murphy-Mariscal (2012) incorporated demographic data by comparing a binary map product for adult trees with another for juvenile trees, which is useful in suggesting that a demographic link with climate change is present, but it is not an actual correlation. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of “High Recruiting” and “Low Recruiting” macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Both of these studies also examined the same area: Joshua Tree National Park, which is a small portion of western Joshua Tree’s total range. Discussion of the vulnerability of early western Joshua tree life stages is discussed in the Establishment and Early Survival and Climate Change Direct Impacts sections of the Status Review. Added a sentence to the Direct Impacts section of the Status Review to state that seedlings and juveniles may be particularly vulnerable to warming and droughts from climate change. Added a new sentence with a reference to Esque et al. 2015 in the Herbivory and Predation section. Information available to the Department suggests that there will be more climate extremes, and that overall aridity will likely rise, but the Department does not have data that suggests the frequency of wet years will go down.

Line	Reviewer Comment	Department Response
2035	The statement that the Department lacks data showing that western Joshua tree populations are experiencing "delayed local extinction" — in which populations of established adult trees are failing to recruit new seedlings — is contradicted by the earlier discussion of demographic studies showing that, at multiple sites in the Mojave, juvenile Joshua trees are sufficiently rare to be consistent with population declines. Such a demographic population decline is a "delayed local extinction" in a long-lived species such as western Joshua tree.	Population decline is not synonymous with delayed local extinction, and the reviewer does not provide justification for the assertion that a demographic population decline is a "delayed local extinction" in a long-lived species such as western Joshua tree. Due to the lack of basic demographic information such as long term recruitment and mortality rates and acceptable fluctuations of those rates over long timescales, the Department does not have a way to determine if populations are subject to a delayed local extinction or not.
2145-2161	The discussion of uncertainties in the SDM study by Cole *et al.* (2011) fails to acknowledge that these uncertainties cut two ways. Yes, it is possible the model may overestimate losses of suitable habitat by the end of the century; but by the same token the model may *underestimate* losses of suitable habitat. The model only considers climate, and cannot address reductions in population growth within regions that may remain suitable for mature trees but too harsh for seedlings to survive. Moreover, it makes deliberately optimistic assumptions about the trees' natural capacity for migration (Cole *et al.* 2011, page 145), the limitations of which are discussed earlier in the text. Thus, the dramatic estimate that only 10% of the current range may remain suitable by the end of this century is still in some respects a best-case scenario.	In response to the reviewer comment for line 1787 the Department added a sentence near the beginning of the Species Distribution Models section to say that uncertainty in species distribution modeling results could mean that a species exposure to climate change is either higher or lower than models predict. Text was revised in the Limitations of Models section to state that differences in how climate change exposure may affect seedling, juvenile, and adult trees is another uncertainty of species distribution models. Cole et al. (2011) provided relatively little explanation about how map products in the paper related to the conclusions in the text. It appears that Cole et al. (2011)'s optimistic migration capacity was used for the map product shown in Figure 5 of their paper, not for the "as little as 10%" conclusion that is illustrated by Figure 3 of their paper.

Line	Reviewer Comment	Department Response
2214-2240	Discussion here of the SDM study by Dole *et al.* (2003) appears to misunderstand the degree to which the top-line estimate of a 9% reduction in total suitable habitat relies on Joshua trees migrating to track suitable climates. Even under the modeled scenario in which elevated CO2 allows the trees to tolerate colder conditions, Dole *et al.* project that 71% of the current range will become unsuitable ("... 29% of cells from the current prediction remaining occupied", Dole et al 2003, page 142).	It is unclear what the reviewer is stating is incorrect or unclear. The Status Review already states that "The Dole et al. (2003) species distribution model broadly overestimates the ability of Joshua tree to disperse into new areas" and already states that 29% of grid cells would retain suitable climate conditions.
2241-2279	Discussion of the SDM study of mature and seedling western Joshua trees in Joshua Tree National Park by Barrows and Murphy-Mariscal (2012) assumes the high end of the range of uncertainty in the authors' projections. They find that up to 10% of the current habitat within the park will remain suitable by the end of the century, but it may be as little as 2%. This result must also be viewed in light of the results of the study by Sweet *et al*. (2019) discussed immediately following this work — that later work notes the risks to wildfire in the small climate refugia identified within the park.	Added sentence stating the Barrows and Murphy-Mariscal (2012) prediction for +3°C warming scenario with a 75 mm decrease in annual precipitation with the caveat that climate models do not agree that precipitation will decrease. A discussion of Sweet et al. (2019) noting the risks to climate refugia from wildfire was added to the Climate Change Indirect and Cumulative Effects section of the Status Review.

Line	Reviewer Comment	Department Response
2327	The finding by Sweet *et al*. (2019), that Joshua tree populations in study sites within future climate refugia are more demographically healthy (i.e., have higher density of juvenile trees) than populations outside of climate refugia is as close to demonstrating a demographic effect of climate change as anything short of long-term survey data tracking population declines over the rest of this century. It is particularly relevant because the region examined, Joshua Tree National Park, lies at the southern edge of the species range, where impacts of climate change are expected to manifest first.	While Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of “High Recruiting” and “Low Recruiting” macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Text was added at the end of paragraph to acknowledge the correlation but point out that other possible explanations were not contemplated by Sweet et al. (2019). The last paragraph of this section already includes a discussion of the implication of this work for the trailing edge of the species range.
2368	It is not entirely true that species distribution models cannot account for the “resilience” of “an abundant and widespread species.” A widespread species necessarily occupies a wider range of habitats, and SDMs are fundamentally designed to account for variation in the habitats across which a species occurs. A rare, narrowly endemic species will occupy a narrower range of conditions, and an SDM would be more likely to find that its current range would become uninhabitable under climate change as a result. If a species occupies a wide range of climate conditions and those conditions remain present in the future, an SDM should show that the species will retain its extensive existing range; but this is not what we see for SDM studies of western Joshua tree	Revised the sentence to be less absolute and acknowledge that species distribution models are fundamentally designed to account for variation in the habitat in which a species occurs.

Line	Reviewer Comment	Department Response
2352-2373	Discussion of the limitations to SDM projections of habitat losses under climate change misses a key factor in evaluating SDM studies of Joshua tree: the species is in many respects an excellent candidate for SDM methods. Species distribution models gain power as they incorporate larger and larger sets of validated observations of a species' presence or absence from the landscape. Joshua tree, as the most visible member of most plant communities in which it occurs, is exceptionally well observed. Studies of Joshua trees using SDM methods routinely incorporate thousands of observations — Sweet *et al.* (2019) had 11,142 "presence" data-points in their most spatially extensive model. There certainly remain limitations on these data sets, but they are in many respects the ideal applications for SDM methods.	Added a sentence at the beginning of the species distribution modeling section to say that species distribution models gain power if they incorporate large sets of validated observations, and because western Joshua tree is so visually distinctive and well-observed it is a good species for species distribution modeling applications.
2677	Wildfire: A substantial missed opportunity in the draft Status Review is serious consideration of the joint risks posed by climate change and the increasing frequency of wildfire in the Mojave, driven by the establishment of invasive fire-tolerant grasses. The Review correctly identifies the dramatic increase in burned area over recent decades (Figures 9 and 10), but does not systematically compare this to projected future refugia.	See response to first comment in this table. A new paragraph discussing how climate change and historic wildfire may interact has been added to the (renamed) Climate Change Indirect and Cumulative Effects section of the Status Review. This Status Review is based on the best scientific information available to the Department, and except as discussed in the newly-added paragraph, the Department is not in possession of a quantitative published analysis of the joint risks to western Joshua tree posed by climate change and the increasing frequency of wildfire.
2819	As noted here, smaller trees are more likely to be killed in wildfires; this means that increasing frequency and severity of wildfires is a foreseeable risk to the demographic health of Joshua tree populations.	Additional detail was added to this sentence in response to a comment from another reviewer. Added a sentence saying: The severe effect of wildfire on shorter trees causes long-lasting negative effects on the demographic health of affected populations.

Line	Reviewer Comment	Department Response
2851-2859	Discussion of this study showing recovery of reproduction in a population of eastern Joshua trees after a burn is somewhat misleading, because it is impossible to assess flowering or fruit set in populations with no surviving trees after a burn — so the data is, by necessity, showing recovery of reproduction in populations that were less severely burned.	Added sentence that says: The study only examined areas where some eastern Joshua trees survived, because areas without surviving trees could not be assessed.
2893-2907	Notably unmentioned in this section is the Cima Dome fire of 2020, perhaps because it impacted eastern Joshua tree. That event burned over 43,000 acres in Mojave National Preserve, a probable climate refuge, killing 1.3 million Joshua trees in the estimation of National Parks Service staff (NPS 2020). The Cima Dome fire demonstrates how rapidly a “stochastic” event can impact even a dense, demographically healthy population, and subsequent recovery efforts emphasize the substantial resources required to restore a Joshua tree population afterward.	Added a sentence at an appropriate location in the Wildfire section of the Status Review noting the Dome Fire as an example of how rapidly a wildfire can impact a dense Joshua tree population.

Line	Reviewer Comment	Department Response
3854-3867	The consideration here of the combined effects of threats to Joshua tree, particularly the joint impacts of climate change and increased wildfire frequency and severity, is really insufficient in considering their joint power. An example of how fire risk might be weighed in concert with climate change is the work by Sweet *et al.* (2019), which compares the extent of recent fires in Joshua Tree National Park to the extent of projected suitable habitat at the end of the century, and finds that up to 50% of the projected climate refuge area within the park has been burned. If western Joshua tree does indeed suffer predicted habitat losses as great as projected by even somewhat optimistic SDM studies, the remaining populations will be dramatically more vulnerable to stochastic losses, such as wildfires. It is unlikely that a single fire could substantially damage the survivability of currently extant Joshua tree populations, but losses on the scale of the Cima Dome fire could represent a large fraction of the populations remaining in climate refugia by the end of this century.	See response to first comment in this table. A new paragraph discussing how climate change and historic wildfire may interact has been added to the (renamed) Climate Change Indirect and Cumulative Effects section of the status review, which includes reference to the work by Sweet et al. (2019). This Status Review is based on the best scientific information available to the Department, and except as discussed in the newly-added paragraph, the Department is not in possession of a quantitative published analysis of the joint risks to western Joshua tree posed by climate change and the increasing frequency of wildfire. An additional paragraph regarding uncertainty was added to the Present or Threatened Modification or Destruction of Habitat section of the Status Review.
N/A	In conclusion, it is undoubtably the case, as the draft Status Review concludes, that western Joshua tree currently remains widespread and abundant. However, I do not feel that the draft reflects a full assessment of the risk that this species “is likely to become an endangered species in the foreseeable future” as specified for assigning “threatened” status under the CESA (Fish and Game Code, sect. 2067.) As currently written, the draft Status Review interprets uncertainty in predicted threats in the most optimistic light, misses ways in which available data can answer questions that it poses, and does not seriously consider the joint effects of the interlocking threats to western Joshua tree.	See responses to previous comments. An additional paragraph regarding uncertainty in the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review was also added to the Present or Threatened Modification or Destruction of Habitat section of the Status Review.

State of California
Natural Resources Agency
Department of Fish and Wildlife

REPORT TO THE FISH AND GAME COMMISSION
STATUS REVIEW OF WESTERN JOSHUA TREE (*Yucca brevifolia*)

Western Joshua tree, photo by Jeb McKay Bjerke

Charlton H. Bonham, Director
Department of Fish and Wildlife

TABLE OF CONTENTS

List of Figures v
List of Tables vi
Abbreviations, Acronyms, and Terms vi
Executive Summary 1
Introduction 3
  Species Being Reviewed 3
  Petition Evaluation Process 3
  Status Review Overview 4
Biology 5
  Species Description 5
  Taxonomy 7
  Range and Distribution 12
    Current Range 12
    Past Range 12
    Current Distribution 15
  Life History 18
    Flowering, Pollination, and Fruit Production 18
    Seed Dispersal 20
    Seed Germination 23
    Establishment and Early Survival 25
    Growth and Longevity 26
    Summary of Important Life History Needs 28
  Similar-looking Plants 29
Habitat That May Be Essential to the Continued Existence of the Species 30
  Natural Communities 30
  Geology and Soils 33
  Climate, Hydrology and Other Factors 34
    Precipitation 34
    High Temperatures 37
    Low Temperatures 37
Abundance and Trends in California 38

Abundance ... 38
Population Trends ... 40
Inferred Long-term Trends ... 41
Direct Population Monitoring ... 42
Demographic Information ... 44
Factors Affecting the Ability to Survive and Reproduce ... 50
Large Population Size and Widespread Distribution ... 50
Climate Change ... 52
Regional Effects ... 52
Direct Effects ... 53
Species Distribution Models ... 57
Summary of Species Distribution Models ... 68
Indirect Effects ... 68
Development and Other Human Activities ... 70
Wildfire ... 73
Summary of Wildfire Threat ... 80
Invasive Plants ... 81
Herbivory and Predation ... 82
Use and Vandalism ... 85
Existing Management ... 85
Regulatory Status and Legal Protections ... 85
Federal ... 86
Federal Endangered Species Act ... 86
National Environmental Policy Act ... 86
State ... 87
California Endangered Species Act ... 87
Native Plant Protection Act ... 87
California Desert Native Plants Act ... 88
California Environmental Quality Act ... 88
Local ... 89
Inyo County ... 89
City of Bishop ... 90

Kern County ... 90
California City ... 90
Ridgecrest ... 90
Tehachapi ... 91
Los Angeles County ... 91
City of Lancaster ... 91
City of Palmdale ... 91
County of Riverside ... 92
County of San Bernardino ... 92
City of Adelanto ... 93
Town of Apple Valley ... 94
City of Barstow ... 94
Hesperia ... 94
City of San Bernardino ... 94
Twentynine Palms ... 95
Victorville ... 95
Town of Yucca Valley ... 95
Nonregulatory Status ... 96
Natural Heritage Program Ranking and IUCN Red List ... 96
California Rare Plant Rank ... 97
Management Efforts ... 97
National Park Service ... 98
Joshua Tree National Park ... 98
Death Valley National Park ... 99
United States Department of Defense ... 99
Bureau of Land Management ... 100
United States Forest Service ... 100
State of California ... 101
Other ... 102
Summary of Listing Factors ... 103
Present or Threatened Modification or Destruction of Habitat ... 104
Overexploitation ... 107

Predation 107
Competition 108
Disease 108
Other Natural Occurrences or Human-related Activities 108
Summary of Key Findings 109
Protection Afforded by Listing 111
Recommendation for Petitioned Action 111
Management Recommendations and Recovery Measures 112
Public Response 113
Peer Review 113
Acknowledgements 114
Literature Cited 114
Literature 114
Appendix A: Comments from Affected and Interested Parties on the Petitioned Action ..... A
Appendix B: Comments from Peer Reviewers on the Western Joshua Tree Status Review Report ..... B

LIST OF FIGURES

Figure 1: Western Joshua Tree Fruit with Seeds Consumed by Moth Larvae 8
Figure 2: Western Joshua Tree Range and California Ecoregions 13
Figure 3: Joshua Tree Range in California 14
Figure 4: Joshua Tree Absolute Cover 16
Figure 5: Average Deviation of Annual Precipitation in the Mojave Desert Region 36
Figure 6: Heights of western Joshua trees in 2021 at a development project site near Hesperia 47
Figure 7: Heights of western Joshua trees in 2013 from three sampling locations in California 47
Figure 8: Heights of western Joshua trees at six development project sites near the cities of Palmdale and Lancaster in 2021 48
Figure 9: Fires within the California Range of Western Joshua Tree, 1900–2020 77
Figure 10: Area Burned Within Western Joshua Tree Range, 1900–2020 78

LIST OF TABLES

Table 1: Vegetation alliances in California that may support Joshua tree 32
Table 2: Status Review Peer Reviewers 114

ABBREVIATIONS, ACRONYMS, AND TERMS

BLM – Bureau of Land Management
CCVI – Climate Change Vulnerability Index
CEQA – California Environmental Quality Act
CESA – California Endangered Species Act
CNDDB – California Natural Diversity Database
Commission – California Fish and Game Commission
Department – California Department of Fish and Wildlife
DNPA – California Desert Native Plants Act
ESA – Federal Endangered Species Act
et al. – “and others”
Ibid. – “in the same source”
Id. – “the same”
INRMP – Integrated natural resources management plan
IUCN – International Union for Conservation of Nature
JTNP – Joshua Tree National Park
NEPA – National Environmental Policy Act
NPPA – Native Plant Protection Act
ssp. – Subspecies
var. – Variety

EXECUTIVE SUMMARY

This Status Review is based on the best scientific information available to the California Department of Fish and Wildlife (Department) on western Joshua tree (*Yucca brevifolia* Engelm.) and serves as the basis for the California Department of Fish and Wildlife's (Department) recommendation to the California Fish and Game Commission (Commission) on whether to list the species as threatened under the California Endangered Species Act (CESA). On October 21, 2019, the Center for Biological Diversity submitted a petition to the Commission requesting that western Joshua tree be listed as a threatened species under CESA (Petition). At its scheduled public meeting on September 22, 2020, the Commission considered the Petition, and based in part on the Department's Petition evaluation and recommendation, found sufficient information exists to indicate the petitioned action may be warranted and accepted the Petition for consideration. Western Joshua tree was designated a candidate species on October 9, 2020, upon publication of the Commission's notice of its findings. This Status Review has also been independently reviewed by scientific peers.

Western Joshua tree is relatively widespread and abundant in California and is found in a variety of desert habitats in the Mojave Desert and Great Basin. Precipitation in these habitats is low and oscillates between wetter and drier conditions over multi-year and multi-decade timescales. Sexual reproduction of western Joshua tree requires the obligate pollinating moth *Tegeticula synthetica,* and seed dispersal is facilitated by the scatter hoarding behavior of rodents. Several successive years of wet and/or cool conditions are then required to ensure seed germination and seedling survival. A western Joshua tree may require 30 to 50 or more years to reach reproductive maturity, and individual trees can survive for very long periods of time, perhaps over 150 years. The species is capable of asexual (clonal) reproduction which may allow individuals to survive indefinitely under appropriate conditions.

The population size and area occupied by western Joshua tree have declined since European settlement due to habitat modification and destruction, a trend that has continued to the present. Primary threats to the species are climate change, development and other human activities, and wildfire. Climate change represents the greatest threat to the species, with available species distribution models suggesting that areas predicted to be suitable for the species based on 20th century climate data will decline substantially through the end of the 21st century (2100), especially in the southern and lower elevational portions of its range. Predicted suitable habitat for western Joshua tree based on 20th century climate conditions will likely remain in some areas at the end of the 21st century as refugia, and newly appear to the north and in higher elevation areas, although western Joshua tree is unlikely to colonize areas with newly suitable climate conditions quickly. The degree to which climate change will affect

western Joshua tree populations will depend on both the magnitude of climate disruption and the species' resilience to a changing climate. Predicted loss of areas of 20th century suitable climate conditions for western Joshua tree could result in an overall reduction in recruitment or increase in adult tree mortality, but the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts on existing populations that are severe enough to threaten to eliminate the species from a significant portion of its range by the end of the 21st century. The effects of development and other human activities will cause suitable habitat and populations of western Joshua tree to be lost, particularly in the southern part of the species' range, but many populations within the range of the species are protected from development, suggesting that a significant portion of the species' range will not be lost by development alone. Wildfire can also kill over half of western Joshua trees in areas that burn, and wildfire impacted approximately 2.5% of the species' range in each of the last two decades, but wildfire does not appear to result in loss of range, only lowering of abundance within the species' range.

There will be a substantial reduction in areas with 20th century suitable climate conditions for western Joshua tree by the end of the 21st century (2100), which is considered to be the foreseeable future for the purposes of this Status Review. This reduction in areas with 20th century suitable climate conditions in combination with other threats to the species is expected to have negative effects on the abundance of western Joshua tree and is substantial cause for concern. Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species, and substantially lowers the threat of extinction within the foreseeable future. Furthermore, the Department does not have the data to determine the extent to which climate changes that are expected to occur in the foreseeable future are likely to affect western Joshua tree range within California within this timeframe. While the Department recognizes the threats faced by the species, and the evidence presented in favor of the petitioned action, the scientific evidence that is currently possessed by the Department does not demonstrate that populations of the species are negatively trending in a way that would lead the Department to believe that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future.

The Department recommends that the Commission find that the recommended action to list western Joshua tree as a threatened species is not warranted.

INTRODUCTION

Species Being Reviewed

This Status Review addresses the plant *Yucca brevifolia* Engelm. For the purposes of this Status Review the term “western Joshua tree” shall mean the species *Yucca brevifolia* and the term “eastern Joshua tree” shall mean the species *Yucca jaegeriana* (McKelvey) L.W. Lenz. The more general term “Joshua tree” shall be used to mean both western Joshua tree and eastern Joshua tree collectively, or it may be used when the information presented is not known to be specific to one of the two species. Information that is specific to eastern Joshua tree is sometimes presented in this Status Review because it may be applicable to western Joshua tree or may provide relevant context. Additional information on the distinction between western Joshua tree and eastern Joshua tree is presented in the Taxonomy section of this Status Review.

Petition Evaluation Process

A petition to list the western Joshua tree (*Yucca brevifolia* Engelm.) as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission) on October 21, 2019 by the Center for Biological Diversity. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on November 1, 2019 and published a formal notice of receipt of the petition on November 22, 2019 (Cal. Reg. Notice Register 2019, No. 47-Z, pp. 1592-1593). A petition to list or delist a species under CESA must include “information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant” (Fish & G. Code, § 2072.3).

On March 11, 2020, the Department provided the Commission with its evaluation of the petition to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). By evaluating the information provided in the petition on its face and in relation to other relevant information the Department possessed or received relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.

At its scheduled public meeting on September 22, 2020 by webinar/teleconference, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, western Joshua tree was designated a candidate species on October 9, 2020 (Cal. Reg. Notice Register 2020, No. 41-Z, p. 1349).

Status Review Overview

Following the Commission's action to designate western Joshua tree a candidate species, the Department notified affected and interested parties and solicited data and comments on the petitioned action pursuant to Fish and Game Code section 2074.4 (see also Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). Comments received are included in Appendix A of this report. The Department promptly commenced its review of the status of the species as required by Fish and Game Code section 2074.6, which has now concluded with this Status Review.

The review process included independent peer review of the draft Status Review by persons in the scientific/academic community acknowledged to be experts on subjects relevant to this Status Review and possessing the knowledge and expertise to critique the scientific validity of the Status Review contents. Appendix B contains the specific input provided to the Department by the individual peer reviewers, the Department's written response to the input, and any amendments made to the Status Review (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). The Department does not have a duty or obligation to undertake independent studies or other assessments of western Joshua tree (Fish & G. Code, § 2074.8), and this Status Review is focused on presenting the relevant scientific information that was in the Department's possession during preparation of this Status Review.

The Commission's action designating western Joshua tree as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing the species is warranted. At its scheduled public meeting on June 16, 2021 by webinar/teleconference, the Commission granted the Department a six-month extension to complete this Status Review and facilitate external peer review.

This Status Review report is not intended to be an exhaustive review of all published scientific literature relevant to western Joshua tree; rather, it is intended to summarize the key points from the best scientific information available relevant to the status of the species. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to western Joshua tree. This review is intended to provide the Commission with the most current information on western Joshua tree and to serve as the basis for the Department’s recommendation to the Commission on whether the petitioned action is warranted. The Status Review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

BIOLOGY

Species Description

Western Joshua tree is a visually distinctive plant found in California’s Mojave Desert and adjacent areas. The unique silhouette and tall stature of western Joshua tree relative to typical surrounding vegetation make it one of the most recognizable native plants of California deserts. Joshua tree has been utilized by Native American cultures for food, fiber, and other uses (Coville 1892, Stoffle et al. 1990, Fowler 1995, Small 2013, Gaughen pers. comm. 2020). Joshua tree landscapes are frequently represented in western art and culture (U2 1987, Bruno and Bruno 2017, Harrower 2019) and have become increasingly popular tourist destinations (NPS 2021). Joshua trees may also have medicinal properties (Patel 2012).

A summary of western Joshua tree’s appearance and physical attributes was compiled from a number of sources, including scientific papers (Simpson 1975, Lenz 2007), botanical manuals (McKelvey 1938, Little 1950, Webber 1953, Hess and Robbins 1993, 2002, Alexander et al. 2008, Hess 2012), and the U.S. Forest Service’s Fire Effects Information System (Gucker 2006).

Western Joshua tree is a woody evergreen plant, that can mature to heights of approximately 5 to 20 m (16 to 66 ft), although trees exceeding 10 m (33 ft) are rare (Cornett 1997). Western Joshua trees often have one main trunk that branches approximately one to three m (3 to 10 ft) above the ground, and older trees can have extensive branching and a large, rounded tree-like canopy. Western Joshua trees have a monopodial branching pattern, which means that after branching, one stem remains dominant, even though the branches may appear to be approximately equal in size. Branching of western Joshua tree typically occurs after an inflorescence is produced at the end of a stem, or after the growing tissue at the end of a stem (called the apical meristem) is otherwise damaged, such as by the yucca-boring weevil (*Scyphophorus yuccae*) (Jaeger 1965). Western Joshua trees typically produce two or three branches at the end of the stem after the apical meristem is damaged, but can produce up to five branches (Simpson 1975).

The leaves of western Joshua tree are narrowly tapered, 15 to 35 cm (5.9 to 13.8 in) long and 0.7 to 1.5 cm (0.3 to 0.6 in) wide with spiny tips, parallel veins, and expanded bases where they attach to the stem of the tree. The edges of the leaves are lined with minute teeth. The outer surface of the leaf has a thick and waxy coating to help reduce water loss. Leaves near the ends of stems tend to be oriented more vertically, while leaves that are lower tend to be oriented more horizontally, which may be an adaptation to optimize light utilization (Smith et al. 1983). The evergreen leaves of Joshua trees are used by the plant for many years, reducing the need to produce new biomass. Dead leaves can remain attached for a number of years, and fold down, concealing the younger stems and bark, contributing to western Joshua tree’s distinctive shaggy appearance when viewed from a distance. Western Joshua trees produce woody stems via tissue called monocot cambium, but unlike many woody plants, the stems of western Joshua trees do not produce discernable secondary growth rings that may be used to precisely age plants (Barkley 1924, Simpson 1975, Zinkgraf et al. 2017, Jura-Morawiec et al. 2021). The soft, cork-like bark of western Joshua tree is visible after dead leaves fall from the stems of older plants.

Few observations of Joshua tree root systems are available. The root system of *Yucca* was described as “deep and rather massive” by Crosswhite and Crosswhite (1984), and also described as shallow-rooted with little or no developed taproot system by Rundel and Gibson (1996). Gucker (2006) reports that mature Joshua trees may take advantage of infrequent rains by storing near-surface water collected through their extensive network of fibrous roots. Underground roots of eastern Joshua tree were observed 11 m (36 ft) away from the aboveground portion of the plant by Bowns (1973). Communities of fungi occur in association with western Joshua tree roots, forming mycorrhizal associations which may benefit western Joshua tree (Harrower and Gilbert 2021).

Some western Joshua trees grow in close groupings that are the result of asexual growth from underground stems called rhizomes; this growth form is more common at higher elevations. When present, rhizomes grow horizontally and often produce sprouts approximately 1 to 3 m (3 to 10 ft) away from the parent plant (Gucker 2006); however, at higher elevations in the San Bernardino Mountains, sprouts as far as 5 m (16 ft) from parent plants have been observed (Borchert pers. comm. 2021). In areas where western Joshua tree exhibits abundant asexual growth, clumps of plants may form ring shapes when viewed from above, similar to the ring-shaped clumps found in other clonal plant species (Bonanomi et al. 2014).

Western Joshua trees produce a dense group of flowers at the ends of branches. These groups of flowers are arranged in panicles, which means that each group of flowers is branched, and the flowers that are near the base or outside of the group open before the flowers at the tip or close to the center. These panicles are approximately 20 to 40 cm (8 to 20 in) long, and tend to bend or tilt towards the south (Warren et al. 2016). Western Joshua tree panicles are composed of spherical-shaped generally cream-colored to greenish flowers, described by Trelease (1893) as having an “odor which is so oppressive as to render the flowers intolerable in a room,” and described by Simpson (1975) as having a “strong, sweet, mushroom-like fragrance.” Western Joshua tree flowers produce little if any nectar (Trelease 1893). The flowers of western Joshua tree have six perianth segments all resembling petals. These perianth segments are strongly incurved and never fully expand. Western Joshua tree flowers are bisexual, and have six male sexual parts called stamens, and one female sexual part called a pistil that has three ovary chambers. The stylar canal is the portion of a pistil that is used to transport genetic material from pollen to the ovules via pollen tubes. The length of the stylar canal of western Joshua tree pistils matches with the length of the organ that western Joshua tree’s obligate pollinating moth, *Tegeticula synthetica*, uses to deposit eggs into the ovaries of western Joshua tree pistils.

After pollination, Joshua tree panicles develop into groups of approximately 2 to 30 fruits that are approximately 6 to 10 cm (2 to 4 in) long and approximately 5 cm (2 in) in diameter. Western Joshua tree seeds are thinly disc-shaped, generally black, and approximately 10 mm (0.39 in) in diameter (Figure 1). There are approximately 80 seeds in mature western Joshua tree fruits, and they are arranged in stacks. The fruits are spongy or leathery when young but become dry when mature and do not open to release seeds on their own. Fruits become brittle when dry, making it easier for animals or environmental influence to break open fruits and release the seeds.

Taxonomy

Western Joshua tree (scientific name *Yucca brevifolia*) belongs to the group of flowering plants called monocots, which are characterized by having one embryonic leaf in their seeds, and often having leaves with parallel veins and flower parts that are in multiples of three. Within the monocots, Joshua tree has been placed in various plant families over the years, including the lily family (Liliaceae) and the agave family (Agavaceae). More recently, *Yucca* has been placed within an agave subfamily (Agavoideae) within a larger treatment of the asparagus family (Asparagaceae) (Chase et al. 2009, APG 2016, ITIS 2019).

The earliest known recorded accounts of Joshua trees include a written description from 1844 (Fremont 1845) and an illustration from 1853 (Williamson 1853) which are

Figure 1: Western Joshua Tree Fruit with Seeds Consumed by Moth Larvae, photo by Jeb McKay Bjerke

discussed in more detail by Lenz (2007). The first scientific description of Joshua tree was in 1871 (Engelmann 1871, McKelvey 1938). The taxonomy of Joshua tree has subsequently been the subject of some dispute, and this dispute has largely focused on whether or not intraspecific taxa (additional taxonomic divisions within the species) exist, and if so, at what taxonomic rank those taxa should be recognized (i.e., variety, subspecies, or species). The history of this uncertainty has been described in various sources (McKelvey 1938, Lenz 2007, Jones and Goldrick 2015, Wallace 2017, USFWS 2018, Cummings 2019), and a summary of this history from these sources is presented below.

Two intraspecific taxa have been validly described since Engelmann's 1871 publication of the name *Yucca brevifolia*. *Yucca brevifolia* var. *herbertii* was described by Webber (1953) and included in Munz (1959), but this form is now understood to be a result of asexual growth of western Joshua tree from underground rhizomes, and this growth form is more common at higher elevations. *Yucca brevifolia* var. *herbertii* is therefore no longer recognized as a distinct taxon and is not discussed further in this Status Review.

Yucca brevifolia var. *jaegeriana* was first described by McKelvey (1938) and a number of sources have recognized this name since that time (Clokey 1951, McMinn 1951, Webber 1953, Munz 1959, Kearney and Peebles 1960, Rowlands 1978, Thorne et al. 1981, Kartesz 1987). The taxonomic rank of the name was recognized as a subspecies by Hochstätter (2001, 2002). Other sources, however, did not recognize the *jaegeriana* taxon to be distinct from *Yucca brevifolia* (Reveal 1977, Hess and Robbins 1993, 2002, McKinney and Hickman 1993, 2002, Hess 2012). As described by Wallace (2017), timing or oversight may have been the reason that the *jaegeriana* taxon was not recognized as distinct from *Yucca brevifolia* in the Flora of North America (Hess and Robbins 2002) or the second edition of the Jepson Manual (Hess 2012).

Lenz (2007) provided evidence that the *jaegeriana* taxon is distinct from *Yucca brevifolia*, and described *Yucca jaegeriana* as a species, highlighting differences in overall shape and form, branching, leaves, flowers, fruits, and different species of obligate pollinating moth. The pollinating moth for western Joshua tree is *Tegeticula synthetica* and the pollinating moth for eastern Joshua tree is *Tegeticula antithetica* (Pellmyr and Segraves 2003).

Since Lenz's work in 2007, a substantial amount of scientific attention has been directed towards understanding the coevolution of western Joshua tree, eastern Joshua tree, and their obligate pollinating moths, with much of this attention focused on a small area in Tikaboo Valley, Nevada where the two species co-occur, and hybridization has been observed (Pellmyr 2003; Smith et al. 2008b, 2008a, 2009, 2011, 2021; Godsoe et al. 2008, 2009, 2010; Starr et al. 2013, Yoder et al. 2013, Royer et al. 2016, 2020; Cole et al. 2017). Some of this work has revealed that the length of the stylar canals of western Joshua tree and eastern Joshua tree match the length of the organs that each of their respective pollinating moths use to deposit eggs into flower ovaries. Some of this scientific work has also provided information on the divergent selection pressures on these taxa that may have contributed to their evolution and speciation. Several researchers have examined genetic relationships between western Joshua tree and eastern Joshua tree (Starr et al. 2013, Yoder et al. 2013, Royer et al. 2016, Smith et al. 2021). Royer et al. (2016) found that western Joshua tree and eastern Joshua tree are genetically distinct, and that natural selection is maintaining the differences between them. Smith et al. (2021) also found strong support for the conclusion that western Joshua tree and eastern Joshua tree are genetically distinct taxa.

Under CESA, threatened and endangered species definitions include the description "…a native species or subspecies…" (Fish & G. Code, § 2062 and § 2067). The Legislature left the interpretation of what constitutes a "species or subspecies" under CESA to the Department and the Commission, the organizations responsible for providing the best scientific information and for making listing decisions, respectively. (*Cal. Forestry Assn. v. Cal. Fish and G. Com*. (2007) 156 Cal.App.4th 1535, 1548-49). In 2018, a California court of appeals decision determined that courts should give a "great deal of deference" to Commission listing determinations supported by Department scientific expertise (*Central Coast Forest Assn. v. Fish & G. Com*. (2018) 18 Cal. App. 5th 1191, 1198-99). The Commission's authority to list necessarily includes discretion to determine what constitutes a species or subspecies (*Id*. at p. 1237).

In 2015, the U.S. Fish and Wildlife Service (USFWS) received a petition to list Joshua tree under the federal Endangered Species Act (federal ESA) (Jones and Goldrick 2015). In their Species Status Assessment, the USFWS considered both *Yucca jaegeriana* (eastern Joshua tree) and *Y. brevifolia* (western Joshua tree) as species for purposes of the federal ESA during consideration of that petition (Wallace 2017; USFWS 2018, 2019). The Petition submitted to the Commission includes a discussion of Joshua tree taxonomy and specifically requests that the Commission list western Joshua tree as threatened under CESA, regardless of the taxonomic rank into which the Commission classifies western Joshua tree. Based on the available scientific information, the Department considers western Joshua tree and eastern Joshua tree to be separate species (not subspecies of the same species) for the purposes of CESA and this Status Review.

The Petition states that western Joshua tree warrants protection under CESA throughout its range in California; however, the Petition also requests that the Commission assess whether either of two population clusters, denoted as *Y. brevifolia* North [YUBR North] and *Y. brevifolia* South [YUBR South], warrant listing separately as "ecologically significant units." In the 2018 Joshua tree Species Status Assessment, the USFWS treated YUBR South and YUBR North as two geographically separate "populations" of western Joshua tree, and these two populations are discussed separately in much of the document (USFWS 2018). The distinction between the YUBR South and YUBR North populations in the USFWS Species Status Assessment appears to be based primarily on the distinct vegetational and climatic “regions” of western Joshua tree that were described and distinguished by Rowlands (1978).

A population of organisms considered distinct for conservation purposes based on scientific analysis of the reproductive isolation and genetic differences between population groups is eligible for listing under CESA (see *Cal. Forestry Assn. v. Cal. Fish and G.*, *supra*, 156 Cal.App.4th at 1535 [upholding the Commission’s listing of two evolutionarily significant units of Coho Salmon]. The Department has recognized that similar populations of a species can be grouped for efficient protection of genetic diversity (Id. at p. 1546-47). Further, genetic structure in populations is important because it fosters enhanced long-term stability (Id. at p. 1547). Genetic diversity spreads risk and supports redundancy in the case of catastrophes, provides a range of raw genetic materials that allow adaptation and increase the likelihood of persistence in the face of long-term environmental change, and leads to greater abundance (Ibid.).

The Department recognizes that genetic divergence among populations and genetic diversity within those populations are critical to species protection. Genetic divergence indicates the amount of time that population lineages have been separated. Effective conservation strategies often identify the most divergent clades in a group of lineages as key management units. Further, quantifying genetic diversity provides information on population health and indicates the extent to which populations have the capacity to adapt to changing conditions. While it can be difficult to determine when populations within species have sufficiently differentiated to be considered separate species or subspecies, a population-genetics approach using the fixation index F_{ST} is the most widely used summary measure of population divergence.

Recent studies suggest that western Joshua tree and eastern Joshua tree have a moderate degree of genetic differentiation and diverged approximately 100,000 to 200,000 years ago, which is considered a relatively recent divergence (Smith et al. 2021). The work by Smith et al. (2021) supports the conclusion that Joshua trees fall into two distinct groups (K=2) that correspond with western Joshua tree and eastern Joshua tree. Smith et al. (2021) does indicate there is genetic diversity among populations of western Joshua tree, particularly within YUBR South among populations in the southern and western extent of its range, and the Department also recognizes the vegetational and climatic differences between the YUBR South and YUBR North populations identified by Rowlands (1978). Nevertheless, the Department does not currently have enough evidence of a clear genetic subdivision within western Joshua tree, that would support the differentiation of YUBR South and YUBR North as separate and discrete evolutionary significant units that would qualify them as separate “species or subspecies” under CESA. The genetic structure of western Joshua tree from south to north may instead be representative of a genetic “cline”, which is a continuous gradient of change in the genetic composition of populations within the range of the species that is associated with geography. Populations that are near each other are more genetically similar than populations that are farther away, but none appear fully isolated so as to be an evolutionary significant unit (Smith et al. 2021). Therefore, for purposes of this Status Review, the Department does not consider YUBR South or YUBR North to be distinct "species or subspecies" under CESA.

The scientific understanding of the genetic diversity of Joshua tree will continue to improve with the completion of a project to assemble a Joshua tree reference genome (Joshua Tree Genome Project 2020).

Range and Distribution

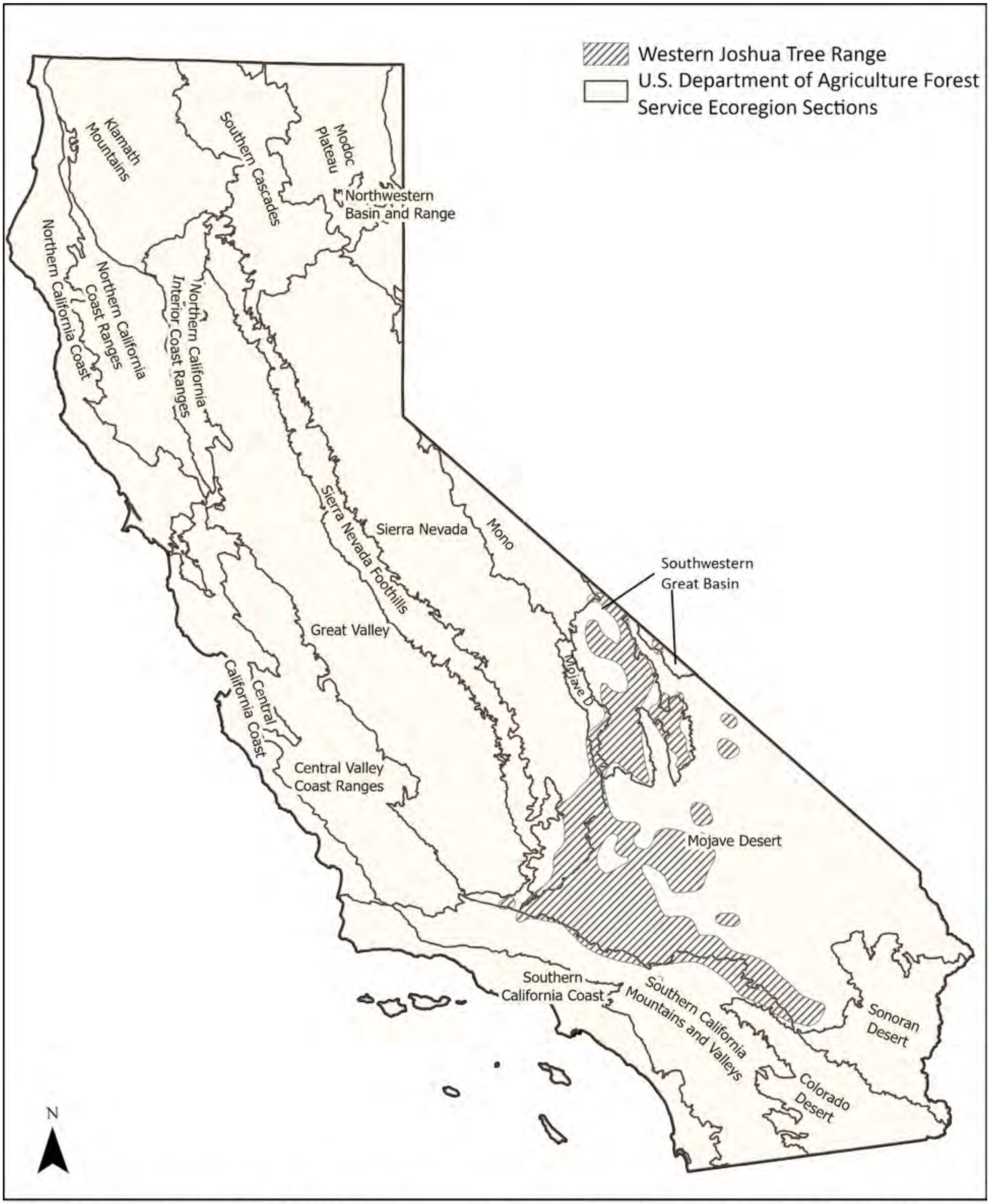
Range is the general geographical area in which an organism occurs. For purposes of CESA and this Status Review, the range is the species' California range only (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal.App.4th 1535, 1551), even though western Joshua tree extends into southern Nevada, reaching north to Alkali and east to Tikaboo Valley (USFWS 2018). Range is largely independent of species abundance, because population declines within an area do not necessarily change the overall geographical area in which an organism occurs. Species distribution describes the actual sites where individuals and populations of the species occur within the species' range.

Current Range

The California range of western Joshua tree is in southeastern California and covers much of the western half of the Mojave ecoregion (Figure 2) (USDA 2017). The southern and eastern extent of the species' range is at Joshua Tree National Park (JTNP) in San Bernardino County and the western extent of the species' range is near Gorman in Los Angeles County, where the species is found to the west of Interstate 5 (Figure 3). Within California, western Joshua trees extend to the north into Inyo County and occur within Death Valley National Park. The northernmost western Joshua trees are likely in the southeastern corner of Mono County near Fish Lake Valley, which is close to the California/Nevada border (Figure 3). Throughout California, substantial stands of western Joshua tree were reported as high as 2,100 m (6,900 ft) and as low as 750 m (2,500 ft) elevation by Rowlands (1978), and individual trees can likely be found at elevations that are slightly higher or lower than this range.

Past Range

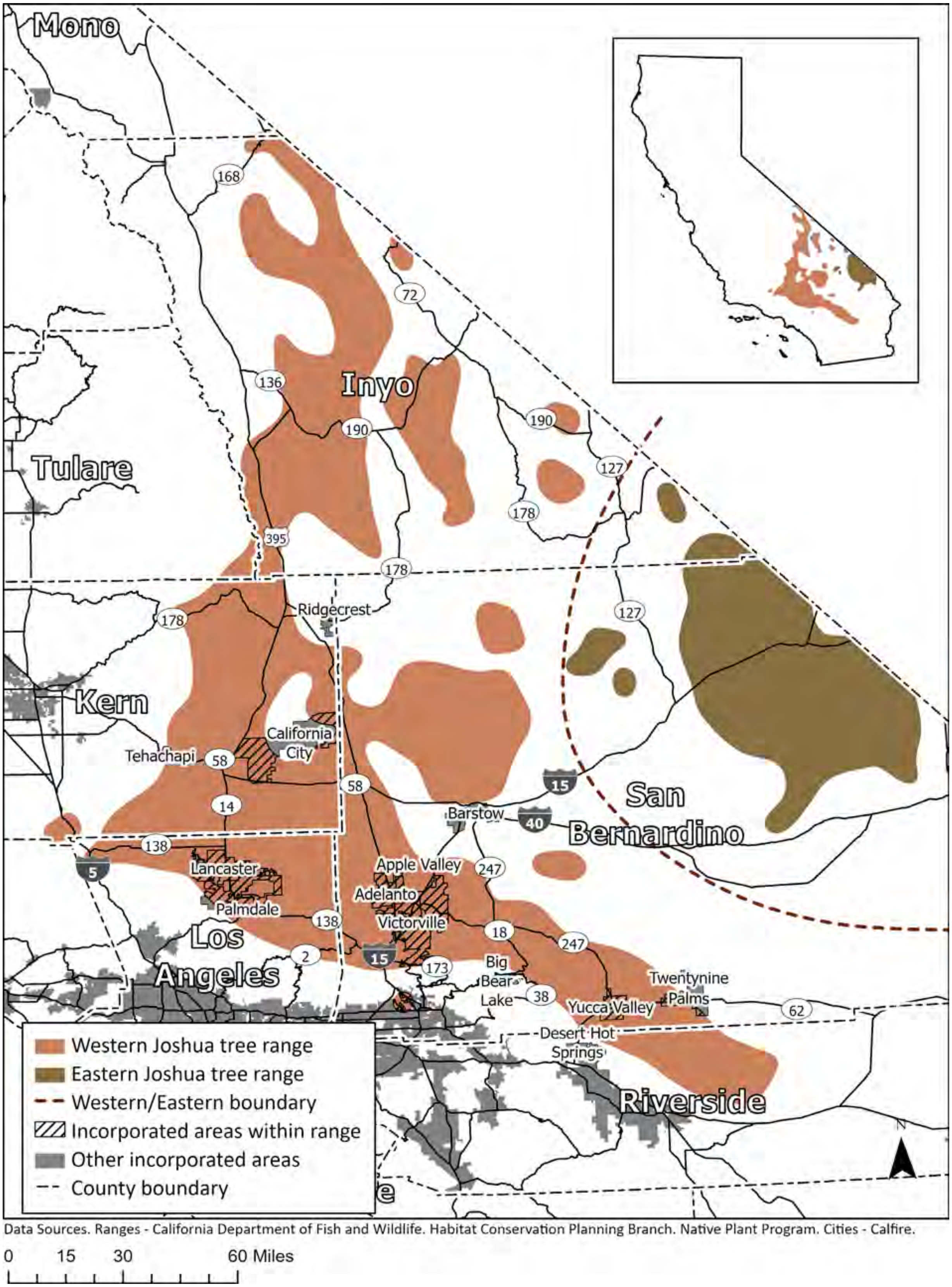
Fossil evidence indicates that Joshua tree was more widespread during the late Pleistocene period (22,000 to 13,000 years before present) (Cole et al. 2011). Joshua



Data Source: Ecoregions -USDA Forest Service; Range - California Department of Fish and Wildlife, Habitat Conservation Planning Branch, Native Plant Program

0 25 50 100 Miles

Figure 2: Western Joshua Tree Range and California Ecoregions



583 *Figure 3:* Joshua Tree Range in California

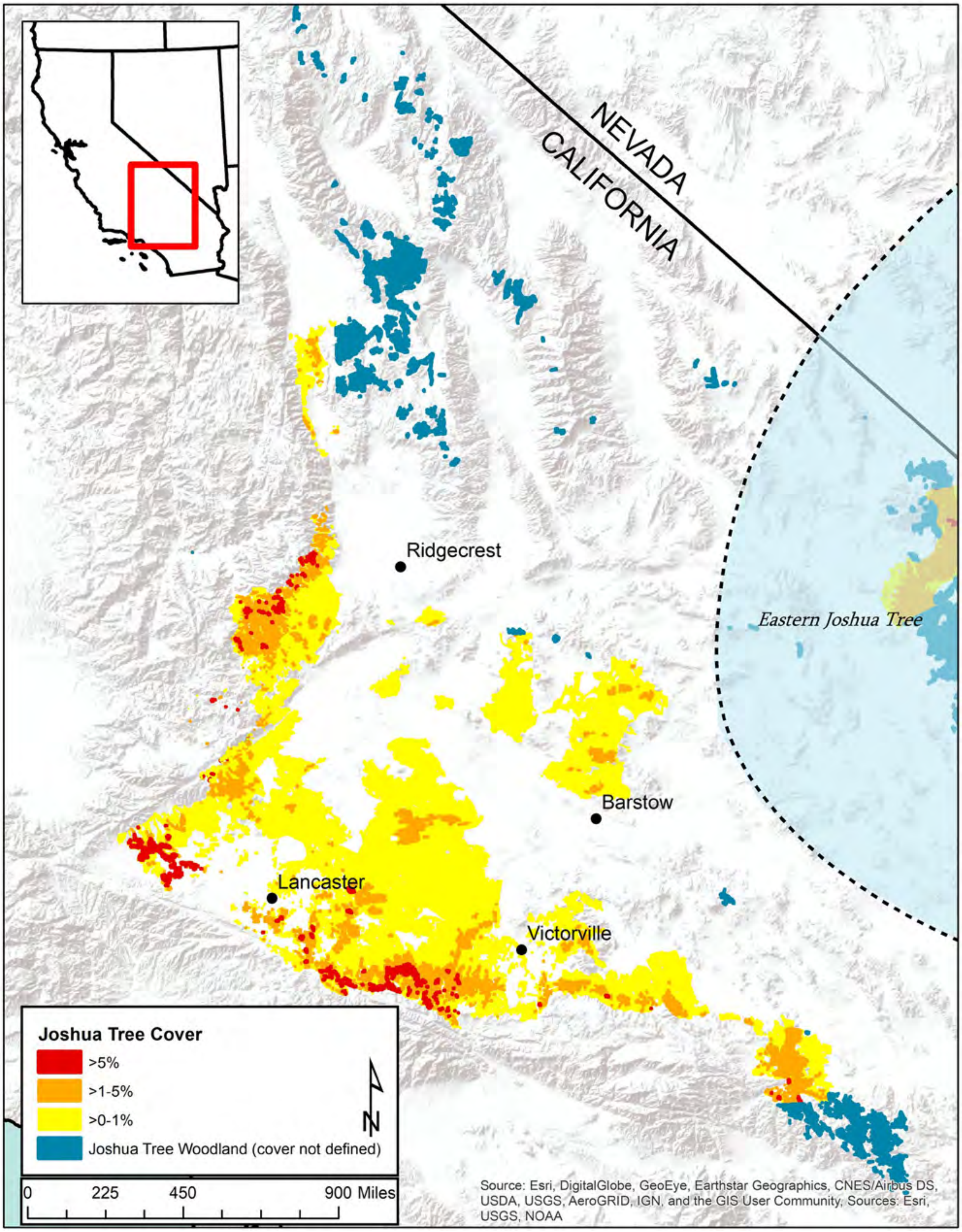
tree's range during the late Pleistocene period extended south of its present range farther into southern California and into Arizona, and likely also into northwestern Mexico (Rowlands 1978, Cole et al. 2011). Joshua tree's range suddenly contracted from the south as climates rapidly warmed approximately 11,700 years ago at the beginning of the Holocene period, and now only the northernmost Joshua tree populations remain (Cole et al. 2011). While Joshua tree's range contracted from the south as climates warmed, Cole et al. (2011) states that it also may have expanded very slowly to the north, and attributed this to very limited dispersal capabilities, which are discussed in more detail in the Seed Dispersal section of this Status Review. Smith et al. (2011) modeled historical distribution using 20th century suitable climate conditions to reconstruct a potential distribution of Joshua tree approximately 21,000 years before present during the last glacial maximum. The results of this modeling also suggested that Joshua trees formerly occupied a larger range in the southern Mojave Desert. Smith et al. (2011) suggested that loss of range in the southern part of Joshua tree's range between 21,000 years ago and the present may have been offset by the addition of new potential habitats in the north.

Current Distribution

Western Joshua tree is distributed in discontinuous populations in the Mojave Desert and in a portion of Great Basin Desert (Figure 2). Western Joshua tree is often noted as being abundant near the borders of the Mojave Desert in transition zones. The general distribution of Joshua tree has been described in various sources, with newer, larger datasets of presence points generally contributing to more accurate distribution maps over time.

The USFWS described the distribution of both western Joshua tree and eastern Joshua tree as part of a Species Status Assessment for the two species in 2018 and produced a distribution map as part of the assessment. The USFWS distribution map was based on several sources including Rowlands (1978); Cole et al. (2003, 2011); Webb et al. (2003); the LANDFIRE Reference Database (2007); Godsoe et al. (2009); and other available databases (USFWS 2018).

The Department possesses vegetation maps that cover a large portion of the California deserts where western Joshua tree generally occurs. Joshua tree woodland (*Yucca brevifolia* vegetation alliance) is mapped with an approximate accuracy of 95% in the vegetation maps that are related to the Desert Renewable Energy Conservation Plan, and these maps also denote the absolute cover of Joshua tree canopy in all vegetation polygons by cover class (0, >0-1%, >1-5%, and >5%) (CDFW 2017). Based on the information in these vegetation maps, the Department produced a map of western Joshua tree cover within mapped vegetation polygons, which shows areas where Joshua tree occurs at a relatively high density (Figure 4).



623 *Figure 4:* Joshua Tree Absolute Cover (Data from Vegetation Maps)

The Department used vegetation mapping information (polygons) available to the Department (Thomas 2002; Agri Chemical and Supply, Inc. 2008; NPS 2012; CDFW and USGS 2014; CDFW and Chico State University 2015; CDFW et al. 2017; CDFW 2019 a, b, c, d) combined with data from other sources including herbarium records, Calflora, and iNaturalist (points) to create the western Joshua tree range shown in Figures 2 and 3. The Department reviewed outlier point observations from herbaria, Calflora, iNaturalist and other observations to ensure that incorrectly mapped and erroneous observations did not substantially expand the map extent. Creating a range map with incomplete presence data can sometimes be misleading because the absence of data does not necessarily mean the absence of the species. Additionally, different buffer distances around data points can yield wildly different results for occupied areas. To create the general western Joshua tree range shown in Figures 2 and 3, the Department did not use a specific buffer value, and instead used the data described above in a geographic information system analysis to extend the range polygons to closely follow known occurrence boundaries while eliminating small gaps between them.

The area occupied by the western Joshua tree range shown in Figures 2 and 3 is approximately 30,200 km^2 (11,660 mi^2); however, this is very likely an overestimation of the area occupied by the species in California. If the point and polygon data used for the range is instead buffered by 0.2 km (0.12 mi) the area occupied would be 10,160 km^2 (3,920 mi^2) which is likely an underestimation of the area occupied by the species within California, because populations represented only by points are likely larger than the buffered distance, and the Department does not have data for every location where western Joshua tree occurs. If each occupied area was reported as a point, with an average area of 0.59 km^2 (0.23 mi^2), and all point and polygon areas were additionally buffered by 0.2 km (0.12 mi), the area occupied by western Joshua tree would be 13,880 km^2 (5,360 mi^2). To put these areas in perspective, the area occupied by western Joshua tree is likely larger than the land area of the State of Connecticut, but smaller than the land area of the State of Hawaii. As part of its Species Status Assessment, the USFWS (2018) estimated that the area occupied by western Joshua tree was 22,823 km^2 (8,812 mi^2), but this estimate included areas occupied by western Joshua tree that were outside of California. In an effort to estimate population size, WEST Inc. (2021a) used data from Cole et al. (2011) to report the area occupied by western Joshua tree as 15,071 km^2 (5,819 mi^2), but WEST Inc. (2021b) later reported that this area was only for the southern part of the species range, and the northern and southern portions of the species range together occupy an area of approximately 23,101 km^2 (8,919 mi^2), although this estimate likely includes areas outside of California.

The distributions of most plant species of conservation concern within California are documented in the Department's California Natural Diversity Database (CNDDB) (CDFW 2021a). The taxa that are tracked in the CNDDB are referred to as "elements." An "element occurrence" (occurrence) is a location record for a site which contains an individual, population, or stand of a special status element (Bittman 2001). Prior to being designated a candidate species under CESA, western Joshua tree was not considered to be a plant species of conservation concern by the Department, and the species was therefore not tracked in the CNDDB. Although the Department has not begun tracking occurrences of western Joshua tree, initial estimates suggest that the number of western Joshua tree occurrences could total approximately 846. The highest number of occurrences for a plant currently tracked by the Department in the CNDDB is 249 (CDFW 2021a). If the species were tracked in the CNDDB, the number of western Joshua tree occurrences in the CNDDB would likely be much higher than any other plant element currently tracked in the database.

Scientific understanding of current western Joshua tree distribution is continuing to improve. Both remote sensing techniques using satellite imagery as described by Esque et al. (2020a) and citizen science applications such as iNaturalist are making it possible to develop a more detailed map of western Joshua tree distribution. These efforts nevertheless have limitations. Remote sensing techniques are most effective on western Joshua tree in lower-elevation areas where western Joshua trees are not surrounded by vegetation of similar height. Additionally, despite peer review of citizen science observations by other users, citizen science data frequently includes erroneous identification of species (including of western Joshua tree).

Based on information available to the Department, western Joshua tree is relatively widespread across a large geographic area of southeastern California, western Joshua tree populations occupy relatively large areas within this geographic area, and the number of occurrences of western Joshua tree within California is very high compared with the number of occurrences for the approximately 1,700 plant species of conservation concern that are tracked and mapped by the Department's CNDDB.

Life History

Flowering, Pollination, and Fruit Production

Mature western Joshua trees do not produce flowers every year, and flowering is thought to be episodic, possibly only occurring in wetter years (Gucker 2006, St. Clair and Hoines 2018), although cold and dry conditions have also been implicated for early-season flowering (Brenskelle et al. 2021). In some years, many western Joshua trees produce flowers synchronously, leading to the production of large quantities of fruits and seeds in that year, which is part of a reproductive strategy called masting (Kelly and

Sork 2002, Borchert and DeFalco 2016, St. Clair and Hoines 2018). A mast seeding reproductive strategy is beneficial for species whose seeds are dispersed by seed predators, because when more seeds are produced than predators can eat, the surviving seeds have a higher likelihood of establishing and developing into a reproductive adult (Kelly and Sork 2002). Large flowering events are relatively infrequent, perhaps only occurring once or twice per decade, and the environmental or other conditions that lead to large flowering and mast seeding events are currently unknown (Esque et al. 2010, DeFalco and Esque 2014, Borchert and DeFalco 2016).

Western Joshua tree flowers have been reported between January and May, but flowering as early as November has also been observed (Hess 2012, Waitman et al. 2012, Cornett 2018a, 2018c, Harrower and Gilbert 2018, Barve et al. 2020, Brenskelle et al. 2021). Esque et al. (2015) reported that flowering may occur in Joshua trees that are as short as one meter, but that 30-year-old trees at their study site had yet to flower. Rowlands (1978) investigated the average height to first branching, which is likely indicative of the height at first flowering. The information presented in Rowlands (1978) from ten populations of western Joshua tree showed that the average height to first branching was between 1 and 1.5 m at the three northernmost populations examined, and the average height to first branching was between 2 and 2.5 m at more southern populations. Larger western Joshua trees tend to produce more flower clusters than smaller trees (Harrower and Gilbert 2018).

Joshua tree flowers require pollination to produce fruits. Like most species in the genus *Yucca*, western Joshua tree is pollinated by a unique species of yucca moth. Within California, western Joshua tree forms an obligate pollination mutualism with its specialized nocturnal pollinating yucca moth *T. synthetica*, and eastern Joshua tree forms an obligate pollination mutualism with its specialized pollinating yucca moth *T. antithetica* (Trelease 1893, Pellmyr and Segraves 2003). The interactions between *Yucca* species and yucca moths have captivated the attention of biologists for over 150 years, beginning with observations by George Engelmann and Charles Riley in the 1800s, and these interactions continue to be the subject of research (Riley 1873, Sheppard and Oliver 2004, Royer et al. 2020). In a letter, Charles Darwin (1874) once described the *Yucca*-yucca moth interaction mutualism as “the most wonderful case of fertilisation ever published.”

Western Joshua tree flower panicles create large, light-colored landing pads for *T. synthetica* moths to use, and residual heat in the flower panicles that were warmed by the sun during the day may provide a thermal reward for its nocturnal pollinating moths (Warren et al. 2016). Female *T. synthetica* moths have special tentacle-like mouth parts for collecting, transporting, and transferring western Joshua tree pollen (Cole et al. 2017). Female moths first gather a ball of western Joshua tree pollen with their special mouth parts, next they oviposit eggs into the western Joshua tree flower, and finally the moths actively transfer pollen to a portion of the female sexual part of a western Joshua tree flower called a stigma, ensuring that the flower will be fertilized (Pellmyr 2003, Cole et al. 2017). When ovipositing her eggs, a female yucca moth cuts through the ovary wall of a western Joshua tree flower so she can insert her ovipositor down the stylar canal to lay eggs near ovules that can eventually become seeds after the flower is fertilized (Cole et al. 2017). The moth eggs hatch within a few days and feed on developing seeds (Pellmyr 2003). By actively pollinating western Joshua tree flowers, female yucca moths can ensure that there will be a food source for their developing moth larvae. Both western Joshua trees and *T. synthetica* moths benefit from this pollination mutualism because each species is dependent on the other for a critical aspect of sexual reproduction. In the late summer, moth larvae that developed within Joshua tree fruits fall to the ground below the tree, burrow into the ground, create a cocoon, and enter a period of suspended development called diapause (Pellmyr 2003). Yucca moth larvae are likely able to remain in diapause for several years before pupating into moths; the environmental or other cues that trigger this pupation are currently unknown (Riley 1892, Pellmyr 2003).

After pollination, western Joshua tree fruits develop and seeds are produced. Borchert and DeFalco (2016) found that fruits may reach full size around late May, although seeds did not become black and capable of germination until approximately 14 days after they are full size. Fruits turn from pale green to a whitish light brown as they dry and may fall to the ground or into the leaves of the tree or remain attached to the panicle of the tree. As would be expected in a masting species, the amount of western Joshua tree seeds and fruits produced can be highly variable from year to year (Borchert and DeFalco 2016). Viable seed production by western Joshua tree may be limited more by pollen than other resources, and greater sexual reproduction tends to occur in areas with more *T. synthetica* moths (Harrower and Gilbert 2018). Within the vicinity of JTNP, *T. synthetica* moths were found at elevations ranging from 1,049 m (3,442 ft) to 2,076 m (6,811 ft), but not at the lowest elevation study site that had western Joshua trees at 1,004 m (3,294 ft) or the highest elevation study site with western Joshua trees at 2,212 m (7,257 ft) (Harrower and Gilbert 2018).

<u>Seed Dispersal</u>

The primary current method of western Joshua tree seed dispersal is from the scatter-hoarding behavior of rodents who actively collect seeds from fruits in the canopies of trees and fruits and seeds that have fallen on the ground (Vander Wall et al. 2006, Waitman et al. 2012, Borchert 2016). Other methods and agents of seed dispersal such as wind, other mammals, birds (e.g., western scrub jay (*Aphelacoma californica*)), and extinct megaherbivores (e.g., giant sloths and relatives of elephants) have also been suggested in the scientific literature (McKelvey 1938, Lenz 2001, Borchert 2016). Although western Joshua tree currently has limited seed dispersal ability, rare long-distance dispersal events were likely important for plant migrations over large geographic scales in the past (Clark et al. 1998), and may have occurred for Joshua tree.

Lenz (2001) provided observations of apparent dispersal distances in areas that had been previously cleared of vegetation and left fallow at a population of western Joshua tree in the western portion of the Antelope Valley (Los Angeles County), and at a population of eastern Joshua tree in Lanfair Valley, California (San Bernardino County). Lenz (2001) found young plants (cluster of leaves, no stem) or juvenile plants (with stem but unflowered) in limited numbers as far as 151 m (495 ft) from potential seed donors in the Antelope Valley, and 251 m (823 ft) from potential seed donors in Lanfair Valley. Lenz (2001) did not explicitly test seed dispersal mechanisms but hypothesized that these dispersal events were the result of wind dispersal. However, the role of rodents in Joshua tree seed dispersal was not well understood at that time.

Joshua trees produce fruits that do not open when seeds are ripe and produce seeds with an undersized wing structure relative to seed mass, which are morphological characteristics that can indicate seed dispersal via scatter-hoarding rodents. Borchert (2016) used camera traps and affixed line to 208 western Joshua tree fruits and placed them under trees at two sites in the San Bernardino Mountains to observe and measure fruit dispersal. White-tailed antelope squirrel (*Ammospermophilus leucurus*) and kangaroo rats (*Dipodomys merriami* and *D. agilis*) were observed carrying fruits away from trees before dismantling them. The maximum distance that a fruit was moved was 46.9 m (154 ft), and the average dispersal distance was 6.4 m (21 ft) (Borchert 2016). White-tailed antelope squirrels were responsible for carrying away the most western Joshua tree fruits. Kangaroo rats readily collected loose western Joshua tree seeds from dishes (Borchert 2016). Other species observed interacting with western Joshua tree seeds and fruits included pocket mice (*Chaetodipus fallax* and *Perognathus longimembris*), pinyon mice (*Peromyscus trueii*), and western scrub jays (Borchert 2016).

Vander Wall et al. (2006) placed a total of 1,000 radioactively marked eastern Joshua tree seeds at the base of five different eastern Joshua trees (200 seeds per tree). Rodents removed 995 of the 1,000 seeds within two days, and researchers were able to find 67.7%–97.5% of the seed originally placed below each tree in seed caches at distances between 0.5 and 56.6 m (1.6 and 186 ft) away from where the seeds were originally placed. The average maximum dispersal distance was 30.0 m (98.4 ft). On a subsequent visit, Vander Wall et al. (2006) found that many of the seeds discovered in the seed caches on the previous visit were re-cached in secondary caches located between 0.2 and 32.2 m (0.7 and 106 ft) away from the original cache. Assuming seeds are sometimes re-cached in the same direction away from the source tree, results of the Vander Wall et al. (2006) study suggest that rodents may be capable of moving eastern Joshua tree seeds as far as 88.8 m (291 ft) away from a source plant (56.6 meters plus 32.2 meters). If entire fruits are first carried away from source trees by rodents, dispersal distance could be farther (Borchert 2016). The Vander Wall et al. (2006) study examined dispersal from only five source trees, and therefore may not demonstrate the maximum possible dispersal distances that seed caching rodents are capable of moving eastern Joshua tree seeds. In a subsequent study by Waitman et al. (2012) using camera traps, white-tailed antelope squirrels cached eastern Joshua trees seeds a mean distance of 21.3 ± 2.8 m (69.9 ± 9.2 ft) from the source tree, but only three trials were conducted, because the primary purpose of this treatment was for comparison with treatments involving rodents kept within an enclosure.

Waitman et al. (2012) also examined factors related to seed dispersal of eastern Joshua trees and found evidence that rodents are a factor causing eastern Joshua tree fruits to drop from the tree canopy at two study sites. Waitman et al. (2012) also placed a total of 160 eastern Joshua tree fruits on the ground and found that approximately 90% of these fruits were removed by ground-foraging rodents within approximately 15 days. Eastern Joshua tree seeds placed on the ground were also removed, but less rapidly than whole fruits. Waitman et al. (2012) also conducted experiments that involved placing a white-tailed antelope squirrel or Merriam’s kangaroo rat into a 10 by 10 m enclosure with 200 radioactively marked eastern Joshua tree seeds to study the scatter-hoarding behavior of these rodents, including the depth of seed caches, distance of caches from source trees, and whether seeds were cached in the open or under shrubs. Seed caches created by rodents in this study were buried at a mean depth of 12 ± 3 mm. One study suggested that scatter-hoarding rodents may preferentially place Joshua tree seeds under shrubs which would likely be beneficial for seedling emergence (Swartz et al. 2010), but Vander Wall et al. (2006) and Waitman et al. (2012) found that rodents do not appear to disperse eastern Joshua tree seeds with regard to shrub cover.

Using a wind tunnel, Waitman et al. (2012) also measured the wind speeds necessary to move eastern Joshua tree fruits and seeds on a sandy and a rocky substrate. Wind speeds required to move fruits was lower than wind speeds required to move seeds (31.9 ± 2.6 km/h and 43.6 ± 2.6 km/h, respectively on the sandy substrate). Wind speeds sufficient to move fruits and seeds on the rocky substrate averaged and 73.6 ± 4.8 km/h and 87.6 ± 5.5 km/h, respectively. Waitman et al. (2012) suggested fruits and seeds that do fall are unlikely to be carried far by wind and are instead much more likely to be gathered by rodents; therefore, wind is unlikely to be a primary mode of dispersal where rodents are present.

Although scatter hoarding rodents and Joshua trees are capable of a mutualistic relationship where both organisms benefit each other, in non-masting years when Joshua trees only produce a small number of seeds, an overabundance of rodents may consume all the seeds, resulting in a shift from a mutualistic relationship to a predatory relationship, and Joshua tree may not benefit from the relationship in these years (Waitman et al. 2012).

Joshua tree has been found to be a chief component in fossilized dung of the now-extinct Shasta ground sloth (*Nothrotheriops shastensis* Sinclair) that was found in a cave in southern Nevada (Harrington 1933, Laudermilk and Munz 1935, Cole et al. 2011). Poorly masticated fragments of Joshua tree up to 2 cm long were found in the dung, including sharp leaf tips, parts of the flower stalk and fruits, and entire seeds, although all seeds observed were split. Researchers have speculated that Joshua tree's large fruits may have been an adaptation for consumption by large mammals that are now extinct (Simpson 1975, Lenz 2001). In addition to extinct ground sloths, extinct long-necked members of Camelinae (relatives of camels and llamas) and extinct relatives of elephants in the order Proboscidea were present within the range of Joshua tree in the past. Extinct members of the order Proboscidea may have been capable of feeding on Joshua tree fruits via an elephant-like trunk, and elephants are known seed dispersers because they consume large quantities of material that is passed relatively undigested within a relatively short period of time (Lenz 2001 and citations therein). Shasta ground sloth and other megaherbivores became extinct approximately 12,900 years before present, perhaps due to rising populations of humans (Steadman et al. 2005) and/or a meteorite impact (Firestone et al. 2007). Joshua tree's height may have been an evolutionary strategy to elevate leaves, flowers, and fruits so they could not be reached by large herbivores (Lybbert and St. Clair 2017). Assuming that even a small proportion of Joshua tree seeds were capable of remaining viable in the dung of Shasta ground sloth or another extinct herbivore, Joshua tree may have been capable of more frequent longer-distance seed dispersal in the past. However; using genetic data, Smith et al. (2011) found no evidence of a change in the rate of Joshua tree dispersal corresponding with the timing of the extinctions of such herbivores, which would be expected were they important Joshua tree seed dispersers.

<u>Seed Germination</u>

While western Joshua tree seeds germinate readily under optimal conditions, successful seedling establishment is exceptionally rare (Reynolds et al. 2012), and few Joshua tree seedlings are observed in the field, particularly at lower elevations (Webber 1953, Wallace and Romney 1972, Comanor and Clark 2000, Esque et al. 2010).

Twenty-year-old western Joshua tree seeds stored at California Botanic Garden had 100% germination with no pretreatment and grown on agar in a germination chamber (Birker pers. comm. 2021). Other studies have reported similarly high Joshua tree germination success under controlled conditions (Wallace and Romney 1972, McCleary 1973, Gucker 2006, Alexander et al. 2008, Waitman et al. 2012).

Joshua tree seed viability decreases dramatically after dispersal in the wild. Reynolds et al. (2012) found that after one year in an underground cache, only 50%–68% of recovered eastern Joshua tree seeds were able to germinate, and after three years and four months in an underground cache, approximately 3% of recovered eastern Joshua tree seeds were able to germinate. This suggests that Joshua tree has limited capacity to maintain viable seeds in the soil for long periods of time. In years when fruit production is enough to satiate predation by larvae and rodents, Borchert and DeFalco (2016) speculated that uneaten fruits in the tree canopy may function as a viable aerial seed bank, because seeds may remain viable for a longer duration when protected within fruits than loose in the soil.

Once western Joshua tree seeds have dispersed in the wild, they appear to be able to germinate any time after rain (Went 1948, Reynolds et al. 2012). Reynolds et al. (2012) examined several cohorts of artificially placed eastern Joshua tree seeds, and found that seedling emergence was greatest during spring and summer, when increased soil moisture was accompanied by warm soil temperatures, but seedlings were also able to emerge at other times of the year, suggesting some potential for adaptation to shifting conditions. McCleary (1973) tested four different eastern Joshua tree germination temperatures and found seed germination was fastest at 25°C.

Waitman et al. (2012) found that seed caching by rodents increased the likelihood of successful seedling emergence and seeds were most likely to produce seedlings when buried 1–3 cm (0.4–1.2 in) deep, and that seeds placed on the soil surface seldom germinated. Between August 2007 and September 2008, Waitman et al. (2012) found that only 133 of 2,880 artificial caches (4.6%) placed in the field produced seedlings and only 183 of the 5,760 seeds (3.2%) placed in those caches produced seedlings. Significantly more Joshua tree seedlings emerge from under shrubs than in the open (Vander Wall et al. 2006, Waitman et al. 2012, Reynolds et al. 2012). One study suggested that scatter-hoarding rodents may preferentially place seeds under shrubs which would likely be beneficial for seedling emergence (Swartz et al. 2010), but Vander Wall et al. (2006) and Waitman et al. (2012) found that rodents do not appear to disperse eastern Joshua tree seeds with regard to shrub cover.

Establishment and Early Survival

Successful recruitment of plants may be limited by the availability of seed and/or by other constraints on seedling establishment (Grubb 1977, Clark et al. 1999, 2007). Few experiments involving the addition of seeds to Joshua tree habitat have been conducted (Waitman et al. 2012, Reynolds et al. 2012), but results suggest that constraints on seedling establishment may be a critical factor limiting successful western Joshua tree recruitment. Following germination, several successive years of sufficiently wet and/or cool conditions are likely required for successful establishment of Joshua tree seedlings (Wallace and Romney 1972, Cole et al. 2011). Joshua tree seedlings and very young plants appear to require sufficient soil moisture to survive, periods of cold temperatures for optimal growth, and must avoid consumption by herbivores (Went 1957, Esque et al. 2015). Of seedling cohorts monitored by Reynolds et al. (2012), seedlings emerging in September survived the longest, although approximately 90% of them died within one year. Esque et al. (2015) identified the seedling height of 25 cm as an important size class threshold because seedlings that attained this height before the onset of drought conditions had a greater likelihood of longer-term survival.

Nurse plants appear to be critical habitat components for Joshua tree establishment (Waitman et al. 2012, Reynolds et al. 2012, Esque et al. 2015), likely by providing a microclimate with less direct sun, higher soil moisture, lower soil temperature, a reduction in water loss to the atmosphere, increased soil nutrients, and/or a reduction in the drying effects from wind (Holmgren et al. 1997, Brittingham and Walker 2000, Legras et al. 2010). Many plants in Joshua tree habitat including blackbrush (*Coleogyne ramosissima*) and creosote bush (*Larrea tridentata*) can act as nurse plants for Joshua tree seedlings by providing favorable conditions for seedling growth and survival, and perhaps some protection from small mammal herbivory.

Harrower and Gilbert (2021) found that the presence of arbuscular mycorrhizal fungi in association with the roots of western Joshua tree seedlings generally appeared to have positive benefits for nitrogen absorption and plant biomass. Some species of arbuscular mycorrhizal fungi from low elevation areas in JTNP were found to have an initial negative impact on one- to three-month old western Joshua tree seedlings, but these associations became beneficial when seedlings were six-months old.

McCleary (1973) tested four different light cycles on young eastern Joshua tree plants and found that 10 hours of light and 14 hours of dark produced the highest average number of leaves, and the longest average total length of leaves per plant. Western Joshua tree seedlings were observed by Wallace and Romney (1972) to grow best at root temperatures near 18°C and without calcium carbonate ($CaCO_3$) in the soil.

Germination and emergence of perennial desert plants have been associated with infrequent weather events such as those associated with the El Niño–Southern Oscillation (Bowers 1997, Holmgren et al. 2006). Such events bring winter and early spring precipitation after seed germination and may be the conditions that are most conducive to establishment of western Joshua tree.

Esque et al. (2015) monitored a cohort of 53 western Joshua tree plants that were 5 to 6 years old for a period of 22 years at Lee Flat, Nevada. These western Joshua trees had an average height of 21.5 cm when monitoring began in 1989, and the surviving 10 plants had an average height of approximately 1 meter in 2011. Most of the mortality was attributed to the plants being consumed by black-tailed jackrabbit (*Lepus californicus*) during drought years. DeFalco et al. (2010) monitored burned and unburned western Joshua trees for a five year period after a wildfire in JTNP, and found that plants that were less than approximately one meter (3.3 feet) were more vulnerable to drought, herbivory, and fire than larger size classes, which had a greater likelihood to survive. Harrower and Gilbert (2018) found considerable western Joshua tree seedling recruitment within JTNP at elevations around 1,300 m (4,300 ft), where trees were generally the biggest, and they produced the most flowers, fruits, and seeds.

Growth and Longevity

Smith et al. (1983) investigated the photosynthetic characteristics and transpiration (water loss through leaves) of western Joshua tree, and despite early assumptions to the contrary, found that western Joshua tree survives solely on the C_3 carbon fixation pathway, despite growing in arid areas where other photosynthetic pathways (e.g., C_4 and CAM) are sometimes utilized by plants as an adaptation to hot environments. Western Joshua tree is capable of carefully controlling the stomata (openings for transfer of gases to and from the environment) of its leaves throughout the day and the year, which is an adaptation allowing it to control water loss and maintain its leaves during the summer and fall dry seasons (Smith et al. 1983). Because western Joshua tree’s evergreen leaves are maintained for many years, there is a reduced need to produce new biomass. Western Joshua tree’s moderate photosynthetic rate, arrangement of leaves, and high leaf area nevertheless also allow it to exhibit substantial photosynthetic productivity during the winter-spring growth period (Smith et al. 1983). Wallace and Romney (1972) estimated that western Joshua trees at one site in Nevada produced about three sets of six leaf blades per year but noted that six to eight sets of six blades were developed in 1969 due to the large amount of rain in that year. Like many desert plants, Joshua trees must exercise extreme frugality in utilizing moisture reserves of intermediate and deep soils and moisture that is stored in leaves, trunk, and roots (Crosswhite and Crosswhite 1984). Although Joshua tree trunk diameter is generally expected to increase with time, the diameter of Joshua tree trunks has also been reported to decrease, perhaps as a result of drought (Phillips et al. 1980, Gilliland et al. 2006).

Western Joshua tree grows in height very slowly, and growth rates can vary based on location and other factors. Esque et al. (2015) monitored one site in Nevada over 22 years and found an average western Joshua tree growth rate of 3.12 cm in height per year. Comanor and Clark (2000) monitored three plots over 20 years (two with western Joshua tree and one with eastern Joshua tree) and found an average growth rate of approximately 4 cm per year. Gilliland et al. (2006) observed a growth rate of 3.75 cm per year at a population of eastern Joshua trees in Utah over a period of 14 years. Wallace and Romney (1972) estimated average western Joshua tree growth rates of about 1.5 cm per year at one site in Nevada. A growth rate of over 8 cm per year through approximately 17 years was observed in one tree near Rose Mine in the San Bernardino Mountains, which Rowlands (1978) reported as supporting clonal trees that are the tallest and fastest growing Joshua trees recorded in the southwest. Rowlands attributed this high growth rate to relatively high water availability coupled with deep sandy loam soil. Western Joshua tree growth rates as high as 14.3 cm per year were reported by McKelvey (1938). In one monitoring plot at Cima Dome in Mojave National Preserve, Cornett (2018b) found that annual height increase of eastern Joshua tree was moderately correlated with summer precipitation ($r = 0.53$, $P = 0.009$). Because Joshua tree does not produce clearly identifiable secondary growth rings in its wood, tree height is often used to approximate the age of the plants (Gilliland et al. 2006). Estimates for the ages of western Joshua trees are therefore dependent on the assumptions used for annual growth rate, and these estimates include a high level of uncertainty. Went (1957) published data demonstrating that after Joshua tree has reached a certain age the plant requires exposure to low temperatures for optimal growth.

In areas outside of the distribution of *T. synthetica* moths, asexual reproduction is the only viable reproductive strategy for western Joshua tree. Asexual reproduction occurs from underground stems called rhizomes that grow horizontally and produce sprouts near the parent plant, resulting in plants with more than one main stem and clumps of plants growing together. Asexual reproduction may allow western Joshua tree individuals to survive for indefinite periods of time, because new sprouts create genetically identical clones of parent plants that may replace the parent plants after they have died, and this process can continue for many generations. The extent of asexual reproduction in Joshua tree populations increases with elevation (Simpson 1975, Rowlands 1978), and asexual reproduction has also been reported at lower elevations where sexual reproduction is not occurring (Harrower and Gilbert 2018), which is consistent with observations that asexual reproduction tends to be more frequent at the edges of plant species ranges (Silvertown 2008). The use of asexual growth for reproduction and survival by western Joshua tree may be an adaptation to higher elevations, harsher environmental conditions, or may be an adaptation to lower availability of yucca moths for pollination at these locations (Webber 1953, Rowlands 1978, Harrower and Gilbert 2018). As is the case with some relict species, the ability to reproduce asexually may extend the ability of western Joshua tree to persist in marginal and refugial climate conditions for very long periods of time. Western Joshua tree often resprouts after fire (Vogl 1967, Loik et al. 2000b, Gucker 2006, DeFalco et al. 2010), and like Joshua tree asexual growth, fire is also more frequent at higher elevation areas of the Mojave Desert (Brooks et al. 2018). DeFalco et al. (2010) found that resprouting of burned but still living western Joshua trees in JTNP generally prolonged the survival of burned plants five years after fire, compared with plants that did not resprout, but only at wetter, high-elevation sites. Abella et al. (2020) found resprouting to aid in eastern Joshua tree population persistence in areas that had previously burned, and therefore sprouting may be an important adaptation of Joshua tree to fire (Brooks et al. 2018). DeFalco et al. (2010) found that while sprouting may have increased survival of burned trees, sprouting in unburned trees may have negatively affected survival, suggesting that there is also a cost to sprouting, particularly during periods of low precipitation.

Assuming an average height of first flowering for western Joshua tree is approximately 2 m (6.6 ft), and an average growth rate for western Joshua tree is 4 cm (1.6 in) per year, the average time required for a germinated seed to reach reproductive maturity may be approximately 50 years, which appears to be consistent with the 50 to 70 years estimated by Esque et al. (2015). Western Joshua tree individuals that have reached reproductive maturity have high survivorship and are therefore likely to maintain reproductive potential for decades. Esque et al. (2020b) used an estimate of annual survival rate of 0.992 for eastern Joshua tree from one 14-year study (Gilliland et al. 2006) to calculate a generation length for western Joshua tree of approximately 185 years. Despite speculation that western Joshua tree may live for hundreds of years or even more than a thousand years, the maximum lifespan of western Joshua tree is unknown (Cornett 2006, Gilliland et al. 2006). If the average western Joshua tree lifespan becomes shorter than the generation length, populations will decline.

Summary of Important Life History Needs

Successful sexual recruitment of western Joshua trees requires a number of conditions to occur in succession; however, western Joshua trees are also capable of asexual growth for indeterminate periods of time, particularly at higher elevations, if the environmental conditions for survival and growth are maintained. Available information suggests that seed germination is most likely after large mast seeding events, which perhaps only occur once or twice per decade. The environmental or other conditions that lead to large simultaneous flowering events that result in mast seeding events are not currently known. Sexual reproduction requires the presence of western Joshua tree’s obligate pollinating moth *T. synthetica*. The conditions that lead to the emergence and survival of *T. synthetica* moths are not currently known. After a mast seeding event, seed dispersal is facilitated by the scatter hoarding behavior of rodents, which results in burial of some western Joshua tree seeds at a soil depth suitable for successful germination and sometimes under a nurse plant that may aid in seedling survival. After burial of seeds, several successive years of sufficiently wet and/or cool conditions are likely required to ensure that seeds germinate, and that seedlings reach a sufficiently large size (perhaps at least 25 cm) before the arrival of a period of hotter and/or drier conditions. This period of several successive years of sufficiently wet and/or cool conditions must occur relatively soon after a mast seeding event, because western Joshua tree seeds do not remain viable in the soil for long periods of time. After a seedling has become established, it must survive a long period of time (perhaps 30-50+ years) to reach reproductive maturity. A minimum rate of recruitment is necessary to keep populations from declining (Wiegand et al. 2004).

Similar-looking Plants

Although Joshua tree is a distinctive plant, differentiating between western Joshua tree and eastern Joshua tree may be difficult, and there are several plant species known to occur within the range of western Joshua tree that look superficially similar to the species. In California, western Joshua tree and eastern Joshua tree do not co-occur in the same location.

Lenz (2007) described the differences between western Joshua tree and eastern Joshua tree, and highlighted differences in the overall shape and form, branching, leaves, flowers, fruits, and different species of obligate pollinating moth. Lenz provided photos showing visual differences between flowers, fruits, and entire trees, and provided the following key to differentiate between the two species:

> Plants ca. 6–9 (–16) m tall, arborescent with distinct trunk and monopodial branching, branches stout; leaves 15–35 cm long; corollas cream-colored, globular to depressed globular, never opening fully; perianth segments broadly ovate, tightly incurved; fruits ovoid to broadly ovoid, rounded at tips; pollinator *Tegeticula synthetica*. CALIFORNIA, NEVADA: *Yucca brevifolia*

> Plants ca. 3–6 (–9) m tall, stemless or with trunks, usually branching less than 1 m above ground, the branching dichotomous until flowering, irregular thereafter; branches relatively numerous, somewhat slender; leaves 10–20 cm long; corollas greenish to cream-colored, narrowly campanulate, conspicuously expanded at bases; perianth segments narrowly oblong, tips recurving; fruits ellipsoid, tapering at tips; pollinated by *Tegeticula antithetica*. ARIZONA, CALIFORNIA, NEVADA, UTAH: *Yucca jaegeriana*

There are two other species in the *Yucca* genus that occur in California: banana yucca (*Yucca baccata* var. *baccata*) and Mojave yucca (*Yucca schidigera*) (Hess 2012). Both of these species can look superficially similar to western Joshua tree, but can be easily distinguished from Joshua tree by examining the edges of leaves: banana yucca and Mojave yucca have “fibrous-shredding” leave edges that peel off, while Joshua tree’s leaf edges do not peel off, and are slightly serrated when viewed up close.

HABITAT THAT MAY BE ESSENTIAL TO THE CONTINUED EXISTENCE OF THE SPECIES

The Department’s preliminary identification of the habitat that may be essential to the continued existence of western Joshua tree includes habitats that fit the general habitat descriptions provided below and habitats that are located at any of the currently known western Joshua tree populations. Habitat for plants can often be described in terms of the other species they are found in association with (natural communities), the geology and soils in the area they grow, and the climate, hydrology, and other factors that support the species’ survival and successful reproduction.

Natural Communities

The Department uses *A Manual of California Vegetation*, Second Edition (Sawyer et al. 2009) to classify natural communities within California. Within this classification system Joshua tree is the defining species for the *Yucca brevifolia* vegetation alliance (Joshua tree woodland), which is within the Mojavean–Sonoran Desert Scrub vegetation macrogroup. Joshua tree woodland is classified as having Joshua trees evenly distributed at greater than or equal to one percent absolute cover, and with junipers (*Juniperus* spp.) and/or pines (*Pinus* spp.) with less than one percent absolute cover in the tree canopy (Thomas et al. 2004). Joshua tree woodlands have Joshua trees as emergent small trees over a shrub or grass layer with white bur-sage (*Ambrosia dumosa*), cheesebush (*Ambrosia salsola*), common sagebrush (*Artemisia tridentata*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), blackbrush (*Coleogyne ramosissima*), buckhorn cholla (*Cylindropuntia acanthocarpa* var. *acanthocarpa*), Nevada ephedra (*Ephedra nevadensis*), California buckwheat (*Eriogonum fasciculatum*), sticky snakeweed (*Gutierrezia microcephala*), winterfat (*Krascheninnikovia lanata*), creosote bush (*Larrea tridentata*), Anderson thornbush (*Lycium andersonii*), banana yucca, and Mojave yucca (CNPS 2021a). Other trees may be present in Joshua tree woodlands at low cover, including California juniper (*Juniperus californica*), Utah juniper (*Juniperus osteosperma*), or single leaf pinyon (*Pinus monophyla*). If Joshua trees occur in areas where single leaf pinyon, junipers, or other trees have higher cover than Joshua trees, the vegetation alliance would be classified by the dominant tree species present.

The Department possesses vegetation maps that cover a large portion of the California deserts where western Joshua tree generally occurs (Thomas 2002; Agri Chemical and Supply, Inc. 2008; NPS 2012; CDFW and USGS 2014; CDFW and Chico State University 2015; CDFW et al. 2017; CDFW 2019 a, b, c, d), and Joshua tree woodland is mapped with an approximate accuracy of 95% in the vegetation maps that are related to the Desert Renewable Energy Conservation Plan, with those maps denoting the absolute cover of Joshua tree canopy in all vegetation polygons by cover class (0, >0%–1%, >1%–5%, and >5%) (CDFW et al. 2017). Figure 4 shows the areas in California where western Joshua tree has been mapped as present within one of three cover classes (>0%–1%, >1%–5%, and >5%), and the darkest red areas in Figure 4 therefore provide a rough approximation of the areas in California where the species is most abundant.

While Joshua trees are the defining feature of Joshua tree woodland, Joshua trees may also be components of many other vegetation alliances within California (Table 1) (Rowlands 1978, Turner 1982, CNPS 2021a).

Rowlands (1978) found the largest Joshua trees in habitats dominated by blackbrush, creosote bush, and big galleta grass (*Hilaria rigida*). Some researchers suggest that while Joshua tree may be the most visually dominant plant in an area due to its height, understory species are often more dominant components of the natural communities where Joshua trees occur (Rowlands 1978, Turner 1982). Due to the variety of natural communities that Joshua trees are found in, there is not a unique assemblage of associate plant species in an area that defines western Joshua tree habitat. Western Joshua trees can meet critical life history needs in a variety of plant assemblages.

Joshua tree seedlings are often found growing under the canopy of other woody shrubs and perennial plants which act as nurse plants for the seedlings and aid in their survival. Loik et al. (2000b) reports that blackbrush appears to be an important nurse plant for western Joshua tree in the Covington Flats area of JTNP. Brittingham and Walker (2000) found that a large majority of eastern Joshua tree seedlings in southern Nevada were found growing under the canopy of 16 different woody shrubs, with blackbrush appearing to be the most common nurse plant in the study area. Advantages of germination under the canopy of another plant likely include higher soil moisture, reduced exposure to direct sun, reduced surface temperatures, reduced evapotranspirational (water) demand, increased nutrients, reduced herbivory, and/or reduced wind desiccation. Brittingham and Walker (2000) found that eastern Joshua tree recruitment occurred predominantly on the east and west sides of nurse shrubs, indicating the importance of specific microhabitats.

Communities of fungi occur in soils and can sometimes form mutualisms with plants. Mycorrhizal fungi grow into plant roots and provide nutrients to the plant. Western

Table 1: Vegetation alliances in California that may support Joshua tree (CNPS 2021a)

Scientific name	**Common name**	**Primary lifeform**
Ambrosia salsola - Bebbia juncea	Cheesebush - sweetbush scrub	Shrub
Chilopsis linearis - Psorothamnus spinosus	Desert-willow - smoketree wash woodland	Tree
Coleogyne ramosissima	Blackbrush scrub	Shrub
Ephedra nevadensis - Lycium andersonii - Grayia spinosa	Nevada joint fir – Anderson’s boxthorn - spiny hop sage scrub	Shrub
Ericameria nauseosa	Rubber rabbitbrush scrub	Shrub
Eriogonum fasciculatum - Bahiopsis parishii	California buckwheat – Parish’s goldeneye scrub	Shrub
Gutierrezia sarothrae - Gutierrezia microcephala	Snakeweed scrub	Shrub
Hilaria jamesii	James’ galleta shrub-steppe	Herb
Hilaria rigida	Big galleta shrub-steppe	Herb
Juniperus californica	California juniper woodland	Tree
Juniperus osteosperma	Utah juniper woodland and forest	Tree
Larrea tridentata	Creosote bush scrub	Shrub
Larrea tridentata - Ambrosia dumosa	Creosote bush - white bursage scrub	Shrub
Menodora spinescens	Spiny menodora scrub	Shrub
Pinus sabiniana	Foothill pine woodland	Tree
Prunus fasciculata - Scutellaria mexicana	Desert almond - Mexican bladdersage scrub	Shrub
Purshia tridentata - Artemisia tridentata	Bitter brush scrub	Shrub
Quercus lobata	Valley oak woodland and forest	Tree
Stipa speciosa	Desert needlegrass grassland	Herb
Yucca brevifolia	Joshua tree woodland	Tree
Yucca schidigera	Mojave yucca scrub	Shrub

Joshua tree has been shown to sometimes form mycorrhizal associations that may benefit western Joshua tree (Harrower and Gilbert 2021). In a study of western Joshua tree across an elevational gradient in JTNP, Harrower and Gilbert (2021) found that mycorrhizal fungal communities change with elevation, and that mycorrhizal colonization of western Joshua tree roots decreased significantly at higher elevations.Natural communities that support the presence of western Joshua tree's obligate pollinating moth *T. synthetica* and that support populations of scatter-hoarding rodents for seed dispersal are likely important components of Joshua tree habitat, yet the specific characteristics of the natural communities that support these species that are important for the reproduction and dispersal of western Joshua tree are not currently known.

Geology and Soils

The origin and properties of bedrock materials and the tectonic history of the Mojave Desert and Great Basin regions are important components of the geology of these areas; however, most of the current desert landforms in the region are likely due to climatic changes during the last million years, erosion, and other processes within the past several thousand years (Stoffer 2004). Within the Mojave Desert and Great Basin regions, western Joshua trees occur on various desert landforms including gentle alluvial fans, bajadas, ridges, flats, mesas, and gentle to moderate slopes, often near the bases of desert mountains (Huning and Petersen 1973, Thomas et al. 2004, Gucker 2006). The highest densities of Joshua trees may be found on well-drained sandy to gravelly alluvial fans within and adjacent to desert mountains. In some areas where western Joshua trees are less common, such as Edwards Air Force Base, they may be restricted to areas that store sufficient groundwater, such as large sand dunes or along groundwater drainages (Charlton and Rundel 2017).

Joshua tree habitat soil textures have been described as silts, loams, and/or sands, and variously described as fine, loose, well drained, and/or gravelly. Huning and Petersen (1973) collected a number of soil samples along transects within and outside of western Joshua tree habitat in California in an investigation of soil water potential. Huning and Petersen (1973) found western Joshua tree to occur more frequently in areas with bimodal soil textures (with both larger sand particles and smaller silty clay particles) that facilitate soil moisture retention than in areas with well-sorted soil (with soil particles tending to all be of similar size). Huning and Petersen (1973) reasoned that soil moisture is the limiting factor governing the distribution of western Joshua tree, and therefore when the amount of precipitation is a limiting factor for western Joshua tree survival, soil textures that retain moisture become an important habitat characteristic. Similarly, Huning and Petersen reported that western Joshua tree tends to not occur where the depth to bedrock is less than one meter because there is insufficient groundwater to support the Joshua trees in these locations. Western Joshua tree also appears to be unable to grow well in soils with a high clay content or other “extremes of composition” such as high volumes of coarse fragments (Huning and Petersen 1973, Borchert 2021). Wallace and Romney (1972) reported that western Joshua tree grows best at root temperatures near 18°C (64°F) and without calcium carbonate in the soil. Huning and Petersen (1973) found that soil pH, soil nutrients, and the age of soils (more modern soils versus soils from the Tertiary period) did not seem to be significant factors determining western Joshua tree distribution.

Areas that collect water due to topography, subsurface bedrock, and/or soil structure could allow western Joshua tree to grow in some areas that may otherwise be too hot or too dry, and such areas could provide important habitat refugia for the species in the future.

Climate, Hydrology and Other Factors

Climate in the desert regions where western Joshua tree occurs consists of long, hot summers, mild winters, and low overall precipitation. The climate in these desert regions varies primarily due to elevation. Precipitation across the Mojave Desert region is highly variable from year to year and oscillates between wetter and drier conditions within multi-year and multi-decade timescales. Little information about the climate tolerances of western Joshua tree is known; however, some inferences and assumptions have been made by examining available information about average climatic conditions during all or a portion of the 20th century within the species’ range. These assumptions have primarily been used for species distribution models, which are described in more detail in the Climate Change section of this Status Review. While examining 20th century suitable climate conditions within the known range of the species undoubtedly provides insight into the species’ climate tolerances, it is unlikely that average climate conditions from a single century (or portion thereof) is entirely representative of the climate conditions and climate variability that western Joshua tree has endured in the past or can endure in the future.

Precipitation

As in many desert regions, the magnitude and seasonality of precipitation is a principal driver of ecosystem processes (Holmgren et al. 2006), and precipitation is likely a critical factor for understanding what constitutes suitable western Joshua tree habitat. Precipitation provides water for plants to absorb immediately and may also replenish underground moisture that plants may utilize later in the season via deep roots. With deep root systems and moisture stored in tissues, adult Joshua trees are somewhat resilient to periods with little precipitation. Juvenile Joshua trees and seedlings, on the other hand, cannot access deep groundwater and cannot store as much water in their tissues, and are therefore more dependent on regular precipitation for their establishment and survival. The intensity and duration of droughts and periods of relatively high precipitation are likely important factors in determining where western Joshua trees can survive and reproduce.

In areas where western Joshua trees occur, precipitation is received in the form of rain and less frequently snow. Most precipitation occurs between October and April, and May and June are consistently dry, accounting for less than five percent of average annual precipitation (Hereford et al. 2004). Isolated thunderstorms are possible in summer (typically July-September), and more of these summer thunderstorms occur in the eastern part of the Mojave Desert than in the western part (Hereford et al. 2004). Precipitation across the Mojave Desert region is highly variable from year to year and oscillates between wetter and drier conditions within multi-year and multi-decade timescales. During the period of 1893 to 2001 annual precipitation averaged across the Mojave Desert region ranged from as low as 34 mm (1.3 in) in one year to as high as 310 mm (12.2 in) in another year, with an average annual precipitation across all 108 years of 137 mm (5.4 in) (Hereford et al. 2004, 2006). During the 108-year period, Hereford et al. (2006) and Tagestad et al. (2016) identified multi-year or multi-decade periods of drought or otherwise predominantly dry conditions with contrasting multi-year or multi-decade periods that had above average precipitation (Figure 5). This interannual variation and longer-term oscillation of relatively wet and relatively dry conditions are likely the result of global-scale climate fluctuations including the El Niño-Southern Oscillation and the Pacific Decadal Oscillation (Cayan et al. 1998, McCabe and Dettinger 1999, Mantua and Hare 2002). The El Niño-Southern Oscillation in the Southwestern U.S. may result in El Niño conditions which can often result in relatively wet winters, La Niña conditions which can often result in relatively dry winters, or years that are considered neither El Niño nor La Niña. Analysis by Hereford et al. (2006) suggests that Mojave Desert precipitation oscillates between El Niño and La Niña conditions irregularly, but with each successive El Niño event occurring an average of 4.8 years after the previous El Niño event. The Pacific Decadal Oscillation appears to result in decades-long periods of relatively wet or relatively dry conditions in the Mojave Desert, with each condition lasting for periods of two to three decades.

The timing and minimum amount of precipitation necessary for adult western Joshua tree survival, or for the germination and establishment of western Joshua tree seedlings is not currently known, but the available life history information suggests that seedlings require periods with regular precipitation to establish, and therefore it is likely that El Niño conditions, combined with longer-duration wet periods of the Pacific Decadal Oscillation provide the best chance for germination and establishment of western Joshua tree seedlings. In one monitoring plot at Cima Dome in Mojave National Preserve, Cornett (2018b) found that survivability (percentage of trees that survived

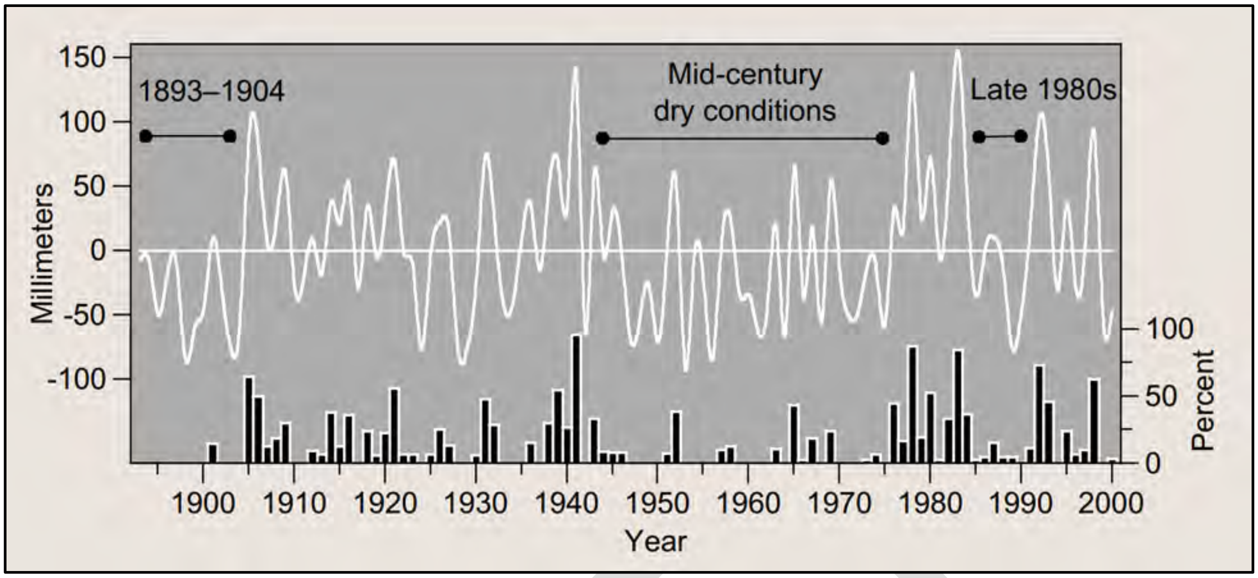


Figure 5: Average Deviation of Annual Precipitation in the Mojave Desert Region (Source: United States Geological Survey, Hereford et al. 2004)

since previous year) of eastern Joshua tree plants was moderately correlated with annual precipitation (r = 0.51, P = 0.01). Western Joshua tree is somewhat more abundant in the western Mojave Desert, where summer thunderstorms and precipitation are less common, and therefore western Joshua trees in the western Mojave Desert have likely relied more on winter precipitation (Hereford et al. 2006). The amount of precipitation required for western Joshua tree is also likely dependent upon a multitude of contributing factors including soil texture, ambient temperatures, local topography, elevation, and the presence and extent of other plants.

Climatic water deficit is a metric that has been correlated with vegetation distribution across many spatial scales, can be used to quantify the drought stress on plants in an area, and is generally considered to be a much more biologically meaningful metric than precipitation alone (Stephenson 1998). Climatic water deficit is defined as the amount of water that could have evaporated or been utilized by plants in an area (this is called potential evapotranspiration), minus the water that actually evaporated or was utilized by plants in an area (actual evapotranspiration). These metrics are less intuitive to understand than precipitation and temperature on their own, but they take into account several abiotic factors that are important for plants, including soils, and the slopes and aspects of terrain, in addition to the timing and durations of precipitation, temperature, and solar radiation. Low elevation warm desert areas tend to have high climatic water deficits, and these deficits often decrease with increasing elevation.

Precise information on the climatic water deficits that western Joshua trees are able to tolerate, and the timing and amount of precipitation necessary for western Joshua trees to establish and survive are not directly known and are likely dependent on a number of factors. Nevertheless, some inferences may be made by examining available information on previous climatic conditions within the known range of the species. Much of the species distribution modeling work for western Joshua tree discussed in the Species Distribution Models section of this Status Report utilizes information on 20th century suitable climate conditions to make assumptions regarding the conditions necessary for western Joshua tree survival and establishment in the future.

High Temperatures

Smith et al. (1983) tested the thermal tolerances of western Joshua tree by subjecting leaves to temperature treatments, with results suggesting that the high temperature limit is 57°C (135°F), at which point photosynthetic functions are impacted. Although such high air temperatures are not expected to occur in western Joshua tree habitat in the foreseeable future, thermal tolerances in laboratory settings are different than thermal tolerances in the natural environment, which are confounded by a number of factors including duration of exposure, water availability, and exposure to wind. High temperature alone may not be a direct physiological limit on western Joshua tree survival, and high temperatures alone may not limit the distribution of the species, but nevertheless, high temperatures contribute to climatic water deficit of an area, and other physiological stresses, particularly water stress, and therefore high temperatures likely limit the distribution of western Joshua tree indirectly.

St. Clair and Hoines (2018) found positive correlations between temperature and Joshua tree flower and seed production, suggesting that warming may positively affect Joshua tree reproduction. However, increased seed production would also depend on adequate pollination by *T. synthetica* under warmer climatic conditions. St. Clair and Hoines (2018) also found negative relationships between temperature and Joshua tree stand density, and suggested that there may be potential constraints of warmer temperatures on establishment success. Reynolds et al. (2012) found greatest seedling emergence occurred during spring and summer when warm soil temperatures were accompanied by increased soil moisture.

Low Temperatures

Smith et al. (1983) found the low temperature thermal tolerance of western Joshua tree to be approximately -6°C (21°F), which is a temperature that is reached in some areas of western Joshua tree's range, and may therefore be a limit on the distribution of the species in colder and higher elevation areas. Went (1957) published data demonstrating that after a Joshua tree has reached a certain age the plant requires exposure to low temperatures for optimal growth. This suggests that while extreme cold may be a limit on distribution, cold winter periods may be an important component for Joshua tree growth (Turner 1982).

Loik et al. (2000a) examined the effects of elevated carbon dioxide (CO_2) levels and low temperatures on Joshua tree seedlings, and found that low-temperature tolerance was enhanced for Joshua tree seedlings maintained in an elevated CO_2 environment. Loik et al. (2000a) also found that western Joshua tree seedlings that were acclimatized to low temperatures were better able to survive extreme low temperature events. Dole et al. (2003) utilized the work of Loik et al. (2000a) by incorporating the effects of elevated CO_2 levels on low temperature tolerance into a species distribution model for Joshua tree, which is discussed under the Species Distribution Models section of this Status Review.

ABUNDANCE AND TRENDS IN CALIFORNIA

Abundance

Western Joshua tree is currently relatively abundant in the portions of California that it occupies. Plant abundance can be quantified via a complete census of plants or estimated via statistical sampling. It is challenging to accurately estimate the size of plant populations that are patchy, occur at varying densities, or that occur over large geographical areas, and the western Joshua tree population has all of these characteristics. Estimates of the abundance of western Joshua tree therefore have a high amount of uncertainty associated with them.

As shown in Figures 2 and 3, western Joshua tree is widespread in the western Mojave Desert, and its range extends north into the southwestern Great Basin. Based on vegetation mapping data possessed by the Department, and as described in the Current Distribution section of this Status Review, western Joshua tree woodland could occupy an area within California of approximately 10,160 km^2 (3,920 mi^2) to 13,880 km^2 (5,360 mi^2), and additional areas could have lower densities of western Joshua trees. The USFWS (2018) estimated that the area occupied by western Joshua tree was 22,823 km^2 (8,812 mi^2), but this estimate included areas outside of California. WEST Inc. (2021a) used data from Cole et al. (2011) to report the area occupied by western Joshua tree as 15,071 km^2 (5,819 mi^2), but WEST Inc. (2021b) later reported that this estimate was only for the southern part of the species range, and the northern and southern portions of the species range together occupy an area of approximately 23,101 km^2 (8,919 mi^2), although this combined area likely includes areas outside of California. Within the areas occupied by western Joshua tree, the density of individuals varies widely. Some areas of the Mojave Desert have scattered Joshua trees at very low densities, while other areas have dense stands of trees.

WEST Inc. (2021a) used an analysis of aerial imagery to estimate the density of western Joshua trees within the species' southern range, and corrected for undercounting using density data from areas that were censused for western Joshua tree as part of renewable energy projects. WEST Inc. (2021a) used similar methods to separately estimate the density of western Joshua trees near the edges (± 5 km) of its southern range extent, which generally had a lower density of trees. WEST Inc. (2021a) estimated an overall western Joshua tree density of 4.27 to 7.04 trees per ha (95% confidence) within its southern range. Although the estimate from WEST Inc. (2021a) is only for the southern range of the species, is likely the most accurate estimate of overall western Joshua tree density available. WEST Inc. (2021b) later revised their estimation methods to account for the effects of historical wildfire, but WEST Inc. did not provide the revised density estimates.

More localized estimates of western Joshua tree population density have also been made. Esque et al. (2010) examined 50 random plots containing at least one Joshua tree in JTNP and 50 random plots containing at least one Joshua tree in Death Valley National Park and found high variability in western Joshua tree density. Esque et al. (2010) reported an average density of 95.2 western Joshua trees per ha in JTNP and an average density of 62 Joshua trees per ha in Death Valley National Park. St. Clair and Hoines (2018) collected demographic information from ten different Joshua tree sites distributed across the Mojave Desert. Five of the sites were within the range of western Joshua tree, and three of those were within California. Western Joshua tree population density varied by more than an order of magnitude from 20 trees per ha in the eastern portion of JTNP to 280 trees per ha at Walker Pass, California. The average density of the five western Joshua tree sites studied by St. Clair and Hoines (2018) was 140 trees per ha. Rowlands (1978) recorded densities of Joshua trees at 21 stands throughout the range of eastern and western Joshua tree. Eight of these sites were within the range of western Joshua tree, and these had an average density of 81 trees per ha. It is unlikely that the density data from St. Clair and Hoines (2018) and Rowlands (1978) was intended to be representative of the entire California range of western Joshua tree, particularly areas with very low densities of trees. Frakes (2017b) reported densities of western Joshua tree at twelve 500 x 500 m (1,640 x 1,640 ft) plots within JTNP in 2016 and 2017, which were highly variable but had an average density of 13.7 trees per ha. Densities of 3.2 and 33.9 western Joshua trees per ha have been reported to the Department at a preserve near Red Rock Canyon State Park and a preserve east of the North Haiwee Reservoir, respectively (Natural Resources Group, Inc. 2021). Despite the limitations of the estimates described above, they do provide information on possible densities of western Joshua tree.

Estimates indicate that the abundance of western Joshua tree is currently relatively high, but there is high uncertainty in estimates of population size due to both the uncertainty of density estimates, and uncertainty regarding how much area is occupied by the species. Assuming that the average density of western Joshua trees in all age classes in California is between 4.27 and 7.04 trees per ha (427 to 704 trees per km^2) (WEST Inc. 2021a), and the area occupied by western Joshua tree in California is between 10,160 km^2 and 13,880 km^2 (see Current Distribution section of this Status Review), there could be between 4.3 million and 9.8 million western Joshua trees in California (all age classes). An analysis by WEST Inc. (2021a) concluded that there are between 6.5 million and 10.6 million western Joshua trees, but this estimate appears to have only been for the southern part of the species range and did not take into account population reductions due to historical wildfires (WEST Inc. 2021b).

The Department also made a separate estimate of the number of adult western Joshua trees within California via stratified random sampling of aerial imagery. Due to the resolution of aerial imagery used (Google 2021), we were unable to accurately recognize and count short and unbranched trees via aerial imagery, and the Department's estimates are therefore representative of taller adult trees, and not representative of all western Joshua trees like the density estimates previously described in this section of the Status Review. We randomly placed 150 circular 4-ha sampling plots entirely within mapped vegetation polygons containing western Joshua tree in California. We stratified these 150 sampling plots (50 per strata) within vegetation polygons with three different cover classes of western Joshua tree (>0%-1%, >1%-5%, and >5%) as identified on vegetation maps possessed by the Department. Cover class information was not available for 8% of the mapped area containing western Joshua tree and we had difficulty discerning individual trees in areas with abundant clonal growth. Based on the Department's stratified random sampling estimates, the average sample density across all areas and cover classes was approximately 3.1 to 3.5 adult western Joshua trees per ha (95% confidence). Applying this estimate of adult western Joshua tree density to an estimated range of area that could be occupied by western Joshua tree within California (10,160 km^2 to 13,880 km^2) suggests that there could be between 3.1 million and 4.9 million adult western Joshua trees in California that are discernable via aerial imagery.

Population Trends

This section of the Status Review provides information on population trends of western Joshua tree from the past to the present. Discussion of western Joshua tree population trends that may occur in the future is provided in the Factors Affecting the Ability to Survive and Reproduce section of this Status Review. Population trends may be measured directly, inferred from available demographic information, or indirectly inferred from fossil evidence or environmental impacts that have occurred in the past. Population trends can be an important predictor for extinction risk (O'Grady et al. 2004).

Based on the available information, the Department concludes that development and other human activities have resulted in the greatest decline in the number of western Joshua trees in California, which began with European settlement and has continued to the present.

Inferred Long-term Trends

Genetic signatures suggest that western Joshua tree had a large, concerted population growth and range expansion into the Sonoran and Great Basin deserts from the Mojave Desert beginning about 200,000 years before present (Smith et al. 2011). Studies have made contradictory conclusions about Joshua tree's population trend over the past 20,000 years. Fossil evidence indicates that Joshua tree was more widespread during the late Pleistocene period (22,000 to 13,000 years before present) than it is today, with its range at that time extending south of its present range farther into southern California and Arizona, and likely also into northwestern Mexico (Rowlands 1978, Holmgren et al. 2010, Cole et al. 2011, Smith et al. 2011). The apparent reduction in Joshua tree range from the late Pleistocene period to modern times suggests the population trend of Joshua tree across its entire range has been in decline. However, Smith et al. (2011) found no indication of dramatic Joshua tree population declines since the last glacial maximum approximately 21,000 years before present and suggested that habitat loss in the southern part of the Joshua tree's range may have been offset by the addition of new potential habitats in the north.

More recently, populations of western Joshua tree within California have declined following European settlement of the Mojave Desert region, primarily due to habitat loss and degradation related to agricultural conversion and development. It is difficult to quantify the magnitude of this population decline because there has been no long-term range-wide population monitoring, and the distribution of western Joshua tree prior to European settlement is not completely known. Nevertheless, western Joshua trees were removed from the Mojave Desert region as a result of human activities and continue to be removed to this day. Prior to 1920 and ending in the 1980s, much of the western portion of the Antelope Valley was utilized for alfalfa production (Borge 2018; Historic Aerials 2021), likely resulting in a widespread decline of western Joshua tree individuals as the desert was cleared for agricultural use. Figure 4 shows conspicuous areas where western Joshua tree is absent from western Antelope Valley and near the metropolitan areas of Palmdale and Lancaster, and these areas approximately overlap the same locations as current and historical agricultural activity and developed land use. These areas likely supported substantially more western Joshua trees in the past, as did other population centers and agricultural areas in western Joshua tree's range, such as Victorville, Hesperia, and Yucca Valley. Based on historic aerial imagery and presumed general distribution of western Joshua trees prior to European settlement, the

Department estimates that approximately 30% of the habitat occupied by western Joshua tree in California may have been modified between European settlement and the present. While the historical densities of western Joshua tree in the areas of agricultural conversion and development are not known, the loss in number of individuals may have been somewhat proportional to the area of habitat lost. Information from aerial photography and the United States Geological Survey National Land Cover Database also show continuing land development within portions of western Joshua tree habitat from 2001 to 2021 (Krantz pers. comm. 2021). Despite the loss of a substantial number of western Joshua tree individuals from habitat loss since European settlement, the range of the species appears to have remained more or less unchanged, with fragmented populations remaining in Antelope Valley and near the metropolitan areas of Palmdale and Lancaster, and dense stands remaining to the west of the areas presumed to have suffered the most serious historical habitat loss (see Figure 4).

Photographic evidence has shown various changes to western Joshua tree populations that are unrelated to direct tree removal and habitat loss. Historical photographs have been used to compare current and past conditions of western Joshua trees in some areas of California and Nevada (Cornett 1998), and a number of photographic monitoring plots were also established in Nevada in 1964 (Webb et al. 2003). Photo monitoring provides a view into the past that can be used to make direct comparisons, and photos have shown a range of changes to western Joshua tree populations including mortality of individuals, increases in individual plant size and number of branches, changes in vegetation composition, and migration into areas that appeared to be previously unoccupied (Wallace and Romney 1972, Webb et al. 2003). While localized observations from repeat photo monitoring can provide insights, they are not necessarily representative of landscape-wide trends.

Direct Population Monitoring

Recruitment is rare for many perennial plants in the Mojave Desert (Cody 2000), which provides a challenge for direct population monitoring. In addition to rare recruitment, western Joshua tree has a long generation time (see the Growth and Longevity section of this Status Review), and plants are long-lived. As a result, the population dynamics for western Joshua tree take place over long timescales and monitoring them directly requires planning and a long-term perspective. Very little long-term monitoring data for western Joshua tree is currently available, and the quantitative monitoring data that are available appear to span less than one full generation of the species, and therefore provide only a narrow view of population dynamics. Most long-term monitoring efforts for western Joshua tree include data from a very limited number of plots, and few monitoring efforts have reported data spanning a period greater than 30 years.

Early monitoring plots were established, and data were collected from several locations within JTNP in the 1970s; however, attempts by JTNP staff to revisit and recollect data from these plots has not been possible because staff have been unable to replicate the original methods to collect comparable data (Frakes 2017b, Frakes pers. comm. 2021).

Comanor and Clark (2000) collected monitoring data from 1975 to 1995 from three circular 0.1-ha plots containing Joshua trees, but only two of these three plots had western Joshua tree and only one of those plots was in California. That plot was near Victorville at a relatively low elevation of 875 m (2,870 ft). Over the monitoring period from 1975 to 1995, the number of western Joshua trees in the Victorville plot remained the same (21 plants), and no recruitment was evident (Comanor and Clark 2000). Similarly, the number of Joshua trees in the other two plots examined by Comanor and Clark (2000) remained largely unchanged over the 20-year monitoring period.

Cornett (2009, 2012, 2013, 2014, 2016, 2020) established several 1 ha monitoring plots in the late 1980s and mid-1990s at different western Joshua tree populations in the Mojave Desert and began collecting periodic data on western Joshua trees within those plots, with monitoring results spanning between 18 and 23 years. Western Joshua tree population declines were observed at the monitoring plot in Saddleback Butte State Park (Cornett 2016), Red Rocks Canyon State Park (Cornett 2020), and in the three monitoring plots within JTNP (Cornett 2009, 2012, 2014). The western Joshua tree population increased at the monitoring plot at Lee Flat in Death Valley National Park (Cornett 2013).

DeFalco et al. (2010) monitored western Joshua tree at five pairs of burned and unburned sites in JTNP from 1999 to 2004, to study post-fire effects. DeFalco et al. (2010) found that plants in burned plots declined by 80% at the end of the study, and plants in unburned plots declined by 26%, with drought likely increasing the decline in both burned and unburned plots during the monitoring period.

Barrios and Watts (2017) conducted a geographic information system (GIS) analysis of western Joshua tree population trends on Edwards Air Force Base from 1992 to 2015, focusing on area occupied by western Joshua trees as a proxy for the number of trees. The report identified 18,673 ha (46,142 ac) as containing Joshua trees in 1992, 28,408 ha (70,198 ac) containing Joshua trees in 2008, and 32,508 ha (80,329 ac) as containing Joshua trees in 2015; however, the resolution of methods used for quantifying the number of trees improved greatly over time; 1992 (photogrammetry) methods were substantially different than the methods used in 2008 (LIDAR with 1.0-meter spot spacing) and in 2015 (LIDAR with 0.33-meter spot spacing). The different methodologies used, the known life history characteristics of the species, and a number of other factors identified by Barrios and Watts (2017) cast significant doubt on the validity of the reported 74% expansion of area occupied by western Joshua tree at

Edwards Air Force Base between 1992 and 2015. This increase in area occupied may instead be better explained by technological advances that substantially increased the ability to detect western Joshua trees.

Gilliland et al. (2006) monitored a group of eastern Joshua trees by collecting demographic data from 77 trees at two-year intervals from 1987 through 2001. During the 14 years of the study, 8 of the 77 trees died, and Gilliland et al. (2006) did not report the establishment of any new eastern Joshua trees.

Several additional efforts to monitor Joshua tree populations have been initiated more recently and are discussed in the Management Efforts section of this Status Review. These monitoring efforts will likely provide additional direct population monitoring data in the future.

Demographic Information

The demographics of western Joshua tree are closely tied to the life history requirements of the species which are described in the Life History section of the Status Review. Important components in the life history of western Joshua tree include seed production, dispersal, and germination, seedling establishment, plant growth, sexual reproduction, asexual reproduction, long-term survival, and mortality of individuals. If comprehensive demographic data are available, it may be possible to use those data to provide insight into both the past and possible future demographic structure and size of populations (Brook et al. 2000). Demographic data that is not comprehensive nor collected in a systematic randomized sample should not be used to make statistical inferences about western Joshua tree populations on a larger population or species-wide scale. The Department does not currently have data on mortality levels of western Joshua tree across its range and similarly does not have data on the amount of recruitment needed to maintain populations of western Joshua tree. Mortality and recruitment likely vary with the location and density of populations. Because the Department does not have demographic data on current levels of mortality and recruitment and does not have data on the minimum amount of recruitment needed to maintain populations, many of the conclusions presented below on future population trends are somewhat speculative. Nevertheless, demographic information from the studies and other sources described in this Status Review provides the best available evaluation of western Joshua tree population trends in the late 20^{th} century and may provide insight into possible future demographic structure and size of western Joshua tree populations.

Tree height is the most practical character to use for estimating Joshua tree age, and data from tree height censuses at a single point in time can provide insight into the current demographic structure of an area, an estimate of when trees were recruited into the population, and the trend of the population based on the relative numbers of plants in different Joshua tree age cohorts. Populations of Joshua trees that are increasing or sustainable at current population levels would be expected to have high numbers of young plants, decreasing numbers of older plants, and relatively few very old plants.

Although tree height is the best proxy to use for tree age, there are some limitations. The smallest size class is often underestimated because seedlings that are obscured beneath the canopies of other plants are very difficult to see, and researchers often note the difficulty in finding Joshua tree seedlings (Webber 1953, Wallace and Romney 1972, Comanor and Clark 2000, Esque et al. 2010, Reynolds et al. 2012). This limitation makes it difficult to utilize tree height data to identify relatively recent trends involving seedling establishment and early growth. Furthermore, the abundance of the youngest class of long-lived plants such as western Joshua tree are expected to fluctuate because seedling establishment is episodic. Nevertheless, seedlings that may initially be difficult to detect eventually become tall enough to be easily seen, with Cornett (2013) suggesting that it may take a minimum of three years for seedlings to become readily detectable. As trees get older, growth rates are affected by microhabitats and other factors, and distinct cohorts of trees that germinated near the same time may become less well-defined by height.

The Department does not possess a comprehensive random field sample of western Joshua tree heights across the species' range in California, and therefore the overall demographic trend of western Joshua tree in California is not currently known. The Department has, however, received western Joshua tree height information that is related to recently proposed development projects, and information that has been published or summarized in various scientific papers and reports.

In 2007, the National Park Service and U.S. Geological Survey established 50 randomly-placed 0.25 ha monitoring plots within the range of western Joshua tree in both JTNP and Death Valley National Park to collect initial demographic data and eventually monitor long-term trends of the species (Esque et al. 2010). The National Park Service and U.S. Geological Survey also established plots on National Park Service land within the range of eastern Joshua tree. The size distribution of Joshua trees reported in Esque et al. (2010) was aggregated among sampling locations within the range of both western Joshua tree and eastern Joshua tree and is typical of what would be expected for sustainable or increasing populations of long-lived plant species, e.g., large numbers of plants in the smallest size classes, moderate numbers of middle-sized plants, and greatly reduced numbers of the largest and oldest plants. Based on the information presented by Esque et al. (2010), which does not isolate data on western Joshua tree, Joshua tree populations on National Park Service lands appear to be sustainable, with large numbers of trees in younger age classes. For a development project near the city of Hesperia, the Department also received western Joshua tree height data (Figure 6) showing a size distribution that is similar to the results presented by Esque et al. (2010), typical of what would be expected for a sustainable or increasing population of a long-lived plant species.

The Department also aggregated western Joshua trees size class data reported for 11 recent solar energy development project sites in Kern County. Three broad size classes were reported for 222,073 western Joshua trees. Forty-four percent of trees were less than 1 m tall, 55% of trees were between 1 and 5 m tall, and 1% of trees were 5 m or greater in height. While these data are not as detailed as the height data presented in Figures 6, 7, and 8, the aggregated demographic structure in the form of tree height from these 11 project sites appears to be representative of relatively sustainable populations of western Joshua tree, with nearly half of the trees measuring under one meter tall, suggesting that they established in the early 1990s. The Department also received size class information for western Joshua trees at a preserve near Red Rock Canyon State Park which appears to be representative of a relatively sustainable population of western Joshua trees, with 83 percent of the trees measuring under one meter tall, suggesting that they established in the early 1990s (Natural Resources Group, Inc. 2021). The Department also received size class information for western Joshua trees at a development project site west of Adelanto and a mining project south of Lucerne Valley that appear to be representative of relatively sustainable populations of western Joshua tree. The demographic structure reported by Gilliland et al. (2006) for eastern Joshua tree was also broadly similar to that reported by Esque et al. (2010), with more trees in younger, smaller size classes than in older and larger size classes.

A Joshua tree height dataset was made available by St. Clair and Hoines (2018) that consists of demographic information randomly collected from ten different Joshua tree sites distributed across the Mojave Desert. At each site, data were collected from 20 trees at each of six transects that were placed at one km intervals, so that 120 trees were sampled at each site. Five of the sites were within the range of western Joshua tree, and three of those were within California (Walker Pass, western JTNP, and eastern JTNP). While these three sites are not representative of the entire California range of western Joshua tree, they do provide a small sample of demographic data. The height of western Joshua tree at the three sites within the California range of western Joshua tree is presented in Figure 7. Unlike the tree height data shown in Figure 6 and the tree height data reported by Esque et al. (2010), St. Clair and Hoines (2018) found relatively fewer western Joshua trees in the younger (i.e., shorter tree height) categories. Assuming an average growth rate of 3-4 cm per year (Comanor and Clark 2000, Gilliland et al. 2006, Esque et al. 2015), these data suggest a decline in western Joshua tree establishment since perhaps the 1950s. This decline may have been due, in part, to the mid-20th century dry conditions identified in Figure 5. The demographic

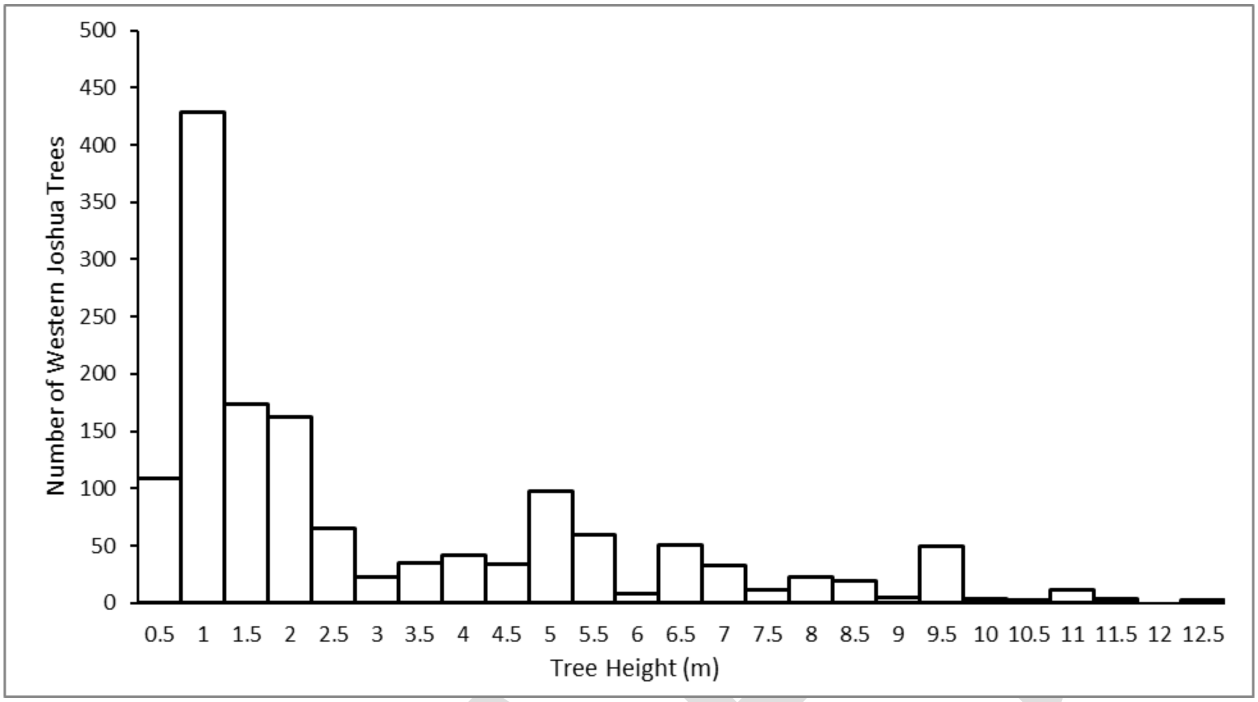


Figure 6: Heights of western Joshua trees in 2021 at a development project site near Hesperia (unpublished data from incidental take permit application to the Department)

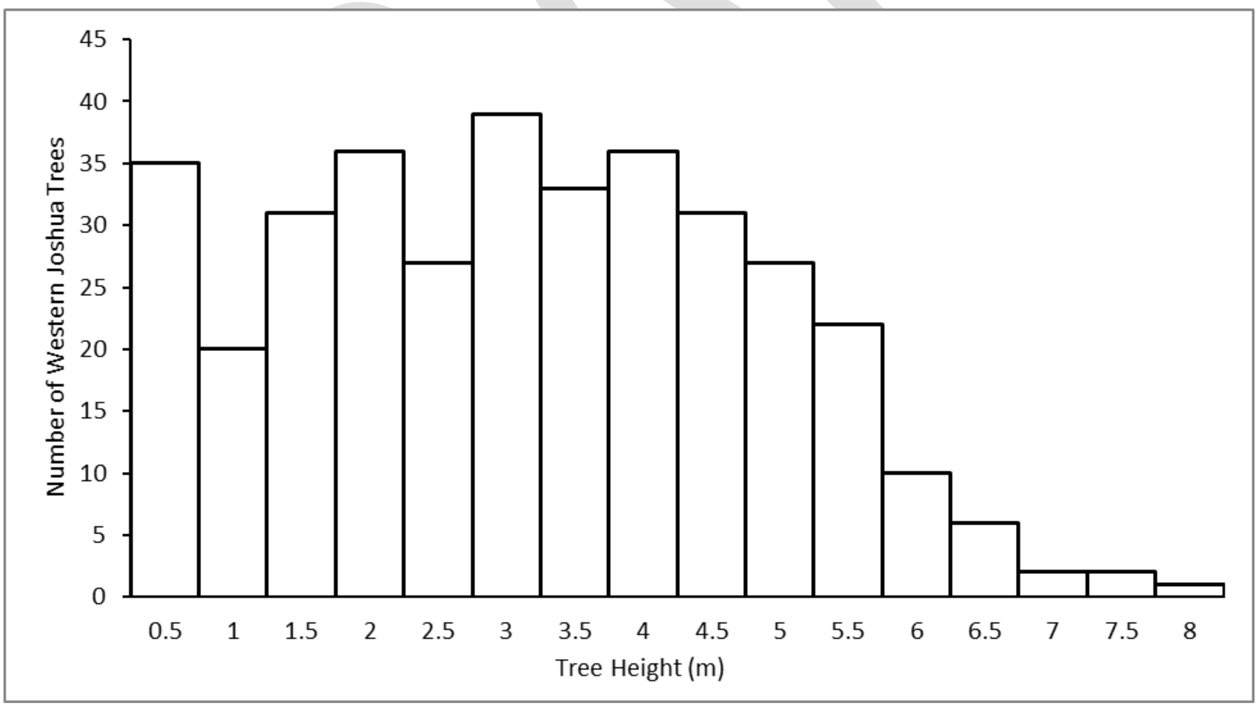


Figure 7: Heights of western Joshua trees in 2013 from three sampling locations in California (data from St. Clair and Hoines (2018))

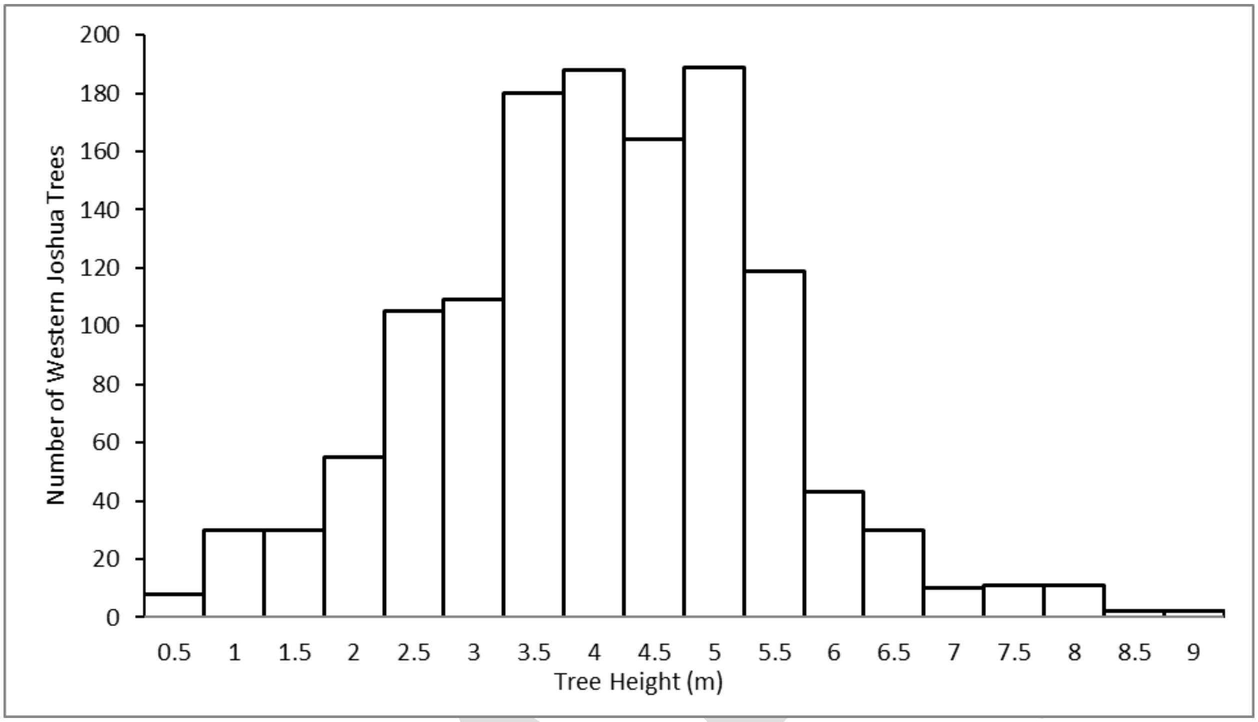


Figure 8: Heights of western Joshua trees at six development project sites near the cities of Palmdale and Lancaster in 2021 (unpublished data from incidental take permit applications sent to the Department)

structure of Joshua tree populations sampled by St. Clair and Hoines (2018) does not appear to be as sustainable as that reported for lands managed by the National Park Service; nevertheless, western Joshua trees have continued to establish within California in recent decades. The Department also received size class information for western Joshua trees at a preserve in southwestern Inyo County that is somewhat similar to the size class information shown in Figure 7, suggesting a decline in western Joshua tree establishment at that preserve since perhaps the 1950s (Natural Resources Group, Inc. 2021).

WEST Inc. (2021a) used an analysis of aerial imagery combined with and corrected by field data from solar energy development project sites to estimate the number of western Joshua trees in the southern portion of the species' range in three broad size classes. The estimate by WEST Inc. (2021a) indicated that 21% of western Joshua trees were less than 1 m tall, 58% of trees were between 1 and 5 m tall, and 21% of trees were 5 m or greater in height. These estimates of tree height include uncertainty because they are statistically estimated and not direct counts of plants in the field. The estimate of trees in the smallest, less than 1 m tall size class has the highest amount of uncertainty due, in part, to the difficulty in discerning them via aerial imagery, and therefore the number of plants in the smallest size class may have been underestimated. Furthermore, the size classes reported by WEST Inc. (2021a) are not as detailed as the height data presented in Figures 6, 7, and 8. Unlike the tree height data shown in Figure 6, reported by Esque et al. (2010), and reported for 11 recent solar energy development project sites in Kern County, the estimates provided by WEST Inc. (2021a) had fewer western Joshua trees in the youngest size class of less than 1 m tall. Fewer western Joshua trees in the youngest size classes suggests that an overall decline in western Joshua tree establishment may have taken place in the southern portion of the species range since at least the early 1990s and perhaps earlier, but western Joshua trees have nevertheless continued to establish.

Contrasting further with the information presented in Figure 6 and presented by Esque et al. (2010), western Joshua tree height data from six development project sites near urban areas of Palmdale and Lancaster in Los Angeles County were reported to the Department in 2021 and are presented in Figure 8. Again, assuming an average growth rate of 3-4 cm per year, these data suggest that relatively few western Joshua trees have established at these sites since perhaps the 1950s, and successful establishment has continued to decrease since that time. While this decrease may have been due, in part, to mid-20th century dry conditions identified in Figure 5, environmental degradation related to urban and agricultural development may have disrupted an important aspect of western Joshua tree life history which contributed to the reduced ability of western Joshua tree populations to establish new plants at these project sites in recent decades.

The range-wide demographic trend of western Joshua tree in California is not currently known, although the Department does have anecdotal information of recent demographic trends in some localized areas, and the information provided by WEST Inc. (2021a). Given the relatively long lifespan of western Joshua tree, the window for successful western Joshua tree reproduction is many decades long, and with the high abundance of existing populations the species may also be able to recruit a high number of individuals during favorable conditions, such as during multi-year or multi-decade periods of above-average precipitation described in the Precipitation section of this Status Review. If recruitment does not keep pace with mortality, population sizes will decline. Based on the anecdotal information available to the Department, local populations of western Joshua tree are currently exhibiting short-term demographic trends ranging from apparent increase or stability to apparent decline. Data from WEST Inc. (2021a) suggests that there may be an overall declining trend in western Joshua tree establishment in the southern portion of the species' range in recent decades, however, this trend may not be accurate due to the methods used and the high uncertainty in estimating the abundance of the youngest size class. Populations of western Joshua tree are showing signs of drastic short-term decline in recruitment at six development project sites near the cities of Palmdale and Lancaster. More gradual decline in recruitment can be seen at the three locations in California sampled by St.

Clair and Hoines (2018) and at a preserve in southwestern Inyo County. Populations appear to be experiencing stable short-term recruitment levels at a development project site near Hesperia (Figure 6), another development project site west of Adelanto, a mining project south of Lucerne Valley, the locations of solar energy development project sites in Kern County, a preserve near Red Rocks Canyon State Park, and lands managed by the National Park Service as reported by Esque et al. (2010). The recent demographic trend information available to the Department suggests that density or extent of some populations may decline by the end of the 21st century (2100), but due to continuing recruitment, high abundance, widespread distribution, and the longevity of the species, the available demographic data does not currently suggest that western Joshua tree is likely to be at risk of disappearing from a significant portion of its range during this timeframe.

With an increasing number of monitoring plots being established for Joshua tree and other desert vegetation (see the Management Efforts section of this Status Review), the understanding of western Joshua tree recruitment, mortality, population trends, and demographic structure is expected to improve substantially in the coming decades, improving understanding of the status of the species.

FACTORS AFFECTING THE ABILITY TO SURVIVE AND REPRODUCE

Large Population Size and Widespread Distribution

As described in the Range and Distribution and Abundance Sections of this Status Review, western Joshua tree is widespread and abundant in California. The abundance and widespread distribution of western Joshua tree within California are significant factors affecting the ability of the species to survive and reproduce. The smaller a species' range, the higher the probability that disturbances and environmental changes will affect a large enough portion of the species' range to jeopardize its persistence. Species with large ranges therefore tend to be less vulnerable to extinction from disturbances, environmental changes, random events, and other threats than species with more limited ranges (Purvis et al. 2000, Harris and Pimm 2007, Gaston and Fuller 2009, Pimm et al. 2014, Leão et al. 2014, Newbold et al. 2018, Silva et al. 2019, Enquist et al. 2019, Staude et al. 2020).

Population size and trends are also important predictors for extinction risk (Shaffer 1981, Pimm et al. 1988, O'Grady et al. 2004). Abundant populations can suffer substantial losses and still remain viable. Species with large populations that occupy large environmentally variable regions also generally have higher genetic diversity than species restricted to smaller areas and, therefore, avoid many problems of smaller populations (Ellstrand and Elam 1993, Reed 2005, Hobohm 2014). Populations with high levels of genetic diversity are less likely to require rapid evolutionary adaptation or migration to favorable habitats in order to persist in the face of climate change. Populations containing more genetic variability are more likely to contain traits that are beneficial under changing conditions, increasing the likelihood of persistence in their current range (Hoffmann et al. 2005, Hoffmann and Sgro 2011, Stotz et al. 2021). Western Joshua tree's current range, distribution, and abundance are all evidence that the species has been able to adapt to or endure the range of climate conditions and climate variability that has occurred within the species' range since the late Pleistocene period (22,000 to 13,000 years before present).

In assessing whether western Joshua tree should be listed under the federal ESA (16 U.S.C. §§ 1531-1544), the USFWS concluded that western Joshua tree has a relatively large population and distribution that covers a range of elevations with differing climatic conditions and soil types, and concluded that western Joshua tree had: (1) a high capacity to withstand or recover from stochastic disturbance events (resilience); (2) the ability to recover from catastrophic events (redundancy); and (3) ability to adapt to changing conditions (representation) (USFWS 2018, 2019), however the USFWS findings for Joshua tree were set aside and remanded to the USFWS for reconsideration in 2021 as described in the Federal Endangered Species Act section of this Status Review.

The concept that widespread and abundant species are less vulnerable to extinction is also reflected in the methodologies used by international nonprofit organizations to objectively rank the vulnerability to extinction of species throughout the world. The two most widely used approaches for assessing the conservation status of species in North America are NatureServe's assessments which prioritize rarity in assessing extinction risk and the International Union for Conservation of Nature (IUCN) Red List which places a higher emphasis on trends (Frances et al. 2018). NatureServe considers the abundance and distribution of species, or rarity, to be more than twice as important as threats in assessing the conservation status of a species (Faber-Langendoen et al. 2012). The IUCN uses any of several criteria to assess and rank the status of species under their Red List, including: (A) significant population size reduction, (B) significant reduction in geographic range, (C) small population size and decline, (D) very small or restricted population, or (E) a quantitative analysis demonstrating probability of extinction (Mace et al. 2008, IUCN 2012). The abundance and distribution of many widespread species excludes them from consideration under many of the IUCN Red List criteria listed above unless significant declines have been observed or quantitative analysis demonstrates a probability of extinction within 100 years or less.

Climate Change

It is unequivocal that human influence has warmed the atmosphere, ocean, and land, and widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred (IPCC 2014, 2021). Global surface temperature will continue to increase until at least the mid-21st century under all emissions scenarios considered by the Intergovernmental Panel on Climate Change, and global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in emissions occur in the coming decades (Schwalm et al. 2020, IPCC 2021). Experimental and empirical evidence indicates that climate change is negatively impacting wildlife species and natural systems across the globe (Parmesan and Yohe 2003, Parmesan 2006, Scheffers et al. 2016), is increasing extinction risk (Warren et al. 2011, Nic Lughadha et al. 2020), and has already caused local extinction of some species (Wiens 2016). California's physical and biological systems have already been affected by climate change (Office of Environmental Health Hazard Assessment 2018, Iknayan and Beissinger 2018, Riddell et al. 2019). According to the California Global Warming Solutions Act of 2006, climate change is now considered one of the greatest threats to California's ecosystems, and over the 21st century, climate change will alter the fundamental character, production, and distribution of the ecosystems in California and elsewhere (Snyder et al. 2002, Snyder and Sloan 2005, California Energy Commission 2009, Shaw et al. 2011, Notaro et al. 2012, Garfin et al. 2013, Bedsworth et al. 2018). Climate change is a major challenge to the conservation of California's biological resources, and it will amplify existing threats and create new threats to natural systems.

Species distribution modeling efforts that have been conducted for Joshua tree so far and much of the climate change science available to the Department focus their predictions on conditions at the end of the 21st century (2100). Due to the high uncertainty in projecting the pace and magnitude of climate change and other threats in the 22nd century (after 2100), and the lack of scientific information in the Department's possession that contemplates such timeframes for the species, the Department cannot yet consider the range of the species in the 22nd century to be foreseeable. For the purposes of this Status Review, the Department considers the foreseeable future to be through the end of the 21st century (2100).

Regional Effects

Studies indicate that by the end of the 21st century California's climate will be considerably warmer than it is today, precipitation will become more variable, droughts will become more frequent, heavy precipitation events will become more intense, more winter precipitation will fall as rain instead of snow, snowpack will melt earlier in the year, and snowpack will be diminished (Leung et al. 2004, Hayhoe et al. 2004, Mote et al. 2005, Knowles et al. 2006, Garfin et al. 2013, Bedsworth et al. 2018, He et al. 2018). California is also more vulnerable to climate fluctuations relative to the rest of the United States because it derives a disproportionately large percentage of its water supply from only a small number of winter storms. These storms arise from “atmospheric rivers” which are long and narrow corridors of enhanced water vapor that are often associated with a low-level jet stream of an extratropical cyclone (Dettinger 2011, Dettinger et al. 2011).

The Mojave Desert and other regions of California where western Joshua trees grow are expected to become significantly hotter by the end of the 21^{st} century, with daily average high temperatures in the Inland Deserts Region (all of Imperial County and the desert portions of Riverside and San Bernardino Counties) projected to increase by up to 4.5°C to 8°C (8°F to 14°F) at the end of the 21^{st} century (Hopkins 2018), an increase that is greater than most other areas of California (He et al. 2018). Higher temperatures will exacerbate water stress on a region that is already limited by water availability. In areas supporting western Joshua tree the number of days with freezing temperatures is expected to go down (Sun et al. 2015).

Precipitation in western Joshua tree habitats is currently low, and highly variable from year to year, and this variability is projected to increase in the coming decades, with extreme droughts and extreme precipitation events both becoming more common (Hopkins 2018). The effects that climate change will have on overall average annual precipitation within the range of western Joshua tree is still uncertain, and projections suggest that there may be only slight changes, even under different emission scenarios (Allen and Luptowitz 2017, Hopkins 2018, He et al. 2018), or an overall drying pattern (Seager and Vecchi 2010). The Mojave Desert receives most of its average annual precipitation between October and April; however, a substantial amount of summer precipitation is also possible in the form of thunderstorms, with more summer precipitation falling in the eastern part of the Mojave Desert than in the western part (Hereford et al. 2004). According to current climate models, average winter precipitation (falling mainly in December, January, and February) may increase in the region (Allen and Luptowitz 2017), however, average precipitation from summer thunderstorms may decrease (Pascale et al. 2017). There may also be a slight reduction in wildfire ignitions due to lightning as a result of the reduced number of thunderstorms. Effects of climate change on oscillations between wetter and drier conditions within multi-year and multi-decade timescales are uncertain.

Direct Effects

The climatic conditions across western Joshua tree’s range have already changed and will continue to change as a result of ongoing global carbon emissions. The Department expects that the direct effects of climate change (e.g., increased temperatures and decreased total water availability locally) will likely contribute to a decline in populations of western Joshua tree within California through the end of the 21st century; however, the extent to which the negative effects of climate change will impact the species' range within California in this timeframe is less clear. The primary reasons for the decline of populations of western Joshua tree within California may be the incremental contribution of climate change to high intensity and longer duration droughts, coupled with extreme high temperatures during the summer months, which may have direct physiological effects on western Joshua tree plants. These effects of climate change will likely reduce western Joshua tree seedling recruitment, and to a lesser extent also increase adult western Joshua tree mortality, leading to population declines as recruitment does not keep pace with mortality. Climate change may also contribute to the decline of populations of western Joshua tree via other more indirect mechanisms, including increased impacts from small mammals during drought, reduced growth due to lack of low winter temperatures, increases in fire activity, or effects on pollinating moths, which are discussed in more detail in the Indirect Effects, Wildfire, and Herbivory and Predation sections of this Status Review.

While the available evidence predicts that areas with suitable climate conditions based on 20th century climate data for western Joshua tree within California will decline substantially through the end of the 21st century (2100) due to climate change, the Department does not have data on the extent to which these changes to the climate conditions are likely to affect the demographics (e.g., recruitment and mortality) of the species in the foreseeable future. Without data on the extent to which climate change is likely to affect western Joshua tree demographics through the end of the 21st century (2100), the Department does not have the data to conclude that climate change will likely result in a significant reduction of the species' range during this timeframe. The most direct evidence of climate change affecting the range of Joshua tree comes from Cole et al. (2011). Cole et al. (2011) noted that after the climate rapidly warmed over an approximately 50-year period at the beginning of the Holocene period (approximately 11,700 years ago), available fossil records suggest that the range of Joshua tree contracted from the south over the following 3,700 years until the current southern range extent was reached. For this reason, the Department expects that any declines in abundance or changes in range of western Joshua tree that are caused by climate change will occur very slowly. Because western Joshua tree currently occupies such a highly variable environment, some areas of climate refugia are expected to remain throughout the species' range in the foreseeable future, even at its southern trailing edge (Barrows and Murphy-Mariscal 2012, Sweet et al. 2019, Barrows et al. 2020). Migration may help some species respond to climate change (Neilson et al. 2005); however, western Joshua tree grows very slowly, and its dispersal ability is limited, so it may take centuries or millennia for the species to naturally colonize areas of newly suitable climate. Because western Joshua tree evolved in a highly variable environment, the species may also have some resilience to a changing climate, particularly at the warmer and drier extents of its range. Species responses to increased climate variability are likely to be complex, and may be difficult to predict (Vázquez et al. 2017).

Based upon the information in the Life History and Climate, Hydrology and Other Factors sections of this Status Review, successful recruitment of western Joshua tree seedlings requires a number of conditions to occur in succession, notably the conditions leading to large mast seeding events, followed by several successive years of sufficiently wet and/or cool conditions so that seeds can germinate, and seedlings can reach a sufficiently large size before the arrival of a period of hotter and/or drier conditions. Increasing summer temperatures and related water stress that are expected to occur by the end of the 21st century likely mean that successful recruitment of western Joshua tree seedlings will occur less frequently in many areas, and as a result, populations of western Joshua trees in these areas will decline in size over time. Declines due to reduced seedling recruitment will likely be most severe in areas of western Joshua tree's range that are already near the thermal and water stress tolerance limits for recruitment, such as at hotter, low-elevation areas. St. Clair and Hoines (2018) found significant positive relationships between temperature and Joshua tree flower and seed production, suggesting that Joshua trees have higher reproduction when temperatures are warmer; however, St. Clair and Hoines (2018) also found negative relationships between temperature and Joshua tree stand density, and suggested that there may be potential constraints of warmer temperatures on establishment success. Despite concerns of lack of western Joshua tree seedling recruitment at low elevation areas within JTNP, Frakes (2017a) reported the presence of Joshua trees that were less than 50 cm (20 in) tall in 500 x 500 m (1,640 x 1,640 ft) monitoring plots across the entire elevation gradient in which the species occurs in the park, including the three lowest elevation plots. Due to the relatively long lifespan of western Joshua tree, and the species' ability to reproduce asexually, adult western Joshua trees may be able to persist on the landscape for long periods of time, even if they are not able to recruit new individuals into the population through sexual reproduction. As described in the Demographic Information section of this Status Review, it may be possible to use demographic information on western Joshua tree to identify areas where seedling recruitment in recent decades does not appear to be sufficient to maintain current population levels, but the Department does not possess a comprehensive random field sample of western Joshua tree demographic information in California.

Increasing summer temperatures and related water stress are also likely to negatively affect adult western Joshua trees in some areas, or even cause them to die, particularly during periods of extended drought. In instances where increasing summer temperatures and related water stress are not severe enough to result in direct mortality of established adult Joshua trees, this water stress may nevertheless reduce the ability of the adult trees to grow or reproduce asexually or limit the resources available to produce flowers and mature fruits for sexual reproduction. In 2016 and 2017, Frakes (2017b) collected data in JTNP on the health of live western Joshua trees and the number of trees that appeared to have died within the previous five years (i.e., recent mortality rate). Frakes (2017b) acknowledged there was likely some error in their ability to visually assess when a western Joshua tree had died, and some may have died more than five years earlier. Frakes (2017b) reported that across the 12 500 x 500 m (1,640 x 1,640 ft) plots, most live Joshua trees appeared robust or moderately healthy, but the estimated recent mortality rates ranged from 4% to 57% over five years, and the mortality rates across all 12 plots averaged together was 20% over five years. Drought from 2012 to 2016 was hypothesized to have contributed to the recent mortality. Harrower and Gilbert (2018) collected western Joshua tree demographic data at 11 sampling sites along a 1,200 m (3,900 ft) elevational gradient in JTNP in 2016 and 2017, and found that the number of dead western Joshua trees was greatest at the highest elevation sampling site at 2,212 m (7,257 ft) and at the lowest elevation sampling site at 1,004 m (3,294 ft). Harrower and Gilbert (2018) suggested that this observation at the lowest elevation sampling site was consistent with expectations from species distribution models (Cole et al. 2011, Barrows and Murphy-Mariscal 2012), which are discussed in more detail in the Species Distribution Models section of this Status Review. Huxman et al. (1998) found evidence that elevated CO_2 conditions may help offset high-temperature stress in a coastal *Yucca* species, but not Joshua tree.

There may be a time delay between the time when an area becomes no longer suitable for a species (crossing an extinction threshold) and when that species is no longer present, (Tilman et al. 1994, Kuussaari et al. 2009, van Mantgem et al. 2009, Svenning and Sandel 2013, Figueiredo et al. 2019). Extinction processes often occur with a time delay and populations living close to their extinction threshold might survive for long periods of time despite local extinction being inevitable (Hanski and Ovaskainen 2002, Lindborg and Eriksson 2004, Helm et al. 2006, Vellend et al. 2006, Malanson 2008, Cronk 2016). Because western Joshua tree is a long-lived species, adults could persist for decades or longer in areas that are no longer suitable for recruitment, or recruitment may continue, but at rates that are ultimately insufficient to maintain the species. Although these areas may appear occupied, the presence of western Joshua tree may merely represent a delayed local extinction. The ability of western Joshua tree to reproduce asexually may extend the ability of the species to persist within its range for very long periods of time, and delay local extinction for centuries or millennia, or perhaps preserve it as a relict species from an earlier climate. The ability of western Joshua tree to reproduce asexually and the episodic nature of western Joshua tree recruitment may also mask the ability to determine whether populations have passed a local extinction threshold. The Department does not currently have any data showing that western Joshua tree populations are experiencing delayed local extinction.

While the direct effects of climate change are likely to result in the decline of populations at hotter, lower-elevation areas due to adult mortality and reduced recruitment of seedlings, climate change could also allow for the expansion of western Joshua tree into areas that were previously too cold or perhaps too wet to support the species. Smith et al. (1983) found the low temperature thermal tolerance of western Joshua tree to be approximately -6°C (21°F). As the climate warms, habitats at higher elevations and higher latitudes that were sometimes below this low temperature thermal tolerance, but that were otherwise suitable for western Joshua tree, may become suitable for the species. Newly suitable climates could therefore become populated by western Joshua tree, assuming that western Joshua tree is able to disperse into those areas. Trends since the beginning of the Holocene period approximately 11,700 years ago (Cole et al. 2011) suggest that natural colonization of newly suitable habitats for western Joshua tree will take place slowly. As discussed in the Seed Dispersal section of this Status Review, western Joshua tree dispersal ability is very limited, so it may take many centuries for the species to naturally colonize newly suitable habitat, although dispersal facilitated by humans (assisted migration) could accelerate colonization. Loik et al. (2000a) further examined the effects of low temperatures and elevated CO_2 levels on Joshua tree seedlings, and found that low-temperature tolerance was enhanced for Joshua tree seedlings maintained in an elevated CO_2 environment, which suggests that western Joshua tree populations that experience extreme low temperature events may receive a survival benefit from elevated CO_2 conditions that are expected in the future, further expanding the ability of the species to occupy colder habitats.

Species Distribution Models

Efforts to predict effects of global climate change on the future range and distribution of species can be conducted using species distribution models (Elith and Leathwick 2009), which may also identify important areas of climate change refugia where species may persist (Barrows et al. 2020). These efforts usually involve inputting relevant geographic data into computer software, identifying variables that appear to influence the distribution of a species at one time period, and then modifying the appropriate climate variables to match the conditions that are expected under climate change scenarios to generate a prediction of where climate conditions that supported the species during a historical period could be expected to persist in the future. The species distribution models for Joshua tree discussed below model suitable climate conditions using climate data from 30- to 100-year timespans from the 20th century, combined with past or current species distributions, to project potential future species distributions.

Species distribution models have substantial inherent limitations (described near the end of this section), but despite the limitations, species distribution models are one of the primary ways to anticipate how climate change may affect species distributions in the future, and can provide a useful first approximation of the direction and magnitude of potential impacts of climate change on species range (Ackerly et al. 2010). While species distribution models can help identify areas where climate will change from what a species experienced during a prior period, they cannot predict how and when a species will respond to that change in climate (i.e., whether the change in climate is likely to cause the species to disappear from affected areas or not, and when that may happen).

Six Joshua tree species distribution modeling efforts that assess possible future distributions have been published, and four of them consider western Joshua tree and eastern Joshua tree collectively as one species across their entire range (Thompson et al. 1998, Shafer et al. 2001, Dole et al. 2003, Cole et al. 2011). Two of the species distribution modeling efforts are specific to western Joshua tree, but only examine climate changes within JTNP and the surrounding vicinity (Barrows and Murphy-Mariscal 2012, Sweet et al. 2019). The Department is not aware of any species distribution modeling efforts that are specifically focused on the California range of western Joshua tree. The Department did not independently produce a species distribution model to predict the effects of global climate change on the future range and distribution of western Joshua tree within California as a part of this Status Review, but did assess the vulnerability of western Joshua tree to climate change using the NatureServe Climate Change Vulnerability Index (CCVI) Version 3.02 (NatureServe 2016, CDFW 2021b).

The species distribution modeling efforts that have been conducted for Joshua tree suggest that climate change could cause substantial reductions in areas with 20th century suitable climate conditions for the species at the southern parts of western Joshua tree's range, including within JTNP. These species distribution modeling efforts also suggest that substantial additional areas of 20th century suitable climate conditions may become available for western Joshua tree to the north, particularly in Nevada (outside of the scope of CESA) but also in some parts of eastern California, although the species is unlikely to naturally colonize these areas in the foreseeable future. There is also evidence that areas of 20th century suitable climate refugia will remain within the species' range at the end of the 21st century, including within JTNP. While species distribution models suggest that climate change could result in substantial negative effects on western Joshua tree populations, the timing and ultimate effect of changing climate conditions on western Joshua tree populations specifically remain highly uncertain. Therefore, the magnitude of climate change effects on western Joshua tree's range and distribution is highly uncertain. The Department does not have data that shows the extent to which the demographics of the species will likely be affected by loss of areas with 20th century suitable climate conditions at the end of the 21st century. Due in large part to this lack of information, in combination with resiliency of the species due to its high abundance and widespread distribution (as discussed in the Large Population Size and Widespread Distribution section of this Status Review), the Department does not yet have enough information to conclude that climate change is likely to cause western Joshua tree to become in serious danger of disappearing from a significant portion of its range in the foreseeable future (prior to 2100). While the Department does not yet foresee that the species is likely become in serious danger of reductions in a significant portion of its range in the foreseeable future, western Joshua tree populations within the areas that will be most severely impacted by climate change are likely to experience declines in density and distribution.

The most relevant and comprehensive range-wide species distribution modeling effort for this Status Review is Cole et al. (2011) because it includes the entire range of western Joshua tree (lumped with eastern Joshua tree), it uses climate variables at a relatively fine scale (1-km and 4-km grids), it considers some climate variables at a monthly scale rather than annually, it utilizes baseline climate conditions that may be somewhat more representative of what the species endured during its evolution than other models (the entire 20th century record and 1930-1969), and the effort involved six different species distribution models and compared their effectiveness. The models developed by Cole et al. (2011) that most accurately describe how climate affects Joshua tree’s present distribution relied on average precipitation, extreme high and low temperatures, and average high and low temperatures in certain months. Based on these species distribution models, Cole et al. (2011) suggested that the northern portion of Joshua tree’s range is spatially limited by extreme winter cold events, but at lower elevations it is limited by extreme high temperature events in summer or winter. The species distribution models also suggest that average precipitation patterns limit the range of Joshua trees on the east and west edges of its distribution, as well as above and below its elevational range during portions of the year. Cole et al. (2011) explains that low precipitation in April and May seems to prevent Joshua tree from growing at lower elevations, and high winter rainfall or snow limit it from the higher elevations in some ranges of Nevada. The June drought period and summer thunderstorm season may also be important in limiting the distributions of western Joshua tree and eastern Joshua tree.

Cole et al. (2011) provides a map showing how one of their suitable climate models for Joshua tree compares with current distribution presence points. While there is rough concordance between many of the Joshua tree presence points and the model results, the Cole et al. (2011) model of baseline conditions also shows many areas that were predicted to be highly suitable but that do not support the species, along with many areas that were predicted to have low suitability but that nevertheless do support the species. This demonstrates that while species distribution models have utility for providing a useful first approximation of the direction and magnitude of potential impacts of climate change on species range, they nevertheless include a high amount of uncertainty. Even under baseline conditions, current species distribution models can only partially explain observed species distribution patterns and range. When current species distribution models can only partially explain observed species distribution patterns and range and are not strengthened with concordant demographic data, predictions of species distributions in the future become more uncertain, to a degree that it would be too speculative to rely on them to conclude that anticipated changes in climate are likely to lead to a serious danger of elimination of western Joshua trees from a significant portion of the species' range by the end of the 21st century.

Based on the variety of models and scenarios analyzed, Cole et al. (2011) concludes that as much as 90% of the area with 20th century suitable climate conditions within Joshua tree's range is predicted to disappear by 2070-2099. Areas of historically suitable climate conditions are predicted to be lost throughout most of the southern portions of Joshua tree's current range (Cole et al. 2011). Although the estimates that Cole et al. (2011) used for future monthly precipitation differed between the models used for the study, the changes in precipitation were outweighed by large increases in temperature common to all models used.

Cole et al. (2011) also compared the projected loss of suitable Joshua tree climate with a climate-related contraction of Joshua tree range from the south that occurred as the climate rapidly warmed approximately 11,700 years ago, at the beginning of the Holocene period. Joshua tree now only occurs at the northern periphery of its late-Pleistocene range, and this contraction may have occurred over a period of approximately 3,700 years. Cole et al. (2011) points out that while suitable climate may shift after warming, Joshua tree is a poor long-distance disperser, and based on historical migration rates, and current information on dispersal distances via seed-caching small rodents (Vander Wall et al. 2006, Waitman et al. 2012, Reynolds et al. 2012), Joshua tree may only be capable of migrating at a rate of perhaps two meters per year, and therefore the species may have a difficult time naturally keeping pace with projected shifts in suitable climate conditions.

Thompson et al. (1998) modeled the range-wide response of Joshua tree to doubled CO_2 conditions, along with the responses of 15 other common trees and shrubs of the western United States. Thompson et al. (1998) used a somewhat coarse 15-km grid, a range map from 1976, and climate data from a 30-year period as the baseline, with average January and July temperature and precipitation data for the analysis. The model of Joshua tree distribution prepared by Thompson et al. (1998) projects a reduction of historically suitable Joshua tree climate conditions at the western edge of its range, near Antelope Valley and to the north, but also projects a significant expansion of suitable climate conditions for Joshua tree in many directions into Mexico, Texas, and Washington. The model prepared by Thompson et al. (1998), poorly matches the current observed distribution of Joshua tree, which calls into question the modeling methodology and/or the assumptions used.

Shafer et al. (2001) modeled range-wide shifts in mid-20th century climate conditions within the range of Joshua tree and 76 other North American tree and shrub species in response to climate change by 2090–2099, assuming a one percent per year compound increase in greenhouse gases and using three different future climate change scenarios. Shafer et al. (2001) used a somewhat coarse 25-km grid, a range map from 1976, and climate data from a 30 year period (1951–1980) as the baseline, with (1) the average temperature of the coldest month, (2) a sum of the number of °C that was over 5°C on days that were warmer than 5°C, and (3) a moisture index similar to climatic water deficit for the analyses (climatic water deficit is discussed in the Precipitation section of this Status Review). All three future climate change scenarios used by Shafer et al. (2001) produced what appears to be near complete elimination of 1951–1980 suitable climate conditions from the southern portion of western Joshua tree's range by the year 2099, and also substantial expansion of 1951–1980 suitable climate conditions to the north and to the east into Nevada, Arizona and Utah, but also as far away as New Mexico, Wyoming, and Washington (outside of the scope of CESA). Unlike some of the other species distribution modeling efforts discussed, Shafer et al. (2001) did not perform checks of their model parameters by using 1951–1980 suitable climate conditions to assess how well their model accurately predicts the current distribution of Joshua tree, which calls into serious question the modeling methods used and therefore the accuracy of model predictions.

Dole et al. (2003) modeled the range-wide response of areas predicted to be suitable for Joshua tree based on late 20th century climate conditions under doubled CO_2 conditions, while also taking into account increased tolerance of extreme cold temperatures that could be expected to occur with increased CO_2 conditions (Loik et al. 2000a). Dole et al. (2003) used a relatively coarse grid-based distribution map for the current range of the species. Dole et al. (2003) used temperature data from a 30-year period (1961–1990) as the baseline for the species distribution model, and the climate variables used were January precipitation, July precipitation, annual precipitation, January average daily minimum temperature, July average daily maximum temperature, and July average temperature. All data layers used for the analysis were resampled to a 10-km grid. The results of the Dole et al. (2003) species distribution model under doubled CO_2 conditions show an overall 9% decrease in the number of grid cells with predicted late-20th century suitable climate conditions across the entire range, with 29%

of grid cells retaining suitable climate conditions, and the remaining grid cells representing either loss or expansion of suitable climate conditions (percentages of loss and expansion were not reported). While the Dole et al. (2003) model predicted that some areas of late 20th century suitable climate conditions could become unsuitable in the future, grid cells of suitable climate conditions remained in substantial portions of the species' range, including in the southern portion. The model also projected new areas with late 20th century suitable climate conditions in the Mojave Desert, north of the current distribution limit in Nevada (outside of the scope of CESA), in the Owens Valley, in the Panamint and Inyo Mountains of California, and also in the southern San Joaquin Valley which is currently under intensive agricultural land use. The Dole et al. (2003) species distribution model broadly overestimates the ability of Joshua tree to disperse into new areas, but nevertheless identifies several areas where late 20th century suitable climate conditions for western Joshua tree would persist in California under doubled CO_2 conditions.

Barrows and Murphy-Mariscal (2012) used a finer-scale species distribution modeling approach, focusing only on western Joshua tree within and near JTNP under scenarios of 1°C, 2°C and 3°C increases in maximum July temperatures. All three warming scenarios are less severe than the warming that is generally expected to occur in the Mojave Desert by the end of the 21st century (Hopkins 2018). Using western Joshua tree location data from the National Park Service augmented with additional location data from researchers and citizen scientists, Barrows and Murphy-Mariscal (2012) utilized 30 years of July temperature data and average annual precipitation data from 1971-2000 and abiotic variables related to topography and soil to develop several species distribution models. The model that performed the best in predicting current western Joshua tree location data was selected and used to project the distribution of adult western Joshua tree in the future under different precipitation and warming scenarios. Rather than predicting the complete elimination of areas with late 20th century suitable climate conditions for western Joshua tree in JTNP, the model developed and selected by Barrows and Murphy-Mariscal (2012) predicted that approximately 10% of the current distribution of western Joshua tree within JTNP would retain late 20th century suitable climate conditions for adult trees under a +3°C warming with little change in average annual precipitation. Barrows and Murphy-Mariscal (2012) also found that with a temperature increase of 1°C to 3°C, the areas with late 20th century suitable climate conditions for western Joshua tree are expected to shift upward in elevation in JTNP, but because western Joshua tree already occupies the highest elevation areas within JTNP, there will be a net loss of areas with late 20th century suitable climate conditions within JTNP.

Barrows and Murphy-Mariscal (2012) also developed a species distribution model for juvenile western Joshua trees less than 30 cm in height, representing the most recent cohort of juvenile western Joshua trees within JTNP. When areas suitable for juvenile western Joshua trees were modeled using late 20th century climate conditions, the area predicted to be suitable was 51% of the size of the area currently observed to be occupied by adult western Joshua trees. Barrows and Murphy-Mariscal (2012) also compared the area modeled for juvenile western Joshua trees under late 20th century suitable climate conditions to the distribution modeled for adult trees under the +1°C warming scenario and suggested that warming that has already taken place may be related to the apparent reduction in area that appears to be suitable for western Joshua tree recruitment. Barrows and Murphy-Mariscal (2012) did not observe any evidence of mortality of western Joshua trees that was not related to fire within JTNP. Barrows and Murphy-Mariscal (2012) did not model suitable climate for juvenile western Joshua trees under future warming scenarios, nor did they report on how well their distribution model for juvenile western Joshua trees accurately predicted actual observations of the distribution of juvenile western Joshua trees in JTNP.

The most recent effort to model how the distribution of western Joshua tree may respond to changes in 20th century suitable climate was conducted by Sweet et al. (2019). Similar to Barrows and Murphy-Mariscal (2012), Sweet et al. (2019) used a finer-scale species distribution modeling approach, focusing only on western Joshua tree within and near JTNP. Sweet et al. (2019) expanded on the western Joshua tree data used by Barrows and Murphy-Mariscal (2012) to generate a Maxent species distribution model. Maxent is a software package commonly used for species distribution modeling (Phillips et al. 2021). The model developed by Sweet et al. (2019) was developed using climate variables from 1951–1980 and physical environmental variables including soil sand content, slope, and terrain ruggedness. Maxent models utilize two metrics to determine the importance of input variables in the final model: “percent contribution” and “permutation importance.” Sweet et al. 2019 identified annual precipitation as being the most important variable for the model, but slope, and annual maximum hot season temperature, minimum cold season temperature, and climatic water deficit were also important predictors of western Joshua tree presence. The precise percent contribution and permutation importance values were not reported for the input variables that were used in the model.

Based on the results of this Maxent model, Sweet et al. (2019) projected how much of the area with mid-20th century suitable climate conditions for western Joshua tree would remain within JTNP under the observed climate conditions from 1981–2010 and the climate conditions projected between 2070–2099 under three climate change emissions scenarios: CMIP5 MIROC RCP 4.5, 6.0, and 8.5 (Taylor et al. 2012), representing CO_2 emissions under highly mitigated, moderately mitigated, and unmitigated scenarios, respectively. The model predicted that 13.4% of the area with predicted suitable climate for the species based on climate conditions between 1951 and 1980 remained during the subsequent period between 1981 and 2010. Also compared with the area of 1951–1980 predicted suitable climate conditions, the model predicted that 18.6% of the area would remain at the end of the 21^{st} century under the highly mitigated emissions scenario, 13.9% under the moderately mitigated emissions scenario, and only 0.02% would remain by under the unmitigated emissions scenario. Although the Sweet et al. (2019) model projected substantial loss of the area with mid-20^{th} century suitable climate conditions during the 1981–2010 climate period, western Joshua trees continued to recruit in these climate conditions throughout JTNP during this time period (Frakes 2017a). Continuation of western Joshua tree recruitment in areas of JTNP that Sweet et al. (2019) modeled as no longer containing suitable climate demonstrates that a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species.

To examine whether recent recruitment of western Joshua trees in JTNP was occurring in areas predicted to be suitable for western Joshua tree between 2070–2099, Sweet et al. (2019) examined demographic information collected from 14 nine-ha macroplots in JTNP in 2016 and 2017. Sweet et al. (2019) considered macroplots that had fewer than 247 western Joshua trees under 60 cm as “low recruiting” and macroplots that had more than 247 western Joshua trees under 60 cm as “high recruiting,” but did not report the number of trees in each macroplot, or use the number of adult trees in these macroplots to put the number of juvenile trees in the macroplots into relative context (areas with low densities of adult western Joshua trees would naturally be expected to have low densities of juvenile western Joshua trees regardless of climate change effects). Sweet et al. (2019) found that “high recruiting” macroplots tended to be geographically closer to areas predicted to be more suitable for western Joshua tree between 2070–2099 under the species distribution model developed for the study.

Species distribution models for eastern Joshua tree have also predicted shifts in historically suitable climate. In an analysis of potential impacts of climate change on vegetation in Arizona, New Mexico, Utah, and Colorado, Notaro et al. (2012) used Maxent to produce species distribution models for 170 tree and shrub species, including eastern Joshua tree. Similar to the results from other Joshua tree species distribution modeling efforts, Notaro et al. (2012) projected a reduction in areas with historically suitable eastern Joshua tree climate conditions in the southern part of its range, and a substantial expansion of areas with historically suitable climate conditions to the north.

The Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) studies provide evidence for the predicted effects of climate change at the southern (trailing) edge of western Joshua tree’s range, and these studies are the first to associate western Joshua tree demographic data with predictions from species distribution models. The climatic conditions and projections for the small geographic area used in these studies

(JTNP) does not present a comprehensive representation of future conditions across western Joshua tree's range. Nevertheless, studies that show lower recruitment of western Joshua tree in marginal habitats that have already been subject to the warming effects of climate change can provide field evidence that overall, climatic warming is negatively influencing recruitment (Barrows and Murphy-Mariscal 2012, Sweet et al. 2019). Species distribution models for western Joshua tree that are validated with random field samples of western Joshua tree demographic data from across the species' range in California would substantially improve the predictive power of the work initiated by Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019).

Species distribution models have substantial inherent limitations. Natural systems are highly complex, as are the effects of climate change (Pimm 2009), and by necessity predictive species distribution modeling must reduce many complex factors to relatively simple geographic variables that can be used by the relevant software. Limitations in the accuracy and precision of predictive species distribution models arise from the use of relatively coarse-scale data, limitations in available data on many complex biotic and abiotic variables, disturbances, and interactions (Pearson and Dawson 2003, Keith et al. 2008). Species distribution models also often rely on just a few available climate change scenarios that are often selected arbitrarily (Casajus et al. 2016). In addition, species distributions are often dynamic, and not necessarily static on the landscape, and therefore data on the current distribution of species used for models may not accurately represent where species can occur. There are also uncertainties regarding whether species may occupy environments that are not yet present on the landscape, but that are expected to arise in the future (Fitzpatrick and Hargrove 2009). A species may also be adapted to a narrow niche in some areas, and species distribution models that use coarse, homogenized environmental data will not identify small areas of climate change refugia that match the species' niche requirements. Species distribution models also do not account for resilience to a changing climate that an abundant and widespread species (such as western Joshua tree) may already possess. Species distribution models also do not account for the adaptive potential of a species in the face of a changing climate, but long-lived species and species with limitations to dispersal (such as western Joshua tree) may be unlikely to undergo rapid evolutionary change on the timescale that the climate is projected to change.

Limitations in the predictive accuracy of species distribution models evaluated by the Department for western Joshua tree arise from the relatively short time periods used for describing historically suitable climate data, homogenization of the climate variability that is important for western Joshua tree recruitment, the relatively coarse scale of climate data used, the lumping of western Joshua tree and eastern Joshua tree as one species for modeling despite their differences, and the poor performance of species distribution models to accurately and precisely explain current species distribution patterns using historical climate conditions.

All species distribution models evaluated by the Department used historical climate data from a 30-year period, or in the case of the Cole et al. (2011) study a 40- or 100-year period to define what constitutes suitable climate conditions for the species, and the climate data was averaged over these periods. These time periods are shorter than the maximum lifespan of a western Joshua tree, which can likely live for 150 years or more. As described in the Precipitation and Life History sections of this Status Review, precipitation in western Joshua tree's range oscillates between wetter and drier conditions over multi-year and multi-decade timescales with wet or dry conditions of the Pacific Decadal Oscillation often persisting for two to three decades. These oscillations are likely important for recruitment of western Joshua trees because periods of above average precipitation are important for the episodic recruitment of western Joshua trees and therefore may be more important for characterizing the climate conditions necessary for western Joshua tree to survive and reproduce than averaged climate conditions. There were substantial differences in modeled suitable climate between the base historical 1951–1980 suitable climate conditions and more recent (1981–2010) climate conditions reported by Sweet et al. (2019), demonstrating how sensitive species distribution models can be to the climate data they are based on. For these reasons, it may not be appropriate to use averages of narrow (30 to 40 year) timeframes to represent the climate conditions and climate variability that western Joshua tree endured and perhaps developed resiliency to during its evolution in the Mojave Desert and other regions over thousands of years. Climate variability such as the oscillations between wetter and drier conditions over multi-year and multi-decade timescales is excluded from species distribution models that average precipitation data over 30- to 100-year time periods. For this reason, the species distribution models that have been produced so far have, to some extent, mischaracterized the precipitation patterns that western Joshua tree depends on for successful recruitment. Species distribution models that use average climate conditions over relatively short time periods to characterize the climate tolerances of western Joshua tree produce results that contain substantial uncertainty.

There are substantial limitations in the current understanding of the climate tolerances that the range of western Joshua tree is limited by. Some of the species distribution models for Joshua tree evaluated by the Department provided corresponding information on how well the model predictions matched the current distribution of western Joshua tree (Cole et al. 2011, Barrows and Murphy-Mariscal 2012). The species distribution models that have attempted to model the current distribution of Joshua trees have only produced rough approximations of the current species range and distribution. Because of our limited understanding of the true climate tolerances that the range of western Joshua tree is limited by, the magnitude and timing of effects of the loss of areas with 20th century suitable climate conditions is not known. The loss of substantial areas of 20th century suitable climate conditions that is projected by species distribution models in some areas is expected to have negative effects on populations in the affected areas, but the Department does not have information indicating whether western Joshua trees in the affected areas are likely to die, populations are likely to cease reproducing, and/or that populations are unlikely to be sustainable. Loss of areas with 20th century suitable climate conditions may instead result in reductions in population density and distribution that are not likely to result in a serious risk of reduction in a significant portion of the species' range in the foreseeable future.

Due to the inherent limitations in predictions from species distribution models, limitations in the current understanding of the climate conditions that limit western Joshua tree's range (as described in the Climate, Hydrology and Other Factors section of this Status Review), and limited information that relates western Joshua tree demographic and population trends with the predicted effects of climate change (as described in the Population Trends section of this Status Review), the Department does not consider the available data on the potential timing and magnitude of negative effects of climate change on western Joshua tree's range as sufficient to support a conclusion that the species is likely to become endangered in the foreseeable future. The Department does not currently possess information that suggests the effects of climate change on the species in the foreseeable future are likely to place the western Joshua tree in serious danger of becoming extinct throughout all or a significant portion of its range.

In addition to reviewing the species distribution modeling efforts described above, Department staff assessed the vulnerability of western Joshua tree to climate change using the NatureServe Climate Change Vulnerability Index (CCVI) Version 3.02 (NatureServe 2016, CDFW 2021b). The CCVI is a rapid means of estimating a plant or animal species' relative vulnerability to climate change. The CCVI analyzes exposure to local climate change within a species' range and assesses indirect climate change effects and the species sensitivity and adaptive capacity to provide a qualitative assessment of how the abundance and/or range extent of the species may change due to climate change. The results of the CCVI indicated that western Joshua tree has a climate change vulnerability index value of moderately vulnerable (MV), indicating that "abundance and/or range extent within geographical area assessed likely to decrease by 2050;" however, the confidence in this vulnerability index score is low. Factors contributing to these vulnerability assessments include barriers to western Joshua tree dispersal and limited dispersal capability, the species physiological thermal niche, the historical hydrological niche of the species, increasing wildfire activity, dependence on an obligate pollinating moth, and existing documented or modeled response to climate change (i.e., the species distribution models described above).

In 2016, Thorne et al. conducted a CCVI assessment that evaluated the sensitivity and adaptive capacity of five major plant species of the Mojavean–Sonoran Desert Scrub vegetation macrogroup, including Joshua tree (Thorne et al. 2016). Joshua tree was assessed individually as highly vulnerable to climate change. Thorne et al. (2016) ranked the adaptive capacity of Joshua tree to be low due to its low adaptivity to fire and its slow and limited recruitment abilities. Thorne et al. (2016) also identified fire sensitivity, requirements for germination, and limited dispersal capacity as primary reasons for the high sensitivity of Joshua tree to climate change. Thorne et al. (2016) concluded that the Mojavean–Sonoran Desert Scrub vegetation macrogroup was moderately vulnerable to climate change in California.

<u>Summary of Species Distribution Models</u>

All of the studies assessed by the Department come to similar conclusions that the areas with climate conditions that supported western Joshua tree during the 20th century are expected to contract substantially by the end of the 21st century (2100), especially in the southern and lower elevation portions of the species' range. Areas with historical 20th century suitable climate conditions for the species will expand to the north and into higher elevation areas in some parts of eastern California, but most substantially in Nevada (outside of the scope of CESA). Western Joshua tree is only likely to colonize areas with newly suitable climate conditions very slowly. Studies assessed by the Department also suggest that refugia of 20th century suitable climate conditions for western Joshua tree will remain in some limited areas at the southern and lower elevation portions of its range at the end of the 21st century under some climate scenarios. The loss of 20th century suitable climate conditions for western Joshua tree from some areas that is projected by species distribution models is expected to have negative effects on populations in the affected areas, but the Department does not have information indicating that western Joshua trees in the affected areas will likely die, or that populations are likely to cease reproducing or be no longer sustainable at the end of the 21st century. Loss of areas with 20th century suitable climate conditions may instead result in reductions in population density and distribution that are not likely to result in a serious risk of reduction in a significant portion of the species' range in the foreseeable future.

<u>Indirect Effects</u>

Changes to precipitation due to climate change could have cascading effects on western Joshua tree. Climate change within the range of western Joshua tree will affect the abundance and distribution of plant species, sometimes with unexpected results (Kimball et al. 2010). Climate variability could result in more extreme wet periods that result in extensive growth and spread of invasive annual plant species, which would have implications for wildfire frequency and intensity and would affect western Joshua tree. These negative effects on western Joshua tree are discussed in more detail in the Wildfire section of this Status Review. Climate change could also contribute to more severe drought events, which would reduce the amount of resources available for animals, potentially increasing herbivory and damage to western Joshua tree as described in more detail in the Herbivory and Predation section of this Status Review.

Climate change may also indirectly impact western Joshua tree habitat via an increase in renewable energy development in habitats occupied by the species. Impacts of development are discussed in the Development and Other Human Activities section of this Status Review.

Climate change could also indirectly impact western Joshua tree through effects on western Joshua tree's specialized obligate pollinator, the yucca moth *T. synthetica*, because the two species are dependent upon one another for sexual reproduction. In general, species of butterflies and moths are predicted to experience changes in abundance, distribution, and timing of life history events as a result of a warming climate, and examples of such changes have been observed in different parts of the world (Kocsis 2011). The extent to which climate change may affect *T. synthetica* is not currently known, but climate change could affect the mutualism with western Joshua tree in various ways that either increase the number of viable seeds produced (benefitting western Joshua tree), increase the number of seeds eaten by moth larvae (benefitting *T. synthetica*), or disrupting the mutualism in a way that harms both western Joshua tree and *T. synthetica*. Harrower and Gilbert (2018) examined various aspects of the mutualism between western Joshua tree and *T. synthetica* along an elevation gradient within JTNP, which provides some context for how climate change may affect this mutualistic relationship. Harrower and Gilbert (2018) collected western Joshua tree demographic data and data on the abundance of *T. synthetica* and bogus yucca moths (*Prodoxus* sp.) at 11 sampling sites along a 1,200 m (3,900 ft) elevational gradient from 1,004 to 2,212 m (3,294 to 7,257 ft). *Prodoxus* sp. moths are parasitic and do not pollinate western Joshua tree. Harrower and Gilbert (2018) found that near 1,250 m (4,100 ft) in elevation western Joshua trees were numerous and large and produced many flowers, pods, seeds, fertile seeds, and seedlings that grew from seeds; this site also had a high abundance of both *T. synthetica* and *Prodoxus* sp. moths. *T. synthetica* was not observed, and sexual reproduction was not found to occur at the highest elevation sampling site at 2,212 m (7,257 ft) or at the lowest elevation sampling site at 1,004 m (3,294 ft). Harrower and Gilbert (2018) found that at an elevation of approximately 1,500 to 1,600 m (4,900 to 5,250 ft) where western Joshua trees were at their highest density, *T. synthetica* abundance was relatively low, and there were fewer viable seeds produced at that sampling site. Harrower and Gilbert (2018) speculated that the range of environmental conditions that support *T. synthetica* may be narrower than those for western Joshua tree. In areas outside of the distribution of *T. synthetica*, asexual reproduction is the only viable reproductive strategy for western Joshua tree.

Development and Other Human Activities

Habitat loss is considered the primary cause for species extinctions at all scales: local, regional, and global (Dirzo and Raven 2003). Habitat loss is caused by a variety of human activities including cultivation of land for agriculture; development of land for residential, commercial, or industrial use; development of utilities, roads, and other infrastructure; resource harvest and extraction; use of land for livestock; and recreational use of land including off-highway vehicle use. These activities often involve removing native vegetation, disturbing soil and the biological communities therein, and installing structures, impermeable surfaces, and other features that render areas incapable of supporting native species assemblages (habitat destruction). Even if human activities do not result in the complete elimination of natural habitat in an area, the indirect effects from such activities can cause substantial changes to the environment (habitat modification), which can affect the abundance of native species. Indirect effects from development and other human activities include soil disturbance and compaction; introduction and spread of exotic species and pathogens; increased dust, pollution, runoff, and trash; artificial noise, light, and vibration; and use of herbicides, pesticides, and other chemicals. Development and other human activities can reduce the amount of contiguous habitat, resulting in habitat fragmentation. Habitat fragmentation can have several repercussions for individual species or entire ecosystems, including increased edge effects, reduced ability of species to migrate or colonize, and reductions in species richness (i.e., number of total species) (Haddad et al. 2015, Evans et al. 2017). Habitat fragmentation can also disrupt plant and pollinator population dynamics by altering pollinator densities and behavior (Xiao et al. 2016).

Western Joshua tree habitat has been subject to a history of habitat modification and destruction in California (see the Inferred Long-term Trends section of this Status Review), and this habitat modification and destruction is expected to continue. Much of the recent western Joshua tree habitat modification and destruction has been the result of ongoing urban development, typically on private property within the general vicinity of existing developed areas. The USFWS (2019) reported that approximately 50% of the southern part of western Joshua tree's range (YUBR South) is on private property, 2% of the northern part of western Joshua tree's range (YUBR North) is on private property, with the remainder predominately on federal land. WEST Inc. (2021b) found a higher percentage of western Joshua tree's range on private property than the USFWS did, with approximately 65% of the southern range on private property, and approximately 13% of the northern range on private property. Due to very limited regulation prior to CESA candidacy, as described in the Regulatory Status and Legal Protections section of this Status Review, western Joshua trees and habitats on private property have been very vulnerable to habitat modification and destruction. Local land use planning and state legal protections such as the 1970 California Environmental Quality Act may have led to the avoidance of some impacts to western Joshua tree. However, development has continued, and cities within the range of the species have expanded substantially into previously undeveloped areas contributing to the loss of many western Joshua trees and suitable habitat. During the candidacy period for western Joshua tree, the Department received numerous reports of the unpermitted killing of western Joshua trees on private property and related habitat modification and destruction.

Renewable energy development has been increasing rapidly in recent decades with development primarily occurring on private lands and lands managed by the U.S. Bureau of Land Management (BLM) in less-developed portions of the Mojave Desert. Under the Desert Renewable Energy Conservation Plan which was finalized in 2016, 157,000 ha (388,000 ac) of BLM lands in the plan area were identified for solar, wind, and geothermal development, with more than 162,000 additional ha (400,000 ac) that could be considered for renewable energy development in the future (BLM 2016). Under the Desert Renewable Energy Conservation Plan, substantial areas of habitat were also identified for conservation. During the candidacy period for western Joshua tree, land with western Joshua trees has been approved to be cleared for renewable energy development following a Special Order approved by the Commission pursuant to Fish and Game Code section 2084. Authorizations under this Special Order required that take of western Joshua tree is mitigated.

Private property that has not been protected from development is at a high risk of habitat modification and destruction in the foreseeable future, and this threat is highest in the southern and western part of western Joshua tree’s range, where most of the western Joshua trees on private property occur. To a lesser extent, western Joshua tree habitat modification and destruction is likely to occur on federal lands due to renewable energy development, off-highway vehicle use, resource extraction activities, livestock grazing activities on BLM lands, and military activities on U.S. Department of Defense lands. While habitat is likely to be lost on BLM lands and U.S. Department of Defense lands in the foreseeable future, habitat destruction from activities on these lands may be limited, as much of these areas are expected to be maintained in an undeveloped state. Lands close to existing base infrastructure are likely to be developed and used for military purposes, but U.S. Department of Defense has historically maintained large buffers of natural habitat around many of its military bases, including lands maintained to “enable realistic, mission essential testing, training, and operations” (Department of Defense 2021).

Habitat modification from development and other human activities may also impact the ability of western Joshua tree to recruit new individuals from seed in ways that are not fully understood. As described in the Demographic Information section of this Status Review, information submitted to the Department suggests that relatively few western Joshua trees established from seed in recent decades at six proposed development project sites near the cities of Palmdale and Lancaster. This decreasing recruitment may have been due, in part, to mid-20th century dry conditions identified in Figure 5, combined with environmental degradation related to urban and agricultural use and development. Habitat modification and destruction from development and other human activities in these areas may have impacted the ability of western Joshua tree to sexually recruit new individuals by disrupting one or more of western Joshua tree's critical life history needs. Western Joshua tree's obligate pollinating moth *T. synthetica* could be disrupted while dormant in the soil or in its flight phase. The seed dispersal behavior of rodents could be disrupted, which is the primary way that western Joshua tree seeds are buried at a soil depth suitable for successful germination. Nurse plants that are critical for western Joshua tree seedling survival could also be eliminated. Any one or a combination of these disturbances may have contributed to the observed population declines.

There is much uncertainty in predicting the extent of future development within the range of western Joshua tree. The magnitude of this habitat modification and destruction will be related to the economic values of development and other human activities in the Mojave Desert and surrounding areas, and the effectiveness of local, state, and federal regulatory and legal mechanisms for protecting habitat. During the candidacy period for western Joshua tree, the Department received at least 36 applications for incidental take permits to remove western Joshua trees for development projects. Regional general plans, landscape planning efforts, and specific development plans may influence where development of private property occurs in the future, but the Department considers any private property that is not protected to be at substantial ongoing risk of habitat modification and destruction from development and other human activities.

The economic value of western Joshua tree habitat for energy generation may also continue to increase. According to an analysis done by the USFWS using U.S. Environmental Protection Agency Integrated Climate and Land Use Scenarios projections, between 22% and 42% of the habitat within the southern part of western Joshua tree's range may be lost by the year 2095 due to urban growth and renewable energy development; however, less than one percent of the habitat within the northern part of western Joshua tree's range is expected to be lost during this time period (EPA 2009, 2016, USFWS 2018). Irrespective of the ultimate magnitude of habitat that will be lost, habitat modification and destruction of western Joshua tree habitat from development and other human activities is certain to continue.

Some areas within western Joshua tree habitat were subject to temporary disturbances or land clearing in the past but have since been left fallow. Joshua tree reestablishment in areas after disturbance from plowing and other land use such as homestead sites appears to occur very slowly if at all (Carpenter et al. 1986, Abella 2010). As described in the Establishment and Early Survival section of this Status Review, nurse plants appear to be critical habitat components for Joshua tree establishment. Regeneration of western Joshua tree to pre-disturbance levels may require the reestablishment of nurse plants before western Joshua tree seedlings are able to reestablish. The rate that Mojave Desert vegetation recovers from human-related degradation depends on the nature and severity of impacts, but recovery generally happens very slowly (Lovich 1999). Based on a review of 47 studies, Abella (2010) reported that cover of perennial vegetation in the Mojave Desert generally rebounds faster after fire compared with other disturbances such as land clearing, and this is likely due to the roots and seeds that survive wildfire. In this way modification or destruction of habitat from land clearing and other human activities is more destructive to western Joshua tree habitat than the impacts from wildfire.

As described under the Climate Change section of this Status Review, there may be a time delay between when an area becomes no longer suitable for sustaining a species, and when that species becomes locally extinct. Delayed local extinction could be occurring in areas where western Joshua tree adults remain relatively abundant, but juvenile western Joshua trees are rare, such as at the six development project sites near the cities of Palmdale and Lancaster for which the Department received western Joshua tree height data in 2021 (see Figure 8).

Present or threatened modification or destruction of habitat is a substantial threat to western Joshua tree in California, particularly at renewable energy development sites, on private property, and within the vicinity of existing urban areas in the southern part of western Joshua tree's range.

Wildfire

Fire is a defining component in many of California's ecosystems, as it is in most of the world's Mediterranean-climate regions (Keeley et al. 2011, Sugihara et al. 2018); however, the frequency and severity of fire is generally lower in California deserts than it is in other California ecosystems. Fire occurrence in the southeastern deserts of California is primarily limited by the availability of fuels, and fire return intervals in California deserts tend to be relatively long (Brooks et al. 2018, CNPS 2021a). Fire is unevenly distributed in the Mojave Desert, and fire occurrence tends to align with distinct precipitation regime boundaries, with most large and recurring fires occurring in areas that have a relatively high amount of precipitation in summer (Tagestad et al. 2016). Fuels tend to be more available, and fires tend to be more frequent and severe at higher-elevation areas of the Mojave Desert, and the availability of fuels and frequency of fires is somewhat lower at middle elevation areas, and still lower at the low elevation areas of the Mojave Desert (Brooks et al. 2018). Periods of relatively high and low fire activity have been associated with periods of relatively wet and dry conditions in the Mojave Desert Region, respectively, and can be influenced by global-scale climate fluctuations including the El Ninõ-Southern Oscillation and the Pacific Decadal Oscillation, as described in the Precipitation section of this Status Review (see Figure 5). During multi-decadal periods of relatively wet conditions, cover of perennial vegetation may expand, increasing the amount of fuel on the landscape. High precipitation in one or more years may also result in a high biomass of annual plant species in those years, particularly in the spaces between perennial and woody vegetation (Brooks and Matchett 2006, Van Linn et al. 2013, Gray et al. 2014, Hegeman et al. 2014, Rao et al. 2015, Tagestad et al. 2016). Fire potential may, then, be greatest when one or more high precipitation years occurs near the end of a multi-decadal period of relatively wet conditions (Brooks et al. 2018).

Wildfire ignitions in the southeastern deserts of California were prehistorically caused by lightning, which occurs at a higher frequency in the southeastern deserts region of California than in other parts of the state (van Wagtendonk and Cayan 2008). Native Americans also ignited fires in the southeastern deserts when they arrived in California approximately 12,000 years ago (Anderson 2018). Fire regimes and related ecosystem processes were profoundly altered by land use practices associated with Euro-American settlement beginning in the mid-1800s, and these changes have in turn led to major modifications in vegetation distribution, structure, and composition (Skinner and Chang 1996, Barbour et al. 2007, Safford and Van de Water 2014, van Wagtendonk et al. 2018). When Euro-Americans began occupying lands in the Mojave Deserts region in the mid-1800s, ignitions from traditional Native American practices were curtailed, invasive plant species were widely introduced and spread, and livestock grazing became a widely implemented land use practice (Brooks et al. 2018). As the human population and associated electrical and transportation infrastructure rapidly increased from the early 1900s to present, sources of human-caused wildfire ignitions in the Mojave Desert also increased.

Syphard et al. (2017) examined the variety of factors contributing to wildfire in the Mojave Desert and nearby areas for a 40-year timespan. While the variables contributing to wildfires in the region are complex, Syphard et al. (2017) found that the spatial and temporal distribution of most fires (including many small fires) in the Mojave Desert from 1970 to 2010 was correlated with human disturbance, with ignitions concentrated near roads and areas of nitrogen deposition. The relationship between nitrogen deposition and fire is discussed in the Invasive Plants section of this Status Review. Syphard et al. (2017) also looked at the variables contributing to the spatial and temporal distribution of large (> 20 ha) fires, which can affect much larger areas of western Joshua tree habitat during one event. Most large fires in the Mojave Desert from 1970 to 2010 were correlated with a number of variables, but the most important variables identified were measures of the current year's and the previous year's vegetation cover, followed by nitrogen deposition and elevation. The human-caused variables contributing most to the spatial and temporal distribution of large fires was the location of power lines, oil and gas wells, wind turbines, and power plants.

There was less summer precipitation and fewer fires during the mid-20th century period of dry conditions in the Mojave Desert that took place from approximately 1947–1975 (Tagestad et al. 2016), but since that time, particularly since the beginning of the 2000s, desert ecosystems in California have become increasingly susceptible to wildfire (Syphard et al. 2017, Brooks et al. 2018). One reason for this increasing susceptibility to wildfire is the presence of exotic annual plant species (D'Antonio and Vitousek 1992, Brooks et al. 2004, Brooks and Matchett 2006, Brooks and Chambers 2011, Fuentes-Ramirez et al. 2015, 2016). Invasive plant species were likely first introduced to the Mojave Desert by the Spanish during the late 1500s, and current human activities, such as livestock grazing, water diversion, mineral and gas extraction, military training, and recreational activities have likely continued the introduction and spread of invasive plants species in the region (Brooks 1999, Brooks and Pyke 2001). Annual plants in the spaces between shrubs provide a more continuous fuel source that allows fire to spread more easily, increasing wildfire risk (Brooks et al. 2016, Klinger et al. 2018). While native annual plants contribute to wildfire risk in the Mojave Desert, exotic annual plant species have a greater impact on wildfire risk as these species are more likely to occur in areas between shrubs and other vegetation, helping perpetuate the wildfire (Moloney et al. 2019).

There is some evidence that invasive plant species in the Mojave Desert are contributing to a grass/fire cycle (D'Antonio and Vitousek 1992), particularly in the middle-elevation areas, which is where western Joshua tree is most frequently found (Brooks and Matchett 2006, Brooks et al. 2018). The grass/fire cycle occurs when an invasive annual grass colonizes an area and provides the fine fuel necessary for the initiation and propagation of fire, leading to an increase in frequency, area, and perhaps intensity of wildfires. Following these grass-fueled fires, invasive species can increase more rapidly than native species, creating a positive feedback loop that further increases susceptibility to wildfire, and areas that previously burned may burn again (Zouhar et al. 2008, Klinger and Brooks 2017). Red brome (*Bromus madritensis* ssp. *rubens*) can dominate middle-elevations of the Mojave Desert where western Joshua tree is frequently found, and contributes to the grass/fire cycle in these areas. Cheatgrass (*Bromus tectorum*) has dramatically shortened fire return intervals in the Great Basin, which is a cold desert province (Whisenant 1992, Balch et al. 2013), and the grass/fire cycle has caused substantial ecological impacts in the region (Brooks and Pyke 2001, Brooks et al. 2018). Cheatgrass also occurs in higher elevation areas of the Mojave Desert. The Great Basin typically receives enough precipitation to support populations of cheatgrass every year, but warm desert provinces of California such as the Mojave Desert receive less consistent precipitation from year to year and also experience longer multi-decade periods of wet and dry conditions. The abundance and distribution of invasive grasses in the Mojave Desert can therefore fluctuate with these precipitation patterns. The wildfire behavior in the middle elevation areas of the Mojave Desert is influenced by the grass/fire cycle after years of high precipitation, but less so during relatively dry periods (Brooks et al. 2016). Over the short-term, fire may have a positive effect on soil nutrients in the immediate vicinity of burned shrubs, but this effect fades in the long term (Fuentes-Ramirez et al. 2015). Wildfires can increase nitrogen availability, making soils more suitable for invasive annual species like cheatgrass, which in turn can create a feedback loop by increasing the frequency of fire (Kerns and Day 2017). There is also evidence that cheatgrass itself can increase soil nitrogen availability (Stark and Norton 2015).

Western Joshua trees tend to be found at highest densities in the middle-elevation areas of the Mojave Desert. Brooks et al. (2018) reported that the middle elevation areas of the Mojave Desert had a fire return interval of approximately 687 years based on data from 1984–2013, which is equivalent to approximately 3.0% of these middle elevation areas burning every 20 years. Brooks et al. (2018) also reported an increase in annual fire area in middle elevation areas during this 1984–2013 period (Brooks et al. 2018). Fire probability is also related to elevation, as the proportion of area burned was largest at higher elevations and lowest at lower elevations (Brooks and Matchett 2006, Brooks et al. 2018).

The Department evaluated California Department of Forestry and Fire Protection (CALFIRE 2021) records of areas burned by wildfire from 1900 to present within western Joshua tree's California range, as shown on Figure 9. Wildfire primarily affects the southern and western edges of western Joshua tree's range. Based on California Department of Forestry and Fire Protection records, the area burned within western Joshua tree's California range has increased over the period of 1900–2020 (Figure 10). Wildfire has increased from burning less than 0.5% of western Joshua tree's California range each decade in the early 1900s, to burning approximately 2.5% of the species' range per decade between 2001–2020, though some of the increase in burned area shown in Figure 10 may be attributable to increasingly accurate and complete records in the second half of the 20th century and into the 2000s. Some areas of western Joshua

2803 *Figure 9:* Fires within the California Range of Western Joshua Tree, 1900–2020
2804 (CALFIRE 2021)

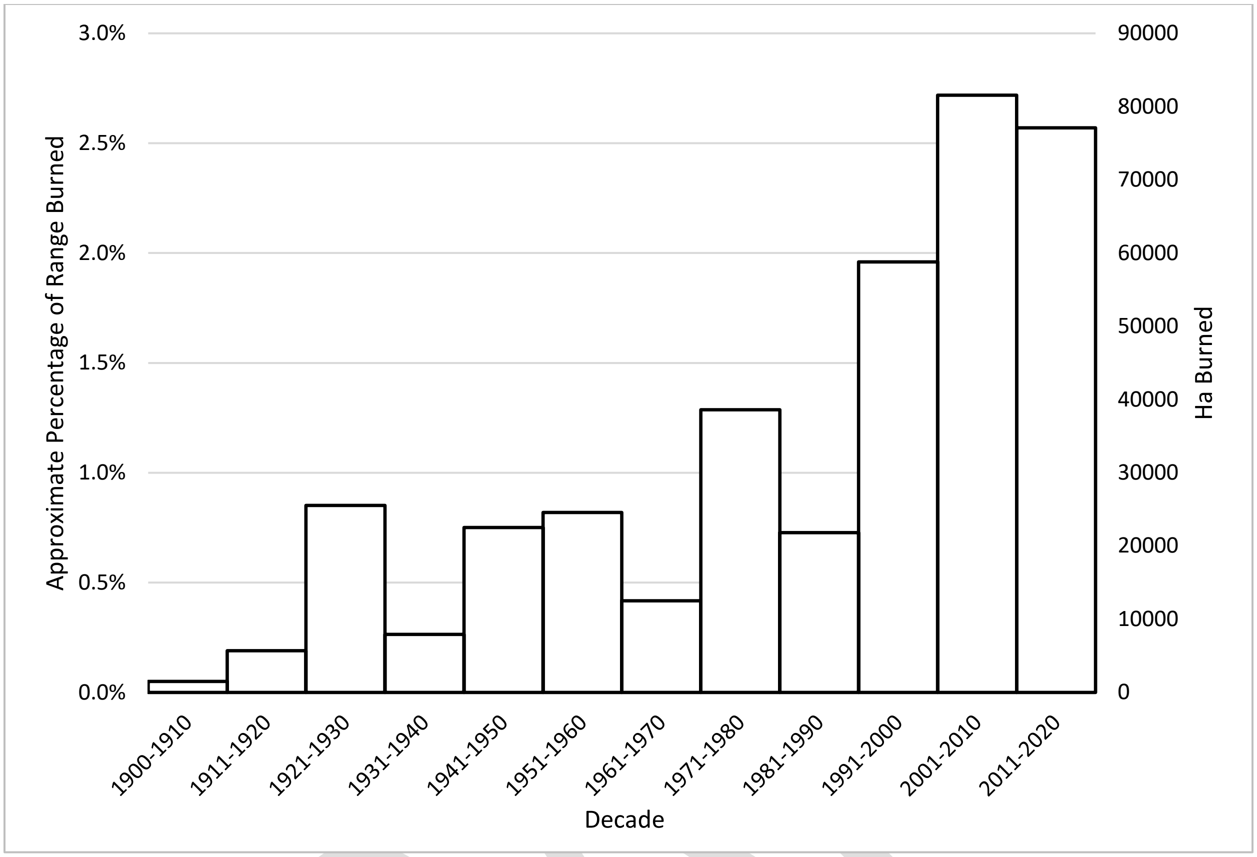


Figure 10: Area Burned Within Western Joshua Tree Range, 1900–2020 (CALFIRE 2021)

tree habitat may have burned more than once over short time periods, so the areas burned within western Joshua tree's range are not necessarily cumulative. Many of the fire areas shown in Figure 9 roughly overlap with areas that have higher cover of western Joshua tree, as shown in Figure 4. In a separate analysis, Thompson (2021) calculated that 6.62% of the southern portion of western Joshua tree's range was affected by one or more wildfires between 1980–2019.

Fire has been recognized as a threat to Joshua tree for many decades (Webber 1953), and Joshua trees are negatively impacted or killed by wildfire and slow to recover from impacts (Minnich 1995, Loik et al. 2000b, DeFalco et al. 2010, Vamstad and Rotenberry 2010, Cornett 2012, Abella et al. 2020). Taller western Joshua trees may escape mortality from fire and heat due to their tall stature (Minnich 1995, DeFalco et al. 2010); however, shorter trees are more severely affected by surface fires. Persistent dead leaves along western Joshua tree trunks sometimes carry fire to the canopies of taller trees (Minnich 1995). As discussed in the Growth and Longevity section of this Status Review, post-fire recruitment from seeds appears to be rare (Borchert 2021), so Joshua tree may primarily recover from wildfire via resprouting. The new sprouts are prone to herbivory, and herbivory of western Joshua tree rhizome sprouts has been observed to be very high in the first year after a fire; however, sprouts continue to be produced in the second year after fire (Borchert pers. comm. 2021).Western Joshua tree populations are very slow to recover from fire. Minnich (1995) observed a 47 year chronological sequence of 13 burned Joshua tree woodland sites within JTNP that were similar, but that had burned at different times in the past. Minnich (1995) found that 64% to 95% of western Joshua tree stems were fatally damaged in all but one of the sample sites, and western Joshua tree cover and density remained low in burned sites compared with unburned sites, even 47 years after burning. DeFalco et al. (2010) monitored western Joshua tree at five pairs of burned and unburned sites in JTNP from 1999–2004 to study post-fire effects. DeFalco et al. (2010) found that plants in burned plots declined by 80% at the end of the study, and plants in unburned plots declined by 26%, with drought likely contributing to the decline in both burned and unburned plots during the monitoring period. Barrios et al. (2017) compared aerial photography from 1992 with field survey results from 2017 to examine western Joshua tree survivorship and regeneration in two areas affected by a fire on Edwards Air Force Base in 1999. Barrios et al. (2017) found that the number of western Joshua trees in study areas increased from 108 in 1992 to 127 in 2017, but acknowledged that smaller western Joshua trees may not have been discernable via aerial imagery in 1992, and therefore may have been underreported. Barrios et al. (2017) reported that 73 of the 127 trees present in 2017 (57%) had been burned by the 1999 fire but resprouted and were alive.

Heat from wildfire may also kill western Joshua tree seeds on or in the soil. Keeley and Meyers (1985) found that Joshua tree seeds could not germinate after heat treatments of two hours at 90°C (194°F) or five minutes at 120°C (248°F). Peak fire temperatures reported by Brooks (2002) under and near shrubs in the Mojave Desert suggests that temperatures hot enough to kill Joshua tree seeds sometimes occur during wildfire, particularly if Joshua tree seeds are near burning shrubs and are not buried under soil.

Lybbert and St. Clair (2016) examined the possible extended effects of wildfire on flower production, fruit production, yucca moth visitation, and cattle herbivory of eastern Joshua tree approximately eight to nine years after fire but did not find significant differences between burned and unburned populations of eastern Joshua tree. These results suggest that the fire did not present a significant long-term impact to the population of its specialized pollinating yucca moth, or a long-term disruption to sexual reproduction, but Lybbert and St. Clair (2016) did note that the selection of eastern Joshua tree study locations in burned areas was limited due to low post-fire survival of the species.

In addition to directly killing adult and juvenile western Joshua trees, wildfire may eliminate important nurse plants (Loik et al. 2000b, Abella 2010, Brooks et al. 2018, Abella et al. 2020), increase herbivory and predation due to lowered resource availability (see Herbivory and Predation section of this Status Review), and create conditions that are more favorable for the establishment and spread of invasive species. Vamstad and Rotenberry (2010) examined how vegetation in a western Joshua tree woodland recovers after fire by examining a chronological sequence of historic burns in JTNP. Vamstad and Rotenberry (2010) found that while plant cover values returned to pre-fire levels between 19 and 65 years after wildfire, the reestablished vegetation assemblages in burned areas did not converge to the assumed pre-burn composition, even after 65 years. The authors suggest that the slow recovery is likely due to slow rates of reestablishment for some species. There is evidence that native annual plants in the Mojave Desert may reestablish more quickly than the Mohave Desert invasive plant species *Bromus madritensis* ssp. *rubens* (red brome) in the years immediately after fire, but red brome populations can reestablish to pre-fire conditions within two to nine years (Abella et al. 2009, Vamstad and Rotenberry 2010, Jurand and Abella 2013). Blackbrush vegetation communities appear to be particularly affected by wildfire in the Mojave Desert, and are very slow to recover from wildfire (Tagestad et al. 2016).

The amount and seasonality of precipitation in the Mojave Desert will drive fire potential in the future, but climate change effects on precipitation patterns in the Mojave Desert are still uncertain. Although many factors could be contributing to the spread of invasive species and increasing wildfire risk in the western U.S., climate change could add to these effects via increases in the length of the growing seasons of invasive species and decreases in episodic cold mortality events, changes in the frequency of extreme precipitation events, and increases in the frequency of conditions that are conducive to increased fire potential (Abatzoglou and Kolden 2011, Hopkins 2018). Smith et al. (2000) found that elevated CO_2 increased the productivity and success of invasive species in an arid ecosystem, which suggests that climate change might enhance the long-term success of invasive species in the Mojave Desert, further increasing wildfire risk. Regardless of the extent to which climate change is contributing to wildfire risk in the Mojave Desert, if the wildfire trends reported by Brooks et al. (2018) and shown in Figure 10 continue, the threat of wildfire to western Joshua tree will increase.

<u>*Summary of Wildfire Threat*</u>

Wildfire is a substantial threat to western Joshua tree and invasive plants contribute to that threat, but wildfire does not affect the entire range of the species evenly, does not necessarily burn through habitat in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. For these reasons, wildfire is likely to reduce the abundance of the species, but it is unlikely to result in a serious danger of elimination of the species throughout a significant portion of its range. Nevertheless, because western Joshua tree recruitment from seed is rare, and because the species takes a long time to reestablish in burned areas, wildfire causes long-lasting negative effects in burned areas. The Department expects that the impacts from continuing and increasing wildfire activity in the Mojave Desert and surrounding areas will cause ongoing gradual reductions in the size of at-risk populations of western Joshua tree within California, but the range of the species is unlikely to be affected by wildfire in the foreseeable future, because western Joshua tree is unlikely to be completely eliminated from affected areas due to its high abundance and widespread distribution.

Invasive Plants

Invasive species are often cited as the second greatest threat to biodiversity behind habitat loss (Wilcove et al. 1998, Mack et al. 2000, Levine et al. 2003, Pimentel et al. 2004) and North America has accumulated the largest number of naturalized, non-native plants in the world (van Kleunen et al. 2015). Many studies hypothesize or suggest that competition is the process responsible for observed invasive species impacts to biodiversity; however, invasive species may impact native species in a variety of ways (Levine et al. 2003). Invasive species may threaten native populations through competition for light, water, or nutrients; deposition of harmful biochemicals to soil; alteration of soil chemistry (e.g., pH, salinity); thatch accumulation that inhibits seed germination and seedling recruitment; changes in natural fire frequency; disruptions to pollination or seed-dispersal mutualisms; changes in soil microorganisms; diseases; or other mechanisms. The magnitude of invasive species impacts depends on the characteristics of the invading species and the habitat being invaded (Gaertner et al. 2009, Fried et al. 2014). Invasive species may also influence native species' colonization rates, leading to declines in local diversity over longer timescales (Yurkonis and Meiners 2004).

Invasive plant species are widespread in the Mojave Desert and throughout California, and in many cases, they compose large proportions of overall plant biomass (Brooks and Berry 2006). Invasive plant species that have reached "infested" to "spreading" status by the California Invasive Plant Council and that are causing severe ecological impacts within the Mojave Desert region of California include Saharan mustard (*Brassica tournefortii*), red brome, and cheatgrass (California Invasive Plant Council 2021). Russian-thistle (*Salsola tragus*), Arabian schismus (*Schismus arabicus*), and common Mediterranean grass (*Schismus barbatus*) are also reported by the California Invasive Plant Council to have reached "infested" to "spreading" status within the Mojave Desert region of California, but are not currently causing as severe of ecological impacts as Saharan mustard, red brome, and cheatgrass (California Invasive Plant Council 2021). There are many other species of plants that are not native to the Mojave Desert region of California but that have become established, and are continuing to reproduce and persist in the region (Weatherwax et al. 2002). The best predictors for the abundance and diversity of non-native and invasive plant species in the Mojave Desert may be proximity to human disturbance and development, including roads, off-highway vehicle use, livestock grazing and agriculture (Brooks and Berry 2006). Even within the protected lands of JTNP, there are few, if any, areas that have not been invaded by non-native and invasive grasses (Frakes pers. comm. 2021).

Increased nutrient availability through anthropogenic nitrogen deposition from air pollution has been shown to be a contributor to the abundance and spread of invasive plant species, including within the Mojave Desert (Allen et al. 2009, Allen and Geiser 2011, Pardo et al. 2011, Bytnerowicz et al. 2015, Rao et al. 2015). While precipitation is the primary driver influencing the biomass of invasive species in the Mojave Desert, nitrogen deposition has a smaller contributing effect (Rao et al. 2015), and this nitrogen deposition is already making an indirect, but substantial contribution to the spatial and temporal patterns of wildfire in the Mojave Desert (Syphard et al. 2017). Nitrogen deposition from anthropogenic sources is expected to increase in some parts of the world with increasing global emissions in the coming decades, particularly in areas that are still developing, but the depositions may show decreases in the 2100s even under different emissions scenarios (Zhang et al. 2019).

The primary way in which non-native and invasive plant species currently affect western Joshua tree is indirectly by fueling wildfire, as discussed in the Wildfire section of this Status Review. The contribution of invasive plant species to wildfire is expected to continue in the future, as human activities continue to promote the spread of non-native and invasive species within the range of western Joshua tree.

The Department is not aware of any studies examining the competitive effects of other plant species on western Joshua tree specifically, but invasive plant species, especially annual grasses, can rapidly invade Mojave Desert habitats and can compete with other plants for light, water, space, and nutrients (Brooks 2000, DeFalco et al. 2003, 2007, Blank 2010, Perkins and Hatfield 2014). Western Joshua tree is likely the most vulnerable to competitive effects from invasive plant species in the years immediately following germination, and plants likely become less vulnerable as they get larger. The Department currently considers competition with invasive plant species to be a minor threat to western Joshua tree.

Herbivory and Predation

Consumption of western Joshua tree seeds by both *T. synthetica* larvae, and seed-caching rodents is a natural component of the western Joshua tree life cycle. While there is a cost of these ecological relationships for western Joshua tree, the species also receives benefits in the form of sexual reproduction and seed dispersal. Physical damage to ovules of another species, Adam's needle (*Yucca filamentosa*), can trigger affected flowers to selectively abort and drop (Pellmyr and Huth 1994, Huth and Pellmyr 2000, Marr and Pellmyr 2003), which suggests that western Joshua tree may also be able to limit excessive negative effects from moth larvae eating seeds by dropping flowers that may have too many moth eggs. The relative costs and benefits of the ecological relationships between western Joshua tree, *T. synthetica*, and seed-caching rodents likely fluctuates based on environmental conditions and other factors, and the costs might outweigh the benefits when other stressors are acting upon the system, such as the factors that are discussed in this Status Review.

Other moth species may also oviposit on Joshua tree flowers so that their larvae may hatch inside and feed on seeds, but this relationship is strictly parasitic, because these moth species do not also pollinate western Joshua tree (Althoff et al. 2004). Along an elevational gradient within JTNP, Harrower and Gilbert (2018) found bogus yucca moth (*Prodoxus* sp.) to be the most abundant in areas with the highest density of western Joshua tree, except at the highest elevation sampling site at 2,212 m (7,257 ft) where no sexual reproduction of western Joshua tree was observed, and asexual reproduction was abundant. Western Joshua tree may be able to limit impacts of seed predation from these moth larvae by dropping fruit before maturity, and infertile seeds could also help limit predation because moth larvae sometimes exit the fruit after encountering infertile seeds (Ziv and Bronstein 1996). There has been some investigation into how strongly the bogus yucca moths negatively impact the reproductive success of *Yucca* spp., but a strong effect has not yet been found (Althoff et al. 2004).

Other insect species feed on western Joshua tree as well. Yucca weevil (*Scyphophorus yuccae*) is a native insect species that feeds on *Yucca* spp. and related plants in the southwestern region of the United States, and has been found on Joshua tree (Vaurie 1971, Huxman et al. 1997). Yucca weevil larvae build protective cases near the ends of Joshua tree branches, and resulting damage to the meristem has been noted to cause branching in affected plants (Jaeger 1965). The Navaho yucca borer butterfly (*Megathymus yuccae navaho*) is reported to ignore young Joshua tree plants growing from seeds, and instead lays eggs only in Joshua trees that arise from asexual growth, with the resulting larvae boring into the underground rhizomes, where they feed and later pupate (Jaeger 1965). Lastly, a small contained outbreak of the yucca plant bug (*Halticoma valida*) was reported as impacting several planted Joshua trees at a demonstration garden in the town of Joshua Tree (JTNP 2017).

Domestic grazing animals can modify and degrade western Joshua tree habitat, and cattle may also eat portions of western Joshua tree plants. Cattle have been reported to graze on Joshua tree flowers when they can be reached (Wallace and Romney 1972, Lybbert and St. Clair 2017), and seeds and fruits are reported to be "fairly good feed materials” (Webber 1953). Cornett (2013) observed conspicuous cattle browsing on shrubs and other plants at one monitoring plot in Death Valley National Park but did not observe any evidence that cattle browsed western Joshua trees within the plot. Lybbert and St. Clair (2017) found that cattle removed 40% of eastern Joshua tree flower inflorescences that were lower than 2 m (6.6 ft) in one study area in Nevada but found that flower inflorescences above this height were not removed. Conversely, Cornett (1995) speculated that grazing by cattle can benefit Joshua tree by reducing bunch grass, favoring the presence of shrubs (nurse plants) that aid in Joshua tree seedling survival.

Small mammals, including antelope ground squirrels (*Ammospermophilus leucurus*), Botta’s pocket gophers (*Thomomys bottae*), black-tailed jackrabbits (*Lepus californicus*), and woodrat (*Neotoma* spp.) sometimes strip the periderm (bark) from Joshua trees, exposing large light-colored patches of underlying tissue and hollowing out stems, and this occurs more frequently during periods of drought (Esque et al. 2003, 2015, DeFalco et al. 2010). Following observations of damage to the trunks of western Joshua trees within JTNP in October of 2001, Esque et al. (2003) measured the survivorship of damaged trees in the summers of 2002 and 2003 and found that 95% of undamaged trees survived, but only 42% of trees with bark damage survived. The more damaged the western Joshua trees were, the less likely they were to be alive in 2003. No trees with more than 25% of their bark removed survived, but 60% of the trees with <5% of their bark removed survived. Five years after a wildfire and after a period of drought in JTNP, DeFalco et al. (2010) found that 14% of western Joshua trees in unburned areas and 28% of western Joshua trees in burned areas had bark damage from small mammals and this bark damage was correlated with reduced survival of plants, particularly at lower elevation areas where the most bark damage occurred.

Mammals can also eat other parts of western Joshua tree. Black-tailed jackrabbits can consume young western Joshua tree rhizome sprouts (Cornett 1995) and seedlings. Over half of a cohort of 53 five to seven year-old western Joshua tree plants were killed from black-tailed jackrabbit herbivory during a drought in 1989 and 1990 (Esque et al. 2015). Herbivory on basal sprouts may also be particularly high in the first year after a fire (Borchert pers. comm. 2021). Sanford and Huntly (2009) found that desert woodrats (*Neotoma lepida*) primarily fed on the tips of eastern Joshua tree leaves, tending to leave the leaf bases intact, and that they prefer leaves with higher nitrogen content, which tends to occur on the south side of plants.

Herbivory and predation result in relatively minor negative impacts to western Joshua tree. Impacts from small mammals are likely highest in non-masting years, when they consume nearly all of the western Joshua tree seeds that are produced, and during periods of drought, when they can damage the bark of trees, potentially causing mortality in affected trees. Cattle may also consume quantities of flowers in grazed areas. Nevertheless, because western Joshua tree is currently abundant and widespread, the Department considers the threat to the species from herbivory and predation to be relatively small.

Use and Vandalism

Western Joshua tree has long been available and used in the horticultural trade, with seeds and plants collected from the wild, and individuals planted within and outside of the species' native range. Joshua tree was briefly but unsuccessfully used for paper pulp and surgical splints in the late 1800s and early 1900s (McKelvey 1938). Concern about impacts from commercial collecting and overutilization of Joshua trees and other desert plants was raised as early as 1930 (Carr 1930, Griffin 1930, Runyon 1930), and shortly afterwards some areas of the Mojave Desert were protected. Desert vegetation also received protection from commercial collection with the passage of the California Desert Native Plants Act (DNPA) in the early 1980s. Collection of western Joshua tree seeds and plants from the wild for horticultural reasons likely continues to occur to some extent near roads, but the impact to the species from these activities is considered relatively minor. Western Joshua tree may also continue to be used traditionally by Native Americans (Coville 1892, Stoffle et al. 1990, Fowler 1995, Small 2013, Gaughen pers. comm. 2020), but impact to the species from these activities is also considered relatively minor. Vandalism of western Joshua trees occasionally occurs in some areas (Airhart 2019), and one of the largest known western Joshua trees was maliciously burned to the ground (McKelvey 1938, Cummings 2019). Western Joshua tree is currently abundant and widespread, and the threat to the species from use and vandalism is currently considered relatively minor.

EXISTING MANAGEMENT

Regulatory Status and Legal Protections

Some local, state, and federal laws apply to activities undertaken in California that may provide western Joshua tree and its habitat some level of protection from development and other human activities. A discussion of some of the local, state, and federal laws that are applicable to western Joshua tree is provided below; however, the following is not an exhaustive list.

In general, the highest level of regulatory protection that western Joshua tree has received so far has been the result of the species being designated a candidate under CESA on October 9, 2020, which prohibits "take" of the species during the candidacy period and typically requires take to be minimized and "fully mitigated" to Department standards. Absent the protections of CESA, other federal, state, and local laws and regulations may provide limited avoidance, minimization, and mitigation of impacts for the species, with protection or mitigation of impacts often only required when a controlling agency or project proponent determines it is feasible to do so. In many cases, removal of western Joshua trees and related habitat destruction may proceed with a permit from a local agency that does not require mitigation for habitat loss. Permits may also be issued that only require moving individual western Joshua trees out of the habitat that is to be destroyed, but the habitat destruction is not mitigated. Absent the protections of CESA, trends of western Joshua tree habitat loss and degradation from development and other human activities will likely continue.

During the candidacy period for western Joshua tree, the Department has also received numerous reports of the unpermitted killing of western Joshua trees on private property, and related habitat modification and destruction. Impacts from unpermitted or illegal activities do take place, and laws and regulatory mechanisms are only effective if they are followed and enforced.

Federal

Federal Endangered Species Act

Both western Joshua tree and eastern Joshua tree were petitioned to be listed as threatened under the federal ESA (16 U.S.C. §§ 1531-1544) in 2015 (Jones and Goldrick 2015). After conducting an assessment of the two species, the USFWS issued a decision (12 Month Finding) that listing Joshua tree as an endangered or threatened species was not warranted (USFWS 2018, 2019). In *WildEarth Guardians v. Haaland*, 2021 U.S. Dist. LEXIS 179024, the United States District Court for the Central District of Columbia set aside the USFWS' 12 Month Finding as arbitrary, capricious, and contrary to the federal ESA and remanded the 12 Month Finding to the USFWS for reconsideration consistent with the court's findings.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to assess the environmental effects of their proposed actions prior to making certain decisions. Using the NEPA process, agencies evaluate the environmental and related social and economic effects of their proposed actions. Agencies also provide opportunities for public review and comment on those evaluations. Title I of NEPA contains a Declaration of National Environmental Policy. This policy requires the federal government to use all practicable means to create and maintain conditions under which man and nature can exist in productive harmony. Section 102 in Title I of the Act requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach. Specifically, all federal agencies are to prepare detailed statements assessing the environmental impact of and alternatives to major federal actions significantly affecting the environment. These statements are commonly referred to as Environmental Impact Statements and Environmental Assessments.

State

California Endangered Species Act

Western Joshua tree was designated a candidate species under CESA on October 9, 2020. During candidacy, CESA prohibits the import, export, take, possession, purchase, or sale of western Joshua tree, or any part or product of western Joshua tree, except as otherwise provided by the Native Plant Protection Act (NPPA), the DNPA, or Fish and Game Code, such as through a permit or agreement issued by the Department under the authority of the Fish and Game Code (Fish & G. Code, § 2080 et seq.). For example, the Department may issue permits that allow the incidental take of listed and candidate species if the take is minimized and fully mitigated, the activity will not jeopardize the continued existence of the species, and other conditions are met (*Id*. at § 2081, subd. (b)). The Department may also authorize the take and possession of listed and candidate species for scientific, educational, or management purposes (*Id*. at § 2081, subd. (a)). Furthermore, the Department may issue a Safe Harbor Agreement to authorize incidental take of listed or candidate species if a landowner provides a net conservation benefit to the species, implements practices to avoid or minimize incidental take, establishes a monitoring program, and meets other program conditions (*Id*. at § 2089.2 et seq.). Finally, the Department may authorize take associated with routine and ongoing agricultural activities through Voluntary Local Programs if management practices avoid and minimize take to the maximum extent practicable, as supported by the best scientific information for both agricultural and conservation practices, among other conditions (*Id*. at § 2086).

Native Plant Protection Act

The NPPA (Fish and G. Code, §§ 1900-1913) was enacted to preserve, protect, and enhance endangered or rare native plants in the state. (*Id*. at § 1900). The NPPA allows the Fish and Game Commission (Commission) to designate plants as rare or endangered. (*Id*. at § 1904). Section 1908 of the NPPA prohibits the take, possession, or sale of any endangered or rare native plant or part or product thereof except as otherwise provided by the NPPA. Provisions in the NPPA allow for the take of rare and endangered plants under limited circumstances, including clearing of land for agricultural practices or fire control measures as authorized by a public agency; timber operations conducted in accordance with a timber harvesting plan submitted pursuant to the Z’berg-Nejedly Forest Practice Act of 1973; required mining assessment work pursuant to federal or state mining laws; removal of endangered or rare native plants from a canal, lateral ditch, building site, or road, or other right-of-way by the landowner or his agent; or performance by a public agency or public utility of its obligation to provide service to the public (*Id*. at § 1913, subd. (a) and (b)). A landowner who has been notified by the Department pursuant to NPPA section 1903.5 that a rare or endangered native plant is growing on their land must notify the Department at least 10 days before changing the land use to allow for salvage of such plants (*Id*. at § 1913, subd. (c)). If the Department fails to salvage plants within 10 days of notification, the landowner shall be entitled to proceed without regard to the NPAA. (*Id*.) The NPPA does not apply to western Joshua tree because it is a candidate for listing as a threatened species, and the NPPA only applies to endangered and rare species.

California Desert Native Plants Act

The DNPA (Food and Ag. Code, § 80001 et seq.) generally allows for take of specified desert native plants (including yuccas, such as western Joshua tree) upon issuance of a permit from the county commissioner or sheriff. The DNPA allows for harvest or possession of five or fewer plants without a permit (*Id.* at § 80118). The DNPA also provides exemptions from permitting for a variety of activities, including land clearing for agricultural purposes, fire control, and required mining assessment work pursuant to federal or state mining laws; recreational events sanctioned by BLM; clearing or removal of native plants from a canal, lateral ditch, survey line, building site, or road, or other right-of-way by a landowner or his agent; and actions taken by a public agency or public utility in the performance of its obligation to provide service to the public (*Id*. at § 80117). The DNPA states that rare, endangered, and threatened native plants are exempt from its requirements (*Id*. at § 80075). Pursuant to this provision, the DNPA does not apply to western Joshua tree because it is a candidate for listing as a threatened species.

California Environmental Quality Act

State and local agencies must conduct environmental review under the California Environmental Quality Act (CEQA) for discretionary projects proposed to be carried out or approved by the public agency unless the agency properly determines the project is exempt from CEQA (Pub. Resources Code, § 21080). If a project has the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species, the lead agency must make a finding that the project will have a significant effect on the environment and prepare an environmental impact report (EIR) or mitigated negative declaration as appropriate before proceeding with or approving the project (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15070, and 15380). An agency cannot approve or carry out any project for which the EIR identifies one or more significant effects on the environment unless it makes one or more of the following findings: (1) changes have been required in or incorporated into the project that avoid the significant environmental effects or mitigate them to a less than significant level; (2) those changes are in the responsibility and jurisdiction of another agency and have been, or can and should be, adopted by that other agency; or (3) specific economic, legal, social, technological, or other considerations make infeasible the mitigation measures or alternatives identified in the environmental impact report (Pub. Resources Code, § 21081; Cal. Code Regs., tit. 14, §§ 15091 and 15093). For (3), the agency must make a statement of overriding considerations finding that the overriding benefits of the project outweigh the significant effects on the environment. CEQA establishes a duty for public agencies to avoid or minimize such significant negative effects where feasible (Cal. Code regs., tit. 14, § 15021). Impacts to western Joshua tree, as a CESA-candidate species, should be identified, evaluated, disclosed, and mitigated or justified under the Biological Resources section of an environmental document prepared pursuant to CEQA.

Local

Many local city and county ordinances regulate tree removal, some with specific regulations potentially applicable to western Joshua trees. As applied to western Joshua tree, most of these local ordinances are currently preempted by CESA given the species' candidacy status and will continue to be preempted if the species is listed. The only two exceptions are the newer ordinances adopted by the City of Palmdale and Town of Yucca Valley to implement the Fish and Game Code section 2084 regulation adopted by the Commission. However, the City of Palmdale and Town of Yucca Valley ordinances will only be valid during western Joshua tree's candidacy since section 2084 regulations cannot apply to western Joshua tree after candidacy. If western Joshua tree is not listed as a threatened or endangered species under CESA or the federal ESA after candidacy, certain local ordinances would allow for removal of western Joshua tree without required mitigation under specified circumstances. Therefore, these local regulations may not adequately protect western Joshua trees from direct removal or loss of habitat, and the species may remain threatened by human development absent protections under CESA.

Inyo County

Property owners are responsible for maintenance of trees on private property and no permit is required for private property owners to trim or remove trees in the streetside apron or on private property (Inyo County Code, tit. 12, §§ 12.20.030, 12.20.040). In districts zoned for wireless communications or solar facilities, the planning commission may consider the nature, type, and extent of tree coverage when reviewing and issuing a conditional use permit (*Id*. at tit. 18, §§ 18.76.080, 18.79.080). Grading, filling, or stripping vegetation during subdivision development must be performed concurrently with the final map or parcel map improvement and required bonds, or must be authorized pursuant to a grading permit issued by the advisory agency with appropriate erosion control conditions to protect adjoining properties and the general welfare (*Id*. at tit. 16, § 16.040.030).

City of Bishop

The location and type of all trees greater than four inches in diameter must be shown on final maps and parcel maps, including parcels proposed for subdivision (City of Bishop Code, tit. 16, §§ 16.20.320, 16.16.100). The city may require removal of trees on right-of-way easements (*Id*. at § 16.28.170). Grading restrictions defer to the subdivision map or parcel map improvement and bonds requirements, or to authority given by the planning commission (*Id*. at § 16.28.170). Applications for conditional use permits for conversion of residential units to condominiums must include development plans specifying the location of and provisions for any unique natural and/or vegetative site features (*Id*. at tit. 17, § 17.84.030).

Kern County

The Kern County Code of Ordinances does not provide any protection for western Joshua trees. In general, tree removal is not prohibited. Development permits may require a landscaping plan or assessment of native vegetation to be removed but do not restrict removal nor encourage retention.

California City

The California City code of ordinances provides regulations for maintenance and removal of trees in public places and prohibits persons operating off-road vehicles from malicious or unnecessary damage to vegetative resources (California City Code, tit. 4, § 4-2.606 and tit. 7, § 7-8.104). No regulations for trees on private property are included in this code of ordinances.

Ridgecrest

The Ridgecrest City Planning Commission may require development plan standards related to planting and maintenance of trees (City of Ridgecrest Code, § 106-347). Development projects and rezoning proposals must undergo site review; applications must describe the location of existing and proposed trees (*Id*. at § 106-172). Grading permits are reviewed by the city engineer and applicants must present detailed written plans for the site (*Id*. at § 104-4).

Tehachapi

In public spaces in Tehachapi, the removal, maintenance, and replacement of trees is overseen by the street superintendent (Tehachapi Code, tit. 12, § 12.08.080). In the area zoned for the airport, regulations limit tree height and provide for removal of nonconforming or deteriorated/decaying trees (*Id*. at tit. 11, § 11.12.150). Removal of trees on utility easements may be required by the city (*Id*. at tit. 17, § 17.28.140).

Los Angeles County

Within Significant Ecological Areas designated in the Los Angeles General Plan, protections for western Joshua tree are thorough and detailed (Los Angeles County Code of Ordinances, tit.22, § 22.102). In these areas, Los Angeles County issues Protected Tree Permits and Conditional Use Permits requiring mitigation for removal of any single heritage tree, removal of two or more non-heritage trees, or encroachment into more than 10% of the buffer zone around any western Joshua tree. Exceptions include removal related to construction or improvement of single-family residences, accessory structures, and animal keeping facilities, fuel reduction around existing buildings (no buffer limit stated), and maintenance related to public utility lines.

City of Lancaster

The City of Lancaster incentivizes the retention of Joshua trees by allowing commercial and industrial zoning parcel adjustments by up to 10% if the changes will result in the retention or preservation of Joshua trees (City of Lancaster Code of Ordinances, tit. 17, §§ 17.12.100, 17.12.780, and 17.16.090).

City of Palmdale

Pursuant to the Special Order approved by the Commission on December 10, 2020, pursuant to Fish and Game Code section 2084, the City of Palmdale amended Chapter 14.04 of the Palmdale Municipal Code to authorize removal of western Joshua trees only as consistent and compliant with the Special Order. With limited exceptions, Chapter 14.04 generally prohibits the removal of western Joshua trees and other specified native desert vegetation without approval by permit from the City's Landscape Architect, or in lieu thereof, the Director of Public Works' designee (Palmdale Municipal Code, § 14.04.040). All development proposals for sites containing native desert vegetation must contain a written report and site plan with specified information on each western Joshua tree located on-site, a site landscaping plan, and a long-term maintenance program for any western Joshua trees preserved on-site (*Id*. at § 14.04.050). These development proposals must also meet minimum preservation criteria, including preservation of at least two western Joshua trees per gross ac on average unless specified conditions are met that allow for use of a different standard determined by a desert native plant specialist (*Id*. at § 14.04.060). In specified circumstances, western Joshua trees may be transplanted (*Id*.). If western Joshua trees will be removed and not replanted on-site, they can be made available to the City of Palmdale or the public to plant elsewhere (*Id*.) If none of those options are feasible, the proponent may pay an in-lieu fee to the City of Palmdale (*Id*.). After construction of the development proposal and final inspection, project proponents must meet ongoing maintenance requirements, including maintaining western Joshua trees and other native desert vegetation in healthy condition for at least two growing seasons (*Id*. at § 14.04.070). Except in limited circumstances, a violation of Chapter 14.04 is a misdemeanor punishable by a fine of up to $1,000, imprisonment for up to six months, or both such fine and imprisonment (*Id*. at §§ 14.04.110, 1.12.010, and 1.12.020). In addition to these penalties, Chapter 14.04 requires the responsible party to replace any damaged, illegally cut, destroyed, killed, removed, mutilated or harvested western Joshua trees pursuant to the recommendation of an authorized desert native plant specialist retained at the responsible party's expense (*Id*. at § 14.04.100).

<u>County of Riverside</u>

A permit is required for the removal of living native trees located above 5,000 ft in elevation in the unincorporated areas of the county, unless an exemption for timber operations, federal or state government actions, or public utility actions applies; unless the removal is authorized under an approved conditional use or public use permit; or unless the tree constitutes an immediate threat to public health, safety, or general welfare. Trees can also be removed if they are located within 20 ft of an existing permitted structure; the tree is diseased, dead, or dying and removal is recommended by the California Department of Forestry and Fire Protection to protect forest health; or the fire protection agency with jurisdiction requires removal pursuant to a fire hazard reduction program. (Riverside County Code of Ordinances, tit. 12, § 12.24). Trees located below 5,000 ft in elevation receive no protection. All known western Joshua trees within Riverside County that are above 5,000 ft are within JTNP.

<u>County of San Bernardino</u>

Preconstruction inspections shall be required before approval of development permits to determine the presence of regulated trees and plants (County of San Bernardino Code, tit. 8, § 83.10.050). All Joshua trees are designated as Regulated Desert Native Plants; thus, a Tree or Plant Removal Permit is required for removal of any western Joshua tree or any part thereof (*Id*. at tit. 8, § 83.10.060). These permits may be issued by the County Director of Land Use Services in conjunction with or not in conjunction with a land use application or development permit. The permit review authority may require certification from an appropriate arborist, registered professional forester, or desert native plant expert that the proposed removal activities are appropriate, supportive of a healthy environment, and in compliance with both the County of San Bernardino Municipal Code and the California Department of Fish and Wildlife’s procedures. The permit conditions of approval may specify criteria, methods, and persons authorized to conduct the tree removal and may require the trees to be transplanted and/or stockpiled for future transplanting.

In order to authorize the removal of a western Joshua tree, the applicable review authority must find that removal is justified for one of the following reasons: the location of the tree or its dripline interferes with an allowed structure, street, or other planned improvement and there is no other feasible location for the improvement; the tree is hazardous to pedestrian or vehicular travel or safety, or is causing extensive damage to public structures, or the tree is in such close proximity to an existing or proposed structure that the tree will sustain significant damage. If the tree is located in the desert region of San Bernardino County, additional findings must be made including that western Joshua trees will be transplanted or stockpiled for future transplanting wherever possible and that for removal of specimen-sized western Joshua trees (circumference equal to or greater than 50 in, total height of 15 ft or greater, possessing a bark-like trunk, or in a cluster of ten or more individual tress of any size), no other reasonable alternative exists for the development of the land.

For each removal of a separate tree, penalties for illegal removal can include misdemeanor charges, fines of $500-$1000 and/or six months in jail, and other requirements to correct the conditions resulting from the violation.

The 2020 San Bernardino Countywide Plan includes the County Policy Plan, which encourages retention of western Joshua trees but does not provide regulations nor clarify a permit review process. Community plans nested within this plan describe values and characteristics of planned communities but do not regulate removal or retention of western Joshua trees. While much of San Bernardino County is federal property, these community plans cover most of the remaining private land within county boundaries.

<u>City of Adelanto</u>

Any application for a new development or for proposal to increase existing land use or outdoor recreational or other use by 25% must provide a biological resources report including mitigating measures to reduce or eliminate impacts to biological resources (City of Adelanto Code, tit. 17, § 17.57.030). Development projects must abide by County of San Bernardino requirements for relocation of Joshua trees (*Id*. at tit. 17, §

17.57.040). Only the City Engineer may be authorized to trim, prune, cut, or deface trees on City property, roads, or streets (*Id*. at tit. 13, § 13.50.050).

Town of Apple Valley

Town of Apple Valley must review and approve any removal of a Joshua tree on any property within any zoning district (Apple Valley Code of Ordinances, tit. 9, § 9.76.040). The code includes detailed requirements for documented removal justification, provides guidance for relocation/transplanting, and establishes a Joshua Tree Preservation and Adoption program. Development permits must find that all Joshua trees are adequately protected and preserved where feasible (*Id*. at tit. 9, § 9.17.080).

City of Barstow

City of Barstow Code of Ordinances suggests retention of native vegetation where possible but does not prohibit removal or require a survey or review process (Barstow Code of Ordinances, tit. 19, § 19.08.050). The code does not specifically reference western Joshua trees.

Hesperia

Removal of any western Joshua tree requires a permit issued by the agricultural commissioner or other applicable review authority (Hesperia Code of Ordinances, tit. 16, §16.24.150). However, the Hesperia Code does not provide specific information about the review process. Penalties for violation of the code include revocation of the permit, prohibition on issuance of new permits for one year (first offence) or life (second offense), and requirements to turn over any unused tags and seals or wood receipts (*Id*. at tit. 16, § 16.24.170). Lot design standards encourage retention of dense stands of Joshua trees to the maximum extent possible (*Id*. at tit. 17, § 17.48.070).

City of San Bernardino

There is a small population of western Joshua trees in Cajon Wash in the City of San Bernardino. A permit is required for removal of more than five trees within any 36-month period from a development site or parcel of property (City of San Bernardino Code of Ordinances, tit. 15, § 15.34.020). Permits are issued by the Development Services Department of the City of San Bernardino, wherein the Planning Official determines whether the trees can be removed without detriment to the environment and welfare of the community and thereby issues or denies the permit (*Id*. at tit. 15, § 15.34.040). Penalties for noncompliance include infraction or misdemeanor, fine, and restitution to the City of San Bernardino for the amount not to exceed the replacement value (*Id*. at tit. 15, § 15.34.060). Development standards encourage retention of natural vegetation where possible and Conditional Use Permits require a landscaping plan showing disposition of existing trees (*Id*. at tit. 19, §§ 19.17.070, 19.17.080).

Twentynine Palms

To reduce disturbances to fragile desert soils and reduce the amount of fugitive dust, removal of natural vegetation on parcels one ac or greater in size for construction of building pads, driveways, landscaping, agriculture, or other allowed uses in the underlying zone requires a Building Permit or Grading Permit issued by the City's Building Official (Twentynine Palms Code of Ordinances, tit. 19, § 19.64.030). In areas zoned for scenic vistas or scenic highways and geologic hazards, retention of native vegetation is encouraged but not required (*Id*. at tit. 19, §§ 19.26.030, 19.26.040). The code does not specifically reference western Joshua trees.

Victorville

Written approval from the director of parks and recreation or his designee is required to cut, damage, destroy, dig up, or harvest a western Joshua tree (Victorville Code of Ordinances, tit. 13, §13.33.040). The code does not include details about the approval process. Penalties include misdemeanor charge and up to six months in jail and/or $500 fine (*Id*. at tit. 13, §13.33.040).

Town of Yucca Valley

Pursuant to the Special Order approved by the Commission on December 10, 2020, pursuant to Fish and Game Code section 2084, the Town of Yucca Valley adopted Chapter 9.56 of its Code of Ordinances authorizing removal of western Joshua trees only as consistent and compliant with the Special Order. The Town of Yucca Valley Planning Commission may authorize the take of western Joshua tree associated with developing single-family residences, accessory structures, and public works projects concurrent with its approval of the project subject to specified census, application, and submittal conditions (Yucca Valley Code of Ordinances, § 9.56.060). No project will be eligible to receive take authorization pursuant to Chapter 9.56 if it will result in the take of more than 10 western Joshua trees from the project site (*Id*. at § 9.56.060(A)(1)). Projects authorized under Chapter 9.56 must avoid take of western Joshua trees to the extent practicable and avoid ground-disturbing activities within 10 ft of any western Joshua tree except under limited specified circumstances (*Id*. at §§ 9.56.070 and 9.56.080). To the maximum extent feasible, the project proponent must relocate all western Joshua trees that cannot be avoided to another location to the project site in accordance with specified conditions (*Id*. at § 9.56.090). Western Joshua trees may only be removed subject to Chapter 9.56 requirements if they cannot feasibly be avoided or relocated pursuant to Chapter 9.56 (*Id*. at § 9.56.100). Before presenting an application to the Planning Commission, project proponents must pay specified mitigation fees to the Town of Yucca Valley's Western Joshua Tree Mitigation fund (*Id*. at § 9.56.110). The Planning Commission may issue permits to authorize the removal of a dead western Joshua tree or the trimming of a western Joshua tree (*Id*. at § 9.56.120). Permits for removal of a dead western Joshua tree or the trimming of a western Joshua tree may be issued without payment of mitigation fees if the tree or limb has fallen over and is within 30 ft of a structure, is leaning against an existing structure, or creates an imminent threat to health or safety (*Id*. at § 9.56.120). Any violation of Chapter 9.56 shall constitute a misdemeanor and may be punishable by an administrative citation of $1,000 per western Joshua tree taken or trimmed without a permit (*Id*. at § 9.56.130). In addition, any person or entity that takes or trims a western Joshua tree without a permit required under Chapter 9.56 must subsequently obtain a permit under this Chapter (*Id*. at § 9.56.130). Failure to submit a permit application within 30 days of service of a notice of violation of Chapter 9.56 shall constitute a separate violation of Chapter 9.56 for which a separate administrative citation, fine, or other penalty may be imposed (*Id*. at § 9.56.130).

Nonregulatory Status

Natural Heritage Program Ranking and IUCN Red List

All natural heritage programs, such as the CNDDB, use the same ranking methodology originally developed by The Nature Conservancy and now maintained by NatureServe. This ranking methodology consists of a global rank describing the rank for a given taxon over its entire distribution, and a state rank describing the rank for the taxon over its state distribution. Both global and state ranks reflect a combination of rarity, threat, and trend factors. The ranking methodology uses a standardized calculator that uses available information to assign a numeric score or range of scores to the taxon, with lower scores indicating that a taxon is more vulnerable to extinction, and higher scores indicating that a taxon is more stable (Faber-Langendoen et al. 2012). The rank calculation process begins with an initial rank score based on rarity and threats, with rarity (multiplied by 0.7) factored more heavily into the calculator than threats (multiplied by 0.3). The combined rarity and threat rank is then either raised or lowered based on trends. When there is a negative trend, the rank score is lowered, and when there is a positive trend the rank score is raised. Short-term trends are factored more heavily into the calculator than long-term trends.

Western Joshua tree has been assigned a global rank of G3G4 indicating that there is uncertainty regarding the rank of the species, and it is either "G3 vulnerable and at moderate risk of extinction or collapse due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors" or "G4 apparently secure and at fairly low risk of extinction or collapse due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors." The factors cited for this rank include fire, drought, climate change, and numerous threats related to habitat loss including off road vehicle use (Master et al. 2012, NatureServe 2021). Western Joshua tree's conservation status in California under this ranking system has not yet been assessed. Natural heritage ranking does not provide any regulatory protections but is often considered during the CEQA process (Hammerson et al. 2008).

The International Union for Conservation of Nature (IUCN) Red List provided a global scope assessment of western Joshua tree in October 2020 (Esque et al. 2020b) resulting in a designation of Least Concern, which is the Red List category representing the lowest risk of extinction, and is assigned when a taxon has been evaluated against the ranking criteria and does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened (IUCN 2012). In the IUCN assessment of western Joshua tree, the reviewers noted a decreasing population trend due to the severely fragmented population as well as the reduced number of and continuing decline of mature individuals (Esque et al. 2020b). Noted threats include renewable energy development, gathering terrestrial plants, fire and fire suppression, invasive non-native species and diseases, and drought. IUCN's assessment also states that no international legislation, management, or trade controls exist for western Joshua tree.

IUCN and NatureServe assess extinction risk for species using a time period of 10 years or 3 generations, whichever is longer, up to a maximum of 100 years (Faber-Langendoen et al. 2012, IUCN 2012).

<u>California Rare Plant Rank</u>

The Department works in collaboration with the California Native Plant Society and botanical experts throughout the state to assign rare and endangered plants a California Rare Plant Rank reflective of their status. Joshua tree was considered for a California Rare Plant Rank in 2011 but a rank was not assigned due to the species being too common (CNPS 2021b).

Management Efforts

There are currently no federal or state range-wide management efforts or recovery plans for western Joshua tree; however, because western Joshua tree is found extensively on land that is under federal jurisdiction, the species receives some special protection and management by federal agencies. Natural resources within designated wilderness areas receive a very high level of protection from human impacts. There are also various ongoing efforts to study Joshua tree biology, ecology, threats, conservation, genetics, and other topics related to the species.

National Park Service

Lands administered by the National Park Service within California that have western Joshua tree include Death Valley National Park, JTNP, and Manzanar National Historic Site (horticultural plantings). Natural resources on lands managed by the National Park Service generally receive a high level of protection, including some active management for the benefit of natural resources, although they may also be subject to impacts from recreational use and development and maintenance of related infrastructure.

Western Joshua tree does not occur in the Mojave National Preserve, but the preserve does support a large population of eastern Joshua tree. Mojave National Preserve is currently undergoing a large restoration effort in response to the 2020 Dome Fire with a primary focus on returning Joshua trees to an area that was predicted to be a climate refugia for the species (Kaiser 2021).

Joshua Tree National Park

The Joshua Tree Wilderness was designated in 1976 and includes 1,890 km^2 (730 mi^2) protected by The Wilderness Act (Public Law 94-567 [H.R. 13160]). The Superintendent's Compendium applies to all persons within the boundaries of federally owned or designated public use lands within JTNP and prohibits possessing, destroying, injuring, defacing, removing, digging, or disturbing Joshua trees, including climbing, sitting, or standing on live Joshua trees or using them as anchors for hammocks or slacklines (36 CFR § 2.1 (a)(1)(ii)).

JTNP established a Foundation Statement which states that adult populations of Joshua trees are stable, but knowledge of community structure and distribution is incomplete, and trends are unknown (Rogers pers. comm. 2021). It further designates Joshua trees as a fundamental resource and value, warranting primary consideration during park planning and management activities. In addition, JTNP is actively engaged in conservation efforts to protect areas identified as potential climate change refugia for Joshua trees. This includes fuel breaks, defensible space, removing nonnative grasses around mature reproductive trees (Frakes 2017b), and extensive long term demographic monitoring across the population. In the early 2000's, JTNP shifted fire management philosophies from considering the use of fire on the landscape (controlled burns and allowing fires to burn) to full suppression, acknowledging the unacceptable risks to Joshua tree woodlands, and JTNP continues to manage fires aggressively to protect native vegetation (Frakes 2017a).

JTNP has also implemented restoration activities involving western Joshua trees and other native plants within JTNP, typically for revegetation purposes associated with road realignment projects, social trails restoration, and burned area rehabilitation (Frakes 2017a). Joshua trees have also been salvaged and subsequently transplanted by JTNP following planned disturbances such as road realignments. These activities are labor intensive and expensive, and generally require prolonged follow-up care in the form of protective caging and two years of bi-weekly irrigation. (Frakes 2017a)

A number of monitoring efforts by JTNP are underway (Frakes pers. comm. 2021). JTNP established three 500 x 500 m (1,640 x 1,640 ft) “range edge plots” in 2016 and 2017 at lower elevation areas of JTNP that support western Joshua trees. In-depth tree-by-tree demographic data were collected within these plots, and these plots will likely be very important in the future for direct observations of possible western Joshua tree range reductions. JTNP also established 100 50 x 50 m (164 x 164 ft) plots that were randomly placed within vegetation communities in JTNP where western Joshua tree is currently relatively abundant to monitor changes that take place in these areas. JTNP staff also revisited and collected data from 55 western Joshua tree monitoring plots in 2021 that were established by Todd Esque in 2008.

Death Valley National Park

The Death Valley Wilderness was designated in 1994 and includes 12,911 km^2 (4,985 mi^2) protected by The Wilderness Act (Public Law 94-567 [H.R. 13160]), making it the largest wilderness in the U.S. The Superintendent’s Compendium applies to all persons within the boundaries of federally owned or designated public use lands within Death Valley National Park and prohibits taking biological specimens (plants, fish, and wildlife) rocks or minerals except in accordance with other regulations or pursuant to the terms and conditions of a specimen collection permit (36 CFR § 2.5 (a)). Death Valley National Park contains roughly 209 km^2 (81 mi^2) of western Joshua tree habitat and supports scientific research through a permitting system (Reynolds pers. comm. 2021).

United States Department of Defense

The Department of Defense manages natural resources on military lands via development and implementation of integrated natural resources management plans (INRMPs). INRMPs use an ecosystem based approach, and balance conservation and mission activities to provide “no net loss” to testing, training, and operational activities (Department of Defense 2021). Military installations coordinate their INRMPs with the USFWS and the appropriate state fish and wildlife agency pursuant to the Sikes Act.

The INRMP for Edwards Air Force Base incorporates avoidance and minimization measures that could reduce individual fatalities of western Joshua tree and disturbance of its habitat. (U.S. Air Force 2020). The INRMP for National Training Center and Fort Irwin requires that if removal is necessary, trees must be re-located to sites with the same orientation and similar characteristics as their original sites to reduce the risk of tree mortality (U.S. Army 2006). The INRMP for Naval Air Weapons Station China Lake does not list western Joshua tree as a sensitive species, but discusses the sensitivity of the species to fire, and mentions transplantation of western Joshua tree as a component of revegetation or landscaping (U.S. Navy n.d.).

Bureau of Land Management

Several wilderness areas managed by the BLM in California support populations of western Joshua tree. Wilderness areas managed by the BLM in California that may support populations of western Joshua tree and provide them with a high level of protection from human impacts include Black Mountain Wilderness, Bright Star Wilderness, Chimney Peak Wilderness, Coso Range Wilderness, Darwin Falls Wilderness, Domeland Wilderness, El Paso Mountains Wilderness, Grass Valley Wilderness, Inyo Mountains Wilderness, Kiavah Wilderness, Owens Peak Wilderness, Piper Mountain Wilderness, Rodman Mountains Wilderness, Sacatar Trail Wilderness, Surprise Canyon Wilderness, and White Mountains Wilderness.

Outside of wilderness areas, populations of western Joshua tree on BLM lands may receive various levels of protection from human impacts, but lands supporting western Joshua tree may also be utilized for destructive non-conservation purposes. A number of plans have been adopted regarding management of BLM lands within the range of western Joshua tree including the California Desert Conservation Area Plan, Desert Renewable Energy Conservation Plan, West Mojave Plan, and West Mojave Route Network Project Land Use Plan Amendment (BLM 1980, 2005, 2016, 2019). The Desert Renewable Energy Conservation Plan identified large areas of western Joshua tree habitat for conservation.

United States Forest Service

There are several wilderness areas managed by the United States Forest Service in California that may support populations of western Joshua tree and provide them with a high level of protection from human impacts, including Bighorn Mountain Wilderness, Golden Trout Wilderness, Kiavah Wilderness, Pleasant View Ridge Wilderness, and Sheep Mountain Wilderness. Western Joshua tree may occur to some extent within Angeles National Forest, Inyo National Forest, San Bernardino National Forest, and Sequoia National Forest. Forest Service lands are generally at a low risk of habitat destruction due to forest management policies, but habitat modification from land use may still occur.

State of California

Some areas of western Joshua tree habitat occur on lands managed by the California Department of Parks and Recreation. Natural resources on lands managed by the California Department of Parks and Recreation generally receive a high level of protection, including some active management for the benefit of natural resources, although they may also be subject to impacts from recreational use and development and maintenance of related infrastructure. Natural resources on vehicular recreation areas are subject to many impacts from off highway vehicle use. The following lands managed by the California Department of Parks and Recreation may support western Joshua tree: Antelope Valley California Poppy Preserve State Natural Reserve, Antelope Valley Indian Museum State Historic Park, Arthur B. Ripley Desert Woodland State Park, Eastern Kern County Onyx Ranch State Vehicular Recreation Area, Hungry Valley State Vehicular Recreation Area, Red Rock Canyon State Park, and Saddleback Butte State Park. California Department of Parks and Recreation is planning to gather baseline information on western Joshua trees within the Great Basin District (Tejada pers. comm. 2020).

Some areas of western Joshua tree habitat are within lands managed by the Department. Natural resources on lands managed by the Department generally receive a high level of protection, including some active management for the benefit of natural resources, although they may also be subject to impacts from recreational use and development and maintenance of related infrastructure. The following lands managed by the Department may support western Joshua tree: Canebrake Ecological Reserve, Fremont Valley Ecological Reserve, King Clone Ecological Reserve, Mojave River Public Access, West Mojave Desert Ecological Reserve, and several undesignated lands.

The California Desert Conservation Act (Fish & G. Code, § 1450 et seq.) became effective on January 1, 2022, and establishes a California Desert Conservation Program within the Wildlife Conservation Board with the goals of protecting habitat in California's Mojave and Colorado deserts by planning and implementing land acquisition and restoration projects. The California Desert Conservation Program could result in conservation or restoration of western Joshua tree habitat in California.

Some habitats with western Joshua tree may benefit from land use planning and conservation planning efforts in the Mojave Desert. The Natural Community Conservation Planning Program is a program by the State of California to promote collaborative planning efforts designed to provide for region-wide conservation of plants, animals, and their habitats, while allowing for compatible and appropriate economic activity. There is currently a Natural Community Conservation Plan in development for the Town of Apple Valley that intends to include Joshua tree as a covered species. However, it is not yet known when this plan will be finalized, or the extent to which this plan may help conserve western Joshua tree habitat. Regional Conservation Investment Strategies is a program by the State of California to encourage voluntary, non-regulatory regional planning intended to result in high-quality conservation outcomes. There is currently one Regional Conservation Investment Strategy in development for the Antelope Valley area that is near completion, and another for western San Bernardino County that is still in development. Both Regional Conservation Investment Strategies include Joshua tree as a focal species, but it is not yet known the extent to which these strategies will help conserve western Joshua tree habitat.

<u>Other</u>

Some nonprofit organizations work to acquire, restore, and protect areas supporting western Joshua tree within the Mojave Desert for conservation and preservation purposes (MDLT 2021).

Desert revegetation may be an important component of western Joshua tree management in the future and there have been some scientific investigations into the effectiveness of desert revegetation activities. Abella and Newton (2009) reviewed 15 planting and 8 seeding studies conducted in the Mojave Desert and found that treatments of irrigation (3 studies), caging (3 studies), and shelter (2 studies) generally resulted in increases in plant survival. Only two of the studies reviewed by Abella and Newton (2009) included Joshua tree. Hunter et al. (1980) examined how fencing affected survival of 14 species of desert plants in Nevada and found that wire fencing generally marginally improved survival of plants, including western Joshua tree and *Yucca schidigera*, but only six western Joshua trees were used in the study. Wallace et al. (1980) reported the results of a similar study in Nevada where 16 western Joshua trees were transplanted in 1971 and watered as needed for the first six months, with seven of them surrounded by wire cages and nine of them left uncaged. Five years later in 1976, two of the seven caged western Joshua trees had survived (28%) and four of the nine uncaged western Joshua trees had survived (44%). Franson (1995) reported the health and survival of 1,447 eastern Joshua trees that were salvaged and transplanted in rows to two different nurseries. Two years after transplanting 36% of the eastern Joshua trees were rated as being in excellent health, 56% of the trees were rated as being in poor health, and 8% of the trees had died.

The Joshua Tree Genome Project (2020) is an ongoing effort to assemble a Joshua tree reference genome and conduct other investigations such as a large common garden experiment. The Department is also aware of various ongoing western Joshua tree research and monitoring efforts that will continue to improve the scientific understanding of the status of western Joshua tree in California.

SUMMARY OF LISTING FACTORS

CESA directs the Department to prepare this report regarding the status of western Joshua tree based upon the best scientific information available to the Department (Fish & G. Code, § 2074.6). CESA's implementing regulations identify key factors that are relevant to the Department's analyses. Specifically, a "species shall be listed as endangered or threatened ... if the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination of the following factors: 1. Present or threatened modification or destruction of its habitat; 2. Overexploitation; 3. Predation; 4. Competition; 5. Disease; or 6. Other natural occurrences or human-related activities" (Cal. Code Regs., tit. 14, § 670.1, subd. (i)(1)(A)).

The definitions of endangered and threatened species in the Fish and Game Code provide key guidance to the Department's scientific analyses. An endangered species under CESA is one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species under CESA is one "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]" (*Id.*, § 2067). A species' range for CESA purposes is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com*. (2007) 156 Cal.App.4th 1535, 1551).

The preceding sections of this Status Review describe the best scientific information available to the Department, with respect to the key factors identified in the regulations. The section below considers the significance of any threat to the continued existence of western Joshua tree for each or a combination of the factors. The best available science focuses on projecting conditions near the end of the 21st century. There is much uncertainty in predicting future outcomes in complicated systems, and there is an even greater uncertainty in projecting outcomes further into the future. Therefore, the Department's determinations for this Status Review focus only on end of the 21st century conditions.

The physical and biological systems and relationships that affect the future of western Joshua tree are complicated, and despite the body of scientific information that is currently available, uncertainty remains. Additionally, the future of western Joshua tree not only depends on predictions that are based on the physical and biological sciences, but factors related to national and international laws, politics, and economics; the value that humanity places on conserving biodiversity; and the global human responses to climate change.

Present or Threatened Modification or Destruction of Habitat

Western Joshua tree habitat could be modified in a negative way or destroyed by several factors discussed under the Factors Affecting the Ability to Survive and Reproduce section of this Status Review. These factors include the direct and indirect effects of climate change; the direct and indirect effects of development and other human activities; and the direct and indirect effects of wildfire. Some of these factors are interconnected and cumulative.

Based on the best available science, available information suggests that the direct and indirect effects of climate change will cause a reduction in the areas with 20th century suitable climate conditions for western Joshua tree by the end of the 21st century (2100), especially in the southern and lower elevation portions of its range. Areas with 20th century suitable climate conditions for the species will also expand to the north and into higher elevation areas, though the species is unlikely to naturally colonize these areas in the foreseeable future. While 20th century suitable climate conditions for the species are predicted to expand into areas of eastern California, it will primarily expand in Nevada where it cannot be considered under CESA. Studies assessed by the Department suggest that at the end of the 21st century, some areas of climate refugia for western Joshua tree will remain at the southern and lower elevation portions of its range.

While the available evidence suggests that areas with 20th century suitable climate conditions for western Joshua tree within California will decline substantially through the end of the 21st century (2100) due to climate change, the Department does not have any data on the extent to which these climate changes will likely affect the demographics of the species (such as recruitment and mortality) in the foreseeable future. Based on fossil records following climate changes approximately 11,700 years ago, the Department expects that any changes in the range of western Joshua tree that are ultimately caused by climate change will likely occur very slowly, perhaps over thousands of years. Because adult western Joshua trees are relatively resilient to harsh climate conditions, the Department expects that the effects of the reduction of areas with 20th century suitable climate conditions within the species' range in the foreseeable future will likely have a greater negative effect on seedling recruitment than on adult tree mortality, although both may occur. Additionally, because western Joshua tree is currently abundant and widespread, it likely has a high capacity to withstand or recover from stochastic (random) disturbance events. Therefore, it may already have capacity to withstand changing conditions, and the species may be able to withstand changes to

20th century suitable climate conditions in the foreseeable future without becoming in serious danger of extinction throughout all or a significant portion of its range within California.

Due to western Joshua tree's ability to survive harsh conditions and reproduce asexually, there may be a long time delay between when an area becomes no longer suitable for sustaining western Joshua tree populations and when the species is no longer present in that area, and it may not be possible to easily recognize whether populations in an area are ultimately sustainable or not. Based on the current best available science, the Department expects that the effects of climate change will cause the abundance of western Joshua tree to decline in the southern part of its range by the end of the 21st century, but because the Department does not have demographic data showing that departures from 20th century suitable climate conditions will mean that the species will not be able to persist in significant portions of its range, the Department does not foresee that western Joshua tree is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range by the end of the 21st century (2100) due to climate change. The Department does not expect that the special protection and management efforts required by CESA would ameliorate the direct and indirect effects of climate change on western Joshua tree.

Based on the best available science, the Department expects that the direct and indirect effects of development and other human activities will cause negative modification and destruction of suitable habitat for western Joshua tree in some areas by the end of the 21st century, particularly in the southern part of the species' range. The Department expects that habitat modification and destruction will primarily be limited to private property, lands within the vicinity of roads and existing development, and lands chosen for renewable energy development. The magnitude of this habitat modification and destruction will likely be related to the economic values of development and other human activities in the Mojave Desert and surrounding areas, and the effectiveness of state and federal regulatory and legal protections that are enforced through the end of the 21st century.

The USFWS predicted that between 22% and 42% of the habitat within the southern part of western Joshua tree's range may be lost by the year 2095 due to urban growth and renewable energy development. The extent to which development and other human activities will cause suitable habitat for western Joshua tree to be negatively modified and destroyed by the end of the 21st century is uncertain. The Department does expect that habitat modification and destruction will continue on lands that remain unprotected from development, but that undeveloped, protected lands supporting western Joshua tree habitat will also remain throughout the range of the species, though they may be fragmented. Additionally, because western Joshua tree is currently abundant and widespread, scattered habitat loss is unlikely to result in a change in the overall range of the species, particularly when lost habitat continues to be surrounded by occupied habitat on protected lands and on occupied undeveloped lands that may be protected in the future. While habitat loss continues to be a substantial, ongoing threat, it does not necessarily mean that the species is likely to be at serious risk of extinction throughout all or a significant portion of its range. The Department does not foresee that western Joshua tree will be in serious danger of becoming extinct in a significant portion of its range by the end of the 21st century due to habitat modification and destruction caused by development and other human activities. The Department does expect that the special protection and management efforts required by CESA would ameliorate some of the direct and indirect effects of development and other human activities on western Joshua tree in the southern portion of its range, because a large proportion of western Joshua tree's habitat in this area occurs on private land that is vulnerable to continuing modification and destruction.

Based on the best available science, available information suggests that when a wildfire burns through an area, the immediate and delayed effects of wildfire may kill a majority (greater than 50%) of western Joshua trees in burned areas. Some western Joshua trees and their seeds are likely to survive burning, providing the opportunity for the species to repopulate burned areas, which may take one or more centuries. The direct and indirect effects of wildfire are also likely to temporarily modify western Joshua tree habitat by eliminating important nurse plants and by potentially increasing the suitability of burned areas for further invasion by invasive plant species. The average area burned by wildfire each decade since the early 1900s appears to have generally increased, and approximately 2.5% of western Joshua tree's range burned each decade from 2001–2010 and from 2011–2020, and some areas may have burned more than once. The wildfire activity in western Joshua tree habitat has likely increased in recent decades due to the effects of invasive species with nitrogen deposition contributing to invasive species abundance. Large fires can be triggered after one or more years of relatively high precipitation, favoring vegetation growth leading to higher fuel loads. Invasive plant species are expected to continue their spread across the Mojave Desert, and nitrogen deposition is not expected to cease in the near future. It is unknown if wildfire activity will continue to increase at the same rate observed in recent decades. Based on the current best available science, the Department expects that wildfire will continue to cause reductions in the population of western Joshua trees and will cause temporary modifications to habitat in burned areas that will reduce the ability of the species to successfully recruit new individuals. However, because western Joshua tree is currently abundant and widespread, it is inherently less vulnerable to extinction from the effects of stochastic and localized events such as wildfire. Furthermore, losses in abundance due to wildfire are not expected to change the species' range in the foreseeable future because some trees within burned areas survive, and occupied habitat remains outside of burned areas. The Department does not foresee that western Joshua tree is in serious danger of becoming extinct in a significant portion of its range by the end of the 21st century due to wildfire. The Department does not expect that the special protection and management efforts required by CESA would ameliorate the direct and indirect effects of wildfire on western Joshua tree.

Considered collectively, the direct and indirect effects of climate change, the direct and indirect effects of development and other human activities, and the direct and indirect effects of wildfire are interconnected and will affect different portions of western Joshua tree's range in different ways, sometimes cumulatively. Climate change is expected to reduce recruitment and abundance in southern and lower elevation portions of western Joshua tree's range, development and other human activities are expected to destroy and modify habitat on unprotected private property, and fire is expected to kill a proportion of trees in burned areas and temporarily reduce recruitment in those areas. The effects of climate change and wildfire will have interconnected and cumulative effects on western Joshua tree populations in some areas, and the effects of climate change and the direct and indirect effects of development and other human activities will also have interconnected and cumulative effects on western Joshua tree populations in some areas. Development and other human activities may also contribute to wildfire risk.

In summary, the Department expects that western Joshua tree will be subject to ongoing habit modification and destruction through the end of the 21st century due to substantial threats from climate change, wildfire, development and other human activities, and the interconnected cumulative effects of some of these threats, particularly in the southern portion of its range, but western Joshua tree is also currently abundant and widespread, which lessens the overall relative impact of these threats to the species.

Overexploitation

Based on the best available science, the Department does not believe that overexploitation is a threat to western Joshua tree, primarily because western Joshua tree is currently abundant and widespread, and the impacts to the species from overexploitation are relatively small.

Predation

Based on the best available science, the Department believes that predation and herbivory is a minor threat to western Joshua tree, and the threat should be considered in the context of the threats from climate change and wildfire. Impacts from small mammals are likely most severe in non-masting years, when they consume nearly all of the western Joshua tree seeds that are produced, and during periods of drought, when they can damage the bark of trees, potentially causing mortality in affected trees. Cattle may also consume quantities of flowers in grazed areas. Nevertheless, because western Joshua tree is currently abundant and widespread, the Department considers the threat to the species from herbivory and predation to be relatively small.

Competition

Based on the best available science, the Department believes that competition is a minor threat to western Joshua tree. Although invasive plant species are prevalent throughout the range of the species, the primary way in which invasive plant species currently affect western Joshua tree is indirectly by fueling wildfires. Invasive plant species may also directly compete with western Joshua tree seedlings for light, water, space, or nutrients, but the Department does not currently have enough information to consider this interaction a major threat to the species.

Disease

The Department does not have any information on diseases or parasites affecting western Joshua tree. The Department does not consider disease or parasites to be a significant threat to the continued existence of western Joshua tree.

Other Natural Occurrences or Human-related Activities

The primary threats to western Joshua tree are from climate change, wildfire, and development and other human activities, and are discussed in the Present or Threatened Modification or Destruction of Habitat section above. While these primary threats may most often manifest themselves in the form of habitat modification and destruction, they could result in direct mortality of western Joshua trees or have other direct or indirect effects to western Joshua trees that are not necessarily related to a modification or destruction of habitat. It could therefore be appropriate to also categorize them here under Other Natural Occurrences and Human-related Activities. The Department’s determinations under the Present or Threatened Modification or Destruction of Habitat section above take into account all of the effects of climate change, wildfire, and development and other human activities on western Joshua tree based on a broad interpretation of what constitutes habitat modification and destruction under the appropriate regulation (Cal. Code Regs., tit. 14, § 670.1, subd. (i)(1)(A)). Under this interpretation, there are no other natural occurrences or human-related activities that the Department considers to be significant threats to the continued existence of western Joshua tree.

Summary of Key Findings

Western Joshua tree is a widespread and abundant species that is found in a variety of desert habitats in the Mojave Desert and Great Basin. Climate in the desert regions where western Joshua tree occurs consists of long, hot summers, mild winters, and low overall precipitation. Precipitation across the Mojave Desert region is highly variable from year to year and oscillates between periods of wetter and drier conditions over multi-year and multi-decade timescales.

Joshua tree has received a large amount of attention from the scientific community, and its life history has been studied for over 150 years. Sexual reproduction requires the presence of western Joshua tree’s obligate pollinating moth *T. synthetica*. After a mast seeding event, seed dispersal is facilitated by the scatter hoarding behavior of rodents, which results in burial of some western Joshua tree seeds at a soil depth suitable for successful germination. Western Joshua tree seedlings most successfully establish after large mast seeding events, which perhaps only occur once or twice per decade. Seedlings that emerge from under nurse plants are more likely to survive. Several successive years of sufficiently wet and/or cool conditions are likely required to ensure that seeds germinate and that seedlings can reach a sufficiently large size before the arrival of a period of drier and/or hotter conditions. A western Joshua tree may require 30 to 50 or more years to reach reproductive maturity and begin producing seeds. Individual western Joshua trees can survive for very long periods of time, perhaps over 150 years, and the species is also capable of asexual growth which may allow individuals to survive indefinitely under appropriate conditions.

The population size and area occupied by western Joshua tree has declined since European settlement of the Mojave Desert due to habitat modification and destruction, a trend that has continued to the present. Despite the declines since European settlement, the range of the species has remained largely unchanged, with the species continuing to occupy the same general geographical area within California. The primary threats to the species are the direct and indirect effects of climate change, development and other human activities, and wildfire. Climate change represents the greatest threat to the species, with available species distribution models suggesting that areas with 20th century suitable climate conditions for western Joshua tree will be reduced substantially through the end of the 21st century (2100), especially in southern and lower elevation portions of its range. Areas with 20th century suitable climate conditions for western Joshua tree may also expand to the north and into higher elevation areas, though the species is unlikely to colonize these areas quickly, and climate refugia for western Joshua tree will likely remain at the southern and lower elevation portions of its range at the end of the 21st century.

Species distribution models of future conditions have substantial limitations, and there is much uncertainty of what the predicted effects of climate change will be on western Joshua tree individuals, populations, distribution, abundance, and ultimately range. The Department does not have scientific information on how changes from the 20th century suitable climate conditions within Joshua tree's range will affect the demographics of western Joshua tree populations in California, which limits the extent to which the effects of climate change on populations of western Joshua tree in the foreseeable future can be reasonably predicted. The future of the species will largely depend on its existing ability to withstand change and the magnitude of the global human response to climate change. The effects of development and other human activities will also cause suitable habitat for western Joshua tree to decline and become more fragmented by the end of the 21st century, particularly in the southern part of the species' range, however, western Joshua tree populations on protected and undeveloped lands are expected to remain, and therefore the continuing habitat loss will not necessarily result in an overall change in the range of the species. Western Joshua trees on private property, on lands within the vicinity of roads and existing development, and lands chosen for renewable energy development may be at the highest risk of being lost. Wildfire poses a substantial threat and may kill over half of western Joshua trees in burned areas. In each of the last two decades, approximately 2.5% of western Joshua tree's range burned. Additionally, western Joshua tree is susceptible to herbivory by large and small mammals, especially during periods of drought, although this is considered a minor threat to the species. Competition from invasive plant species is a minor threat to western Joshua tree, and some of the threats to western Joshua tree are interconnected and may affect the species cumulatively.

The combined threats to western Joshua tree are cause for substantial concern. Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species. The Department anticipates that the threats acting upon western Joshua tree will result in a reduction in the abundance of the species by the end of the 21st century, and that the abundance may continue to decline after that time. However, due to the high uncertainty in projecting the pace and magnitude of climate change and other threats into the 22nd century (after 2100), and the lack of scientific information in the Department's possession that contemplates such timeframes for the species, the Department does not yet consider the range of the species in the 22nd century to be foreseeable. The Department anticipates that the scientific information on the status of western Joshua tree will continue to improve in the coming years and decades, with demographic data and species distribution modeling eventually allowing for an analysis of the viability of western Joshua tree populations across their entire California range.

PROTECTION AFFORDED BY LISTING

It is the policy of the state to conserve, protect, restore and enhance any endangered or any threatened species and its habitat (Fish & G. Code, § 2052). If western Joshua tree is listed under CESA, unauthorized "take" of western Joshua tree would be prohibited, and the conservation, protection, and enhancement of the species and its habitat would be an issue of statewide concern. Under CESA, "take" is defined as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (*Id.*, § 86). Any person violating the take prohibition would be punishable under state law. The Fish and Game Code provides the Department with related authority to authorize "take" under certain circumstances (*Id.*, §§ 2081, 2081.1, 2086, 2087, 2089.6, 2089.10 and 2835). As authorized through an incidental take permit, however, impacts of the take of an endangered or threatened species caused by the activity must be minimized and fully mitigated according to state standards.

Protection of western Joshua tree could also occur with required public agency environmental review under CEQA, and its federal counterpart NEPA. CEQA and NEPA both require affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on endangered, threatened, and rare special status species. Under CEQA's "substantive mandate," for example, state and local agencies in California must avoid or substantially lessen significant environmental effects to the extent feasible. Impacts to species that are of conservation concern may be analyzed and mitigated under CEQA and NEPA even if the species are not listed; however, in common practice, potential impacts to listed species are examined more closely in CEQA and NEPA documents than potential impacts to unlisted species. State listing, in this respect, and required consultation with the Department during state and local agency environmental review under CEQA, may benefit western Joshua tree.

If western Joshua tree is listed under CESA, it may also increase the likelihood that state and federal land and resource management agencies will allocate funds towards protection and recovery actions.

RECOMMENDATION FOR PETITIONED ACTION

CESA directs the Department to prepare this report regarding the status of western Joshua tree in California based upon the best scientific information available to the Department (Fish & G. Code, § 2074.6). CESA also directs the Department to indicate in this Status Review whether the petitioned action is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). Based on the criteria described above, the best scientific information available to the Department at this time indicates that western Joshua tree is not in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease, and is not is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by CESA.

The Department recommends that the Commission find the petitioned action to list western Joshua tree as a threatened species to be not warranted.

MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES

CESA directs the Department to include in its Status Review recommended management activities and other recommendations for recovery of western Joshua tree (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)). Department staff generated the following list of recommended management actions and recovery measures based on considerations from federal agencies, researchers, non-profit organizations, and other interested parties. The following list is not a detailed conservation strategy for western Joshua tree; however, it outlines possible components of a preliminary strategy to conserve the species. Although the Department's recommendation in this Status Review is to find the petitioned action to be not warranted, the Department does recognize that the combined threats to western Joshua tree are a substantial cause for concern. Western Joshua tree faces serious challenges, and long-term conservation of the species is likely beyond the scope of any one government, agency, or organization, and could require legislation. The Department therefore recommends that the following actions be conducted in coordination with a broad group of stakeholders including private citizens, scientists, and other local, state, and federal governments and organizations, consistent with California's goals of conserving biodiversity and preventing the extinction of rare, threatened, and endangered species.

- Continue efforts to drastically reduce greenhouse gas emissions.
- Complete a western Joshua tree conservation plan in collaboration with partners and stakeholders.
- Preserve western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia.
- Minimize wildfire risk to western Joshua tree woodlands, particularly following one or more years of high precipitation, and particularly in areas with high recruitment and areas projected to be climate refugia.
- Manage fires aggressively to protect Joshua tree woodlands, particularly in areas with high recruitment and areas projected to be climate refugia.

- Implement ways to disincentivize destruction of western Joshua tree habitat, particularly in areas with high recruitment and areas projected to be climate refugia.
- Implement state and/or local laws and regulations that limit unmitigated impacts to high quality western Joshua tree habitat.
- Continue scientific investigations into the biology, ecology and genetics of western Joshua tree and the species and habitats upon which it depends:
    - Collect and analyze range-wide demographic information to detect baseline population trends and identify populations that do not appear to be recruiting new individuals at sustainable levels.
    - Implement long-term range-wide direct population monitoring and vegetation monitoring with emphasis on leading and trailing edges and highest and lowest elevations of the species' range.
    - Produce and improve upon range-wide species distribution models for western Joshua tree.
    - Produce range-wide species distribution models for western Joshua tree's obligate pollinating moth.
    - Investigate the significance of multi-year and multi-decade climate variability patterns for western Joshua tree recruitment.
    - Investigate ways to control the spread and abundance of invasive plant species to reduce wildfire risk.
    - Investigate the feasibility, practicality, and risks of implementing assisted migration and translocation.

PUBLIC RESPONSE

Comments on the petitioned action were invited via a general notification dated October 21, 2020, and a tribal notification dated November 12, 2020. These notifications were distributed to tribes; industry organizations; nonprofit organizations; media outlets; scientists familiar with western Joshua tree and related topics; universities; federal, state and local agencies; and other interested individuals and organizations. Responses to the notifications are included in Appendix A.

PEER REVIEW

Independent experts familiar with western Joshua tree and the subjects discussed in this Status Review were invited to review the Status Review report before submission to the Commission. All comments received are included in Appendix B. The Department's response to the independent peer review is included in Appendix B. Independent experts that reviewed the Status Review are listed in Table 2, below.

Table 2: Status Review Peer Reviewers

Name	Affiliation

ACKNOWLEDGEMENTS

Jeb McKay Bjerke in the Department’s Habitat Conservation Planning Branch, Native Plant Program prepared this Status Review. Dr. Christina Sloop in the Department’s Science Institute coordinated scientific peer review of this Status Review. Department staff Katrina Smith, Diane Mastalir, Dr. Melanie Gogol-Prokurat, Rachelle Boul, Rosie Yacoub, Kristi Lazar, and Ashley Kammet contributed important content for this Status Review. Department staff Dr. Raffica La Rosa, Cherilyn Burton, Dr. Benjamin Waitman, Brandy Wood, Reagen O'Leary, Kelly Schmoker-Stanphill, Julie Vance and Carrie Swanberg provided valuable scientific review.

The Department would like to thank X, X, X, X, and X for providing scientific peer review for this Status Review. Conclusions and recommendations in this report are those of the Department and do not necessarily reflect those of the reviewers.

LITERATURE CITED

The following sources were used during the preparation of this Status Review report:

Literature

ABATZOGLOU, J. T., and C. A. KOLDEN. 2011. Climate change in western US deserts: potential for increased wildfire and invasive annual grasses. Rangeland Ecology & Management 64:471–478.

ABELLA, S. R. 2010. Disturbance and plant succession in the Mojave and Sonoran Deserts of the American southwest. International Journal of Environmental Research and Public Health 7:1248–1284.

ABELLA, S. R., E. C. ENGEL, C. L. LUND, and J. E. SPENCER. 2009. Early post-fire plant establishment on a Mojave Desert burn. Madroño 56:137–148.

Abella, S. R., D. M. Gentilcore, and L. P. Chiquoine. 2020. Resilience and alternative stable states after desert wildfires. Ecological Monographs 91. Available at: https://onlinelibrary.wiley.com/doi/10.1002/ecm.1432 (accessed February 12, 2021).

Abella, S. R., and A. C. Newton. 2009. A systematic review of species performance and treatment effectiveness for revegetation in the Mojave Desert, USA. p. 30 Arid Environments and Wind Erosion. Nova Science Publishers, Inc.

Ackerly, D. D., S. R. Loarie, W. K. Cornwell, S. B. Weiss, H. Hamilton, R. Branciforte, and N. J. B. Kraft. 2010. The geography of climate change: implications for conservation biogeography: geography of climate change. Diversity and Distributions 16:476–487.

Agri Chemical and Supply Inc. 2008. Vegetation of Twentynine Palms, CA. Received from California Department of Fish and Wildlife (VegCAMP).

Airhart, E. 2019. Miley Cyrus versus the Joshua tree. Podcast. Available at: https://plantcrimes.podbean.com/e/episode-two-miley-cyrus-versus-the-joshua-tree/ (accessed October 23, 2021).

Alexander, R. R., F. W. Pond, Rodgers, J.E., F. T. Bonner, and Karrfalt, R.P. 2008. The woody plant seed manual. U.S. Department of Agriculture, Forest Service, Washington D.C.

Allen, E. B., and L. H. Geiser. 2011. North American deserts, chapter 12. pp. 133–142 Assessment of nitrogen deposition effects and empirical critical loads of nitrogen for ecoregions of the United States. General Technical Report NRS-80.

Allen, E. B., L. E. Rao, R. J. Steers, A. Bytnerowicz, and M. E. Fenn. 2009. Impacts of atmospheric nitrogen deposition on vegetation and soils at Joshua Tree National Park. The Mojave Desert: Ecosystem Processes and Sustainability, University of Nevada Press:78–100.

Allen, R. J., and R. Luptowitz. 2017. El Niño-like teleconnection increases California precipitation in response to warming. Nature Communications 8:16055.

Althoff, D. M., K. A. Segraves, and J. P. Sparks. 2004. Characterizing the interaction between the bogus yucca moth and yuccas: do bogus yucca moths impact yucca reproductive success? Oecologia 140:321–327.

Anderson, M. K. 2018. The use of fire by Native Americans in California, Chapter 19. pp. 381–397 Fire in California's Ecosystems. Second Edition. University of California Press, Berkeley, California.

[APG] Angiosperm Phylogeny Group. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181:1–20.

Balch, J. K., B. A. Bradley, C. M. D'Antonio, and J. Gómez-Dans. 2013. Introduced annual grass increases regional fire activity across the arid western USA (1980–2009). Global Change Biology 19:173–183.

Barbour, M., T. Keeler-Wolf, and A. A. Schoenherr, editors. 2007. Terrestrial vegetation of California. University of California Press, Berkeley, California.

Barkley, G. 1924. Secondary Stelar Structures of *Yucca*. Botanical Gazette 78:433–439.

Barrios, J., M. Hailstone, J. Papin, and L. Zimmerman. 2017. Joshua tree survivorship and/or regeneration in fire area on Edwards Air Force Base. p. 10. Final Report, U.S. Air Force, 412 CEG/CEVA.

Barrios, J., and S. Watts. 2017. Joshua tree historical status on Edwards AFB. p. 12. Edwards Air Force Base, 412th Civil Engineering Group. Environmental Management Division.

Barrows, C. W., and M. L. Murphy-Mariscal. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: how scale impacts predictions. Biological Conservation 152:29–36.

Barrows, C. W., A. R. Ramirez, L. C. Sweet, T. L. Morelli, C. I. Millar, N. Frakes, J. Rodgers, and M. F. Mahalovich. 2020. Validating climate-change refugia: empirical bottom-up approaches to support management actions. Frontiers in Ecology and the Environment 18:298–306.

Barve, V. V., L. Brenskelle, D. Li, B. J. Stucky, N. V. Barve, M. M. Hantak, B. S. McLean, D. J. Paluh, J. A. Oswald, M. W. Belitz, R. A. Folk, and R. P. Guralnick. 2020. Methods for broad-scale plant phenology assessments using citizen scientists' photographs. Applications in Plant Sciences 8. Available at: https://onlinelibrary.wiley.com/doi/10.1002/aps3.11315 (accessed August 31, 2021).

Bedsworth, L., D. Cayan, G. Franco, L. Fisher, and S. Ziaja. 2018. Statewide summary report. California's fourth climate change assessment. p. 133. California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission.

Bittman, R. 2001. The California Natural Diversity Database: A natural heritage program for rare species and vegetation. Fremontia 29:3–4.

Blank, R. R. 2010. Intraspecific and interspecific pair-wise seedling competition between exotic annual grasses and native perennials: plant–soil relationships. Plant and Soil 326:331–343.

[BLM] Bureau of Land Management. 1980. California desert conservation area plan.

[BLM] Bureau of Land Management. 2005. West Mojave plan, a habitat conservation plan and California desert conservation area plan amendment. Final environmental impact report and statement, Moreno Valley, California. (accessed August 20, 2021).

[BLM] Bureau of Land Management. 2016. Desert renewable energy conservation plan. Available at: https://eplanning.blm.gov/eplanning-ui/project/66459/570 (accessed August 20, 2021).

[BLM] Bureau of Land Management. 2019. West Mojave route network project : draft California desert conservation plan amendment and supplemental environmental impact statement for the California Desert District. Available at: https://archive.org/details/westmojaverouten00unse (accessed August 20, 2021).

Bonanomi, G., G. Incerti, A. Stinca, F. Cartenì, F. Giannino, and S. Mazzoleni. 2014. Ring formation in clonal plants. Community Ecology 15:77–86.

Borchert, M. 2016. Rodent removal of fallen Joshua tree (*Yucca brevifolia*) fruits. Bulletin, Southern California Academy of Sciences 115:146–155.

Borchert, M. I. 2021. Post-fire seedling establishment of *Prunus fasciculata* and *Yucca brevifolia* from simulated seed caches in the Mojave Desert.

Borchert, M. I., and L. A. DeFalco. 2016. *Yucca brevifolia* fruit production, predispersal seed predation, and fruit removal by rodents during two years of contrasting reproduction. American Journal of Botany 103:830–836.

Borge, A. 2018. Alfalfa industry. Available at: https://www.lancastermoah.org/single-post/alfalfa-industry (accessed June 28, 2021).

Bowers, J. E. 1997. Demographic patterns of *Ferocactus cylindraceus* in relation to substrate age and grazing history. Plant Ecology 133:37–48.

Bowns, J. E. 1973. An Autecological Study of Blackbrush (*Coleogyne ramosissima* torr.) in Southwestern Utah. Dissertation, Utah State University.

Brenskelle, L., V. Barve, L. Majure, R. P. Guralnick, and D. Li. 2021. Predicting phenological anomaly: a case study of *Yucca* in the southwestern United States. preprint in review. Available at: https://www.researchsquare.com/article/rs-548860/v1 (accessed August 31, 2021).

Brittingham, S., and L. R. Walker. 2000. Facilitation of *Yucca brevifolia* recruitment by Mojave Desert shrubs. Western North American Naturalist 60:374–383.

Brook, B. W., J. J. O'Grady, A. P. Chapman, M. A. Burgman, H. R. Akçakaya, and R. Frankham. 2000. Predictive accuracy of population viability analysis in conservation biology. Nature 404:385–387.

Brooks, M. L. 1999. Alien annual grasses and fire in the Mojave Desert. Madroño 46:13–19.

Brooks, M. L. 2000. Competition Between Alien Annual Grasses and Native Annual Plants in the Mojave Desert. The American Midland Naturalist 144:92–108.

Brooks, M. L. 2002. Peak fire temperatures and effects on annual plants in the Mojave Desert. Ecological Applications 12:1088–1102.

Brooks, M. L., and K. H. Berry. 2006. Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA. Journal of Arid Environments 67:100–124.

Brooks, M. L., C. S. Brown, J. C. Chambers, C. M. D'Antonio, J. E. Keeley, and J. Belnap. 2016. Exotic annual *Bromus* invasions: comparisons among species and ecoregions in the western United States. pp. 11–60 *in* M. J. Germino, J. C. Chambers, and C. S. Brown, editors. Exotic brome-grasses in arid and semiarid ecosystems of the western US. Springer International Publishing. Available at: http://link.springer.com/10.1007/978-3-319-24930-8_2 (accessed August 17, 2021).

Brooks, M. L., and J. C. Chambers. 2011. Resistance to invasion and resilience to fire in desert shrublands of North America. Rangeland Ecology & Management 64:431–438.

Brooks, M. L., C. M. D'Antonio, D. M. Richardson, J. B. Grace, J. E. Keeley, J. M. DiTOMASO, R. J. Hobbs, M. Pellant, and D. Pyke. 2004. Effects of invasive alien plants on fire regimes. BioScience 54:677.

Brooks, M. L., and J. R. Matchett. 2006. Spatial and temporal patterns of wildfires in the Mojave Desert, 1980–2004. Journal of Arid Environments 67:148–164.

Brooks, M. L., R. A. Minnich, and J. R. Matchett. 2018. Southeastern deserts bioregion, chapter 18. pp. 353–378 Fire in California's ecosystems. Second Edition. University of California Press, Berkeley, California.

Brooks, M. L., and D. A. Pyke. 2001. Invasive plants and fire in the deserts of North America. pp. 1–14 Proceedings of the invasive species workshop: the role of fire in the spread and control of invasive species. Tall Timbers Research Station, Tallahassee, FL.

Bruno, D., and G. Bruno. 2017. Religion, spiritual meaning and traditions associated with succulents 35:203–208.

Bytnerowicz, A., Fenn, Mark, Allen, Edith B., and Cisneros, Ricardo. 2015. Atmospheric chemistry, chapter 7. pp. 107–128 Ecologically relevant atmospheric chemistry. E. Zavaleta and H.A. Mooney. Edited by the University of California Press, Berkeley, California.

[CALFIRE] California Department of Forestry and Fire Protection. 2021. California fire perimeters (all). CALFIRE wildfire perimeters and prescribed burn. Available at: https://gis.data.ca.gov/datasets/CALFIRE-Forestry::california-fire-perimeters-all/about (accessed August 1, 2021).

California Energy Commission. 2009. The impact of climate change on California's ecosystem services. California Energy Commission, Sacramento, California.

California Invasive Plant Council. 2021. Invasive species management opportiunities in Mojave Desert USDA ecoregion. California Invasive Plant Council. Available at: https://weedmap.cal-ipc.org/weedmapper/ (accessed August 19, 2021).

Carpenter, D. E., M. G. Barbour, and C. J. Bahre. 1986. Old field succession in Mojave Desert scrub. Madroño 33:111–122.

Carr, H. 1930. The Lancer. Desert Magazine.

Casajus, N., C. Périé, T. Logan, M.-C. Lambert, S. de Blois, and D. Berteaux. 2016. An objective approach to select climate scenarios when projecting species distribution under climate change. PLoS ONE 11:e0152495.

Cayan, D. R., M. D. Dettinger, H. F. Diaz, and N. E. Graham. 1998. Decadal variability of precipitation over western North America. Journal of Climate 11:19.

[CDFW] California Department of Fish and Wildlife. 2019a. Vegetation survey points [ds1020]. California Department of Fish and Wildlife (VegCAMP), Received from California Department of Fish and Wildlife (VegCAMP). (accessed December 5, 2019).

[CDFW] California Department of Fish and Wildlife. 2019b. Jawbone north for AA. unpublished data. [AIS] Aerial Information Systems, California Department of Fish and Wildlife (VegCAMP).

[CDFW] California Department of Fish and Wildlife. 2019c. Owens Valley for AA. unpublished data. [AIS] Aerial Information Systems, California Department of Fish and Wildlife (VegCAMP).

[CDFW] California Department of Fish and Wildlife. 2019d. Jawbone south for AA. unpublished data. [AIS] Aerial Information Systems, California Department of Fish and Wildlife (VegCAMP).

[CDFW] California Department of Fish and Wildlife. 2021. Climate change vulnerability assessment for western Joshua tree. The NatureServe climate change vulnerability index. release 3.02, Sacramento, CA.

[CDFW] California Department of Fish and Wildlife, Aerial Information Systems, Inc., and University of California Riverside Center for Conservation Biology. 2017. Vegetation - Mojave Desert for DRECP [ds735]. Available at: http://bios.dfg.ca.gov (accessed December 12, 2019).

[CDFW] California Department of Fish and Wildlife, Vegetation Classification and Mapping Program and Chico State University, Geographic Information Center. 2015. Vegetation - proposed Tehachapi Pass high speed rail corridor [ds1328]. Available at: http://bios.dfg.ca.gov (accessed November 25, 2019).

[CDFW] California Department of Fish and Wildlife, Vegetation Classification and Mapping Program, and [USGS] U.S. Geological Survey. 2014. Vegetation map - Johnson Valley [ds1019]. Available at: http://bios.dfg.ca.gov (accessed November 25, 2019).

Charlton, D., and P. Rundel. 2017. The vegetation and flora of Edwards Air Force Base, western Mojave Desert, California. Aliso 35:51–68.

Chase, M. W., J. L. Reveal, and M. F. Fay. 2009. A subfamilial classification for the expanded asparagalean families Amaryllidaceae, Asparagaceae and Xanthorrhoeaceae: Asparagales subfamilial classification. Botanical Journal of the Linnean Society 161:132–136.

Clark, C. J., J. R. Poulsen, D. J. Levey, and C. W. Osenberg. 2007. Are Plant Populations Seed Limited? A Critique and Meta-Analysis of Seed Addition Experiments. The American Naturalist 170:128–142.

Clark, J. S., B. Beckage, P. Camill, B. Cleveland, J. HilleRisLambers, J. Lichter, J. McLachlan, J. Mohan, and P. Wyckoff. 1999. Interpreting recruitment limitation in forests. American Journal of Botany 86:1–16.

Clark, J. S., C. Fastie, G. Hurtt, S. T. Jackson, C. Johnson, G. A. King, M. Lewis, J. Lynch, S. Pacala, C. Prentice, E. W. Schupp, T. Webb, and P. Wyckoff. 1998. Reid’s paradox of rapid plant migration. BioScience 48:13–24.

Clokey, I. W. 1951. Flora of the Charleston Mountains, Clark County, Nevada. University of California Publications in Botany 24:1–274.

CNDDB, (California Natural Diversity Database). 2021. RareFind 5 [internet]. Government Version -- Dated, October 31, 2021. Available at: https://apps.wildlife.ca.gov/rarefind/view/RareFind.aspx (accessed November 12, 2021).

[CNPS] California Native Plant Society. 2021a. A manual of California vegetation, online edition. Available at: https://vegetation.cnps.org/ (accessed August 3, 2021).

[CNPS] California Native Plant Society. 2021b. Inventory of rare and endangered plants of California. Online Database. Available at: https://rareplants.cnps.org/Home/ (accessed August 24, 2021).

Cody, M. L. 2000. Slow-motion population dynamics in Mojave Desert perennial plants. Journal of Vegetation Science 11:351–358.

Cole, K. L., K. Ironside, J. Eischeid, G. Garfin, P. B. Duffy, and C. Toney. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications 21:137–149.

Cole, K. L., K. Puhs, and J. A. Cannella. 2003. Range map of Joshua tree (*Yucca brevifolia*). Layer Package, U.S. Geological Survey. Available at:

https://databasin.org/datasets/b74f96cc008d4c7398ea0ef0bb6b4078/ (accessed April 26, 2021).

Cole, W. S., A. S. James, and C. I. Smith. 2017. First recorded observations of pollination and oviposition behavior in *Tegeticula antithetica* (Lepidoptera: Prodoxidae) suggest a functional basis for coevolution with Joshua tree (*Yucca*) hosts. Annals of the Entomological Society of America 110:390–397.

Comanor, P. L., and W. H. Clark. 2000. Preliminary growth rates and a proposed age-form classification for the Joshua tree, *Yucca brevifolia* (Agavaceae). Haseltonia 7:10.

Cornett, J. 1997. Giant Joshua trees. pp. 30–31 Abstracts from proceedings on the 1997 desert research symposium. San Bernardino County Museum Association Quarterly.

Cornett, J. W. 1995. The Joshua tree in ancient surfaces of the east Mojave Desert. San Bernardino County Museum Association Quarterly 42.

Cornett, J. W. 1998. The California deserts: today and yesterday. Palm Springs Desert Museum, Palm Springs, CA.

Cornett, J. W. 2006. Rapid demise of giant Joshua trees. pp. 72–73 Making Tracks Across the Southwest.

Cornett, J. W. 2009. Population dynamics of the Joshua tree (*Yucca brevifolia*): twenty-one year analysis, Upper Covington Flat, Joshua Tree National Park. p. 2009 Desert Symposium.

Cornett, J. W. 2012. Population dynamics of the Joshua tree (*Yucca brevifolia*): twenty-three-year analysis, Queen Valley, Joshua Tree National Park. p. 146.

Cornett, J. W. 2013. Population dynamics of the Joshua tree (*Yucca brevifolia*), Lee Flat, Death Valley National Park. p. Death Valley Natural History Conference Proceedings. Death Valley Natural History Association.

Cornett, J. W. 2014. Population dynamics of the Joshua tree (*Yucca brevifolia*): twenty-three-year analysis, Lost Horse Valley, Joshua Tree National Park. pp. 71–73. Desert Studies Consortium, California State University Desert Studies Center.

Cornett, J. W. 2016. Long-term population dynamics of the Joshua tree (*Yucca brevifolia*) at Saddleback Butte State Park, Los Angeles County, California. pp. 211–217 Going LOCO: Investigations along the Lower Colorado River. California State University Desert Studies Center.

Cornett, J. W. 2018a. The Joshua tree. Second Edition. Nature Trails Press, Palm Springs, CA.

Cornett, J. W. 2018b. Eastern Joshua tree (*Yucca jaegeriana*) growth rates and survivability on Cima Dome, Mojave National Preserve. pp. 84–87 The 2018 Desert Symposium Field Guide and Proceedings.

Cornett, J. W. 2018c. Joshua trees are blooming early in the desert. It’s not a good thing — you can thank climate change. Desert Magazine. Available at: https://www.desertsun.com/story/desert-magazine/2019/01/30/early-bloom-of-joshua-trees-could-be-dire-for-mojave-desert-ecosystem/2706708002/.

Cornett, J. W. 2020. Dynamics of a western Joshua tree (*Yucca brevifolia*) population, Red Rock Canyon State Park, California. p. The 2020 Desert Symposium Field Guide and Proceedings. Desert Symposium, Inc.

Coville, F. 1892. The Panamint Indians of California. American Anthropologist 5:351–361.

Cronk, Q. 2016. Plant extinctions take time. Science 353:446–447.

Crosswhite, F. S., and C. D. Crosswhite. 1984. A Classification of life forms of the Sonoran Desert, with emphasis on the seed plants and their survival strategies. Desert Plants:131–136.

Cummings, B. 2019. A petition to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act (CESA). Center for Biological Diversity.

D'Antonio, C. M., and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63–87.

Darwin, C. 1874. Letter from Charles Darwin to J.D. Hooker.

DeFalco, L. A., D. R. Bryla, V. Smith-Longozo, and R. S. Nowak. 2003. Are Mojave Desert annual species equal? Resource acquisition and allocation for the invasive grass *Bromus madritensis* subsp. *rubens* (Poaceae) and two native species. American Journal of Botany 90:1045–1053.

DeFalco, L. A., and T. C. Esque. 2014. Soil seed banks: preserving native biodiversity and repairing damaged desert shrublands. Fremontia 42:5.

DeFalco, L. A., T. C. Esque, S. J. Scoles-Sciulla, and J. Rodgers. 2010. Desert wildfire and severe drought diminish survivorship of the long-lived Joshua tree (*Yucca brevifolia*; Agavaceae). American Journal of Botany 97:243–250.

DeFalco, L. A., G. C. J. Fernandez, and R. S. Nowak. 2007. Variation in the establishment of a non-native annual grass influences competitive interactions with Mojave Desert perennials. Biological Invasions 9:293–307.

Department of Defense. 2021. DoD Natural Resources Program fact sheet. Available at: https://www.denix.osd.mil/nr/ (accessed August 26, 2021).

Dettinger, M. 2011. Climate change, atmospheric rivers, and floods in California - a multimodel analysis of storm frequency and magnitude changes. Journal of the American Water Resources Association 47:514–523.

Dettinger, M. D., F. M. Ralph, T. Das, P. J. Neiman, and D. R. Cayan. 2011. Atmospheric rivers, floods and the water resources of California. Water 3:445–478.

Dirzo, R., and P. H. Raven. 2003. Global state of biodiversity and Loss. Annual Review of Environment and Resources 28:137–167.

Dole, K. P., M. E. Loik, and L. C. Sloan. 2003. The relative importance of climate change and the physiological effects of CO_2 on freezing tolerance for the future distribution of *Yucca brevifolia*. Global and Planetary Change 36:137–146.

Elith, J., and J. R. Leathwick. 2009. Species distribution models: ecological explanation and prediction across space and time. Annual Review of Ecology, Evolution, and Systematics 40:677–697.

Ellstrand, N. C., and D. R. Elam. 1993. Population genetic consequences of small population size: implications for plant conservation. Annual Review of Ecology and Systematics 24:217–242.

Engelmann, G. 1871. *Yucca brevifolia* in C. King, report no. 5, geological exploration of the fortieth parallel. p. 496. Government Printing Office, Washington D.C.

Enquist, B. J., X. Feng, B. Boyle, B. Maitner, E. A. Newman, P. M. Jørgensen, P. R. Roehrdanz, B. M. Thiers, J. R. Burger, R. T. Corlett, T. L. P. Couvreur, G. Dauby, J. C. Donoghue, W. Foden, J. C. Lovett, P. A. Marquet, C. Merow, G. Midgley, N. Morueta-Holme, D. M. Neves, A. T. Oliveira-Filho, N. J. B. Kraft, D. S. Park, R. K. Peet, M. Pillet, J. M. Serra-Diaz, B. Sandel, M. Schildhauer, I. Šímová, C. Violle, J. J. Wieringa, S. K. Wiser, L. Hannah, J.-C. Svenning, and B. J. McGill. 2019. The commonness of rarity: global and future distribution of rarity across land plants. Science Advances 5:1–13.

Esque, T. C., P. E. Baird, F. C. Chen, D. C. Housman, and J. T. Holton. 2020a. Using remotely sensed data to map Joshua tree distributions at Naval Air Weapons Station China Lake, California, 2018. Scientific Investigations Report, U.S. Department of the Interior U.S. Geological Survey.

Esque, T. C., L. A. DeFalco, W. Hodgson, A. Salywon, R. Puente, and K. Clary. 2020b. *Yucca brevifolia*. The IUCN Red List of Threatened Species. Available at: https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T117423077A117469962.en (accessed June 21, 2021).

Esque, T. C., D. F. Haines, L. A. DeFalco, J. E. Rodgers, K. A. Goodwin, and S. J. Scoles. 2003. Mortality of adult Joshua trees (*Yucca brevifolia*) due to small mammal herbivory at Joshua Tree National Park, California. p. 10. United States Geological Survey, Western Ecological Research Center.

Esque, T. C., P. A. Medica, D. F. Shryock, L. A. DeFalco, R. H. Webb, and R. B. Hunter. 2015. Direct and indirect effects of environmental variability on growth and survivorship of pre-reproductive Joshua trees, *Yucca brevifolia* Engelm. (Agavaceae). American Journal of Botany 102:85–91.

Esque, T. C., B. Reynolds, L. A. DeFalco, and B. A. Waitman. 2010. Demographic studies of Joshua trees in Mojave Desert national parks: demography with emphasis on germination and recruitment. Mojave National Preserve Science Newsletter:9–12.

Evans, M. J., S. C. Banks, D. A. Driscoll, A. J. Hicks, B. A. Melbourne, and K. F. Davies. 2017. Short- and long-term effects of habitat fragmentation differ but are predicted by response to the matrix. Ecology 98:807–819.

Faber-Langendoen, D., J. Nichol, L. Master, K. Snow, A. Tomaino, R. Bittman, G. Hammerson, B. Heidel, L. Ramsay, A. Teucher, and B. Young. 2012. NatureServe conservation status assessments: methodology for assigning ranks. p. 52. NatureServe, Arlington, VA.

Figueiredo, L., J. Krauss, I. Steffan-Dewenter, and J. Sarmento Cabral. 2019. Understanding extinction debts: spatio–temporal scales, mechanisms and a roadmap for future research. Ecography 42:1973–1990.

Firestone, R. B., A. West, J. P. Kennett, L. Becker, T. E. Bunch, Z. S. Revay, P. H. Schultz, T. Belgya, D. J. Kennett, J. M. Erlandson, O. J. Dickenson, A. C. Goodyear, R. S. Harris, G. A. Howard, J. B. Kloosterman, P. Lechler, P. A. Mayewski, J. Montgomery, R. Poreda, T. Darrah, S. S. Q. Hee, A. R. Smith, A. Stich, W. Topping, J. H. Wittke, and W. S. Wolbach. 2007. Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions and the Younger Dryas cooling. Proceedings of the National Academy of Sciences 104:16016–16021.

Fitzpatrick, M. C., and W. W. Hargrove. 2009. The projection of species distribution models and the problem of non-analog climate. Biodiversity and Conservation 18:2255–2261.

Fowler, C. S. 1995. Some notes on ethnographic subsistence systems in mojavean environments in the Great Basin. Journal of Ethnobotany 15:99–117.

Frakes, N. 2017a. Interim report on the distribution, abundance, and health of *Yucca brevifolia* in Joshua Tree National Park report to U.S. Fish and Wildlife Service. p. 15. Joshua Tree National Park.

Frakes, N. 2017b. Invasive plant management at Joshua Tree National Park. PowerPoint presentaion, California Invasive Plant Council Symposium.

Frances, A. L., A. B. Smith, and C. K. Khoury. 2018. Conservation status and threat assessments for North American crop wild relatives: chapter 7. p. *in* S. L. Green, S. A. Williams, C. K. Khoury, M. B. Kantar, and L. F. Marek, editors. North American Crop Wild Relatives, Volume 1: Conservation Strategies. Springer, Switzerland.

Franson, R. L. 1995. Health of plants salvaged for revegetation at a Mojave Desert gold mine: year two. p. INT-GTR-315 *in* B. A. Roundy, E. D. McArthur, J. S. Haley, and D. K. Mann, editors. Proceedings: Wildland Shrub and Arid Land Restoration Symposium. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT. Available at: https://www.fs.usda.gov/treesearch/pubs/34717 (accessed December 18, 2020).

Fremont, J. C. 1845. The exploring expedition to the Rocky Mountains in the year 1842; and to Oregon and Northern California, in the years 1843–1844. Gales and Seaton, Printers, Washington.

Fried, G., B. Laitung, C. Pierre, N. Chague, and F. D. Panetta. 2014. Impact of invasive plants in Mediterranean habitats: disentangling the effects of characteristics of invaders and recipient communities. Biological Invasions 16:1639–1658.

Fuentes-Ramirez, A., J. L. Schafer, E. L. Mudrak, M. Schat, H. A. Parag, C. Holzapfel, and K. A. Moloney. 2015. Spatio-temporal impacts of fire on soil nutrient availability in *Larrea tridentata* shrublands of the Mojave Desert, USA. Geoderma 259–260:126–133.

Fuentes-Ramirez, A., J. W. Veldman, C. Holzapfel, and K. A. Moloney. 2016. Spreaders, igniters, and burning shrubs: plant flammability explains novel fire dynamics in grass-invaded deserts. Ecological Applications 26:2311–2322.

Gaertner, M., A. D. Breeyen, C. Hui, and D. M. Richardson. 2009. Impacts of alien plant invasions on species richness in Mediterranean-type ecosystems: a meta-analysis. Progress in Physical Geography 33:319–338.

Garfin, G., A. Jardine, R. Merideth, M. Black, and S. LeRoy, editors. 2013. Assessment of climate change in the southwest United States: a report prepared for the national climate assessment. Island Press/Center for Resource Economics, Washington, DC. Available at: http://link.springer.com/10.5822/978-1-61091-484-0 (accessed June 24, 2021).

Gaston, K. J., and R. A. Fuller. 2009. The sizes of species' geographic ranges. Journal of Applied Ecology 46:1–9.

Gilliland, K. D., N. J. Huntly, and J. E. Anderson. 2006. Age and population structure of Joshua trees (*Yucca brevifolia*) in the northwestern Mojave Desert. Western North American Naturalist 66:202–208.

Godsoe, W., E. Strand, C. I. Smith, J. B. Yoder, T. C. Esque, and O. Pellmyr. 2009. Divergence in an obligate mutualism is not explained by divergent climatic factors. New Phytologist 183:589–599.

Godsoe, W., J. B. Yoder, C. I. Smith, C. S. Drummond, and O. Pellmyr. 2010. Absence of population-level phenotype matching in an obligate pollination mutualism: absence of phenotype matching. Journal of Evolutionary Biology 23:2739–2746.

Godsoe, W., J. B. Yoder, C. I. Smith, and O. Pellmyr. 2008. Coevolution and divergence in the Joshua tree/yucca moth mutualism. The American Naturalist 171:816–823.

Google. 2021. Google Earth Pro 7.3.4.8248 (64-bit). Aerial imagery in the Mojave Desert. (accessed August 16, 2021).

Gray, M. E., B. G. Dickson, and L. J. Zachmann. 2014. Modelling and mapping dynamic variability in large fire probability in the lower Sonoran Desert of south-western Arizona. International Journal of Wildland Fire 23:1108.

Griffin, H. E. 1930. Preserving California desert scenery. Desert Magazine:118.

Grubb, P. J. 1977. The maintenance of species-richness in plant communities: the importance of the regeneration niche. Biological Reviews 52:107–145.

Gucker, C. L. 2006. *Yucca brevifolia*. In: fire effects information system. Available at: https://www.fs.fed.us/database/feis/plants/tree/yucbre/all.html (accessed December 18, 2019).

Haddad, N. M., L. A. Brudvig, J. Clobert, K. F. Davies, A. Gonzalez, R. D. Holt, T. E. Lovejoy, J. O. Sexton, M. P. Austin, C. D. Collins, W. M. Cook, E. I. Damschen, R. M. Ewers, B. L. Foster, C. N. Jenkins, A. J. King, W. F. Laurance, D. J. Levey, C. R. Margules, B. A. Melbourne, A. O. Nicholls, J. L. Orrock, D.-X. Song, and J. R. Townshend. 2015. Habitat fragmentation and its lasting impact on Earth’s ecosystems. Science Advances 1:e1500052.

Hammerson, G. A., D. Schweitzer, L. Master, J. Cordeiro, A. Tomaino, L. Oliver, and J. Nichols. 2008. Ranking species occurrences: a generic approach and decision key. p. 17. NatureServe.

Hanski, I., and O. Ovaskainen. 2002. Extinction debt at extinction threshold. Conservation Biology 16:666–673.

Harrington, M. R. 1933. Gypsum cave, Nevada. Report of the second Sessions expedition. Southwest Museum:197.

Harris, G., and S. L. Pimm. 2007. Range size and extinction risk in forest birds. Conservation Biology 22:163–171.

Harrower, J., and G. S. Gilbert. 2018. Context-dependent mutualisms in the Joshua tree-yucca moth system shift along a climate gradient. Ecosphere 9:e02439.

Harrower, J. T. 2019. Species interactions and climate change in the loss of Joshua trees and the role of eco-art for understanding multispecies connections. PhD dissertation, University of California Santa Cruz, Santa Cruz, California.

Harrower, J. T., and G. S. Gilbert. 2021. Parasitism to mutualism continuum for Joshua trees inoculated with different communities of arbuscular mycorrhizal fungi from a desert elevation gradient. PLOS ONE 16:e0256068.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences 101:12422–12427.

He, M., A. Schwarz, E. Lynn, and M. Anderson. 2018. Projected changes in precipitation, temperature, and drought across California's hydrologic regions in the 21st century. Climate 6:31.

Hegeman, E. E., B. G. Dickson, and L. J. Zachmann. 2014. Probabilistic models of fire occurrence across National Park Service units within the Mojave Desert network, USA. Landscape Ecology 29:1587–1600.

Helm, A., I. Hanski, and M. Partel. 2006. Slow response of plant species richness to habitat loss and fragmentation. Ecology Letters 0:051109031307003.

Hereford, R., R. H. Webb, and C. I. Longpre. 2004. Precipitation history of the Mojave Desert region, 1893–2001. p. 4. U.S. Geological Survey.

Hereford, R., R. H. Webb, and C. I. Longpré. 2006. Precipitation history and ecosystem response to multidecadal precipitation variability in the Mojave Desert region, 1893–2001. Journal of Arid Environments 67:13–34.

Hess, W. J. 2012. *Yucca brevifolia* In Jepson flora project (eds.) Jepson eFlora. Available at: http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=48766 (accessed December 18, 2019).

Hess, W. J., and R. L. Robbins. 1993. *Yucca brevifolia*. Available at: http://floranorthamerica.org/Yucca_brevifolia (accessed March 5, 2021).

Hess, W. J., and R. L. Robbins. 2002. *Yucca*. pp. 423–439 *in* editorial Committee, editor. Flora of North America, north of Mexico. Oxford University Press, New York.

Historic Aerials. 2021. Historical aerial photographs of the Antelope Valley of California from various years, 1948–1974. Available at: https://www.historicaerials.com/ (accessed June 28, 2021).

Hobohm, C., editor. 2014. Endemism in vascular plants. Springer, Netherlands.

Hochstätter, F. 2001. Geslacht *Yucca*. Agavaceae. 9. *Yucca brevifolia*. Succulenta (Netherlands) 80:262–268.

Hochstätter, F. 2002. *Yucca* II (Agavaceae). English Translation by C. Holland, Privately printed, Germany.

Hoffmann, A. A., and C. M. Sgro. 2011. Climate change and evolutionary adaptation. Nature 470:479–485.

Hoffmann, A. A., J. Shirriffs, and M. Scott. 2005. Relative importance of plastic vs genetic factors in adaptive differentiation: geographical variation for stress resistance in *Drosophila melanogaster* from eastern Australia. Functional Ecology 19:222–227.

Holmgren, C. A., J. L. Betancourt, and K. A. Rylander. 2010. A long-term vegetation history of the Mojave-Colorado desert ecotone at Joshua Tree National Park. Journal of Quaternary Science 25:222–236.

Holmgren, M., M. Scheffer, and M. A. Huston. 1997. The interplay of facilitation and competition in plant communities. Ecology 78:1966–1975.

Holmgren, M., P. Stapp, C. R. Dickman, C. Gracia, S. Graham, J. R. Gutiérrez, C. Hice, F. Jaksic, D. A. Kelt, M. Letnic, M. Lima, B. C. López, P. L. Meserve, W. B. Milstead, G. A. Polis, M. A. Previtali, M. Richter, S. Sabaté, and F. A. Squeo. 2006. Extreme climatic events shape arid and semiarid ecosystems. Frontiers in Ecology and the Environment 4:87–95.

Hopkins, F. 2018. Inland deserts summary report. California's fourth climate change assessment. p. 67. University of California, Riverside.

Huning, J. R., and R. M. Petersen. 1973. Use of *Yucca brevifolia* as a surrogate for detection of near-surface moisture retention. p. 35.

Hunter, R. B., A. Wallace, and E. M. Romney. 1980. Fencing enhances shrub survival and growth for Mojave Desert revegetation. Great Basin Naturalist Memoir 4:212–215.

Huth, C. J., and O. Pellmyr. 2000. Pollen-mediated selective abortion in yuccas and its consequences for the plant-pollinator mutualism. Ecology 81:1100–1107.

Huxman, T. E., E. P. Hamerlynck, M. E. Loik, and S. D. Smith. 1998. Gas exchange and chlorophyll fluorescence responses of three south-western *Yucca* species to elevated CO_2 and high temperature. Plant, Cell and Environment 21:1275–1283.

Huxman, T. E., K. A. Huxman, and M. R. Stamer. 1997. Dispersal characteristics of the yucca weevil (*Sctphophorus yuccae*) in a flowering field of *Yucca whipplei*. Great Basin Naturalist 57:38–43.

Iknayan, K. J., and S. R. Beissinger. 2018. Collapse of a desert bird community over the past century driven by climate change. Proceedings of the National Academy of Sciences 115:8597–8602.

[IPCC] Intergovernmental Panel on Climate Change. 2014. Climate change 2014: synthesis report. contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland. 151 pp.

[IPCC] Intergovernmental Panel on Climate Change. 2021. Summary for policymakers. in: climate change 2021: the physical science basis. contribution of working group I to the sixth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

[ITIS] Integrated Taxonomic Information System. 2019. ITIS Database. Available at: http://www.itis.gov/index.html (accessed December 18, 2019).

[IUCN] International Union for Conservation of Nature. 2012. IUCN Red List Categories and Criteria: Version 3.1. Second edition. IUCN, Gland, Switzerland and Cambridge, UK.

Jaeger, E. C. 1965. The California deserts. Stanford University Press, Stanford, California.

Jones, T., and S. Goldrick. 2015. Petition to list the Joshua tree (*Yucca brevifolia*) under the Endangered Species Act. p. 48. WildEarth Guardians, Denver, Colorado.

Joshua Tree Genome Project. 2020. The Joshua tree genome project gets big boost with NSF funding. Available at: https://joshuatreegenome.org/archives/2020/07/the-joshua-tree-genome-project-gets-big-boost-with-nsf-funding/ (accessed June 7, 2020).

[JTNP] Joshua Tree National Park. 2017. Memorandum to field supervisor, Carlsbad Fish and Wildlife Office, subject: FWS-L&R 2017-07-031, request for information on the Joshua tree.

Jura-Morawiec, J., A. Oskolski, and P. Simpson. 2021. Revisiting the anatomy of the monocot cambium, a novel meristem. Planta 254:6.

Jurand, B. S., and S. R. Abella. 2013. Soil seed banks of the exotic annual grass *Bromus rubens* on a burned desert landscape. Rangeland Ecology & Management 66:157–163.

Kaiser, D. 2021. Dome Fire restoration plan. p. 19. National Park Service, Mojave National Preserve.

Kartesz, J. T. 1987. A flora of Nevada. PhD Dissertation, University of Nevada, Reno.

Kearney, T. H., and R. H. Peebles. 1960. Arizona flora. second edition with supplement by J.T. Howell and E. McClintock. University of California Press.

Keeley, J. E., W. J. Bond, R. A. Bradstock, J. G. Pausas, and P. W. Rundel. 2011. Fire in Mediterranean ecosystems: ecology, evolution and management. Cambridge University Press, New York.

Keeley, J. E., and A. Meyers. 1985. Effect of heat on seed germination of southwestern *Yucca* species. The Southwestern Naturalist 30:303–304.

Keith, D. A., H. R. Akçakaya, W. Thuiller, G. F. Midgley, R. G. Pearson, S. J. Phillips, H. M. Regan, M. B. Araújo, and T. G. Rebelo. 2008. Predicting extinction risks under climate change: coupling stochastic population models with dynamic bioclimatic habitat models. Biology Letters 4:560–563.

Kelly, D., and V. L. Sork. 2002. Mast seeding in perennial plants: why, how, where? Annual Review of Ecology and Systematics 33:427–447.

Kerns, B. K., and M. A. Day. 2017. The importance of disturbance by fire and other abiotic and biotic factors in driving cheatgrass invasion varies based on invasion stage. Biological Invasions 19:1853–1862.

Kimball, S., A. L. Angert, T. E. Huxman, and D. L. Venable. 2010. Contemporary climate change in the Sonoran Desert favors cold-adapted species. Global Change Biology 16:1555–1565.

van Kleunen, M., W. Dawson, F. Essl, J. Pergl, M. Winter, E. Weber, H. Kreft, P. Weigelt, J. Kartesz, M. Nishino, L. A. Antonova, J. F. Barcelona, F. J. Cabezas, D. Cárdenas, J. Cárdenas-Toro, N. Castaño, E. Chacón, C. Chatelain, A. L. Ebel, E. Figueiredo, N. Fuentes, Q. J. Groom, L. Henderson, Inderjit, A. Kupriyanov, S. Masciadri, J. Meerman, O. Morozova, D. Moser, D. L. Nickrent, A. Patzelt, P. B. Pelser, M. P. Baptiste, M. Poopath, M. Schulze, H. Seebens, W. Shu, J. Thomas, M. Velayos, J. J. Wieringa, and P. Pyšek. 2015. Global exchange and accumulation of non-native plants. Nature 525:100–103.

Klinger, R., and M. Brooks. 2017. Alternative pathways to landscape transformation: invasive grasses, burn severity and fire frequency in arid ecosystems. Journal of Ecology 105:1521–1533.

Klinger, R. C., M. L. Brooks, and J. M. Randall. 2018. Fire and invasive plants, chapter 24. pp. 459–476 Fire in California's ecosystems. Second. University of California Press.

Knowles, N., M. D. Dettinger, and D. R. Cayan. 2006. Trends in snowfall versus rainfall in the western United States. Journal of Climate 19:4545–4559.

Kocsis, M. 2011. Impacts of climate change on Lepidoptera species and communities. Applied Ecology and Environmental Research 9:43–72.

Kuussaari, M., R. Bommarco, R. K. Heikkinen, A. Helm, J. Krauss, R. Lindborg, E. Ockinger, M. Partel, J. Pino, F. Roda, C. Stefanescu, T. Teder, M. Zobel, and I. Steffan-Dewenter. 2009. Extinction debt: a challenge for biodiversity conservation. Trends in Ecology and Evolution 24:564–571.

Laudermilk, J., and P. Munz. 1935. Plants in the dung of Nothrotherium from Gypsum Cave, Nevada. pp. 31–51. Carnegie Institute of Washington, Washington D.C.

Leão, T. C. C., C. R. Fonseca, C. A. Peres, and M. Tabarelli. 2014. Predicting Extinction Risk of Brazilian Atlantic Forest Angiosperms: Neotropical Plant Extinction Risk. Conservation Biology 28:1349–1359.

Legras, E. C., S. B. Vander Wall, and D. I. Board. 2010. The role of germination microsite in the establishment of sugar pine and Jeffrey pine seedlings. Forest Ecology and Management 260:806–813.

Lenz, L. W. 2001. Seed dispersal in *Yucca brevifolia* (Agavaceae)-present and past, with consideration of the future of the species. Aliso 20:61–74.

Lenz, L. W. 2007. Reassessment of *Yucca brevifolia* and recognition of *Y. jaegeriana* as a distinct species. Aliso 24:97–104.

Leung, L. R., Y. Qian, X. Bian, W. M. Washington, J. Han, and J. O. Roads. 2004. Mid-century ensemble regional climate change scenarios for the western United States. Climatic Change 62:75–113.

Levine, J. M., M. Vilà, C. M. D'Antonio, J. S. Dukes, K. Grigulis, and S. Lavorel. 2003. Mechanisms underlying the impacts of exotic plant invasions. Proceedings of the Royal Society B: Biological Sciences 270:775–781.

Lindborg, R., and O. Eriksson. 2004. Historical landscape connectivity affects present plant species diversity. Ecology 85:1840–1845.

Little, E. L., Jr. 1950. Southwestern trees; a guide to the native species of New Mexico and Arizona. U.S. Department of Agriculture, Washington D.C.

Loik, M. E., T. E. Huxman, E. P. Hamerlynck, and S. D. Smith. 2000a. Low temperature tolerance and cold acclimation for seedlings of three Mojave Desert *Yucca* species exposed to elevated CO_2. Journal of Arid Environments 46:43–56.

Loik, M. E., C. D. Onge, and J. Rogers. 2000b. Post-fire recruitment of *Yucca brevifolia* and *Yucca schidigera* in Joshua Tree National Park, California. pp. 79–85. U.S. Geological Survey Open-File, Environmental Studies Department, Natural Sciences II, University of California, Santa Cruz.

Lovich, J. E. 1999. Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration. Environmental Management 24:309–326.

Lybbert, A. H., and S. B. St. Clair. 2017. Wildfire and floral herbivory alter reproduction and pollinator mutualisms of yuccas and yucca moths. Journal of Plant Ecology 10:851–858.

Mace, G. M., N. J. Collar, K. J. Gaston, C. Hilton-Taylor, H. R. Akçakaya, N. Leader-Williams, E. J. Milner-Gulland, and S. N. Stuart. 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. Conservation Biology 22:1424–1442.

Mack, R. N., D. Simberloff, W. Mark Lonsdale, H. Evans, M. Clout, and F. A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications 10:689–710.

Malanson, G. P. 2008. Extinction debt: origins, developments, and applications of a biogeographical trope. Progress in Physical Geography: Earth and Environment 32:277–291.

van Mantgem, P. J., N. L. Stephenson, J. C. Byrne, L. D. Daniels, J. F. Franklin, P. Z. Fule, M. E. Harmon, A. J. Larson, J. M. Smith, A. H. Taylor, and T. T. Veblen. 2009. Widespread increase of tree mortality rates in the western United States. Science 323:521–524.

Mantua, N. J., and S. R. Hare. 2002. The Pacific decadal oscillation. Journal of Oceanography 58:35–44.

Marr, D. L., and O. Pellmyr. 2003. Effect of pollinator-inflicted ovule damage on floral abscission in the yucca-yucca moth mutualism: the role of mechanical and chemical factors. Oecologia 136:236–243.

Master, L., D. Faber-Langendoen, R. Bittman, G. A. Hammerson, B. Heidel, L. Ramsay, K. Snow, A. Teucher, and A. Tomaino. 2012. NatureServe conservation status assessments: factors for evaluating species and ecosystem risk. p. 76. NatureServe, Arlington, VA.

McCabe, G. J., and M. D. Dettinger. 1999. Decadal variations in the strength of ENSO teleconnections with precipitation in the western United States. International Journal of Climatology 19:1399–1410.

McCleary, J. A. 1973. Comparative germination and early growth studies of six species of the genus *Yucca*. American Midland Naturalist 90:503.

McKelvey, S. D. 1938. Yuccas of the southwestern United States, part 1. Harvard University, Jamaica Plain, Massachusetts: Arnold Arboretum.

McKinney, K. K., and J. C. Hickman. 1993. *Yucca*. p. 1210 *in* J. C. Hickman, editor. The Jepson manual: higher plants of California. University of California Press, Berkeley, CA.

McKinney, K. K., and J. C. Hickman. 2002. *Yucca*. pp. 551–552 *in* M. Weatherwax, B. Baldwin, S. Boyd, B. J. Ertter, R. W. Patterson, T. J. Rosatti, and D. H. Wilken, editors. Jepson desert manual; vascular plants of southeastern California. University of California Press, Berkeley, CA.

McMinn, H. E. 1951. An illustrated manual of California shrubs. University of California Press, Berkeley, California.

[MDLT] Mojave Desert Land Trust. 2021. Mojave Desert Land Trust 2020 Annual Report. Available at: https://www.mdlt.org/mdlt-annual-report-2020/ (accessed October 1, 2021).

Minnich, R. A. 1995. Wildland fire and early postfire succession in Joshua tree woodland and blackbrush scrub of the Mojave Desert of California. pp. 99–106. San Bernardino County Museum Association Quarterly, San Bernardino, California.

Moloney, K. A., E. L. Mudrak, A. Fuentes-Ramirez, H. Parag, M. Schat, and C. Holzapfel. 2019. Increased fire risk in Mojave and Sonoran shrublands due to exotic species and extreme rainfall events. Ecosphere 10:e02592.

Mote, P. W., A. F. Hamlet, M. P. Clark, and D. P. Lettenmaier. 2005. Declining mountain snowpack in western North America. Bulletin of the American Meteorological Society 86:39–50.

Munz, P. A. 1959. A California flora. University of California Press, Berkeley, California.

Natural Resources Group, Inc. 2021. West Mojave Conservation Bank 2021 western Joshua tree census report. p. 21. Technical Memorandum.

NatureServe. 2016. Climate change vulnerability index. Available at: http://www.natureserve.org/conservation-tools/climate-change-vulnerability-index (accessed June 24, 2021).

NatureServe. 2021. NatureServe explorer. Available at: https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.160735/Yucca_brevifolia (accessed August 24, 2021).

Neilson, R. P., L. F. Pitelka, A. M. Solomon, R. Nathan, G. F. Midgley, J. M. V. Fragoso, H. Lischke, and K. Thompson. 2005. Forecasting regional to global plant migration in response to climate change. BioScience 55:749.

Newbold, T., L. N. Hudson, S. Contu, S. L. L. Hill, J. Beck, Y. Liu, C. Meyer, H. R. P. Phillips, J. P. W. Scharlemann, and A. Purvis. 2018. Widespread winners and narrow-ranged losers: land use homogenizes biodiversity in local assemblages worldwide. PLOS Biology 16:e2006841.

Nic Lughadha, E., S. P. Bachman, T. C. C. Leão, F. Forest, J. M. Halley, J. Moat, C. Acedo, K. L. Bacon, R. F. A. Brewer, G. Gâteblé, S. C. Gonçalves, R. Govaerts, P. M. Hollingsworth, I. Krisai-Greilhuber, E. J. Lirio, P. G. P. Moore, R. Negrão, J. M. Onana, L. R. Rajaovelona, H. Razanajatovo, P. B. Reich, S. L. Richards, M. C. Rivers, A. Cooper, J. Iganci, G. P. Lewis, E. C. Smidt, A. Antonelli, G. M. Mueller, and B. E. Walker. 2020. Extinction risk and threats to plants and fungi. Plants, People, Planet 2:389–408.

Notaro, M., A. Mauss, and J. W. Williams. 2012. Projected vegetation changes for the American southwest: combined dynamic modeling and bioclimatic-envelope approach. Ecological Applications 22:1365–1388.

[NPS] National Park Service. 2012. Death Valley National Park wilderness and backcountry stewardship plan and environmental assessment. Available at: https://parkplanning.nps.gov/showFile.cfm?projectID=23311&MIMEType=application%252Fpdf&filename=DEVA%5FWilderness%5F%5F%5FBackcountry%5FStewardship%5FPlan%2Epdf&sfid=139732 (accessed December 18, 2019).

[NPS] National Park Service. 2021. Joshua Tree National Park Annual Recreation Visits (1941 - Last Calendar Year). Available at: https://irma.nps.gov/STATS/Reports/Park/JOTR (accessed September 30, 2021).

Office of Environmental Health Hazard Assessment. 2018. Indicators of climate change in California. p. 351. California Environmental Protection Agency.

O'Grady, J. J., D. H. Reed, B. W. Brook, and R. Frankham. 2004. What are the best correlates of predicted extinction risk? Biological Conservation 118:513–520.

Pardo, L. H., M. E. Fenn, C. L. Goodale, L. H. Geiser, C. T. Driscoll, E. B. Allen, J. S. Baron, R. Bobbink, W. D. Bowman, C. M. Clark, B. Emmett, F. S. Gilliam, T. L. Greaver, S. J. Hall, E. A. Lilleskov, L. Liu, J. A. Lynch, K. J. Nadelhoffer, S. S. Perakis, M. J. Robin-Abbott, J. L. Stoddard, K. C. Weathers, and R. L. Dennis. 2011. Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States. Ecological Applications 21:3049–3082.

Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution, and Systematics 37:637–669.

Parmesan, C., and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421:37–42.

Pascale, S., W. R. Boos, S. Bordoni, T. L. Delworth, S. B. Kapnick, H. Murakami, G. A. Vecchi, and W. Zhang. 2017. Weakening of the North American monsoon with global warming. Nature Climate Change 7:806–812.

Patel, S. 2012. *Yucca*: A medicinally significant genus with manifold therapeutic attributes. Natural Products and Bioprospecting 2:231–234.

Pearson, R. G., and T. P. Dawson. 2003. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? Global Ecology and Biogeography 12:361–371.

Pellmyr, O. 2003. Yuccas, yucca moths, and coevolution: a review. Annals of the Missouri Botanical Garden 90:35.

Pellmyr, O., and C. J. Huth. 1994. Evolutionary stability of mutualism between yuccas and yucca moths. Nature 372:257–260.

Pellmyr, O., and K. A. Segraves. 2003. Pollinator divergence within an obligate mutualism: two yucca moth species (Lepidoptera; Prodoxidae: *Tegeticula*) on the Joshua Tree (*Yucca brevifolia*; Agavaceae). Annals of the Entomological Society of America 96:716–722.

Perkins, L. B., and G. Hatfield. 2014. Competition, legacy, and priority and the success of three invasive species. Biological Invasions 16:2543–2550.

Phillips, E. A., K. K. Page, and S. D. Knapp. 1980. Vegetational characteristics of two stands of Joshua tree woodland. Madroño 27:43–47.

Phillips, S. J., M. Dudík, and R. E. Schapire. 2021. Maxent software for modeling species niches and distributions. Available at: http://biodiversityinformatics.amnh.org/open_source/maxent/ (accessed September 24, 2021).

Pimentel, D., R. Zuniga, and D. Morrison. 2004. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273–288.

Pimm, S. L. 2009. Climate disruption and biodiversity. Current Biology 19:R595–R601.

Pimm, S. L., C. N. Jenkins, R. Abell, T. M. Brooks, J. L. Gittleman, L. N. Joppa, P. H. Raven, C. M. Roberts, and J. O. Sexton. 2014. The biodiversity of species and their rates of extinction, distribution, and protection. Science 344:1246752–1246752.

Pimm, S. L., H. L. Jones, and J. Diamond. 1988. On the risk of extinction. The American Naturalist 132:757–785.

Purvis, A., J. L. Gittleman, G. Cowlishaw, and G. M. Mace. 2000. Predicting extinction risk in declining species. Proceedings of the Royal Society of London. Series B: Biological Sciences 267:1947–1952.

Rao, L. E., J. R. Matchett, M. L. Brooks, R. F. Johnson, R. A. Minnich, and E. B. Allen. 2015. Relationships between annual plant productivity, nitrogen deposition and fire size in low-elevation California desert scrub. International Journal of Wildland Fire 24:48.

Reed, D. H. 2005. Relationship between population size and fitness. Conservation Biology 19:563–568.

Reveal, J. L. 1977. Agavaceae. pp. 526–538 Intermountain flora: vascular plants of the intermountain west, U.S. Columbia University Press, New York.

Reynolds, M. B. J., L. A. DeFalco, and T. C. Esque. 2012. Short seed longevity, variable germination conditions, and infrequent establishment events provide a narrow window for *Yucca brevifolia* (Agavaceae) recruitment. American Journal of Botany 99:1647–1654.

Riddell, E. A., K. J. Iknayan, B. O. Wolf, B. Sinervo, and S. R. Beissinger. 2019. Cooling requirements fueled the collapse of a desert bird community from climate change. Proceedings of the National Academy of Sciences 116:21609–21615.

Riley, C. 1873. On the oviposition of the yucca moth. The American Naturalist 7:619–623.

Riley, C. V. 1892. The yucca moth and *Yucca* pollination. Missouri Botanical Garden Annual Report 1892:99.

Rowlands, P. G. 1978. The vegetation dynamics of the Joshua tree (*Yucca brevifolia* Engelm.) in the southwestern United States of America. Dissertation, University of California Riverside.

Royer, A. M., M. A. Streisfeld, and C. I. Smith. 2016. Population genomics of divergence within an obligate pollination mutualism: selection maintains differences between Joshua tree species. American Journal of Botany 103:1730–1741.

Royer, A. M., J. Waite-Himmelwright, and C. I. Smith. 2020. Strong selection against early generation hybrids in Joshua tree hybrid zone not explained by pollinators alone. Frontiers in Plant Science 11:640.

Rundel, P. W., and A. C. Gibson. 1996. Ecological communities and processes in a Mojave Desert ecosystem: Rock Valley, Nevada. Cambridge University Press, New York.

Runyon, F. F. 1930. Our natural scenic spots. Desert Magazine:44.

Safford, H. D., and K. M. Van de Water. 2014. Using fire return interval departure (FRID) analysis to map spatial and temporal changes in fire frequency on national forest lands in California. USDA Forest Service Research Paper PSW-RP-266.

Sanford, M. P., and N. Huntly. 2009. Selective herbivory by the desert woodrat (*Neotoma lepida*) on Joshua trees (*Yucca brevifolia*). Western North American Naturalist 69:165–170.

Sawyer, J. O., T. Keeler-Wolf, and J. M. Evans. 2009. A manual of California vegetation. second edition. California Native Plant Society Press, Sacramento, California.

Scheffers, B. R., L. De Meester, T. C. L. Bridge, A. A. Hoffmann, J. M. Pandolfi, R. T. Corlett, S. H. M. Butchart, P. Pearce-Kelly, K. M. Kovacs, D. Dudgeon, M. Pacifici, C. Rondinini, W. B. Foden, T. G. Martin, C. Mora, D. Bickford, and J. E. M. Watson. 2016. The broad footprint of climate change from genes to biomes to people. Science 354:aaf7671.

Schwalm, C. R., S. Glendon, and P. B. Duffy. 2020. RCP8.5 tracks cumulative CO_2 emissions. Proceedings of the National Academy of Sciences 117:19656–19657.

Seager, R., and G. A. Vecchi. 2010. Greenhouse warming and the 21st century hydroclimate of southwestern North America. Proceedings of the National Academy of Sciences 107:21277–21282.

Shafer, S. L., P. J. Bartlein, and R. S. Thompson. 2001. Potential changes in the distributions of western North America tree and shrub taxa under future climate scenarios. Ecosystems 4:200–215.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience 31:131–134.

Shaw, M. R., L. Pendleton, D. R. Cameron, B. Morris, D. Bachelet, K. Klausmeyer, J. MacKenzie, D. R. Conklin, G. N. Bratman, J. Lenihan, E. Haunreiter, C. Daly, and P. R. Roehrdanz. 2011. The impact of climate change on California's ecosystem services. Climatic Change 109:465–484.

Sheppard, C. A., and R. A. Oliver. 2004. Yucca moths and yucca plants: discovery of "the most wonderful case of fertilisation." American Entomologist 50:32–46.

Silva, J. M. C. d., A. Rapini, L. C. F. Barbosa, and R. R. Torres. 2019. Extinction risk of narrowly distributed species of seed plants in Brazil due to habitat loss and climate change. PeerJ 7:e7333.

Silvertown, J. 2008. The evolutionary maintenance of sexual reproduction: evidence from the ecological distribution of asexual reproduction in clonal plants. International Journal of Plant Sciences 169:157–168.

Simpson, P. G. 1975. Anatomy and morphology in the Joshua tree (*Yucca brevifolia*): an arborescent monocotyledon. Dissertation, University of California Santa Barbara.

Skinner, C. N., and C. Chang. 1996. Fire regimes, past and present. pp. 1041–106 Sierra Nevada ecosystem project: final report to Congress, assessments and scientific basis for management options. University of California, Centers for Water and Wildland Resources, Davis, CA.

Small, E. 2013. North American cornucopia: top 100 indigenous food plants. Taylor & Francis. Available at: https://books.google.com/books?id=iZBFAQAAQBAJ (accessed September 3, 2021).

Smith, C. I., C. S. Drummond, W. Godsoe, J. B. Yoder, and O. Pellmyr. 2009. Host specificity and reproductive success of yucca moths (*Tegeticula* spp. Lepidoptera: Prodoxidae) mirror patterns of gene flow between host plant varieties of the Joshua tree (*Yucca brevifolia*: Agavaceae): pollinator host specificity in Joshua trees. Molecular Ecology 18:5218–5229.

Smith, C. I., W. K. W. Godsoe, S. Tank, J. B. Yoder, and O. Pellmyr. 2008a. Distinguishing coevolution from covariance in an obligate pollination mutualism: asynchronous divergence in Joshua tree and its pollinators. Evolution 62:2676–2687.

Smith, C. I., M. R. McKain, A. Guimond, and R. Flatz. 2021. Genome-scale data resolves the timing of divergence in Joshua trees. American Journal of Botany 108:647–663.

Smith, C. I., O. Pellmyr, D. M. Althoff, M. Balcázar-Lara, J. Leebens-Mack, and K. A. Segraves. 2008b. Pattern and timing of diversification in *Yucca* (Agavaceae): specialized pollination does not escalate rates of diversification. Proceedings of the Royal Society B: Biological Sciences 275:249–258.

Smith, C. I., S. Tank, W. Godsoe, J. Levenick, E. Strand, T. Esque, and O. Pellmyr. 2011. Comparative phylogeography of a coevolved community: concerted population expansions in Joshua trees and four yucca moths. PLoS ONE 6:e25628.

Smith, S. D., T. L. Hartsock, and P. S. Nobel. 1983. Ecophysiology of *Yucca brevifolia*, an arborescent monocot of the Mojave Desert. Oecologia (Berlin) 60:10–17.

Smith, S. D., T. E. Huxman, S. F. Zitzer, T. N. Charlet, D. C. Housman, J. S. Coleman, L. K. Fenstermaker, J. R. Seemann, and R. S. Nowak. 2000. Elevated CO_2 increases productivity and invasive species success in an arid ecosystem. Nature 408:79–82.

Snyder, M. A., J. L. Bell, L. C. Sloan, P. B. Duffy, and B. Govindasamy. 2002. Climate responses to a doubling of atmospheric carbon dioxide for a climatically vulnerable region. Geophysical Research Letters 29:9–1 to 9–4.

Snyder, M. A., and L. C. Sloan. 2005. Transient future climate over the western United States using a regional climate model. Earth Interactions 9(11):1–21.

St. Clair, S. B., and J. Hoines. 2018. Reproductive ecology and stand structure of Joshua tree forests across climate gradients of the Mojave Desert. PLOS ONE 13:e0193248.

Stark, J. M., and J. M. Norton. 2015. The invasive annual cheatgrass increases nitrogen availability in 24-year-old replicated field plots. Oecologia 177:799–809.

Starr, T. N., K. E. Gadek, J. B. Yoder, R. Flatz, and C. I. Smith. 2013. Asymmetric hybridization and gene flow between Joshua trees (Agavaceae: *Yucca*) reflect differences in pollinator host specificity. Molecular Ecology 22:437–449.

Staude, I. R., L. M. Navarro, and H. M. Pereira. 2020. Range size predicts the risk of local extinction from habitat loss. Global Ecology and Biogeography 29:16–25.

Steadman, D. W., P. S. Martin, R. D. E. MacPhee, A. J. T. Jull, H. G. McDonald, C. A. Woods, M. Iturralde-Vinent, and G. W. L. Hodgins. 2005. Asynchronous extinction of late Quaternary sloths on continents and islands. Proceedings of the National Academy of Sciences 102:11763–11768.

Stephenson, N. 1998. Actual evapotranspiration and deficit: biologically meaningful correlates of vegetation distribution across spatial scales. Journal of Biogeography 25:855–870.

Stoffer, P. 2004. Desert landforms and surface processes in the Mojave National Preserve and vicinity. U.S. Geological Survey. Available at: http://pubs.usgs.gov/of/2004/1007/index.html (accessed June 10, 2021).

Stoffle, R. W., D. B. Halmo, M. J. Evans, and J. E. Olmsted. 1990. Calculating the cultural significance of American Indian plants: Paiute and Shoshone ethnobotany at Yucca Mountain, Nevada. American Anthropologist 92:416–432.

Stotz, G. C., C. Salgado-Luarte, V. M. Escobedo, F. Valladares, and E. Gianoli. 2021. Global trends in phenotypic plasticity of plants. Ecology Letters:ele.13827.

Sugihara, N. G., J. W. van Wagtendonk, and J. Fites-Kaufman. 2018. Fire as an ecological process. pp. 57–70 *in* J. W. van Wagtendonk, N. G. Sugihara, S. E. Stephens, A. E. Thode, K. E. Shaffer, and J. Fites-Kaufman, editors. Fire in California's ecosystems. second edition. University of California Press, Berkeley, California.

Sun, F., D. B. Walton, and A. Hall. 2015. A hybrid dynamical–statistical downscaling technique. part II: end-of-century warming projections predict a new climate state in the Los Angeles region. Journal of Climate 28:4618–4636.

Svenning, J.-C., and B. Sandel. 2013. Disequilibrium vegetation dynamics under future climate change. American Journal of Botany 100:1266–1286.

Swartz, M. J., S. H. Jenkins, and N. A. Dochtermann. 2010. Coexisting desert rodents differ in selection of microhabitats for cache placement and pilferage. Journal of Mammalogy 91:1261–1268.

Sweet, L. C., T. Green, J. G. C. Heintz, N. Frakes, N. Graver, J. S. Rangitsch, J. E. Rodgers, S. Heacox, and C. W. Barrows. 2019. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. Ecosphere 10:e02763.

Syphard, A. D., J. E. Keeley, and J. T. Abatzoglou. 2017. Trends and drivers of fire activity vary across California aridland ecosystems. Journal of Arid Environments 144:110–122.

Tagestad, J., M. Brooks, V. Cullinan, J. Downs, and R. McKinley. 2016. Precipitation regime classification for the Mojave Desert: implications for fire occurrence. Journal of Arid Environments 124:388–397.

Taylor, K. E., R. J. Stouffer, and G. A. Meehl. 2012. An Overview of CMIP5 and the Experiment Design. Bulletin of the American Meteorological Society 93:485–498.

Thomas, K. 2002. Vegetation - central Mojave Desert [ds166]. US Geological Survey. Available at: http://bios.dfg.ca.gov (accessed December 12, 2019).

Thomas, K., T. Keeler-Wolf, J. Franklin, and P. Stine. 2004. Mojave Desert ecosystem program: central mojave vegetation database. p. 265. Final Report, U.S. Geological Survey, Sacramento, California.

Thompson, J. K. 2021. The last four decades of wildfire impacts on the western Joshua tree (*Yucca brevifolia*) in southern California. University of Redlands, Redlands, California.

Thompson, R. S., Hostetler, Steven W., Bartlein, Patrick J., and Anderson, Katherine H. 1998. A strategy for assessing potential future changes in climate, hydrology, and vegetation in the western United States. U.S. Geological Survey Circular, United States Government Printing Office, Washington.

Thorne, J. H., R. M. Boynton, A. J. Holguin, J. A. E. Stewart, and J. Bjorkman. 2016. A climate change vulnerability assessment of California's terrestrial vegetation. p. 331. California Department of Fish and Wildlife, Sacramento, CA.

Thorne, R. F., B. A. Prigge, and J. Henrickson. 1981. A flora of the higher ranges and the Kelso Dunes of the eastern Mojave Desert in California. Aliso 10:71–186.

Tilman, D., R. M. May, C. L. Lehman, and M. A. Nowak. 1994. Habitat destruction and the extinction debt. Nature 371:65–66.

Trelease, W. 1893. Further studies of yuccas and their pollination. Missouri Botanical Garden Annual Report 1893:181–226.

Turner, R. M. 1982. Mojave desertscrub. pp. 157–168 Biotic communtities southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City, Utah.

U2. 1987. The Joshua tree. Island.

U.S. Air Force. 2020. Integrated natural resources management plan for Edwards Air Force Base 2020–2025. p. 244. 412th Civil Engineer Group Environmental Management Division.

U.S. Army. 2006. National Training Center and Fort Irwin integrated natural resources management plan and environmental assessment 2006–2011. p. 281. U.S. Army.

U.S. Environmental Protection Agency. 2016. Updates to the demographic and spatial allocation models to produce integrated climate and land use scenarios (ICLUS) version 2. National Center for Environmental Assessment, Washington D.C.

U.S. Environmental Protection Agency (EPA). 2009. Land-use scenarios: national-scale housing-density scenarios consistent with climate change storylines. Global Change Research Program, National Center for Environmental Assessment, Washington D.C.

U.S. Navy. (n.d.). Integrated Natural Resources Management Plan Naval Air Weapons Station China Lake (unsigned and undated). p. 531.

[USDA] U.S. Department of Agriculture. 2007. Forest Service LANDFIRE reference database version 0.32. Available at: https://www.landfire.gov/index.php (accessed September 3, 2021).

[USDA] U.S. Department of Agriculture. 2017. Ecological Subregions: Sections and Subsections for the Conterminous United States. ECOMAP Team. Available at: https://data.fs.usda.gov/geodata/edw/datasets.php?dsetParent=EcomapSections_2007 (accessed September 8, 2021).

[USFWS] U.S. Fish and Wildlife Service. 2018. Joshua tree species status assessment. p. 113 pp. + Appendices A-C.

[USFWS] U.S. Fish and Wildlife Service. 2019. Endangered and threatened wildlife and plants; 12-month findings on petitions to list eight species as endangered or threatened species. Federal Register 84:41694.

Vamstad, M. S., and J. T. Rotenberry. 2010. Effects of fire on vegetation and small mammal communities in a Mojave Desert Joshua tree woodland. Journal of Arid Environments 74:1309–1318.

Van Linn, P. F., K. E. Nussear, T. C. Esque, L. A. DeFalco, R. D. Inman, and S. R. Abella. 2013. Estimating wildfire risk on a Mojave Desert landscape using remote sensing and field sampling. International Journal of Wildland Fire 22:770.

Vander Wall, S. B., T. Esque, D. Haines, M. Garnett, and B. A. Waitman. 2006. Joshua tree (*Yucca brevifolia*) seeds are dispersed by seed-caching rodents. Ecoscience 13:539–543.

Vaurie, P. 1971. Review of *Scyphophorus* (Curculionidae: Rhynchophorinae). Coleopterists Bulletin 25:1–8.

Vázquez, D. P., E. Gianoli, W. F. Morris, and F. Bozinovic. 2017. Ecological and evolutionary impacts of changing climatic variability: impacts of changing climatic variability. Biological Reviews 92:22–42.

Vellend, M., K. Verheyen, H. Jacquemyn, A. Kolb, H. Van Calster, G. Peterken, and M. Hermy. 2006. Extinction debt of forest plants persists for more than a century following habitat fragmentation. Ecology 87:542–548.

Vogl, R. J. 1967. Fire adaptations of some southern California plants. pp. 79–109 Proceedings. Tall Timbers Research Station, Lake County, California.

van Wagtendonk, J. W., and D. R. Cayan. 2008. Temporal and spatial distribution of lightning strikes in California in relation to large-scale weather patterns. Fire Ecology 4:34–56.

van Wagtendonk, J. W., N. G. Sugihara, S. E. Stephens, A. E. Thode, K. E. Shaffer, J. Fites-Kaufman, and J. K. Agee, editors. 2018. Fire in California's ecosystems. second edition. University of California Press, Berkeley, California.

Waitman, B. A., S. B. Vander Wall, and T. C. Esque. 2012. Seed dispersal and seed fate in Joshua tree (*Yucca brevifolia*). Journal of Arid Environments 81:1–8.

Wallace, A., and E. M. Romney. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. Rep. TID25954. Atomic Energy Commission, Office of Information Services, Washington D.C.

Wallace, A., E. M. Romney, and R. B. Hunter. 1980. The challenge of a desert: revegetation of disturbed desert lands. Great Basin Naturalist Memoirs 4:216–225.

Wallace, G. 2017. White paper on taxonomy and nomanclature related to the WEG 2015 petition to list *Yucca brevifolia*. p. 6. white paper, U.S. Fish and Wildlife Service, Carlsbad, California.

Warren, R., J. Price, A. Fischlin, S. de la Nava Santos, and G. Midgley. 2011. Increasing impacts of climate change upon ecosystems with increasing global mean temperature rise. Climatic Change 106:141–177.

Warren, S. D., L. S. Baggett, and H. Warren. 2016. Directional floral orientation in Joshua trees (*Yucca brevifolia*). Western North American Naturalist 76:374–378.

Weatherwax, M., B. Baldwin, S. Boyd, B. J. Ertter, R. W. Patterson, T. J. Rosatti, and D. H. Wilken, editors. 2002. Jepson desert manual; vascular plants of southeastern California. University of California Press, Berkeley, CA.

Webb, R. H., M. B. Murvov, T. C. Esque, D. E. Boyer, L. A. DeFalco, D. F. Haines, D. Oldershaw, S. J. Scoles, K. A. Thomas, J. B. Blainey, and P. A. Medica. 2003. Perennial vegetation data from permanent plots on the Nevada Test Site, Nye County, Nevada. U.S. Geological Survey, Tucson, Arizona.

Webber, J. M. 1953. Yuccas of the southwest. U.S. Department of Agriculture, Washington D.C.

Went, F. W. 1948. Ecology of desert plants. I. observations on germination in the Joshua Tree National Monument, California. Ecology 29:242–253.

Went, F. W. 1957. The experimental control of plant growth. Chronica Botanica, Waltham, Massachusetts.

WEST Inc. 2021a. Population size evaluation for the western Joshua tree prepared for: 8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen. p. 19. Cheyenne, Wyoming.

WEST Inc. 2021b. Supplemental report regarding population abundance refinement and data needs for population trend for the western Joshua tree prepared for: 8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen. p. 13. Cheyenne, Wyoming.

Whisenant, S. G. 1992. Changing fire frequencies on Idaho's Snake River plains: ecological and management implications. Biological Conservation 59:276.

Wiegand, K., F. Jeltsch, and D. Ward. 2004. Minimum recruitment frequency in plants with episodic recruitment. Oecologia 141:363–372.

Wiens, J. J. 2016. Climate-related local extinctions are already widespread among plant and animal species. PLOS Biology 14:1–18.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48:607–615.

Williamson, R. S. 1853. Report of the explorations in California for railroad routes. 33rd Congress, 2nd Sess., Sen. Ex. Doc. no. 78. p. 310.

Xiao, Y., X. Li, Y. Cao, and M. Dong. 2016. The diverse effects of habitat fragmentation on plant–pollinator interactions. Plant Ecology 217:857–868.

Yoder, J. B., C. I. Smith, D. J. Rowley, R. Flatz, W. Godsoe, C. Drummond, and O. Pellmyr. 2013. Effects of gene flow on phenotype matching between two varieties of Joshua tree (*Yucca brevifolia*; Agavaceae) and their pollinators. Journal of Evolutionary Biology 26:1220–1233.

Yurkonis, K. A., and S. J. Meiners. 2004. Invasion impacts local species turnover in a successional system. Ecology Letters 7:764–769.

Zhang, J., Y. Gao, L. R. Leung, K. Luo, H. Liu, J.-F. Lamarque, J. Fan, X. Yao, H. Gao, and T. Nagashima. 2019. Impacts of climate change and emissions on atmospheric oxidized nitrogen deposition over East Asia. Atmospheric Chemistry and Physics 19:887–900.

Zinkgraf, M., S. Gerttula, and A. Groover. 2017. Transcript profiling of a novel plant meristem, the monocot cambium: monocot cambium. Journal of Integrative Plant Biology 59:436–449.

Ziv, Y., and J. L. Bronstein. 1996. Infertile seeds of *Yucca schottii*: a beneficial role for the plant in the yucca-yucca moth mutualism? Evolutionary Ecology 10:63–76.

Zouhar, K., J. K. Smith, S. Sutherland, and M. L. Brooks. 2008. Wildland fire in ecosystems: fire and nonnative invasive plants. p. RMRS-GTR-42-V6. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ft. Collins, Colorado. Available at: https://www.fs.usda.gov/treesearch/pubs/30622 (accessed September 2, 2021).

Personal Communication

Birker pers. comm. 2021. E-mail from Cheryl Birker, California Botanic Garden, regarding *Yucca brevifolia* germination study. April 5, 2021.

Borchert pers. comm. 2021. Letter from Mark Borchert. January 18, 2021.

Frakes pers. comm. 2021. Discussion with Neil Frakes, Vegetation Manager, Joshua Tree National Park. January 20, 2021.

Gaughen pers. comm. 2020. Letter from Pala Band of Mission Indians Environmental Director/Tribal Historic Preservation Officer. November 17, 2020.

KRANTZ PERS. COMM. 2021. E-mail from Timothy Krantz, Professor and Chair, Environmental Studies Program, University of Redlands. September 16, 2021.

REYNOLDS PERS. COMM. 2021. Letter from Mike Reynolds, Superintendent, Death Valley National Park. February 8, 2021.

ROGERS PERS. COMM. 2021. E-mail from Jane Rogers, Acting Superintendent, Joshua Tree National Park. July 23, 2021.

TEJADA PERS. COMM. 2020. E-mail from Jonathan Tejada, Environmental Scientist, California Department of Parks and Recreation. November 2, 2020.

APPENDIX A: COMMENTS FROM AFFECTED AND INTERESTED PARTIES ON THE PETITIONED ACTION

APPENDIX B: COMMENTS FROM PEER REVIEWERS ON THE WESTERN JOSHUA TREE STATUS REVIEW REPORT

ANTELOPE VALLEY DISTRICT OFFICE
848 W. LANCASTER BLVD., SUITE 101
LANCASTER, CA 93534
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SANTA CLARITA DISTRICT OFFICE
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California State Senate

SENATOR
SCOTT WILK
SENATE REPUBLICAN LEADER
TWENTY-FIRST SENATE DISTRICT

COMMITTEES
GOVERNMENTAL ORGANIZATION
TRANSPORTATION

April 19, 2022

Ms. Samantha Murray, President
California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

Dear Commissioners,

I understand a final decision on listing the Western Joshua Tree under the California Endangered Species Act is expected by June of this year. My district covers much of the High Desert ecosystem where the Western Joshua Tree is found. The Western Joshua Tree is undoubtedly important to our community identity, our ecosystem, and the natural beauty of our desert. However, it is not necessary or prudent to list the Western Joshua Tree under the Act at this time.

As you may be aware, state biologists recently recommended against designating the Western Joshua Tree as threatened with extinction, saying the tree is "abundant and wide spread" and therefore, the concerns raised in a recent petition by environmentalists about the effects of climate change on the living symbols of the California desert are premature.

The Joshua Tree is well protected in its natural habitat in California. There are millions of acres set aside to preserve the Western Joshua Tree, including the Mojave National Preserve, the Joshua Tree National Park, the Mojave Trails National Monument, the Sand to Snow National Monument, Castle Mountains National Monument, and among many other protected areas at the local, state and federal levels.

The areas of the High Desert in Los Angeles and San Bernardino County are vital to the state's commitment to developing more housing and are areas that have little impact on current and future efforts to protect the Western Joshua Tree. Due to this, and due to its abundance in protected areas, listing the Western Joshua Tree under the Endangered Species Act would unnecessarily jeopardize our ability to meet the state's housing commitments and the region's housing needs.

Not long ago, the federal government wisely rejected this proposal, and in light of the recent report, I believe the Commission will be doing the right thing by rejecting it as well.

Sincerely,

Scott Wilk

SCOTT WILK
Senate Republican Leader, 21st District

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Assembly California Legislature

TOM LACKEY
ASSEMBLYMAN, THIRTY-SIXTH DISTRICT

COMMITTEES
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GOVERNMENTAL ORGANIZATION
JOINT LEGISLATIVE COMMITTEE ON EMERGENCY MANAGEMENT

May 24, 2022

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

RE: Listing of the Western Joshua Tree as a California Endangered Species – OPPOSE

Dear President Murray and members of the Commission,

On behalf of Assembly District 36, I urge you to not list the Western Joshua Tree as a California endangered species. The western Joshua tree is an iconic California native species and an important symbol of the Mojave Desert. We strongly believe that this special species should be protected and preserved for generations to come, and we appreciate the Commission's efforts to do so. However, a listing as an endangered species is not justified given the positive population trends of the Joshua tree.

The recently released Department of Fish and Wildlife Status Review Report found that the Western Joshua tree is abundant and widespread, indicating that it faces a low threat of extinction. A central finding of the Status Review is that "the scientific evidence that is currently possessed by the Department does not demonstrate that populations of the species are negatively trending in a way that would lead the Department to believe that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future." This conclusion, drawing upon the best available scientific data, suggests that listing the Joshua tree as endangered is not justified by the evidence at hand. Furthermore, a listing would be a huge undertaking for the Department of Fish and Wildlife, requiring it to issue taking permits and regulate Joshua tree removal across the Mojave Desert, an area of roughly 25,000 square miles which is larger than the state of West Virginia.

Local governments in the region, both cities, and counties, already have strict regulations to protect the Joshua tree in their planning codes. Generally, they require direct preservation and relocation along with stiff penalties for unpermitted removal and destruction of Joshua trees. These are powerful, effective measures that are in place and actively enforced. While we are grateful for the Commission's interest in protecting the western Joshua tree, given the tree's positive population trends and local protections, an endangered species listing is not warranted.

If you have any questions about our opposition, please contact my office at either (661) 267-7636 or (916) 319-2036, or through my website https://ad36.asmrc.org/.

Sincerely,

Thomas Lackey

Assemblyman Tom Lackey
36th Assembly District

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Telephone (661) 868-3585
TTY Relay 800-735-2929

May 17, 2022

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

RE: Support for Recommendations by the California Department of Fish and Wildlife on the Status Review of the Western Joshua Tree

Dear President Murray,

I am writing on behalf of the Kern County Board of Supervisors to express our support for the findings and recommendations outlined by the California Department of Fish and Wildlife (Department) in its report on the status review of the western Joshua tree (Yucca brevifolia).

As noted in the staff report, the best scientific information available to the Department at this time indicates that western Joshua tree is not in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease, and is not likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by the California Endangered Species Act.

We respectfully urge the Commission to accept the Department's recommendation that the petitioned action to list the western Joshua tree as a threatened species is not warranted and to adopt the Department's management recommendations and recovery measures.

Sincerely,

Zack Scrivner, Chairman
Kern County Board of Supervisors

cc: Erika Zavaleta, Vice President, CA Fish and Game Commission
Jacque Hostler-Carmesin, Commissioner, CA Fish and Game Commission
Eric Sklar, Commissioner, CA Fish and Game Commission
Melissa Miller-Henson, Executive Director, CA Fish and Game Commission
Shaw Yoder Antwih Schmelzer & Lange

City of Hesperia

Gateway to the High Desert

May 18, 2022

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

RE: Listing of the Western Joshua Tree as a California Endangered Species – OPPOSE

Dear President Murray and members of the Commission,

On behalf of the City of Hesperia, I urge you to not list the western Joshua Tree as a California endangered species. The western Joshua Tree is an iconic California native species and an important symbol of the Mojave Desert. We strongly believe that this special species should be protected and preserved for generations to come, and we appreciate the Commission's efforts to do so. However, a listing as an endangered species is not justified given the positive population trends of the Joshua Tree.

The recently released Department of Fish and Wildlife Status Review Report found that the western Joshua Tree is abundant and widespread, indicating that it faces a low threat of extinction. A central finding of the Status Review is that "the scientific evidence that is currently possessed by the Department does not demonstrate that populations of the species are negatively trending in a way that would lead the Department to believe that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future." This conclusion, drawing upon the best available scientific data, suggests that listing the Joshua Tree as endangered is not justified by the evidence at hand. Furthermore, a listing would be a huge undertaking for the Department of Fish and Wildlife, requiring it to issue take permits and regulate Joshua Tree removal across the Mojave Desert, an area of roughly 25,000 square miles which is larger than the state of West Virginia. This heavy administrative burden would detract from the state's ability to protect other species that are at far greater risk of extinction.

The City of Hesperia, through the adoption of various ordinances, is actively working to protect the Joshua Tree. Currently, the City does not approve any Joshua Tree removal unless the trees are safely transplanted where possible and the permittee performing the transplanting has posted a bond to insure Joshua Trees are transplanted appropriately. The City of Hesperia Municipal Code also explicitly states that the Joshua Tree, whether mature or immature, shall

City of Hesperia

Gateway to the High Desert

not be harvested or removed except under a permit issued by the agricultural commissioner or other applicable reviewing authority. These codes are in place to both preserve the Joshua Tree and to preserve the natural desert vegetation that exists in the Mojave River Valley.

The City of Hesperia agrees with the recommendation that the Commission find the petitioned action to list the western Joshua Tree as a threatened species to be not warranted. The petition submitted by the Center for Biological Diversity fails to provide scientific evidence to substantiate a decline of the western Joshua Tree population.

The City supports conservation efforts to protect the western Joshua Tree through existing and extensive protections that already exist at the federal, state, and local levels. However, the listing of the western Joshua Tree as a threatened species would place unnecessary burdens on local governments by severely limiting new development and construction which, consequently, will only worsen the statewide housing shortage and rising homelessness. Furthermore, a listing will harm residents and employees in the Mojave Desert communities by limiting job opportunities and requiring residents to commute to more urban areas which will exacerbate the existing issues of traffic congestion and pollution.

Local governments in the region, both cities and counties, already have strict regulations to protect the Joshua Tree in their planning codes. Generally, they require direct preservation and relocation along with stiff penalties for unpermitted removal and destruction of Joshua Trees. These are powerful, effective measures that are in place and actively enforced. While we are grateful for the Commission's interest in protecting the western Joshua Tree, given the tree's positive population trends and local protections, an endangered species listing is not warranted.

If you have any questions about our opposition to the listing of the Joshua Tree, please contact Jamie Carone from the City of Hesperia at (760) 947-1589 or jcarone@cityofhesperia.us.

Sincerely,

Brigit Bennington

Brigit Bennington, Mayor
City of Hesperia

385 N. Arrowhead Avenue, San Bernardino, CA 92415-0120 | Phone: 909.387.5418 Fax: 909.387.5430

www.SBCounty.gov

SAN BERNARDINO COUNTY

County Administrative Office

Leonard X. Hernandez
Chief Executive Officer

May 31, 2022

Eric Sklar
Commissioner, California Fish and Game Commission
P.O. 944209
Sacramento, CA 94244-2090
fgc@fgc.ca.gov

RE: June 15, 2022, Agenda Item No. 5 – Western Joshua Tree – Final Consideration of Petition to list western Joshua tree (Yucca brevifolia) as threatened under CESA. (Pursuant to Section 2074.6, Fish and Game Code)

Dear Commissioner Sklar:

On behalf of the County of San Bernardino ("County"), we thank the Commission for taking the time to consider our unique concerns regarding listing the western Joshua tree as a threatened species under the California Endangered Species Act ("CESA"). As a key stakeholder, the County appreciates the opportunity to submit information on this important matter.

This submittal is divided into two sections: (1) the County's support for the recommendation and findings of the California Department of Fish and Wildlife ("CDFW" or "Department") in its Status Review Report; and (2) information related to the Department's Management Recommendations and Recovery Measures for the western Joshua tree for the Commission's consideration in its decision process.

We feel strongly that you will see how the County has demonstrated a commitment to the protection of the western Joshua Tree through the various examples covered in this submittal. This is demonstrated most recently through the resolution and urgency ordinance adopted by the County Board of Supervisors which further protects the western Joshua tree from unlawful destruction and disturbance by increasing fines up to $20,000 per offense/tree and enforcing such violations as misdemeanors, which may include up to six months of imprisonment.

1. LISTING OF THE WESTERN JOSHUA TREE UNDER CESA IS NOT WARRANTED

The western Joshua tree is extremely important to the County. At more than 20,000 square miles, San Bernardino County is the largest county in the nation. The range and habitat of the western Joshua tree largely falls within the County's borders, and our local communities have deep appreciation for it as a symbol of resiliency and determination to survive and thrive in the desert. As a result, the County has a long history of land use management, planning and permitting involving the Joshua tree, and has unique insight on the species' range and abundancy, needs and challenges not possessed by other jurisdictions or entities.

It remains the County's position that listing the western Joshua tree under CESA would do little to address any long-term threat to the species and is not warranted under the law or science. The Department, at the Commission's direction in 2020, conducted a comprehensive and lengthy review of the species, and the resulting Status Review Report represents the best scientific information available on the western Joshua tree. The County supports the Department's recommendation that listing the western Joshua tree as threatened is not warranted, as it is based on extensive and peer-reviewed scientific data, thorough and thoughtful analysis, and proper interpretation of the applicable legal standards, as further explained in the County's legal and technical comments concurrently submitted with this letter.

2. THE COUNTY SUPPORTS THE DEPARTMENT'S MANAGEMENT RECOMMENDATIONS AND RECOVERY MEASURES FOR THE WESTERN JOSHUA TREE

The County also supports the Department's Management Recommendations and Recovery Measures for the western Joshua tree. The County agrees that the western Joshua tree faces real challenges and long-term conservation of the species is likely beyond the scope of any one government, agency, or organization.

The County stands ready as a vital and strong partner with the Department and other stakeholders to be at the forefront of such efforts. Among the commitments made by the County:

Recognized Leader in Greenhouse Gas Emissions Reduction, Renewable Energy and Sustainable Development

In the Management Recommendations and Recovery Measures portion of the Status Review Report, the Department placed atop its list of recommended actions to "Continue efforts to drastically reduce greenhouse gas emissions." To that end, the County has long been a leader in efforts to reduce greenhouse gas ("GHG") emissions and to plan sustainably for the future. Planning sustainably includes the County's acknowledgment of its local role in climate change and how the County can continue to reduce GHG emissions.

In 2007, the Board of Supervisors ("Board") launched Green County San Bernardino to spur the use of green technologies and building practices. By supporting green building practices, renewable energy, resource conservation, and other efforts to safeguard our environment, the Board set the course for sustainability and paved the way for responsible growth in the County.

In 2011, the County adopted a Greenhouse Gas Reduction Plan ("GHGRP") that included a comprehensive set of actions to reduce the external (e.g., private development) and internal (e.g., County emissions) GHG emissions to 1990 levels by 2020. The GHGRP was a first of its kind plan that provided measurable reductions of GHG emissions through a development review process by applying appropriate reduction requirements as part of the discretionary approval of new development projects. Through innovation and commitment, the County met its 2020 GHG reduction targets and has since adopted an Updated GHGRP consistent with the statewide target to reduce GHG emissions to 40 percent below 1990 levels by 2030.

In 2017, the County also adopted a Renewable Energy and Conservation Element ("RECE"), choosing to include it as an optional component of its general plan. The County recognizes that its lands have one of the highest potentials for renewable energy sources anywhere in the United States, making it a key stakeholder in achieving our Nation, State, and local goal of reducing GHG emissions through renewable resources. The RECE establishes goals and policies for a new era of sustainable energy production and consumption in the context of sound resource conservation and renewable energy development practices that reduce GHGs and dependency on fossil fuels. Goals and policies of the RECE specifically include the promotion of the County's efforts to meet or exceed the State's GHG reduction goals by encouraging renewable energy developments, as well as supporting the State's initiative to obtain 50% of the energy consumed in the state through renewable energy generation sources by 2040. The County has supported the development of 17 utility-oriented renewable energy projects that produce a combined 192 megawatts of renewable electrical energy, and numerous others have been approved and are awaiting construction.

More recently, the County is proposing to construct our new Emergency Operations Center as a Leadership in Energy and Environmental Design (or "LEED") Certified facility. We believe in making the investment to have a "green facility", even at a cost more than $10 million for the improvements to achieve the certification, is worth the investment to do our part in promoting green building practices.

In short, the County believes it is in the best interest of all stakeholders to work collaboratively on methods that would protect the western Joshua tree and manage it responsibly considering the global climate change threat, balancing the goals of conservation and the need for economic well-being in these challenging times.

Comprehensive Local Protection of the Western Joshua Tree

In addition to policies and plans to reduce GHG emissions, the County is committed to beneficial and sustainable land uses, including clean energy, essential development, and mineral extraction activities, that are necessary to maintain the state's infrastructure, provide critical housing, and achieve climate change goals. The County recognizes such activities and development must make the protection and preservation of the western Joshua tree a key component, as expressed in the Department's Management Recommendations and Recovery Measures with respect to disincentivizing the destruction of western Joshua tree habitat and implementing state and local laws and regulations that limit impacts to the species.

Indeed, the County has a long history of being at the forefront of enforcing robust conservation measures at the local level and across industry sectors to protect the western Joshua tree through a variety of local regulatory programs.

For example, on May 24, 2022, the County Board of Supervisors approved a resolution and urgency ordinance declaring the County's commitment to protecting the western Joshua tree by considering the measures noted above. The urgency ordinance further protects the western Joshua tree from unlawful destruction and disturbance by increasing fines up to $20,000 per offense and enforcing such violations as misdemeanors, which may include up to six months of imprisonment. It is worth noting that the County's local regulations provide protection to all subspecies of Joshua trees, commonly referred to as the western Joshua tree (*Yucca brevifolia*) and the eastern Joshua tree (*Yucca brevifolia jaegeriana*).

Further, for renewable energy generation facilities, like wind and solar, and surface mining projects, the County requires the submission of a closure, revegetation, and rehabilitation plan designed to restore vegetation and wildlife habitats to a condition at least as good as the pre-disturbed condition for renewable energy projects and surface mining operations. The County has consistently made the avoidance and replanting of western Joshua tree a key requirement for such development. In addition, the County requires financial assurances in connection with renewable energy generation facilities and surface mining operations to ensure approved restoration or reclamation plans can be successfully implemented.

Prior to the candidacy period, the County had been a leader in promoting nursery and vegetation programs as part of the resource industry permitting process. These native plant stock nurseries provide for reliable propagation and increase the number of re-establishment of Joshua trees and related endemic plants during required reclamation. The County would also require added measures of assurance including increasing the financial assurances to cover the cost to replace unsuccessful transplants with seedlings and/or nursery stock when identified during inspections.

The County's RECE, discussed above, also sets land development standards that protect the western Joshua tree and encourage responsible land stewardship. Unlike mineral resource extraction that must be located where the resource occurs, there is a degree of flexibility in siting solar energy power generation. This allows for avoidance of impacts to sensitive habitat, which is a very high priority for the County. Siting criteria for utility-scale solar energy generation, as detailed in RECE Policy 5.2, directs these projects to previously disturbed or developed sites, with a preference for sites with existing transmission infrastructure. A good example of this policy in application is the recent approval of the 650 MW Daggett Solar project, which will completely replace a gas-fired power plant on agricultural fields surrounding the plant. Not a single Joshua tree nor any other native plant will be affected by the development of this project.

With respect to residential and other development, the County has long had a regulatory permitting program, rooted in the California Native Desert Plants Act, designed to protect and preserve the western Joshua tree and is reinforced by a dedicated culture of avoidance, monitoring, and enforcement. No project located on a site containing western Joshua trees, or located in an area known to contain them, can proceed without a determination of presence/absence or avoidance within the building permit application, which can be validated through the field investigation process. The County has established a clear avoidance distance of forty (40) feet from any western Joshua tree. If any proposed grading/construction is less than that length, a Desert Native Plant Specialist will need to attest to and confirm avoidance of the species.

This program is discussed in the Status Review Report, along with other similar laws from other local jurisdictions. The County recognizes the need for uniform standards for protecting western Joshua tree habitat and individuals across the region, including strong disincentives to prevent the destruction of western Joshua trees and greater enforcement tools, as acknowledged in the Department's Management Recommendations and Recovery Measures. To that end, the County has spearheaded an effort with local jurisdictions to strengthen western Joshua tree permitting ordinances to provide for uniform avoidance measures, transplanting program, higher permitting fees, enhanced tracking and reporting programs, and stronger enforcement mechanisms to protect and preserve the species.

Established Commitment to Regional Conservation Investment Strategy With Focus on Western Joshua Tree Protection

The Status Review report includes a brief discussion of the San Bernardino County Regional Conservation Investment Strategy ("SBC RCIS") program. The County strongly supports the SBC RCIS and believes it is a vital and well-suited tool for addressing multi-species impacts, such as climate change, to better protect the western Joshua tree and the region. To that end, the County wanted to update the Commission and Department on these efforts.

The County approved pursuing the RCIS in October 2016. With the encouragement and support of CDFW, the County and its partners released a draft in December of 2018. The draft SBC RCIS established a framework for landscape level habitat conservation strategies, including western Joshua tree as a Focal Species. One focus is to maximize benefits of habitat conservation and enhancement activities informed by science and on-going research. For example, the SBC RCIS plans to include practical, community-based conservation strategies that will complement the Joshua Tree Genome Project. Potential strategies such as seed collection, propagation, planting of climate-hardy seedlings and adoption programs for specimens in need of care would engage the community in conservation.

Many local agencies and individuals have contributed to the SBC RCIS, and the groups were successful in obtaining a grant of $562,210 from the State Wildlife Conservation Board to complete a final RCIS. The administrative draft of the RCIS has been completed and is anticipated to be submitted to CDFW for the completeness review in early summer 2022.

Conservation strategies for habitat connectivity, adaptation to climate change and resiliency of multiple species form the core of the SBC RCIS. For these reasons, the RCIS program is ideally suited to address challenges faced by the western Joshua tree, along with many other associated focal species of transitional scrub, chaparral, and woodland habitats in the western Mojave Desert. The County asks that the Commission take into consideration the data, goals, and conservation priorities of the SBC RCIS in its consideration of the petition to list the western Joshua tree under CESA. It would be irresponsible to elevate the western Joshua tree for special protection while ignoring additional threats, as well as regional planning needs and statewide objectives.

In closing, as demonstrated by the Status Review, listing the western Joshua tree under CESA would do little to address any long-term threat to the species and is not warranted under the law or science. Listing the western Joshua tree under CESA would not result in the reduction of greenhouse gas emissions or minimize additional global warming. Indeed, protections focused only on western Joshua tree conservation may discourage sustainable development projects, such as utility-scale solar or other renewable energy facilities, undermining California's ability to achieve renewable energy goals designed to reduce emissions contributing to climate change. The County believes it is in the best interest of all stakeholders to work collaboratively on other methods, such as those identified by CDFW, that would protect the western Joshua tree and manage them responsibly considering the global climate change threat, balancing the goals of conservation and the need for economic wellbeing in these challenging times.

Given that the western Joshua tree habitat largely falls within its borders and that the County has an established role in managing and protecting the species, the County appreciates this opportunity to comment on the Status Review Report and participate in the upcoming Commission meeting as a key stakeholder.

I would like to extend an offer to meet with you and discuss this important issue. If you would like to meet, or if you have any questions regarding this submission, please contact me directly at (909) 387-5417 or at [redacted].

We look forward to a continued partnership with the Commission and the Department in working on this important issue.

Sincerely,

Leonard X. Hernandez
County Executive Officer

CC:
Members, California Fish and Game Commission fgc@fgc.ca.gov
Melissa Miller-Henson, Executive Director, California Fish and Game Commission fgc@fgc.ca.gov
Charlton H. Bonham, Director, California Department of Fish and Wildlife Director@wildlife.ca.gov

REPORT/RECOMMENDATION TO THE BOARD OF SUPERVISORS OF SAN BERNARDINO COUNTY AND RECORD OF ACTION

May 24, 2022

FROM
DAVID DOUBLET, Director, Land Use Services

SUBJECT
Resolution Regarding Joshua Tree Protections and Ordinances to Increase Fines for the Unlawful Removal of Joshua Trees

RECOMMENDATION(S)
1. Adopt **Resolution No. 2022-81** declaring intent to evaluate and consider updates to local regulations and development of programs designed to further protect and preserve Joshua trees.
2. Consider proposed urgency ordinance relating to increased fines for the unlawful removal of Joshua trees in violation of Chapter 88.01 of the County Code.
   a. Make alterations, if necessary, to proposed urgency ordinance.
   b. Approve introduction of proposed urgency ordinance.
      - An urgency ordinance of San Bernardino County, State of California, to add section 11.0206(a)(1)(C) to Chapter 2 of Division 1 of Title 1 of the San Bernardino County Code relating to increased fines for the unlawful removal of Joshua trees.
   c. ADOPT **URGENCY ORDINANCE No. 4432** (Four votes required).
   d. Direct the Clerk of the Board of Supervisors to file a Notice of Exemption.
3. Consider proposed ordinance relating to increased fines for the unlawful removal of Joshua trees in violation of Chapter 88.01 of the County Code.
   a. Make alterations, if necessary, to proposed ordinance.
   b. Approve introduction of proposed ordinance.
      - An ordinance of San Bernardino County, State of California, to add section 11.0206(a)(1)(C) to Chapter 2 of Division 1 of Title 1 of the San Bernardino County Code relating to increased fines for the unlawful removal of Joshua trees.
   c. SCHEDULE FOR FINAL ADOPTION ON TUESDAY, JUNE 14, 2022, on the Consent Calendar.
   d. Direct the Clerk of the Board of Supervisors to file a Notice of Exemption.

(Presenter: David Doublet, Director, 387-4431)

COUNTY AND CHIEF EXECUTIVE OFFICER GOALS & OBJECTIVES
Ensure Development of a Well-Planned, Balanced, and Sustainable County.
Provide for the Safety, Health and Social Service Needs of the County Residents.

FINANCIAL IMPACT
Approval of this item will not result in the use of additional Discretionary General Funding (Net County Cost). Funds collected from fines would go towards efforts and future programs for the increased preservation of western Joshua trees.

BACKGROUND INFORMATION

This item includes a resolution relating to the County's desire to reexamine and consider additional local regulation designed to increase protections for Joshua trees, as well as an urgency ordinance and standard ordinance adopting increased fines for the unlawful removal of Joshua trees in violation of the County Code. The County's local regulations apply to all subspecies of Joshua trees, commonly referred to as the western Joshua tree (*Yucca brevifolia*) and the eastern Joshua tree (*Yucca brevifolia jaegeriana*). The intent of the resolution and ordinance is to establish a policy directive related to future regulations and to adopt an appropriate fine that will serve as an effective deterrence for the unlawful removal of Joshua trees, including western Joshua trees, in the event the tree is not listed as endangered pursuant to the California Endangered Species Act (CESA).

Procedural History

On October 21, 2019, a petition to list the western Joshua tree as threatened under CESA was submitted to the California Fish and Game Commission (Commission). Thereafter, at its scheduled public meeting on September 22, 2020, the Commission found that sufficient information existed to indicate the petitioned action may be warranted, accepted the petition for consideration, and the western Joshua tree was designated a candidate species under CESA on October 9, 2020.

The Commission's action designating the western Joshua tree as a candidate species triggered the California Department of Fish and Wildlife's (Department) process for conducting a status review to inform the Commission's future decision on whether listing the species is warranted under CESA. At its scheduled public meeting on April 21, 2022, the Department provided the Commission with its status review report recommending that the Commission find that the petition to list the western Joshua tree as a threatened species is not warranted. The Commission is expected to consider the Department's status review report and make a determination on whether to list the western Joshua tree as a threatened species under CESA during its scheduled public meeting on June 15 and 16, 2022.

Local Management

The County and its residents have a deep appreciation for the Joshua tree as a symbol of resiliency and determination to survive and thrive in the desert. The Joshua tree has significant psychological and tangible benefits for both County residents and visitors as they contribute to the attractiveness and livability of the desert communities. For these reasons, the County has long had a regulatory permitting program designed to protect and preserve the Joshua tree. However, the County recognizes the need to reexamine local regulations and to consider updated management regulations designed to help further preserve the Joshua tree, as well as an immediate need for enhanced fines to deter violations of local regulations and make enforcement actions more impactful in order to prevent the unlawful removal of Joshua trees.

Resolution

The proposed resolution sets forth a declaration of intent regarding a policy direction for future Joshua tree regulations. The County remains steadfast in its desire to further protect and preserve the Joshua tree, including the western Joshua tree, in the event it is not granted protections under CESA, by reexamining local regulations. The County intends to evaluate and consider the implementation of a transplantation program designed to promote and incentivize the transplantation of Joshua trees when removed, the creation of a census to better track, monitor and study Joshua tree trends, and to establish a mitigation fund to be utilized to help fund efforts to further protect the species.

Ordinance

Section 25123 of the California Government Code provides for action by urgency ordinance when immediate action is needed to preserve public peace, health, and safety. This item proposes an urgency ordinance to increase the fines to deter violators and make enforcement action more impactful in order to prevent the unlawful removal of the Joshua tree, including the western Joshua tree in the event it is not granted protections under CESA. Currently, the fine for illegal removal of a Joshua tree in violation of the County Code is punishable as follows:

Current Fines: Fine of not less than $500 nor more than $1,000, or six months in jail, or both. The unlawful removal of each tree is a new and separate offense.

To ensure the immediate preservation of the Joshua tree, the proposed urgency ordinance would increase the fines as follows:

Proposed Fines: Base fine of up to $5,000 for 1st offense; up to $10,000 for 2nd offense; and, up to $20,000 for 3rd offense, or imprisonment not to exceed six months, or both base fine and imprisonment. The unlawful removal of each tree is a new and separate offense.

This item also includes the adoption of the same regulations on a non-urgency basis.

California Environmental Quality Act Compliance

The proposed action is recommended to minimize and reduce environmental impacts in San Bernardino County for the unlawful removal of Joshua trees. Neither the resolution or ordinances are subject to the California Environmental Quality Act (CEQA), pursuant to sections 15060(c)(2) and 15061(b)(3) of the CEQA Guidelines. These sections apply to actions that will not result in significant physical impacts on the environment. The ordinances are also exempt from CEQA pursuant to section 15308 of the CEQA Guidelines, which applies to actions undertaken by a regulatory agency to ensure the protection of the environment.

PROCUREMENT

Not applicable.

REVIEW BY OTHERS

This item has been reviewed by County Counsel (Jason Searles, Deputy County Counsel, 387-5455) on May 17, 2022; Finance (Erika Rodarte, Administrative Analyst III, 387-4919) on May 17, 2022; and County Finance and Administration (Robert Saldana, Deputy Executive Office, 387-5423) on May 17, 2022.

Resolution Regarding Joshua Tree Protections and Ordinances to Increase Fines for the Unlawful Removal of Joshua Trees
May 24, 2022

Record of Action of the Board of Supervisors
San Bernardino County

APPROVED (CONSENT CALENDAR)

Moved: Curt Hagman   Seconded: Janice Rutherford
Ayes: Col. Paul Cook (Ret.), Janice Rutherford, Dawn Rowe, Curt Hagman, Joe Baca, Jr.

Lynna Monell, CLERK OF THE BOARD

BY Lynna Monell
DATED: May 24, 2022

cc: File – w/ Final BAI

JLL 05/25/2022

RESOLUTION NO. 2022-81

RESOLUTION OF THE BOARD OF SUPERVISORS OF SAN BERNARDINO COUNTY, RELATED TO DESIRE FOR UNIFORM ADOPTION OF WESTERN JOSHUA TREE REGULATIONS

On Tuesday, May 24, 2022, on motion of Supervisor Hagman, duly seconded by Supervisor Rutherford and carried, the following resolution is adopted by the Board of Supervisors of San Bernardino County, State of California.

WHEREAS, on October 21, 2019, a petition to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act (CESA) was submitted to the California Fish and Game Commission (Commission); and

WHEREAS, on March 11, 2020, the California Department of Fish and Wildlife (Department) provided the Commission with its evaluation of the petition to assist the Commission in making a determination as to whether the petitioned action may be warranted; and

WHEREAS, at its scheduled public meeting on September 22, 2020, the Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, western Joshua tree was designated a candidate species under CESA on October 9, 2020; and

WHEREAS, the Commission's action designating western Joshua tree as a candidate species triggered the Department's process for conducting a status review to inform the Commission's future decision on whether listing the species is warranted. The review process included independent peer review of a draft status review by persons in the scientific/academic community acknowledged to be experts on subjects relevant to the status review of the western Joshua tree and possessing the knowledge and expertise to critique the scientific validity of the status review contents; and

WHEREAS, at its scheduled public meeting on April 21, 2022, the Department provided the Commission with its status review that concludes, in part, that scientific evidence does not demonstrate that populations of the western Joshua tree are negatively trending in a way that would lead the Department to believe that the western Joshua tree is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future. As a result, the Department recommended that the Commission find that the petition to list western Joshua tree as a threatened species is not warranted; and

WHEREAS, at is scheduled public meeting on June 16, 2022, the Commission is expected to consider the Department's status review and make a determination on whether to list the western Joshua tree as a threatened species under CESA; and

WHEREAS, notwithstanding the Commission's future action on the petition, San Bernardino County ("County") finds that the western Joshua tree provides a significant psychological and tangible benefit for both residents and visitors to the County that are deserving of additional management regulations to protect and preserve the western Joshua tree from the hazards identified by the Department in the status review report in the event the Commission concludes that the petition to list the western Joshua tree as a threatened species is not warranted.

NOW, THEREFORE, BE IT RESOLVED AND ORDERED, the Board of Supervisors of San Bernardino County declares that:

A. The County remains steadfast in its desire to further protect and preserve the western Joshua tree in the event the western Joshua tree is not granted protections under CESA, by reexamining local regulation and exploring the adoption of uniform set of management regulations with other regulatory agencies that are designed to preserve and manage western Joshua tree habitat, implement disincentives to the destruction of western Joshua trees, and ensure proper enforcement.

B. The County is committed to protecting the western Joshua tree from unlawful destruction or unpermitted disturbance by levying significant fines against those offending individuals or agencies, including enforcing such violations as misdemeanor offenses.

C. The County is supportive of the establishment of a western Joshua tree mitigation fund and the development of a corresponding program to collect funding from fines and penalties assessed to those who unlawfully destroy, or remove without a permit, a western Joshua tree.

D. The County will evaluate and consider the implementation of a transplantation program that provides incentives for transplantation of western Joshua trees, promoting effective transplantation versus the removal of trees where feasible.

E. The County is supportive of the preparation of a western Joshua tree census, which can be tracked, updated, and monitored to ensure the species continues to thrive, and allows adjustments in practices and increased protections should the census demonstrate a significant deterioration in the prevalence or overall health of the western Joshua tree.

PASSED AND ADOPTED by the Board of Supervisors of San Bernardino County, State of California, by the following vote:

AYES: SUPERVISORS: Col. Paul Cook (Ret.), Janice Rutherford, Dawn Rowe Curt Hagman

NOES: SUPERVISORS: None

ABSENT: SUPERVISORS: None

* * * * *

STATE OF CALIFORNIA)
) ss.
SAN BERNARDINO COUNTY)

I, **LYNNA MONELL**, Clerk of the Board of Supervisors of San Bernardino County, State of California, hereby certify the foregoing to be a full, true and correct copy of the record of the action taken by the Board of Supervisors, by vote of the members present, as the same appears in the Official Minutes of said Board at its meeting of May 24, 2022. Item #110 JLL

LYNNA MONELL
Clerk of the Board of Supervisors

By ______________________
Deputy

BOARD OF SUPERVISORS
COUNTY OF SAN BERNARDINO
1853
SAN BERNARDINO COUNTY, CA

URGENCY ORDINANCE NO. 4432

An urgency ordinance of San Bernardino County, State of California, to add section 11.0206(a)(1)(C) to Chapter 2 of Division 1 of Title 1 of the San Bernardino County Code relating to increased fines for the unlawful removal of Joshua trees.

The Board of Supervisors of the County of San Bernardino, State of California, ordains as follows:

SECTION 1. The Board of Supervisors of San Bernardino County finds that:

(a) At just over 20,000 square miles, San Bernardino County (County) is the largest county in the contiguous United States. Among the features that contribute to the attractiveness and livability of the County desert communities are its Joshua trees growing as single specimens or in clusters. These trees have significant psychological and tangible benefits for both residents and visitors. The County and its residents have a deep appreciation for the Joshua tree as a symbol of resiliency and determination to survive and thrive in the desert. The Joshua tree contributes to the visual framework of the County by providing scale, color, silhouette and mass. The Joshua tree also provides screens and buffers to separate land uses and contributes to the protection of other natural resources by providing erosion control for the soil, oxygen for the air and habitat for wildlife. The Joshua tree contributes to the economy of the County by sustaining property values and as an iconic emblem of the region.

(b) The County has a strong desire to protect and preserve the Joshua tree, as shown by the adoption of local regulations designed to regulate the removal of Joshua trees, to prevent unnecessary loss, to encourage replacement planting, and to effectively enforce unlawful removal. The County's local regulations apply to all subspecies of Joshua trees, commonly referred to as the western Joshua tree (*Yucca brevifolia)* and the eastern Joshua tree (*Yucca brevifolia jaegeriana*).

(c) On October 21, 2019, a petition to list the western Joshua tree as threatened under the California Endangered Species Act (CESA) was submitted to the Fish and Game Commission (Commission). Thereafter, at its scheduled public meeting on September 22, 2020, the Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the western Joshua tree was designated a candidate species under CESA on October 9, 2020.

(d) The Commission's action designating the western Joshua tree as a candidate species triggered the California Department of Fish and Wildlife's (Department) process for conducting a status review to inform the Commission's future decision on whether listing the species is warranted.

(e) At its scheduled public meeting on April 21, 2022, the Department provided the Commission with its status review report which recommended that the Commission find that the petition to list the western Joshua tree as a threatened species is not warranted. At its scheduled public meeting on June 15 and 16, 2022, the Commission is expected to consider the Department's status review and make a determination on whether to list the western Joshua tree as a threatened species under CESA.

(f) During the candidacy period the western Joshua tree has received protection from removal (i.e., take) under CESA, including enhanced punishment for the violation of an unlawful removal. (Fish and Game Code §§ 12000-12300.) In the event the Commission accepts the Department's recommendation regarding the western Joshua tree and local regulation is restored, the County's existing misdemeanor fines for the unlawful removal of Joshua trees do not provide an appropriate deterrence given the importance and value of the Joshua tree as described in subsection (a). In order to protect the public peace, health, and safety that the Joshua tree provides, this urgency ordinance provides for increased fines to deter violators and make enforcement actions more impactful in order to prevent the unlawful removal of the Joshua tree.

(g) Accordingly, consistent with Government Code section 25123, subdivision (d), the Board of Supervisors finds that an increase in fines for the unlawful removal of a Joshua tree in violation of the County's plant protection and management regulations are necessary for the immediate preservation of the public peace, health and safety of the residents of the County.

(h) This ordinance is not subject to review under the California Environmental Quality Act (CEQA) pursuant to CEQA Guidelines, 14 California Code of Regulations, sections 15060, subdivision (c)(2) (the activity will not result in a direct or reasonably foreseeable indirect physical change in the environment) and 15061, subdivision (b)(3) (there is no possibility the activity in question may have a significant effect on the environment). In addition to the foregoing general exemptions, the Board of Supervisors further finds that the ordinance is categorically exempt from review under CEQA under the Class 8 Categorical Exemption, 14 California Code of Regulations section 15308 (regulatory activity to assure protection of the environment). There are no unusual circumstances under CEQA Guidelines, 14 California Code of Regulations, section 15300.2, subdivision (c) that would render these exemptions inappropriate. Each exemption stands as a separate and independent basis for determining that this ordinance is not subject to CEQA.

SECTION 2. Section 11.0206(a)(1)(C) is added to Chapter 2, Division 1, Title 1 of the San Bernardino County Code to read:

11.0206 Criminal Actions.

...

(C) *Violations of Chapter 88.01.* Notwithstanding the penalty provisions in Section 88.01.050(j)(1), upon conviction of a misdemeanor, or upon a plea of nolo contendere (commonly called "no contest") involving misdemeanor violations of Chapter 88.01 related to the unlawful removal of a Joshua tree, the penalty shall be as follows:

(I) Any person convicted of a misdemeanor for the unlawful removal of a Joshua tree in violation of Chapter 88.01 shall be punished by a base fine of up to $5,000.00 upon a first conviction, by a base fine of up to $10,000.00 for a second conviction, by a base fine of up to $20,000.00 upon a third or subsequent conviction, or by imprisonment in the County jail for a period of not more than six months, or by both such base fine and imprisonment;

(II) The unlawful removal of each Joshua tree in violation of Chapter 88.01 shall be a new and separate offense.

SECTION 3. The Board of Supervisors declares that it would have adopted this ordinance and each section, sentence, clause, phrase, or portion of it, irrespective of the fact that any one or more sections, subsections, clauses, phrases or portions of it be declared invalid or unconstitutional. If for any reason any portion of this ordinance is declared invalid or unconstitutional, then all other provisions of it shall remain valid and enforceable.

SECTION 4. This ordinance shall take effect immediately upon its adoption.

Curt Hagman

CURT HAGMAN, Chairman
Board of Supervisors

SIGNED AND CERTIFIED THAT A COPY
OF THIS DOCUMENT HAS BEEN DELIVERED
TO THE CHAIRMAN OF THE BOARD

LYNNA MONELL, Clerk of the
Board of Supervisors

Lynna Monell

STATE OF CALIFORNIA)
) ss.
SAN BERNARDINO COUNTY)

I, LYNNA MONELL, Clerk of the Board of Supervisors of San Bernardino County, State of California, hereby certify that at a regular meeting of the Board of Supervisors of said County and State, held on the 24th day of May, 2022, at which meeting were present Supervisors: Col. Paul Cook (Ret.), Janice Rutherford, Dawn Rowe, Curt Hagman, Joe Baca, Jr., and the Clerk, the foregoing ordinance was passed and adopted by the following vote, to wit:

AYES: SUPERVISORS: Col. Paul Cook (Ret.), Janice Rutherford, Dawn Rowe, Curt Hagman, Joe Baca, Jr.

NOES: SUPERVISORS: None

ABSENT: SUPERVISORS: None

IN WITNESS WHEREOF, I have hereunto set my hand and affixed the official seal of the Board of Supervisors this 24th day of May, 2022.

LYNNA MONELL, Clerk of the
Board of Supervisors of
San Bernardino County,
State of California

BOARD OF SUPERVISORS COUNTY OF SAN BERNARDINO 1853 SAN BERNARDINO COUNTY, CA

Deputy

Approved as to Form:

TOM BUNTON
County Counsel

By: Jolena Grider
JOLENA E. GRIDER
Deputy County Counsel

Date: 5-31-2022

2NV7160

May 31, 2022

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

RE: Listing of the Western Joshua Tree as a California Endangered Species – OPPOSE

Dear President Murray and Members of the Commission,

On behalf of Desert Mountain Division of the League of California Cities, I urge you to not list the Western Joshua Tree as a California endangered species. The Western Joshua Tree is an iconic California native species and an important symbol of the Mojave Desert. We strongly believe that this special species should be protected and preserved for generations to come, and we appreciate the Commission's efforts to do so. However, a listing as an endangered species is not justified given the positive population trends of the Joshua Tree.

The recently released Department of Fish and Wildlife Status Review Report found that the Western Joshua Tree is abundant and widespread, indicating that it faces a low threat of extinction. A central finding of the Status Review is that "the scientific evidence that is currently possessed by the Department does not demonstrate that populations of the species are negatively trending in a way that would lead the Department to believe that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future." This conclusion, drawing upon the best available scientific data, suggests that listing the Western Joshua Tree as endangered is not justified by the evidence at hand. Furthermore, a listing would be a huge undertaking for the Department of Fish and Wildlife, requiring it to issue permits and regulate Western Joshua Tree removal across the Mojave Desert, an area of roughly 25,000 square miles which is larger than the state of West Virginia. This heavy administrative burden would detract from the state's ability to protect other species that are at far greater risk of extinction.

The Western Joshua Tree has benefited from extensive conservation efforts and widely expanded habitat protections, many recent, which remove the need for threatened status. In fact, in 2019, the John D. Dingell Jr. Conservation, Management, and Recreation Act placed into protected statuses hundreds of thousands of acres of federal lands upon which Western Joshua Trees grow. Three years prior, nearly 2 million acres of desert lands containing Western Joshua Tree habitat were placed into protection using the Antiquities Act. Outside federal jurisdiction, the Western Joshua Tree is protected under state law through the California Desert Native Plants Act, and by local government development codes, all which require permitting for removal. Additionally, most Western Joshua Trees exist on land already protected by the state and federal governments.

While listing the Western Joshua Tree as a threatened species would have little effect on its population, it would have a disastrous effect on local governments and economies. Our communities are surrounded by federal lands, with little opportunity for new housing or economic development. Listing the Western

Joshua Tree as an endangered species would effectively halt future development at a time when our communities are grappling with housing shortages and rising homelessness.

Local governments in our region, both cities and counties, already have strict regulations to protect the Western Joshua Tree. Generally, they require direct preservation and relocation along with stiff penalties for unpermitted removal and destruction of Western Joshua Trees. These are powerful, effective measures that are in place and actively enforced. While we are grateful for the Commission's interest in protecting the Western Joshua Tree, given the tree's positive population trends and local protections, an endangered species listing is not warranted.

If you have any questions about our opposition to the listing of the Western Joshua Tree, please contact Scott Nassif, Division Past President and Town of Apple Valley Council Member, at 760-617-0941 or at snassif@applevalley.org.

Sincerely,

Randall Putz
Desert Mountain Division President
City of Big Bear Lake Council Member

CITY OF
VICTORVILLE

760.955.5000
FAX 760.269.0013
vville@victorvilleca.gov
http://victorvilleca.gov

14343 Civic Drive
P.O. Box 5001
Victorville, California 92393-5001

May 31, 2022

Ms. Samantha Murray
President
California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090
Emailed to: fgc@fgc.ca.gov

Re: Opposition to the listing of the Western Joshua Tree

Dear President Murray,

On behalf of the Victorville City Council, I write in strong opposition to the listing of the Western Joshua Tree as a threatened species under the California Endangered Species Act (CESA). The Joshua Tree already receives management protections at the federal, state, and local levels. Listing the tree would add redundant protections that place a significant financial burden on private landowners while doing little to address a long-term threat to the species.

The California Mojave Desert is comprised of growing, underserved communities that face economic challenges unlike other areas of our state. Listing the Joshua Tree would effectively halt future development in our communities at a time when California is grappling with housing shortages and rising homelessness.

Much of the Western Joshua Tree population resides on federally protected lands and state preserves, giving them the highest level of protection. Outside those jurisdictions, they are protected under state law through the California Environmental Quality Act, the California Desert Native Plants Act, and local ordinances. Here in Victorville, we rely on our Municipal Code to influence protection of the Western Joshua Tree Species by making it a misdemeanor to unlawfully remove the Western Joshua Tree. Violating our Municipal Code in this regard is punishable by either a fine, jail time or both. I share this with you to help illustrate that our local code is working. Recent testimony to this involves the successful relocation of 119 Western Joshua Trees in 2020 from a 360-acre site that now serves as a 100-megawatt solar generating facility. I am pleased to report that all 119 Western Joshua Trees have been successfully transplanted to our City-owned Greentree Golf course.

I urge you to consider the significant impacts this listing will have on our communities and respectfully ask that the Fish and Game Commission concur with the California Department of

Fish and Wildlife's recommendations and decide not to grant the species permanent protection under CESA.

Thank you,

Debra Jones
Mayor
City of Victorville

cc: Victorville City Council
Keith C. Metzler, City Manager
Sophie Smith, Deputy City Manager
Jenele Davidson, Deputy City Manager
Department/Division Heads
California Assemblymember Thurston "Smitty" Smith
California Senator Scott Wilk
Andre de Bortnowsky, City Attorney

June 2, 2022

Ms. Samantha Murray, President
California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

RE: PETITION AND STATUS REVIEW REPORT RE: THE WESTERN JOSHUA TREE

Dear President Murray,

The Town of Yucca Valley, more than any other community in the state, values the integration of the desert environment, including the Joshua Tree and other unique desert plants, into our continued development as a community. As evidenced by our Town logo, as well as our General Plan Vision and Values, the desert environment is woven into the fabric of this community.

After careful consideration, the Town of Yucca Valley Town ***strongly supports and encourages the Commission to accept*** the Department of Fish and Wildlife staff recommendation regarding the petition as it is "***based on the best scientific information available to the Department***". This approach would be consistent with the past and best practices of the Commission to rely on scientific justification in taking actions within the purview and charge of the Commission, while providing a consistent and defensible basis for further actions and decisions.

The Petition clearly identifies that significant western Joshua tree habitat is located on federal lands. As such, the state of California has the opportunity to collaborate with the federal government on conservation efforts designed to protect the western Joshua tree and its surrounding habitat. To place the conservation requirements onto private property owners without a scientific basis, and prior to governmental agencies attempting to collaborate and cooperate in implementing effective conservation efforts, is neither good public policy nor good governance. Further, local regulations continue to be an effective regulatory tool that will assist in the preservation of the western Joshua Tree through public review and transparency of native plant permit requests, regulations that prioritize avoidance, preservation, and conservation, and enhanced enforcement when necessary.

We would also like to share an example of the current abundance of the western Joshua Tree. Virtually every residential lot in the Town of Yucca Valley has multiple Joshua trees of various ages, from pups to mature trees. While the Town does not have a scientific census of trees, a reasonable estimate of all Joshua trees within Town limits would range in the hundreds of thousands of trees.

TOWN OF YUCCA VALLEY, CALIFORNIA • INC. NOV. 27, 1991 •
The Town of Yucca Valley
57090 Twentynine Palms Highway • Yucca Valley, California 92284
760/369-7207 • Fax (760) 369-0626

The abundance of the western Joshua tree was highlighted over the course of the past year when the Town was authorized through its 2084 take permit to issue limited take of the tree. In the past 14 months, the Town issued 391 take permits for the western Joshua tree for minor ministerial projects including in-fill single family homes, private single family residential sewer connections to meet the state's mandated septic discharge prohibition, and essential public works projects. During this time, the Town conducted over twenty public meetings to review the various permit applications, take public comment, and collected over $600,000 in mitigation fees paid by property owners . A sample agenda report is included as an attachment for the Commission's reference. The Town was not involved in the issuance of any take permits for commercial, industrial, or multi-family projects during this period. We share these facts simply as an illustration that the western Joshua tree is abundant and widespread, and as a practical illustration of the Department of Fish and Wildlife's recommendation that the tree does not warrant listing at this time.

We appreciate the Commission's role in administering the California Endangered Species Act, and recognize the many differing scientific opinions the Commissioner's will be presented with. At the conclusion of the review period, we would ask that the Commission consider the professional and unbiased scientific work completed by the Department of Fish and Wildlife on this petition, and encourage the Commission to accept the Department recommendation.

Thank you for your time and consideration and know that the Commission has a standing invitation to visit our beautiful Town where we can share with you the successful conservation and preservation of regulated desert native plants including the western Joshua Tree.

Jim Schooler

TOWN OF YUCCA VALLEY
Jim Schooler
Mayor

Attachment

Sample staff report for 2084 take permit

Yucca Valley Planning Commission

May 9, 2022

- Staff report for the transplantation of three western Joshua Trees for the installation of solar power at a typical residence in the Town of Yucca Valley
- On the May 9, 2022 Planning Commission agenda, there were 45 similar staff reports with an agenda total of 1,900 pages.

Town of Yucca Valley
PLANNING COMMISSION STAFF REPORT

To:	Honorable Chair and Planning Commissioners
From:	Janet Yochmowitz, Administrative Assistant II Jared Jerome, Associate Planner
Date:	July 20, 2021
Meeting Date:	May 9, 2022
Subject:	Western Joshua Tree (WJT) Permit 048-21, 56005 Highland Trail, Yucca Valley CA. APN: 0586-231-17; Transplant Three (3) Western Joshua Trees

Recommendation:
That the Planning Commission reviews the application for WJT 048-21, transplant of three (3) Western Joshua Trees, based upon Ordinance 291 Section 9.56.090 that the western Joshua Trees are within 10 feet of ground disturbing activities, Section 9.56.070(A) that all necessary submittal materials have been submitted, Section 9.56.100 that to the maximum extent feasible the project proponent shall relocate all Western Joshua trees that cannot be avoided, Section 9.56.120 that all necessary mitigation fees have been paid by the applicant, and Section 9.56.140 that all necessary administrative citation fees have been paid by the applicant for each tree taken without a permit.

Prior Review
There has been no prior review of this matter.

Executive Summary
Native plant permit applications are acted upon by the Planning Commission for review and action at this time.

Order of Procedure

Request Staff Report
Request Public Comment
Council Discussion/Questions of Staff
Motion/Second
Discussion on Motion
Call the Question

Discussion

Applicant:	Better Earth Electric Inc.
Address:	56005 Highland Trail
APN:	0586-231-17
Zoning:	Rural Living (R-L-1)
Parcel Size:	2.5 acres

After obtaining Town approval to build a ground mounted solar installation on a property with an existing single-family-residence, the applicant began ground disturbing activities within ten (10) feet of the Western Joshua Trees on site and relocated the Western Joshua Trees without an approved Western Joshua Tree permit. The applicant was fined pursuant to Section 9.56.130, for each Western Joshua Tree that was within ten (10) feet of the ground disturbing activity and was required to obtain a Western Joshua Tree permit. Only the Western Joshua Tree application is before the Commission; not the construction permits for the solar installation.

Section 9.56.070 of Ordinance 291 requires photos, descriptions of the trees, and a letter from the applicant's arborist; which are attached to this report. The Western Joshua Trees to be transplanted are identified in the attached census report materials as WJT #2, WJT #3, and WJT #3A.

Section 9.56.090 states:
The project proponent shall avoid all ground-disturbing activities within 10 feet of any western Joshua tree, unless those activities will be temporary, will not physically impact the western Joshua tree or its root system, and will not disturb the soil to a depth of greater than twelve inches.

Section 9.56.100 requires "*...to the maximum extent feasible, the project proponent shall relocate all western Joshua Trees that cannot be avoided to another location on the project site,*" and that all relocations of western Joshua Trees which are one meter or greater in height be completed by a desert native plant specialist.

Section 9.56.120 details the mitigation fees required for the transplant or removal of western Joshua Trees. The applicant has provided the Town payment of these mitigation fees.

Alternatives
Staff recommend no alternative actions.

Fiscal Impact
NA

Attachments:
WJT 048-21, 56005 Highland Trail - Solar
ORD 291 Joshua Trees
9.60 Permit Procedures

Western Joshua Tree Application

Date Received [illegible]
Case [illegible]
By [illegible]

General Information

APPLICANT Better Earth Electric Inc Phone 888-373-9379; 909-334-0880

Mailing Address 1815 E. Wilshire Ave Suite 908 Email santaanapermits@betterearth.solar

City Santa Ana State CA Zip 92705

PROPERTY OWNER LISA M BONG Phone [redacted]

Mailing Address [redacted] Email [redacted]

City Yucca Valley State CA Zip 92284

Address/Location of Plants [redacted]

Desert Native Plant Specialist ArborPro Michael Murphy WE-4587A

Project Information

TYPE OF PLANT	# OF PLANTS BEING DESTROYED	# OF PLANTS BEING TRANSPLANTED	# OF PLANTS BEING TRIMMED	APPLICATION FEE	HEIGHT	DIAMETER	MITIGATION FEE FOR REMOVAL
		-0-	0	$500.00			
WESTERN JOSHUA TREE (Yucca brevifolia)	0	3			Report	Attached	$525

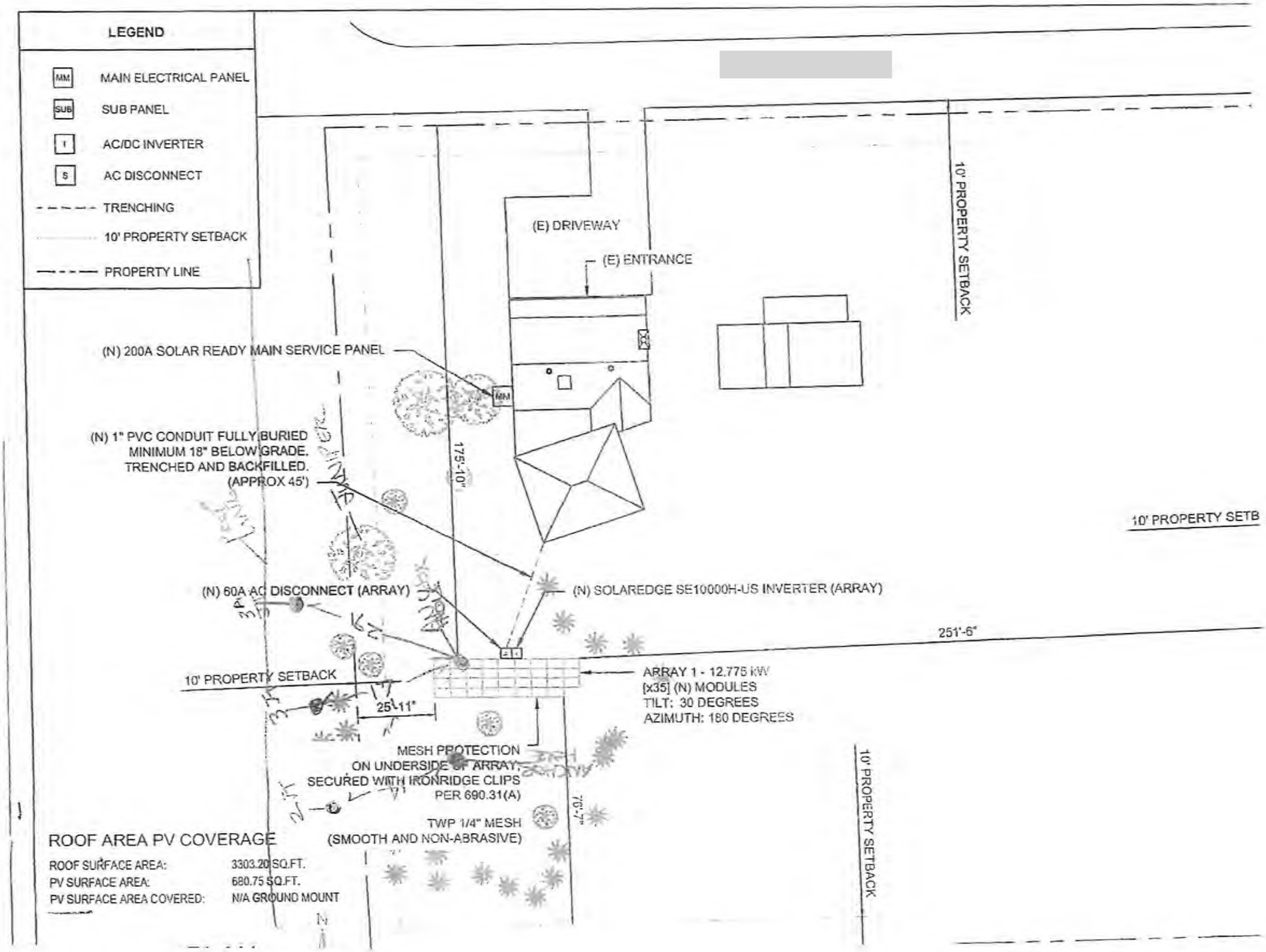
Reason for removal Most of the Joshua Trees on this property appear to be in good health. The #4 tree fell over and is still growing fairly well. #13 is a group of trees counted as one.

Property owner signature Lisa M. Bong Date 6/28/21

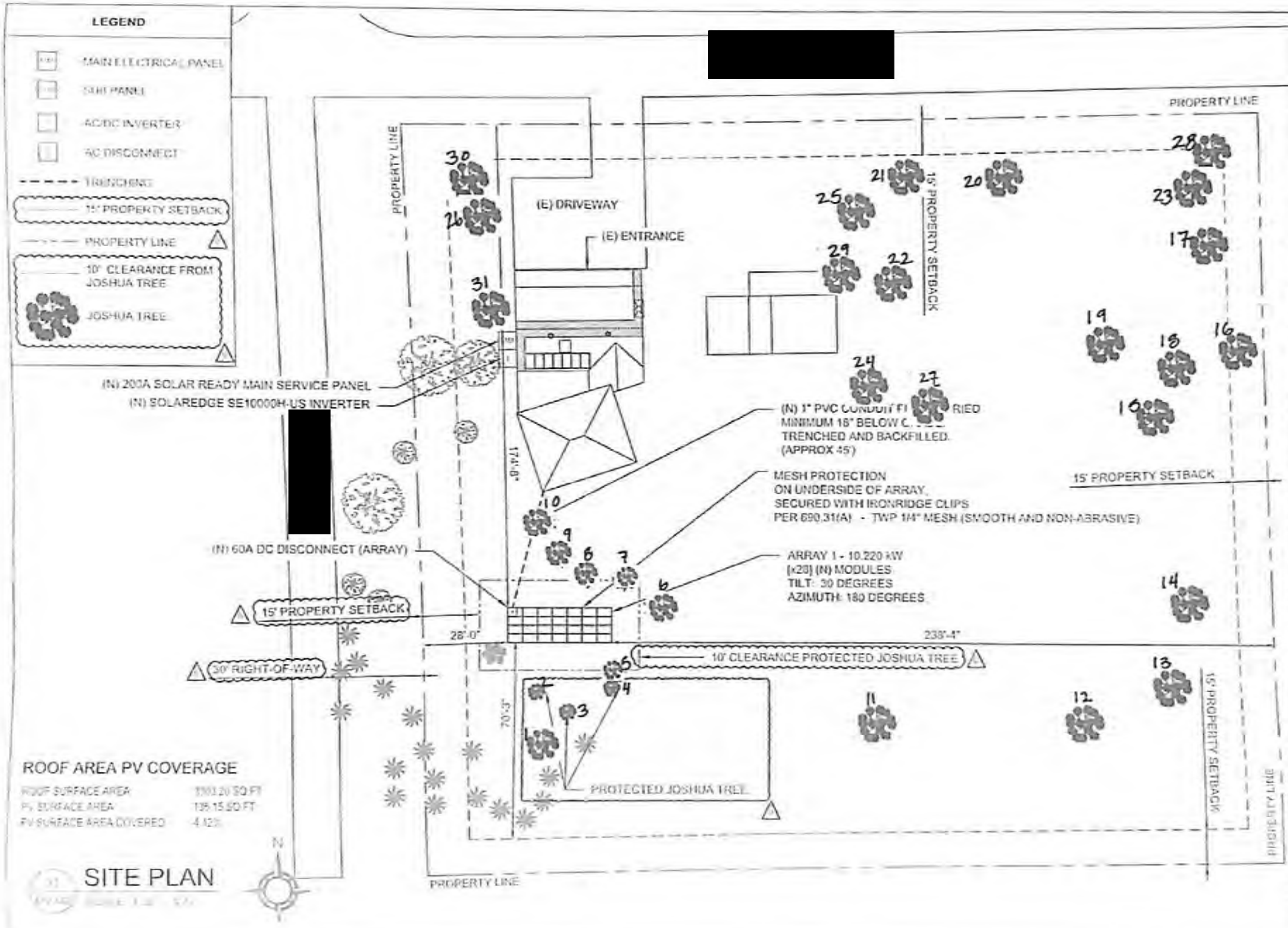
Staff Use Only
Issuance Date: ______ Issued By: ______

Approved as shown on plot plan ____ photos ____ Total Fees: ______

Denied ______ Reason for Denial ______



LEGEND
MAIN ELECTRICAL PANEL
SUB PANEL
AC/DC INVERTER
AC DISCONNECT
TRENCHING
10' PROPERTY SETBACK
PROPERTY LINE
(E) DRIVEWAY
(E) ENTRANCE
10' PROPERTY SETBACK
(N) 200A SOLAR READY MAIN SERVICE PANEL
(N) 1" PVC CONDUIT FULLY BURIED MINIMUM 18" BELOW GRADE. TRENCHED AND BACKFILLED. (APPROX 45')
175'-10"
10' PROPERTY SETB
(N) 60A AC DISCONNECT (ARRAY)
(N) SOLAREDGE SE10000H-US INVERTER (ARRAY)
251'-6"
10' PROPERTY SETBACK
ARRAY 1 - 12.775 kW
[x35] (N) MODULES
TILT: 30 DEGREES
AZIMUTH: 180 DEGREES
25'-11"
MESH PROTECTION ON UNDERSIDE OF ARRAY, SECURED WITH IRONRIDGE CLIPS PER 690.31(A)
TWP 1/4" MESH (SMOOTH AND NON-ABRASIVE)
76'-7"
10' PROPERTY SETBACK
ROOF AREA PV COVERAGE
ROOF SURFACE AREA: 3303.20 SQ.FT.
PV SURFACE AREA: 680.75 SQ.FT.
PV SURFACE AREA COVERED: N/A GROUND MOUNT



better earth

BETTER EARTH ELECTRIC INC
1815 WILSHIRE AVE, STE 908/909
SANTA ANA, CA 92705
PHONE: (888) 373-9379
LIC NO. C10-1024460

Bryan Jeffs

NEW PV SYSTEM: 12.775 kWp

LISA M. BONG

[redacted]

ENGINEER OF RECORD

REGISTERED PROFESSIONAL ENGINEER
LOYD W. MARTIN
No. C58724
Exp. 3-31-23
CIVIL
STATE OF CALIFORNIA

April 20, 2021
www. Loyd W Martin .com
Solar Structures Engineering
#2020-2943 Structural Only

SITE PLAN

PV.02 D

PLOT PLAN

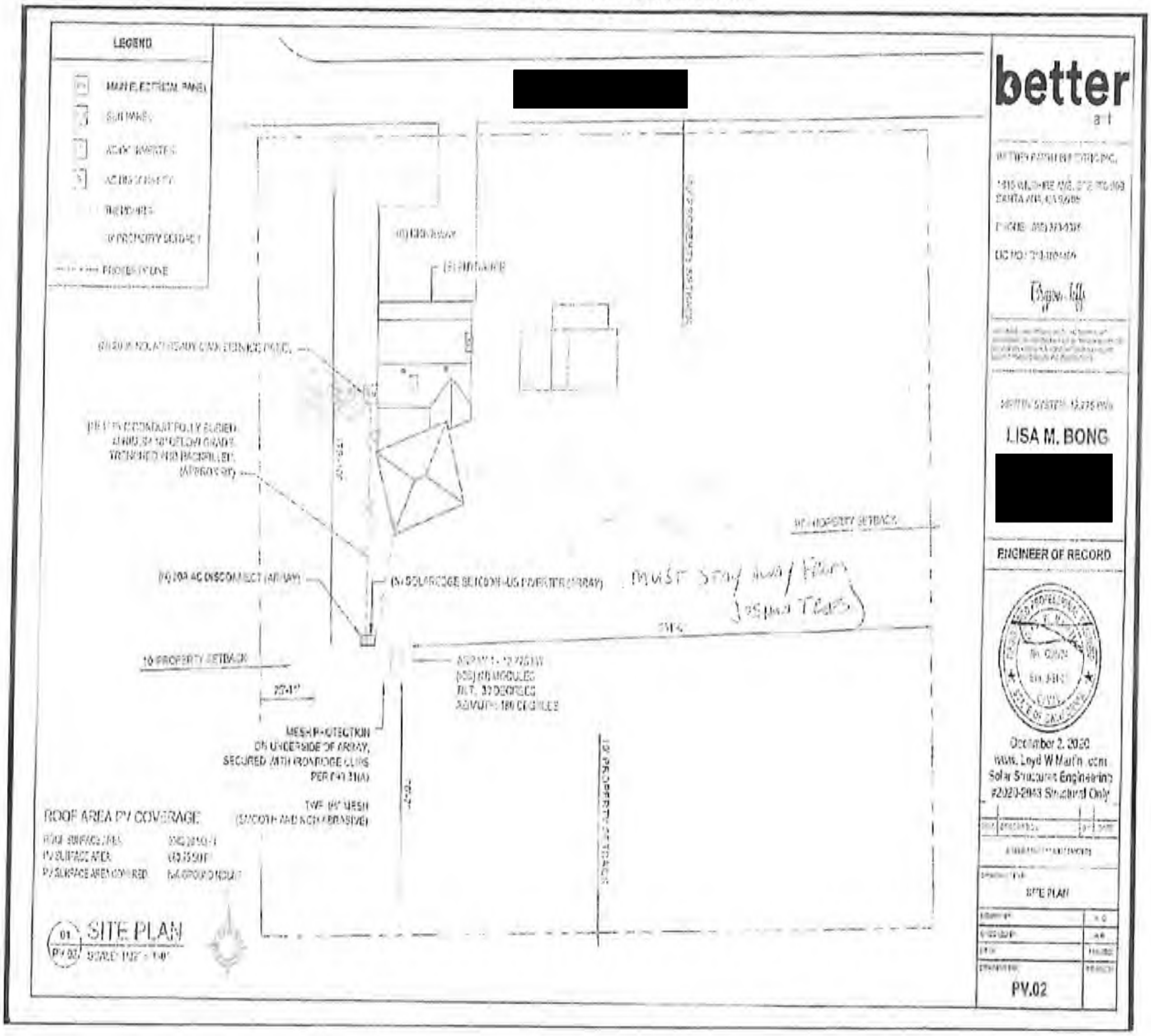
NAME LISA M BONG

PROJECT ADDRESS [redacted]

ASSESSOR PARCEL NO. [redacted]

IF YOUR LOT IS NOT RECTANGULAR, PLEASE DRAW CORRECT DIMENSIONS AND SHAPE

REAR PROPERTY LINE



FRONT PROPERTY LINE
STREET

ARBORPRO 58036 DESERT GOLD DRIVE, YUCCA VALLEY, CA 92284 / 760-275-4660
C-27 CONTRACTORS LICENSE #799469 / CERTIFIED ARBORIST #WE-4587A / DESERTTREEDOC@AOL.COM

Western Joshua Tree Take Permit Submittal Requirements

Please note - The census shall tag and count all western Joshua trees on the project site and classify them by size class.

1. The name of the desert native plant specialist who conducted the census and the employer of the desert native plant specialist.

Name: Michael Murphy, CERTIFIED ARBORIST #WE-4587A
Employer Name: ArborPro

2. The name of the desert native plant specialist who will relocate Western Joshua trees, if applicable, and the employer of the desert native plant specialist:

Name: N-A
Employer Name: N-A

3. The date of the census: 6-19-21

4. The date or dates of the proposed relocation of western Joshua trees, if applicable:

5. Address of site: [redacted]
Client Name: LISA M BONG
A map of the project site that depicts the location of the proposed single-family residence, accessory structure, or public works project; the number and location of all Western Joshua trees on the project site; and if applicable, the proposed Western Joshua trees for removal, or the proposed placement of each relocated Western Joshua tree (Note: this can be included on the 24"x36" plans).

6. Photographs of each western Joshua tree on the project site, including a **visual representation** (e.g., tape measure, yardstick, etc.) of the scale of the height of each tree.

7. Aerial imagery of the site in sufficient detail to identify the property and the Western Joshua trees that are on the site and are a part of the application submitted.

8. Narrative written descriptions of each western Joshua tree, its diameter, height, existing health condition and any other information deemed necessary.
MOST OF THE JOSHUA TREES ON THIS PROPERTY APPEAR to IN GOOD HEALTH. THE # 4 TREE FELL OVER AND IS STILL GROWING FAIRLY WELL. # 13 IS A GROUP OF TREES COUNTED AS ONE. SEE CENSUS TABLE FOR SIZE AND HEALTH INFO.

MMurphy WE-4587A

ARBORPRO 58036 DESERT GOLD DRIVE, YUCCA VALLEY, CA 92284 / 760-275-4660
C-27 CONTRACTORS LICENSE #799469 / CERTIFIED ARBORIST #WE-4587A / DESERTTREEDOC@AOL.COM

9. New construction of single-family residential units as well as accessory structures shall require the submittal of all information on plans measuring approximately 24" x 36", shall be legibly drawn and shall accurately reflect aerial photography and satellite imagery generally available for the subject property.

   a. All property lines, dimensions, and existing structures, if any, shall be depicted on plans submitted with the application materials.
   b. Property owners name, mailing address, phone number, and email address.
   c. Applicant's name, mailing address, phone number and email address.
   d. Assessor parcel number(s), address, and general location of the property for which the application is submitted.
   e. General Plan designation and zoning designation of the subject project site.

[redacted] ADDENDUM

Census Table

Tag Number	Height	Diameter	Health	Transplant, Destroy, or Protect in Place	Size Class (Place an "X" in the corresponding column)		
					Class 1 (Less than 1 Meter)	Class 2 (Between 1 Meter and 4 Meters)	Class 3 (4 Meters or Taller)
1	16'+	13"	GOOD	Protect			X
2	12'10"	8"	FAIR	TRANSPLANT		X	
3	11'	7"	GOOD	TRANSPLANT		X	
3A	7'4"	3"	GOOD	TRANSPLANT		X	
4							
5							
6							
7							
8							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

[redacted]

ARBORPRO 58036 DESERT GOLD DRIVE, YUCCA VALLEY, CA 92284 / 760-275-4660
C-27 CONTRACTORS LICENSE #799469 / CERTIFIED ARBORIST #WE-4587A / DESERTTREEDOC@AOL.COM

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Census Table

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					Class 1 (Less than 1 Meter)	Class 2 (Between 1 Meter and 4 Meters)	Class 3 (4 Meters or Taller)
1							
2							
3							
4	6'10"	9"	FAIR	PROTECT		X	
5	8'7"	3"	GOOD	PROTECT		X	
6	11'	5"	GOOD	PROTECT		X	
7	11'	7"	GOOD	PROTECT		X	
8	5'7"	3"	GOOD	PROTECT		X	
9	4'6"	3"	GOOD	PROTECT		X	
10	9'7"	6"	GOOD	PROTECT		X	
11	10'	6"	GOOD	PROTECT		X	
12	8'	4"	FAIR	PROTECT		X	
13	16'	7"	FAIR	PROTECT			X
14	12'	6"	GOOD	PROTECT		X	
15	4'9	3"	GOOD	PROTECT		X	
16	14'3"	9"	GOOD	PROTECT			X
17	7'4"	4"	GOOD	PROTECT		X	
18	8'8"	6"	GOOD	PROTECT		X	
19	15+	6"	FAIR	PROTECT			X
20	6'	4"	GOOD	PROTECT		X	

[redacted]

ARBORPRO 58036 DESERT GOLD DRIVE, YUCCA VALLEY, CA 92284 / 760-275-4660
C-27 CONTRACTORS LICENSE #799469 / CERTIFIED ARBORIST #WE-4587A / DESERTTREEDOC@AOL.COM

9. New construction of single-family residential units as well as accessory structures shall require the submittal of all information on plans measuring approximately 24" x 36", shall be legibly drawn and shall accurately reflect aerial photography and satellite imagery generally available for the subject property.

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Census Table

Tag Number	Height	Diameter	Health	Transplant, Destroy, or Protect in Place	Size Class (Place an "X" in the corresponding column)		
					Class 1 (Less than 1 Meter)	Class 2 (Between 1 Meter and 4 Meters)	Class 3 (4 Meters or Taller)
21	10'	7"	FAIR	PROTECT		X	
22	7'	4"	GOOD	PROTECT		X	
23	8'	5"	GOOD	PROTECT		X	
24	12'7"	8"	FAIR	PROTECT		X	
25	14'+	14"	GOOD	PROTECT			X
26	9'9"	10"	GOOD	PROTECT		X	
27	15'	8"	GOOD	PROTECT			X
28	16'+	8"	FAIR	PROTECT			X
29	16'+	10"	GOOD	PROTECT			X
30	16'+	12"	GOOD	PROTECT			X
31	16'+	19"	GOOD	PROTECT			X
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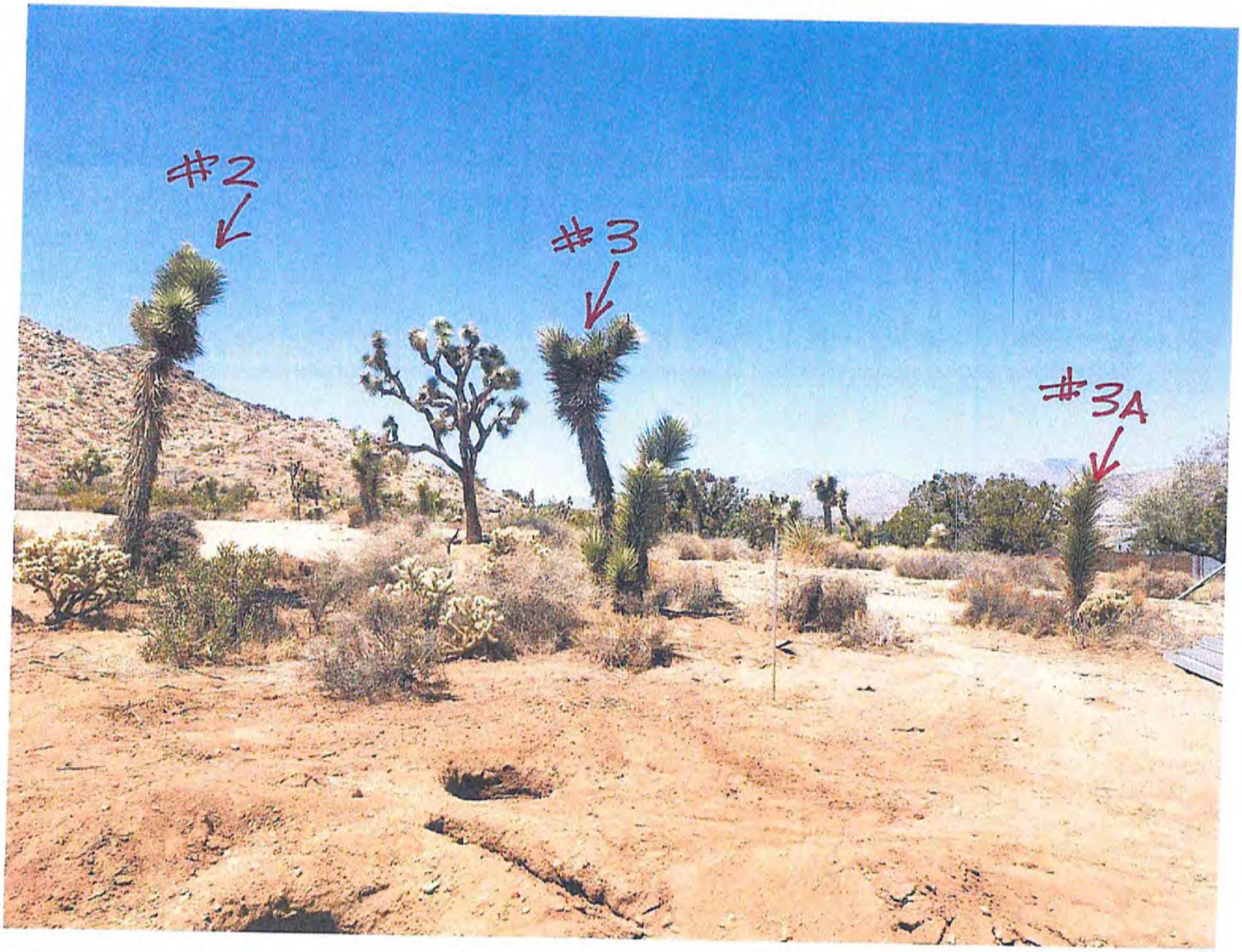
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3A


#2
#3
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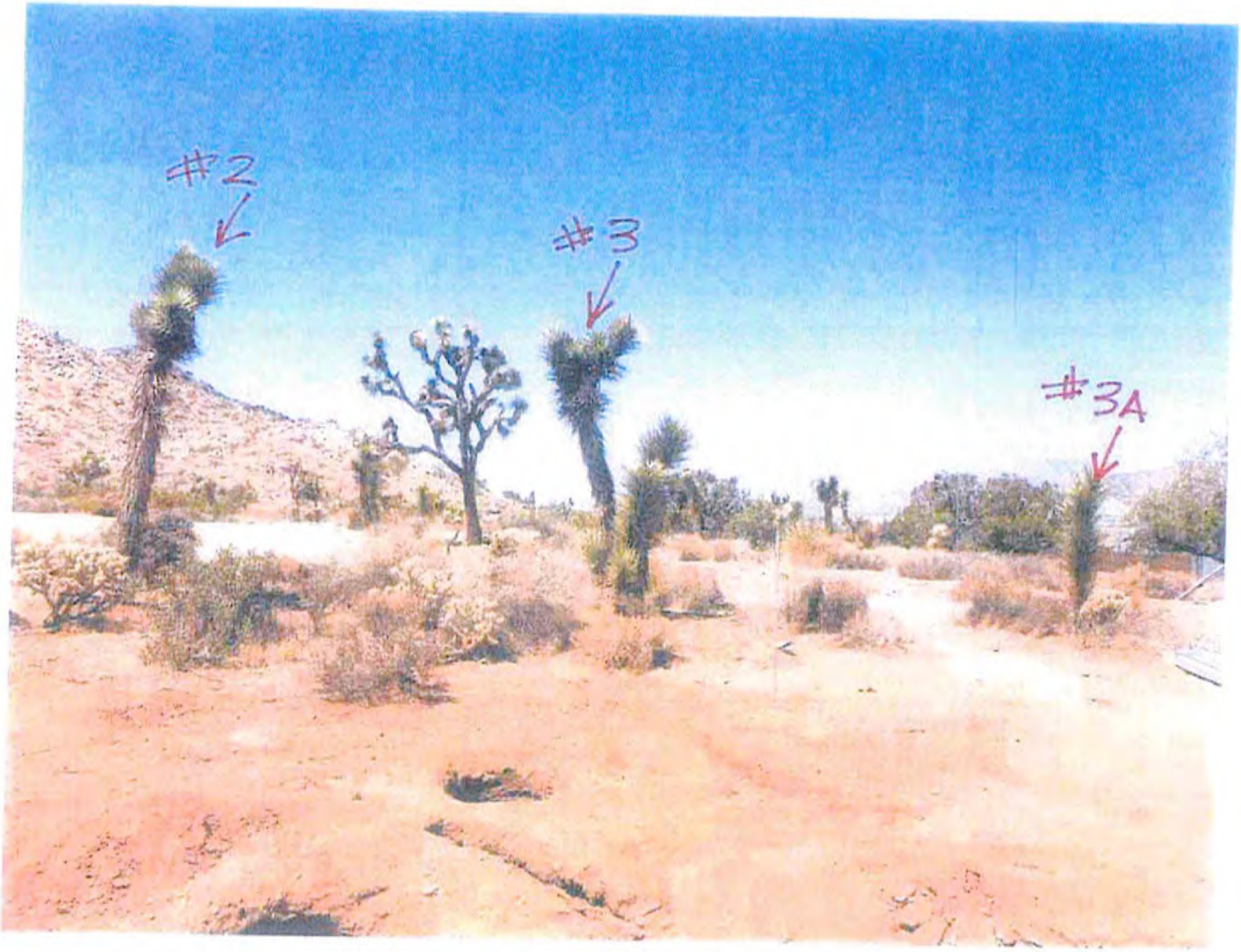
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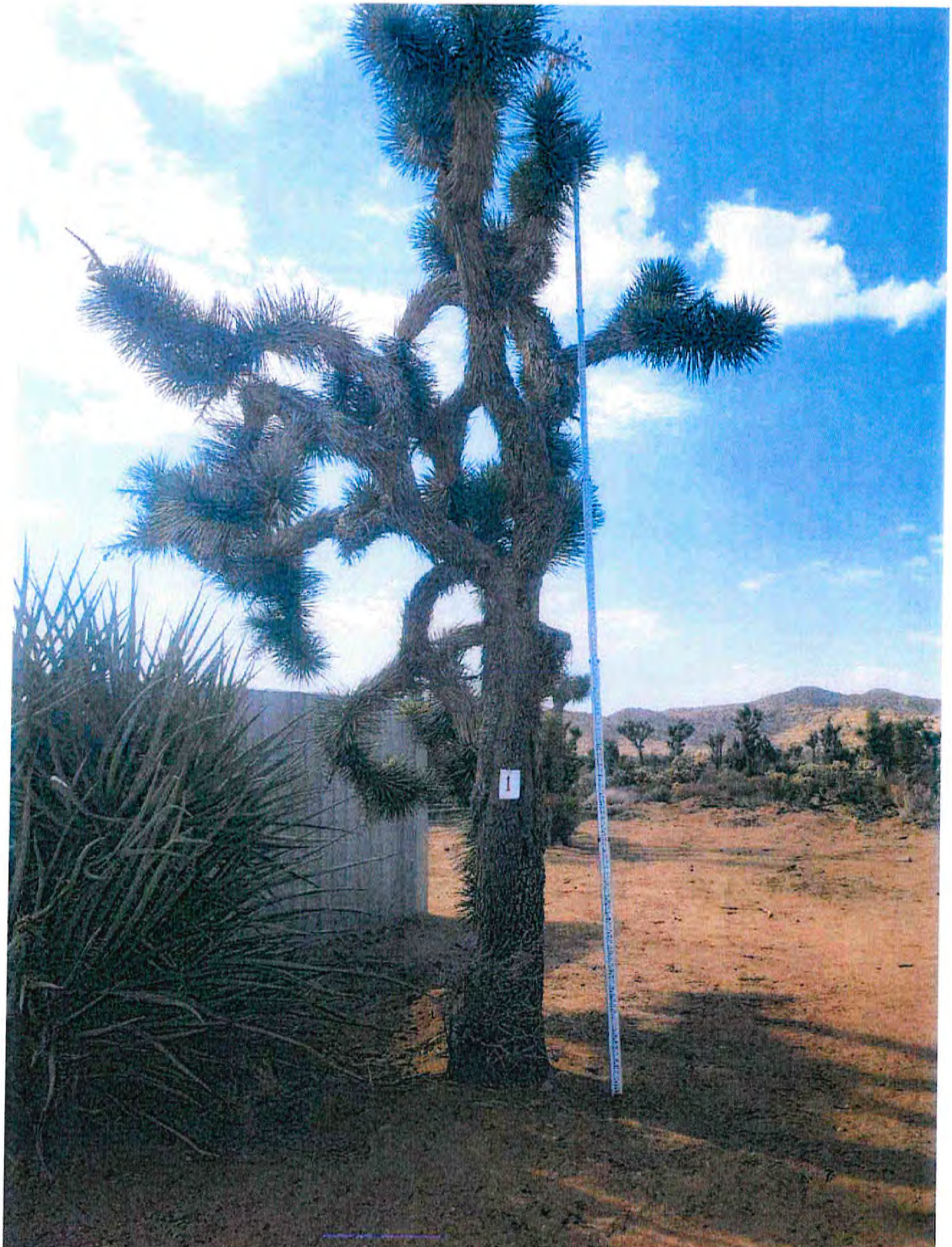
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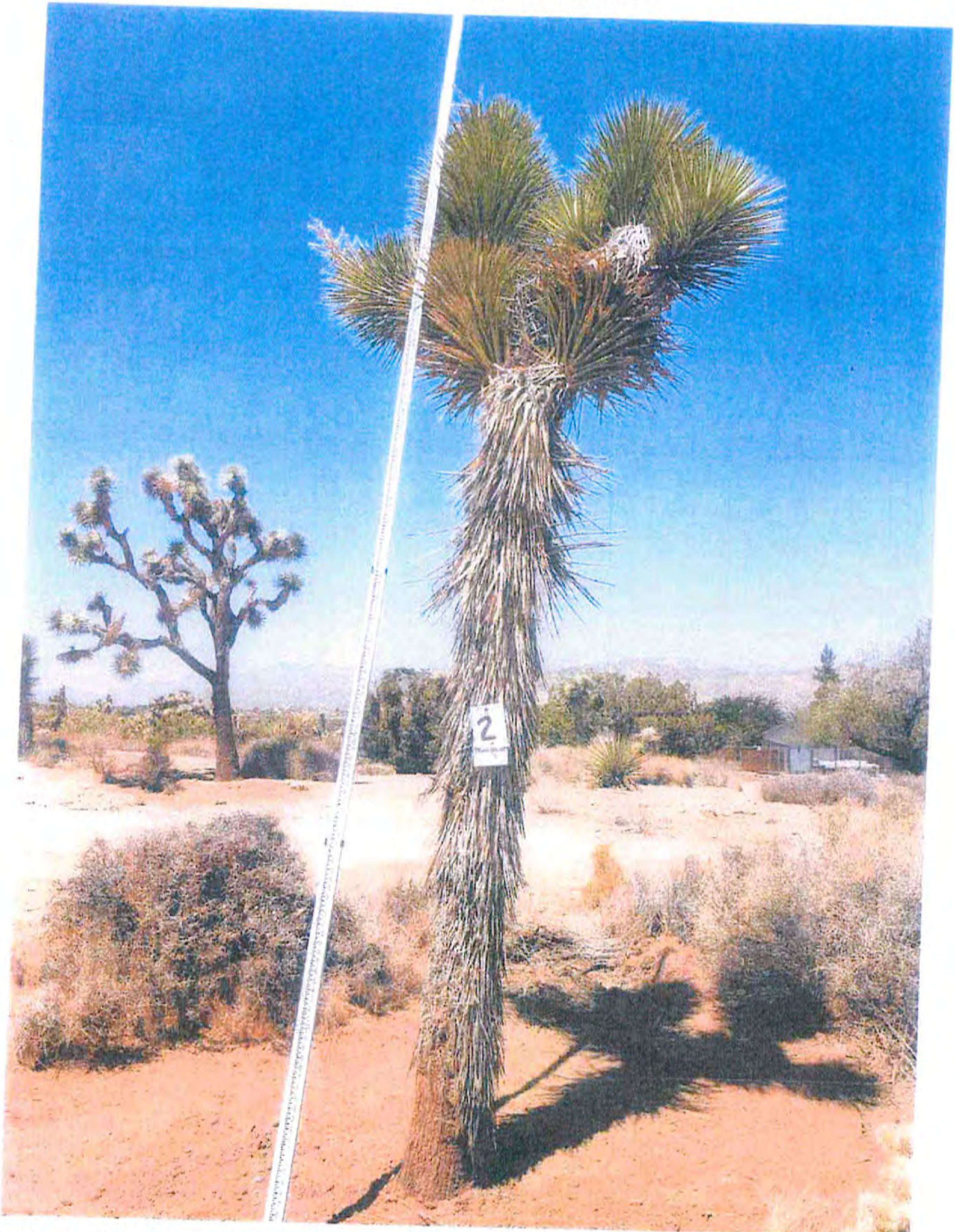
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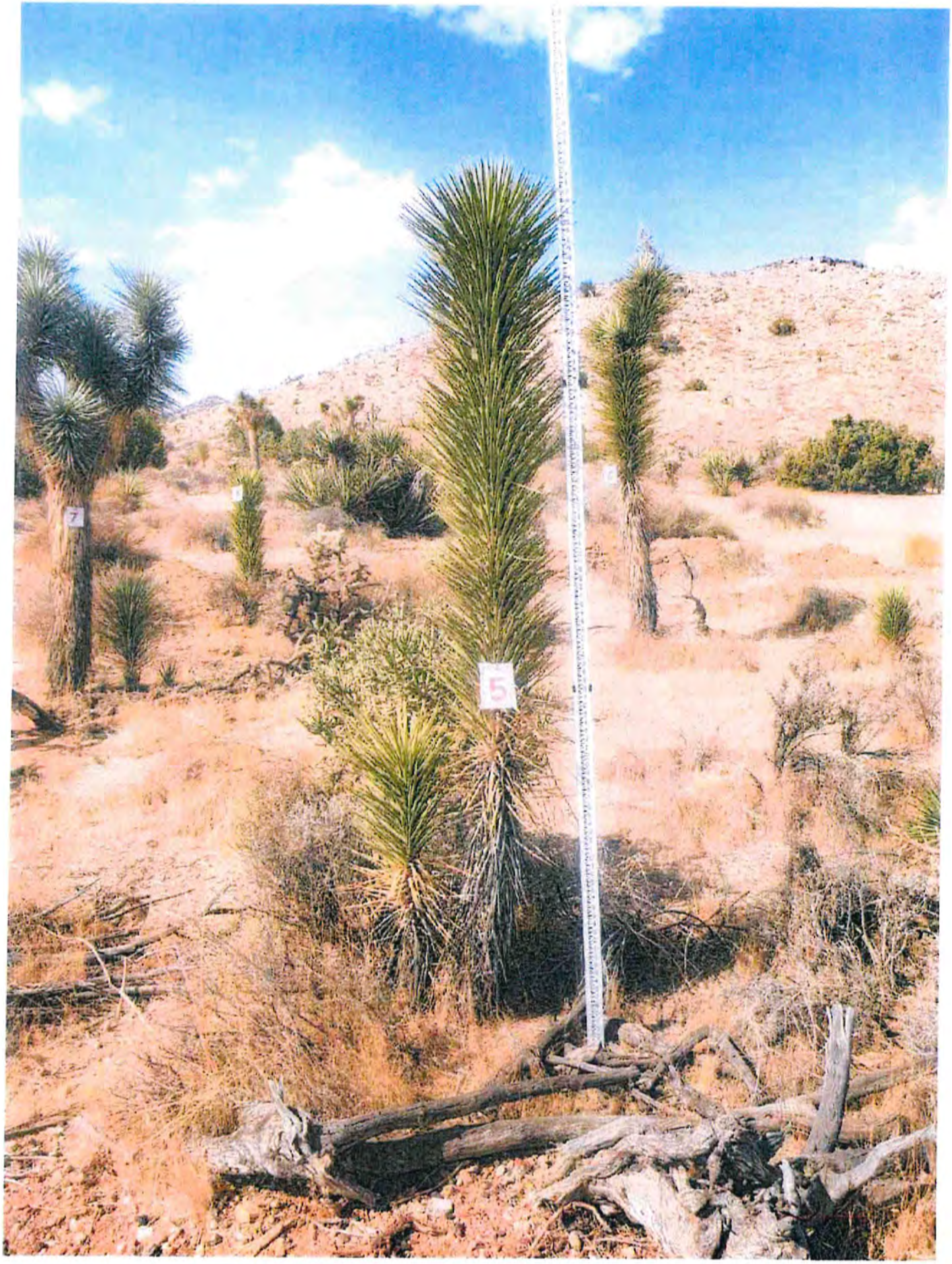
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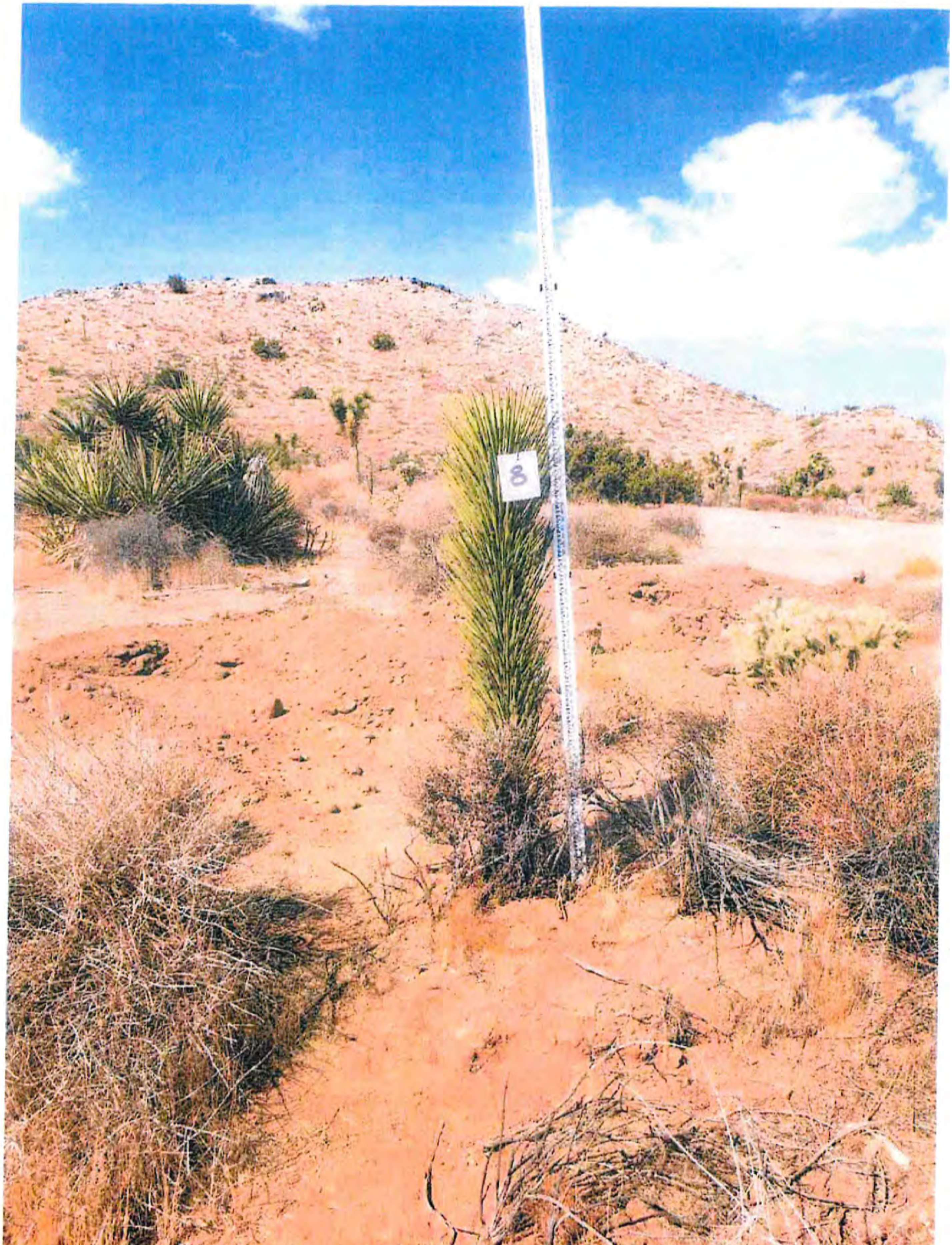
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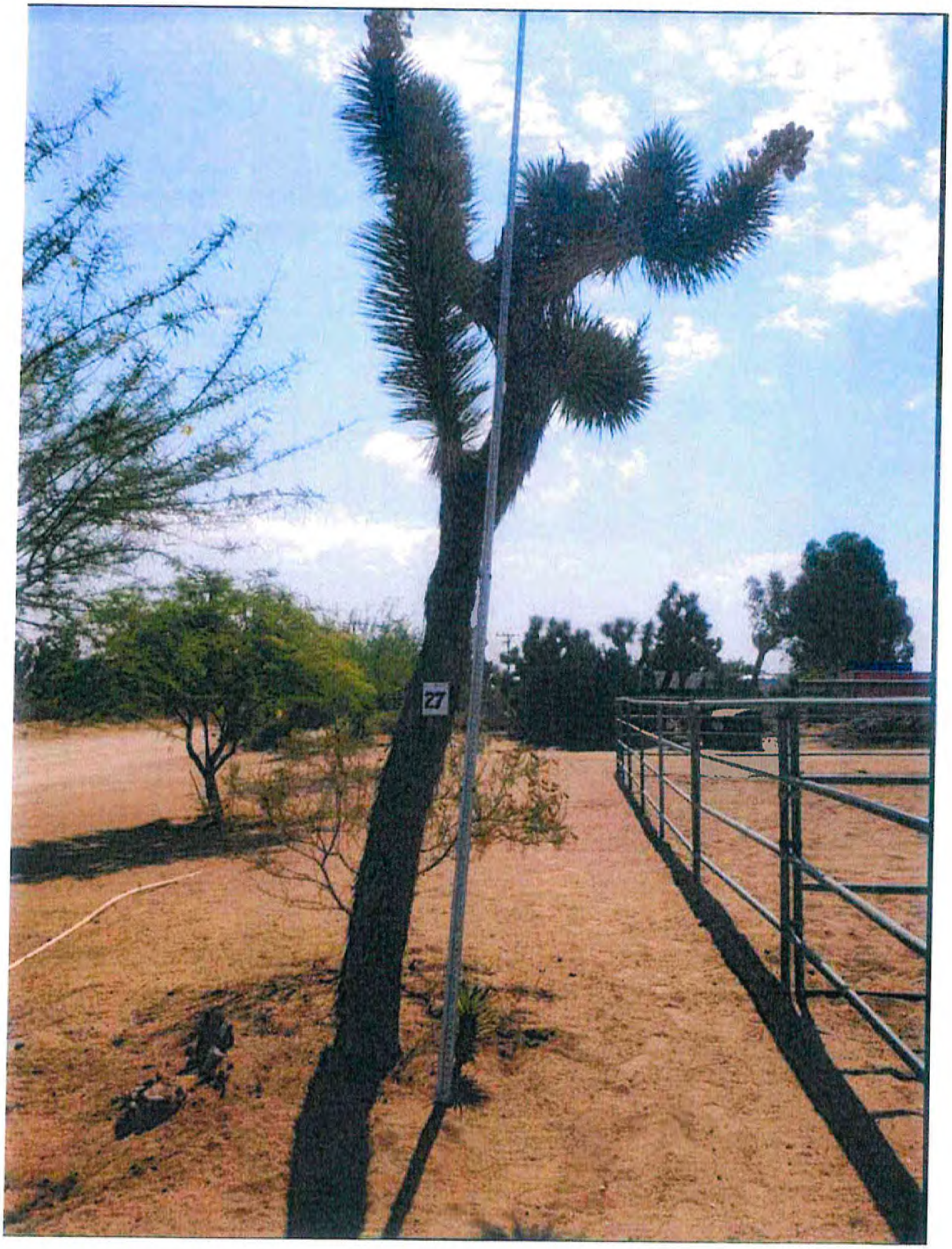
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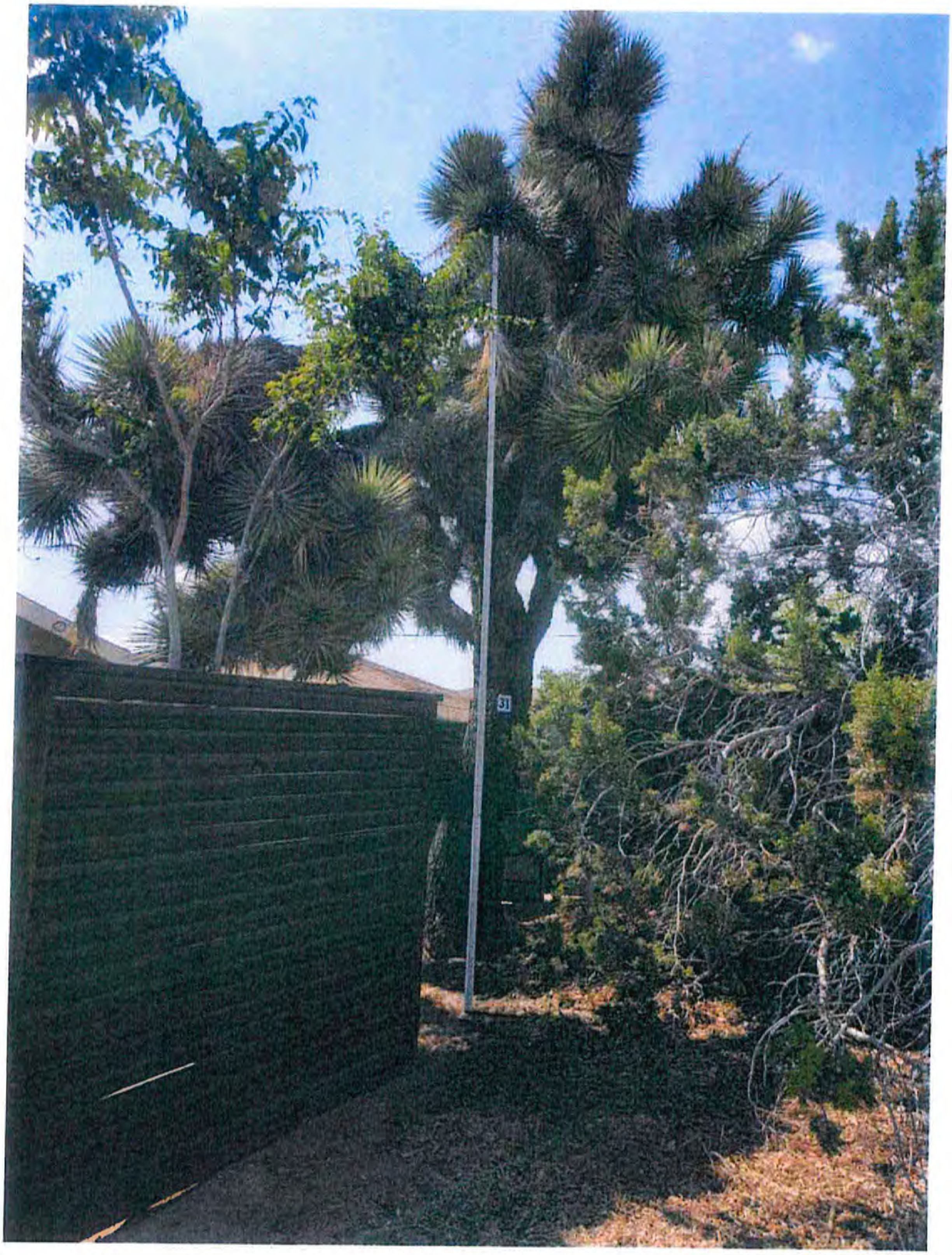

Town of Yucca Valley
Community Development/Public Works Depts
58928 Business Center Dr
Yucca Valley CA 92284

Receipt # 25845
Date 7/13/2021
Rcvd By Mary

Received From: Better Earth Electric, Inc./WJT 048
-21: [redacted]
5020 Pacheco Boulevard
Martinez, CA 94553-4327
USA
(888) 373-9379

Customer Number	Name	Payment Type	Check/Auth #	Amount Received
19136	Better Earth Electric, Inc.	Check	#401	2,575.00

Description : [redacted]

Code Enforcement Admin Fine	1,000.00
Wildlife Mitigation State Pass Thru Fees	1,575.00

Town of Yucca Valley
Community Development/Public Works Depts
58928 Business Center Dr
Yucca Valley CA 92284

Receipt # 26290
Date 8/04/2021
Rcvd By Janet

Received From: Better Earth Electric, Inc./WJT 048-21: [redacted]
5020 Pacheco Boulevard
Martinez, CA 94553-4327
USA
(888) 373-9379

Customer Number	Name	Payment Type	Check/Auth #	Amount Received
19136	Better Earth Electric, Inc.	Check	0000410	950.00

Description : Better Earth Electric, Inc./WJT 048-21: [redacted]

Code Enforcement Admin Fine	950.00

Town of Yucca Valley
Community Development/Public Works Depts
58928 Business Center Dr
Yucca Valley CA 92284

Receipt # 25690
Date 7/06/2021
Rcvd By Janet

Received From
Bet[redacted]WJT 048
-21[redacted]
5020 Pacheco Boulevard
Martinez, CA 94553-4327
USA
(888) 373-9379

Customer Number	Name	Payment Type	Check/Auth #	Amount Received
19136	Better Earth Electric, Inc./WJT 048-21:	Check	0000280	500.00

Description : Better Earth Electric, Inc.

WJT Take Permit Fees	500.00

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June 1, 2022

VIA EMAIL

Samantha Murray
President, California Fish and Game Commission
P.O. 944209
Sacramento, CA 94244-2090
fgc@fgc.ca.gov

Re: Legal and Technical Comments on the Petition to List the Western Joshua Tree (*Yucca brevifolia*) as Threatened Under the California Endangered Species Act (Agenda Item No. 5, June 15-16, 2022, Meeting)

Dear President Murray and Commission Members:

San Bernardino County (County) submits these legal and technical comments in response to the petition by the Center for Biological Diversity (Petition) for the listing of the western Joshua tree (*Yucca brevifolia*) as a threatened or endangered species under the California Endangered Species Act (Fish & Game Code § 2050 *et seq.*) (CESA) and after review of the Status Review Report submitted by the Department of Fish and Wildlife (Department or CDFW) in March 2022. The California Fish and Game Commission (Commission) is scheduled to consider the Petition, the Status Review Report, and related public comments at its June 15-16, 2022 meeting.

The County fully supports the Department's recommendation that listing the western Joshua tree as threatened is not warranted under CESA. The Department, at the Commission's direction in 2020, conducted a comprehensive and lengthy review of the species and the resulting Status Review Report represents the best scientific information available on the western Joshua tree. As explained below, this thorough and thoughtful analysis, and proper interpretation of the applicable legal standards, mandates that the Commission adopt the Department's recommendation, deny the Petition and decline to list the western Joshua tree under CESA.

I. LEGAL OVERVIEW

The Commission is vested with the authority under CESA to adopt and maintain a list of "endangered" and "threatened" species. (Fish & Game Code, § 2070.) An "endangered species" is a "native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease." (*Id.*, § 2062.) CESA defines a threatened species as "a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]." (*Id.*, § 2067.)

Any interested person may petition to list any species under CESA. (Fish & Game Code, § 2071.) If the Commission determines that the petition provides sufficient information to indicate that the petitioned action may be warranted, the Department is charged with preparing a status review of the species and provide a recommendation based on the best available science information. (*Id.*, § 2074.6.) Upon receipt of the Department's recommendation, the Commission must then make the final determination whether to proceed with the petitioned action. (*Id.*, § 2075.5.)

Thus, the standard for the Commission is whether the best available science demonstrates a likelihood that the species is going to become endangered in the foreseeable future. (Fish & Game Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f).)[1] Furthermore, if the Commission decides to adopt a regulation to include a new species as "threatened," it must make additional findings and issue a "final statement of reasons" that sets forth, among other things, why the regulation is more effective and less burdensome to affected private parties than possible alternatives, and that the regulation is necessary and non-duplicative of other state and federal statutes. (See Gov't Code § 11346.9(a)(4), 11349.1(a), 11349(f).)

The Commission must deny the Petition because the criteria for listing the western Joshua tree as a threatened species pursuant to Fish and Game Code section 2067 and California Code of Regulations, Title 14, section 670.1, cannot be established based on the best available science. The County strongly endorses the findings of the Status Review Report (Report) that listing the western Joshua Tree (WJT) under CESA as threatened is not warranted, and urges the Commission to adopt this recommendation as its action on the Petition.

II. THE COMMISSION SHOULD ADOPT THE RECOMMENDATION IN THE STATUS REVIEW REPORT THAT LISTING IS NOT WARRANTED

The comprehensive and well-supported Status Review Report is based on the best scientific information available to the Department. The Report details how this scientific evidence does not demonstrate that populations of the species are negatively trending in a way that would support a conclusion that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future. The

[1] For the purposes of this Status Review, the Department considers the foreseeable future to be through the end of the 21st century.

Report also provides management recommendations for recovery of the species and demonstrates how such measures are best achieved outside of the CESA regulatory scheme. The Department further strengthened the Report through the peer review process, in which the Department solicited critical examination of its conclusions, revised the Report as appropriate and provided extensive responses to each of the peer review comments made.

In the Report, the Department properly determined that the listing of the WJT as threatened under CESA is not warranted. This recommendation is supported by the law and the facts, and the Commission should adopt the Department's recommendation for three primary reasons:

- The population, broad range and abundancy of the western Joshua tree do not support listing the species as threatened.
- The impacts of climate change and other possible threats to the western Joshua tree in the foreseeable future are either minimal or unclear, and do not pose a risk of extinction.
- The Commission cannot make the required findings to list the western Joshua tree as threatened under the CESA and thus, listing the species would be arbitrary and capricious.

Each of these reasons separately serve as an independent reason for denying the Petition and are discussed in greater detail below.

A. The Best Available Science Demonstrates that the Western Joshua Tree Is Abundant and Pervasive Over a Broad Range, and Is Not Likely to Become Endangered In the Foreseeable Future

The Status Review Report, based on studies and data in the record, make clear that the WJT has an abundant population that will prevent the species from becoming threatened or endangered in the foreseeable future.

While acknowledging it is difficult to estimate the true population size of the WJT, the Status Review Report cites evidence that the abundance of WJT is currently relatively high with estimates of up to 9.8 million WJT in California. This is supported by, among other studies in the record, a report from Western Ecosystems Technology, Inc. (WEST Report), which, based on ground surveys, estimates that more than 8 million trees currently occupy the South portion of the range of WJT.[2] Another study by WestLand Engineering & Environmental

[2] WEST INC. 2021a. Population size evaluation for the western Joshua tree prepared for: 8minute Solar Energy, EDF Renewables, Longroad Energy, and Terra-Gen (December 17, 2021).

Services (WestLand Report) and reviewed by Stantec Inc., also supports this finding. The WestLand Report used population viability analyses (PVAs), a common tool used to evaluate population dynamics and estimate extinction probabilities, to predict that the species is not in danger of extinction over the next 100 years.[3] Estimates of the initial population size of WJT used in the models were conservative. The calculation assumed developed areas, like cities, contained no trees and used a density estimate of zero for some smaller ecoregions likely in range of the species. Moreover, the PVA model incorporated increases in fire impacts, drought, and urbanization and development into the population parameters developed for the base model. Under no scenario did the species go extinct in the simulation or become extirpated in either the southern or northern portions of its range.

The Status Review Report further describes how the number of occurrences of the WJT within California is very high compared with the number of occurrences for the approximately 1,700 plant species of conservation concern that are tracked and mapped by the Department's California Natural Diversity Database (CNDDB). The Status Review Report also discussed how the area occupied by the species is around 23,000 square kilometers (or roughly 8,880 square miles), as reported by the United States Fish and Wildlife (USFWS) and WEST. Collectively, this is approximately the same size as the state of New Hampshire. Based on this demographic data, it cannot be disputed that the WJT is significantly more abundant and its range is significantly broader than other CESA-listed species.

The Status Review Report relies on this data with respect to the WJT's abundance and population to discuss species' resiliency to decline. CESA predicates a determination that a species is "threatened" on the risk of extinction "throughout all, or a significant portion, of [that species's] range." (Fish & Game Code, §§ 2062, 2067.) WJT's current range, distribution and abundance are all evidence that the species has been able to adapt to or endure the range of climate conditions and climate variability that has occurred within the species' range since roughly 22,000 years before present. The Status Review Report also discusses how the maximum lifespan of the WJT is likely 150 years or more. Given the relatively long lifespan of WJT, the window for WJT reproduction is many decades long, and with the high abundance of existing populations the species may also be able to recruit a high number of individuals during favorable conditions. Based on this data, the Status Review Report properly concludes that "[d]ue to continuing recruitment, high abundance, widespread distribution, and the longevity of the species, the available demographic data does not currently suggest that WJT is likely to be at risk of disappearing from a significant portion of its range."[4]

[3] WestLand Engineering and Environmental Services 2022. Population Viability Analysis of the Western Joshua Tree (April 5, 2022).
[4] Status Review Report, p. 53

The Department reached its conclusion based on the common sense principle that widespread and abundant species are less vulnerable to extinction. This concept is also reflected in the methodologies used by international nonprofit organizations to objectively rank the vulnerability to extinction of species throughout the world. For example, NatureServe, a nonprofit that provides wildlife conservation data, considers the abundance and distribution of species, or rarity, to be more than twice as important as threats in assessing the conservation status of a species. The abundance and distribution of many widespread species excludes them from consideration under the International Union for Conservation of Nature (IUCN) Red List criteria unless significant declines have been observed or quantitative analysis demonstrates a probability of extinction within 100 years or less.

In short, the best available scientific evidence, including the high abundance, widespread distribution, and longevity of the species, does not demonstrate that the WJT population is at risk of disappearing from all or a portion of its range in the foreseeable future. This is not surprising to anyone who lives within, or is otherwise familiar with, the western Joshua tree range, as many residents take pride in having WJTs as part of their desert landscaping, yards and gardens. In other words, WJTs are simply part of everyday life in part of the County, and its presence is commonplace and ubiquitous. The record does not support listing a species with such abundance, range and prevalence as the WJT as a threatened species, and the Commission should adopt the Department's recommendation.

B. The Impacts of Possible Threats to the Western Joshua Tree Do Not Pose a Significant Risk of Extinction in the Foreseeable Future, and Would Not Be Redressed by Listing Under CESA

Without sufficient evidence showing an actual and significant decline in the WJT population range or abundance, the possible threats to the species remain largely theoretical and do not support a finding that the listing of the western Joshua tree as threatened is presently warranted. The record further lacks substantial evidence that listing would address the possible threats faced by the WJT.

The Petition claims that wildfire and climate change are the two most significant threats to WJT's continued viability.[5] However, both climate change and wildfire will affect nearly every other plant species, and there is no evidence that listing the WJT under CESA (and dedicating resources to the protection of only that species) would address such threats. With respect to impacts of climate change on the WJT, the studies show uncertain results or demonstrate that the WJT will actually be more resilient than many other plant species due to its broad range. Similar findings existed with respect to wildfire, which is unlikely to present a severe threat to the continued existence of the WJT. More importantly, there is no evidence that listing the WJT would reduce the risks associated with climate change and wildfire.

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[5] Petition, p. 24

These threats would continue to exist if the WJT was listed or not. Indeed, the record shows that reducing greenhouse gas emissions will do far more to protect the WJT and other species than by expending limited resources to list an individual species that is well-adapted to climate fluctuations.[6]

The Petition also asserts that the effects of (a) predation, (b) invasive species, (c) wildfires, (d) global climate change, and (e) habitat loss are 'synergistic' factors that, when evaluated together, warrant a finding that the listing of the species as threatened or endangered is warranted. This analysis of synergistic factors is flawed because it is not supported by information and real data showing an actual decline in the WJT population range or abundance. Threats aside from climate change and wildfire, including predation and invasive species, are categorized as less significant by the Petition and are discussed in the Report as only minor threats to the species. Indeed, the Department conducted a comprehensive review of the evidence of the potential impacts posed by such threats, including threats due to "one or more causes," or the "cumulative effects" of the proposed threats, and concluded that the evidence does not warrant listing of the species at this time.[7]

Accordingly, the Department properly concluded that the WJT is not in danger of extinction throughout all, or a significant portion, of its range due to any single threat or interconnected cumulative effects of threats, and a contrary decision by the Commission would not be supported by substantial evidence.

1. The Threat Posed by Climate Change Does Not Demonstrate a Risk of Extinction of the WJT In the Foreseeable Future and Cannot Be Redressed Under CESA

Even assuming threats relating to climate change are addressable by individual CESA management actions, the record does not demonstrate that climate change will affect the WJT to support listing under CESA.

According to the Status Review Report, the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts severe enough to threaten or eliminate the species from a significant portion of its range by the end of the 21st century.[8] Available studies show that the range of outcomes resulting from climate change impacts is highly uncertain, and this uncertainty increases as projections extend deeper into the 21st century. Some studies have predicted growth and

[6] Status Review Report, pp. 120-121.
[7] Status Review Report, pp. 120 and 115
[8] This represents the applicable period for consideration of WJT impacts to support a listing.

expansion of the range of the WJT as a result of a warming climate,[9] while others have predicted a more modest contraction of the tree's range.[10] The Petition did not provide adequate analysis of how this global concern would be unique to the WJT and would directly affect the WJT's migration and other resiliency factors. CESA notably does not require the Commission or the Department to undertake its own independent study of a species when preparing and reviewing the Status Review Report.[11] Thus, this lack of information is the end of the inquiry for the Commission, as the law requires any final determinations by the Commission to list a species as threatened or endangered "must be based solely upon the best available scientific information."[12]

In an attempt to amplify the potential threats of climate change on some WJTs, the Petition requested that the Commission assess whether the two population clusters warrant listing separately as ecologically significant units (ESUs), as individual trees appear to be more prone to climate changes impacts in the southern part of the WJT range. Some peer reviewers also advocated for consideration of two separate and distinct populations of the WJT, "YUBR North" and "YUBR South."[13] This request is not based on science. A population of organisms considered distinct for conservation purposes based on scientific analysis of the reproductive isolation and genetic differences between population groups is eligible for listing under CESA. These differences are not present here with respect to the WJT. While WJT located within the southern range may be more prone to adverse impacts of climate change, this comparative susceptibility is not based on any genetic distinction, but rather location only, and there is no evidentiary support to treat the WJT population in the northern range as distinct and separate for listing consideration. Accordingly, the Department found that the best available science does not support any distinction between these two alleged populations, and specifically does not support them as valid ESUs.

Furthermore, a species (or a subset of a species) should not be listed under the CESA based on a global condition not shown to have any unique impacts on the species or without any indication as to how it can be redressed through protections and management actions. According to the 2021 independent review conducted by Heritage Environmental Consultants (2021 Heritage Report), climate change is also a threat to almost every other plant species and plants with smaller ranges will be far more threatened than the WJT.[14] The WJT occurs across a wide swath of desert with substantial variation in temperature and

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[9] Petition, p. 38; *see also* Steven R. Archer and Katharine I. Predick, Climate Change and Ecosystems of the Southwestern United States, Rangelands 30(3): 23-38 (June 2008).
[10] *See, e.g.,* Cameron W. Barrows, Michelle L. Murphy-Mariscal, Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions, Biological Conservation 152: 29-36 (2012).
[11] Fish & Game Code, § 2074.8.
[12] *See* Fish & Game Code §§ 2070, 2075.5. S.B. 473 also added provisions for the Commission to adopt nonregulatory recovery plans, along with revisions to the California State Safe Harbor Agreement Program Act.
[13] YUBR refers to "Yucca Brevifolia" which is the scientific name of the WJT.
[14] Attached as Exhibit 2.

precipitation across its range. While there may be unknowns in the ability of the WJT to migrate with climate change, its potential to survive is greater than other CESA-listed species. This is further supported by the Department's assessment of the vulnerability of WJT to climate change using the NatureServe Climate Change Vulnerability Index (CCVI). The CCVI is a rapid means of estimating a plant or animal species' relative vulnerability to climate change. While acknowledging the difficulty of forecasting vulnerability, the CCVI indicated that WJT has a climate change vulnerability index value of moderately vulnerable. This result falls below any sort of indication that the species is going to become threatened or endangered in the foreseeable future, or needs to be singled out for special protections.

2. The Threat of Wildfire Is Not Severe Enough to Endanger the WJT in the Foreseeable Future

The Status Review Report also appropriately concluded that wildfire has not presented a severe threat to the continued existence of the WJT and is unlikely to do so in the future. The WEST Report estimates that fire events affected 2% of the species' population over the past 10 years, and 8% over the past 100 years. The analysis showed that previous fire events have had, at most, a minimal impact on the Joshua Tree population across the species' southern range. Even an assumption of zero Joshua tree density in previously burned areas resulted in estimates of total WJTs in the southern range of well over 8 million Joshua trees at 10, 25, 50, 75, and 100 year intervals.

According to the Status Review Report, wildfire does not affect the entire range of the species evenly, does not necessarily burn through areas in a uniform, high-intensity way, and does not typically result in the complete elimination of WJT from burned areas. Moreover, the range of the species is unlikely to be affected by wildfire in the foreseeable future, because WJT is unlikely to be completely eliminated from affected areas due to its high abundance and widespread distribution. For these reasons, wildfire may negatively affect the species distribution, however, it is unlikely to result in serious danger of elimination of the species throughout a significant portion of its range.

3. Other Possible Threats to the WJT, Such as Predation, Invasive Species and Human Development, are Minor or Uncertain

The Status Review Report addresses the additional threats identified in the Petition, and properly concludes that these threats are insignificant or uncertain.

With respect to invasive species, the Department concluded the evidence showed that competition with invasive plant species to be a minor threat to WJT. The primary way in which non-native and invasive plant species currently affect WJT is indirectly by fueling wildfire. Similarly, herbivory and predation result in relatively minor negative impacts overall to WJT. Because WJT is currently abundant and widespread, the Department considers the overall threat to the species from herbivory and predation to be relatively small.

There is much uncertainty in predicting the extent of future development within the range of WJT. While development and other human activities could result in habitat loss and largely negative impacts to native species, some native species could benefit from certain human activities. For example, irrigation near populated areas could increase survival of perennial plants during drought. In addition, several local and parkland areas have already put in place protections from development. Restrictions under CESA will not apply to federal lands, where a substantial portion of the WJT population occur. Assertions from the Petition regarding loss due to human development and installation are exaggerated and speculative. There are physical limitations to development in the desert ecoregion that serves as habitat for the WJT, such as water availability, proximity to employment centers, and increasingly hot desert climate. The Status Review Report concludes that WJT populations on protected and undeveloped lands are expected to remain, and therefore habitat loss will not necessarily result in an overall change in the range of the species. In addition, the abundance of the WJT lessens the impact of these threats to the species.

C. The Commission Cannot Make the Required Findings to List the Western Joshua Tree as Threatened Under the CESA

The Status Review Report, which is based on the best scientific information available at this time, indicates that the WJT is not in serious danger of becoming extinct throughout all, or a significant portion, of its range. Analysis of the abundance and range data of the WJT in comparison with the CESA-listed species highlights the arbitrary nature of a proposed listing by demonstrating that the WJT has little in common with species that are truly threatened or endangered. In addition, a majority of land that contains the WJT is federally owned which means that a CESA listing would protect only a limited amount of the WJT in California. Local rules and schemes, including those within the County, as well as other California regulatory laws, such as the California Environmental Quality Act (CEQA), can provide protections to the WJT regardless of listing. Accordingly, the Commission lacks evidence to list the species as threatened and cannot find, as a matter of law, that listing is necessary, effective and not duplicative compared to other available management options.

1. The WJT Is More Abundant, Has a Greater Range and Is Less at Risk Than Other Listed Species

The best scientific information available to the Commission demonstrates that the WJT is not in serious danger of becoming extinct throughout all, or a significant portion, of its range. This is further highlighted when the WJT is compared to other listed species.

In 2021, the County engaged Heritage Environmental Consultants to conduct an analysis of distribution and abundance of the WJT in comparison with other plant species listed or being considered for listing under CESA. The resulting report, the 2021 Heritage Technical Memorandum (attached as Exhibit 2), conducted two sets of analysis for comparison with the WJT: first, it examined the data from seven recent listing decisions or proposed listings for plant species; and second, it expanded the scope to include all 219 plant species listed under the CESA. Based on these sets of data, the 2021 Heritage Technical Memorandum concludes that the WJT is both widespread and abundant relative to the recent listing proposals and the entire set of CESA-listed plants. The key findings of the 2021 Heritage Technical Memorandum include:

- **The western Joshua tree range is much more extensive than any CESA-listed species.** This conclusion is based on an analysis of the number of U.S. Geological Survey (USGS) 7.5-minute quadrangle (quad) maps in which each tracked species is known to occur, as listed in the California Natural Diversity Database (CNDDB). Quad data is a good surrogate for distribution (range) of a species—the more quads a species occupies, the broader its range. Of the 219 plaints species analyzed, 171 species are known from 10 or fewer quads, while only two species are known from more than 50 quads. In contrast, the WJT occupies 243 quads, making its range a significant outlier compared to other species.

- **The western Joshua tree is significantly more abundant than any CESA-listed species.** This conclusion is based on the estimated number of Element Occurrences (EO) of the WJT, compared with the number of EOs in the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants of California (Inventory) for other species. An EO is defined as a group of a species found within 0.25 miles and not separated by substantial habitat discontinuities. EO data provide a rough surrogate for abundance—the more EOs are known for a species, the more abundant it generally is. Of the 219 listed plants analyzed, 104 species are known from 10 or fewer EOs, while only 14 species are known from more than 50 EOs, and only three are known from more than 100 EOs. Although EO data is not available for the WJT because it is not listed in the Inventory, the 2021 Heritage Technical Memorandum (page 7) applied the ratio of EOs to quads for all CESA-listed species to provide an estimate of 2.55 EOs per quad. Multiplying this ratio by the 243 quads occupied by the WJT yields a conservative estimate of 620 EOs—again, an order of magnitude greater than for any of the other CESA-listed species

- **The western Joshua tree is substantially less rare than CESA-listed species.** This conclusion is based on the CNPS rare plant, state, and global ranks for each species. The majority (95%) of CESA-listed species are assigned CNPS rare plant ranks of 1A (extirpated in California) or 1B (rare, threatened or endangered in California). The western Joshua tree has a rare plant rank of CBR (Considered But Rejected) and was rejected as “too common.” No other CESA-listed species has this rank in the CNPS. Indeed, the WJT shares many characteristics with the giant sequoia, an iconic species not listed at the state or federal level and rejected for inclusion in the CNPS Inventory, despite being subject to current and future threats including climate change.

- **Threats to the western Joshua tree are shared by all plant species, but risks to western Joshua tree are offset by range and abundance.** The WJT is subject to some of the same threats as CESA-listed species, including climate change. However, the WJT is not subject to threats that pose a high risk to species that have small population sizes or narrow distributions, such as those caused by local, stochastic threats. As an abundant and widespread species, the WJT is also less threatened by climate change than species with small population sizes or narrow distributions. Plants with the smallest range or most exacting habitat requirements (such as a single mountaintop) are the most threatened by climate change. In contrast, the WJT occurs across a wide swath of desert, with substantial variation in temperature and precipitation across its range, and, thus, more potential to survive than other truly rare CESA-listed species.

The 2021 Heritage Technical Memorandum's findings and conclusions also underscore the management limitations and policy implications of listing the WJT. Listing the species of such range and abundance would pose significant oversight and administrative hurdles, even without taking into account the Department's limited staffing and funding. No other agency has ever taken on the regulation and active management of a species on such a scale. Furthermore, elevating the WJT for special protection over other, more threatened species would appear to be a misuse of scarce public resources. These comparisons show that the WJT has little in common with species that are truly threatened or endangered and should not be a listed species under CESA, and a decision to list would be arbitrary and capricious.

2. The Peer Review Comments Are Not Best Available Evidence to Support Listing

To the extent the Commission believes that the peer review comments represent best available scientific evidence in support of listing, this is not the case. The peer review comments from the five reviewers provide insightful and instructive guidance to the Department in its preparation of the Status Review Report. While some comments were critical and clearly came from a place of advocacy, the Department properly reviewed them and incorporated changes as appropriate. None of the comments serves as independent, substantial evidence to support a listing.

The County engaged Heritage Environmental Consultants to conduct a technical review of the Status Review Report, including each of the peer review comments and responses. The resulting 2022 Heritage Technical Memorandum (attached as Exhibit 1) found that "the status review provides an objective, thorough, and well-reasoned compilation of the best available science on the WJT."[15] The Status Review Report successfully integrated the more helpful and technical scientific peer review comments in order to conduct a thorough analysis

[15] 2022 Heritage Report, pg. 2

of the prospect of WJT endangerment. The 2022 Heritage Technical Memorandum also confirmed the Department's conclusion that the peer review comments more supportive of listing to be unsupported by factual evidence or not to have been significant enough to overturn central findings of the Status Review Report.

For example, the Status Review properly addressed the unsupported contention that the WJT in the southern range should be treated as a distinct species. Dr. Tim Krantz was the only peer reviewer to offer explicit support for any type of listing, albeit based on this mistaken notion that the WJT should be subdivided as two distinct populations in YUBR North and YUBR South. He commented that "the levels of threat from land development, energy projects, wildfires and climate change are generally greater in the YUBR South range than the YUBR North range, thus warranting separate consideration of the appropriateness of listing under the CESA."[16] The Department recognized in its Status Review that populations of WJT in the southern part of its range face more serious threats than WJT in the northern part of its range. However, the Department correctly responded, and the 2022 Heritage Technical Memorandum concurs, that the seriousness of threats faced is not a factor in species concepts or determinations. The Department did not have evidence, genetic or otherwise, that would support the differentiation of southern and northern populations as separate and discrete evolutionary significant units that would qualify them as separate "species or subspecies" under CESA.

Moreover, peer review comments regarding certain negative WJT population and recruitment trends do not demonstrate serious endangerment of extinction or fail to acknowledge the necessary standard for listing. In the Status Review Report, the Department shared evidence of demographic information from some populations that appear consistent with negative population trends. Dr. Cameron Burrows posed the question of why WJT should not be given additional protection based on certain negative trends found within WJT populations. He also pointed to several studies to demonstrate possible constraints on WJT recruitment resulting from climate change. Both the Department and the 2022 Heritage Technical Memorandum acknowledge potential correlation between climate change and loss of recruitment in modelled studies. However, these studies are often limited to a smaller range of WJT and do not provide a clear enough link with climate change to suggest potential endangerment. Moreover, potential population declines discussed within the peer review do not demonstrate widespread decline and fail to meet the high standard for listing—that the best available science shows the species is in serious danger of becoming extinct in all or a significant portion of its range in the foreseeable future. This standard is not met by merely pointing to uncertainty with respect to predicted threats faced by the WJT.

Similarly, the wildfire threats raised within the peer review comments are largely addressed within the Status Review Report and should not result in a listing of the species. The Status

[16] 2022 Heritage Report, pg. A-36

Review Report found that wildfire does not affect the entire range of the species evenly and does not typically result in the complete elimination of WJT from burned areas. Some peer review comments discuss the indirect impacts of wildfire on the species, including elimination of seeds and pollinators, and the potential for wildfire to interact with other potential threats to WJT, like climate change. These issues are addressed in the Status Review Report's discussion of wildfire, wherein the Department concluded that wildfire is unlikely to result in a serious danger of elimination of the species throughout a significant portion of its range. While the Department discussed how there is little information or certainty with respect to predicting how threats to the WJT may interact, the Status Review Report makes clear at several points that its recommendation not to list the species is based on analyzing individual as well as cumulative potential threats. Given the Department's extensive review of peer review comments (as confirmed by the 2022 Heritage Technical Memorandum) did not change the main findings of the Status Review Report, the peer review comments should not serve as a basis to support a listing.

3. The Commission Cannot Make Findings that Listing the Western Joshua Tree Would Be Necessary, More Effective and Less Burdensome Than Other Management Alternatives and Would Not Be Duplicative of Other Laws

The Commission can only adopt a regulation to list the WJT as threatened if it makes required findings that, among other things, establishes that listing is more effective and less burdensome to affected private parties than possible alternatives, and that the listing is necessary and non-duplicative of other state and federal statutes. (See Gov't Code § 1346.9(a)(4), 11349.1(a), 11349(f).) The Commission cannot make such findings, as explained below.

(a) The Majority of WJT Is on Federal Land and Already Subject to Protection and Preservation

CESA's limited applicability to many WJTs weighs against a species listing. The California Desert Protection Act (CDPA), enacted by Congress in 1994, established the Death Valley and Joshua Tree National Parks, and the Mojave national preserve. (Pub. L. No. 103-433, 108 Stat. 4471 (1994).) Pursuant to CDPA, the National Park Service (NPS) manages 189 square miles of Joshua Tree National Park within the Desert Region of the County. The NPS also manages the Mojave National Preserve, encompassing 1.4 million acres in the heart of the Mojave Desert and the third largest national park system in the contiguous United States. The preserve is primarily composed of Joshua tree forests and dunes, and features an abundance of wildlife such as desert bighorn sheep, mule deer, coyotes, and desert tortoises.

Through the CDPA, Congress declared its policy that public lands in California desert be included in the national park and national wilderness preservation systems in order to perpetuate the diverse ecosystem of the California desert in its natural state. The CDPA withdrew designated areas from "all forms of entry, appropriation, or disposal under the public land laws" and effectively functions to preserve and protect the very habitat necessary for the Joshua tree's survival. (16 U.S.C. §§ 410aaa-42, 410aaa-47.)

Through these and other federal laws, the vast majority of WJT habitat and population fall within federal jurisdiction. The WJT South population region is comprised of approximately 3,661,960 acres, of which 47-percent is federally owned. The WJT North population region is comprised of approximately 1,977,837 acres, of which 96-percent is federally owned.[17] As a result of the Supremacy Clause (Article VI, Paragraph 2) of the Constitution, CESA has no legal standing with respect to federal agencies' management of these lands.

The substantial amount of WJT on federal land significantly limits the applicability of any proposed CESA management actions and may already provide for certain protections of the species. As discussed in the WEST Report, among other parts of the record, federal land affords opportunities for identification and protection of the species, as federal lands are likely not as susceptible to urbanization or private development. Listing the species would be ineffective and duplicative of these existing protections and preservation measures.

(b) Existing Laws and Policies Provide Substantial WJT Protections

CESA is not the sole or most practicable mechanism for protecting WJTs. It is a violation of CEQA to fail to feasibly mitigate impacts to biological species, such as the WJT.[18] Because Joshua trees are listed as a "sensitive natural community" within the CNDDB, CEQA therefore requires project applicants to inventory all accessible Joshua trees within the proposed project disturbance areas and have a qualified botanist identify those likely to survive transplantation. Suitable trees must be relocated prior to grading to off-site reclamation or restoration areas, and maintained to ensure successful transplantation. Alternatively, project applicants are often required to permanently conserve land (on or off the project site) that comprises suitable Joshua tree habitat as mitigation for the clearance of any Joshua trees on their site. Under NEPA, federal agencies evaluate the environmental and related social and economic effects of their proposed actions. All federal agencies must prepare detailed statements assessing the environmental impact of and alternatives to major

[17] See Felicia Sirchia, Scott Hoffman, and Jennifer Wilkening, "Joshua Tree Species Status Assessment," U.S. Fish and Wildlife Service (July 20, 2018). In contrast, one USGS 2021 study found that roughly 32% of the southern range for WJTs and 85% is owned by the federal government (cited by WEST Report, pg. 8).

[18] *See, e.g., Mira Mar Mobile Cmty. v. City of Oceanside*, 119 Cal. App. 4th 477, 495, citing CEQA's statutory requirement that "an EIR is required to describe feasible mitigation measures that will minimize significant environmental effects." *See also, Ctr. for Biological Diversity v. City of Desert Hot Springs*, Petition for Writ of Mandate and Complaint for Declaratory Relief, which included claims by CBD of "inadequate mitigation proposed for biological impacts, [and] the failure to adopt feasible mitigation measures for biological, aesthetic, and traffic impacts…." (2007 WL 5444324.)

federal actions significantly affecting the environment in the form of Environmental Impact Statements and Environmental Assessments.

As noted above, the NPS has regulations preventing adverse impacts to the WJT. For example, Joshua Tree National Park includes land protected by the Wilderness Act. 36 CFR § 2.1 (a)(1)(ii) prohibits possessing, destroying, injuring or disturbing Joshua Trees. The Department of Defense manages natural resources on military lands via development and implementation of integrated natural resources management plans (INRMPs). Populations of WJT on Bureau of Land Management (BLM) lands receive various levels of protection from human impacts. For example, the Desert Renewable Energy Conservation Plan on BLM land identified large areas of WJT habitat for conservation. CESA management and enforcement actions are unnecessary, burdensome and duplicative when there are so many other measures in place or can be used to protect the WJT.

As noted by the Status Review Report, at the state and local level, numerous laws and ordinances also serve to provide significant additional protection for the WJT. For example, as noted above, under the California Desert Native Plant Act, the WJT may not be harvested without a permit in Imperial, Inyo, Kern, Los Angeles, Mono, Riverside, San Bernardino, and San Diego counties. (Food & Agr. Code §§ 80073(a), 80003.) Local jurisdictions have adopted measures similar to those set forth in CDNPA, including specific prohibitions on removing Joshua trees. For example, the County had a comprehensive regulatory program designed to protect and preserve both the eastern and western Joshua tree, the Plant Protection and Management Ordinance. (San Bernardino County Code §§ 88.01.010-88.01.090.) The County provisions applicable to the WJT have been paused during the candidacy period for the species, but, as explained in the accompanying letter from the County, the San Bernardino County Board of Supervisors recently adopted an ordinance to impose greater penalties on any unlawful removal of WJTs and a resolution outlining the planned expansion of the County's Joshua tree management efforts and regulatory program. These types of regulatory programs, rooted in a stringent set of codified regulations adopted under the California Native Desert Plants Act, are reinforced by a dedicated culture of mitigation, monitoring, and enforcement throughout the region to protect this iconic species at the local level.

III. CONCLUSION

Based on the above, and the comments previously and concurrently submitted in opposition to the Petition by other parties, the best available science on the WJT demonstrates that a likelihood does not exist that the species will become endangered in the foreseeable future and that listing is not warranted under CESA. The Commission should adopt the Status Review Report's recommendation as its action on the Petition.

The County thanks the Commission for considering these comments, and we look forward to working together to address any concerns or questions.

Respectfully Submitted,

MEYERS NAVE

Shaye Diveley
Special Counsel
San Bernardino County

Enclosures:

1. **Technical Memorandum**, prepared by Heritage Environmental Consultants (2022 Heritage Report), May 26, 2022.
2. **Technical Memorandum**, prepared by Heritage Environmental Consultants (2021 Heritage Report), May 7, 2021.

c: Chuck Bonham, Director (

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EXHIBIT 1

Technical Memorandum

Prepared For: County of San Bernardino

Prepared By: Heritage Environmental Consultants

Subject: Status Review of the Western Joshua Tree

Date: May 26, 2022

Background

In October 2019, the Center for Biological Diversity (CBD) submitted a petition to the California Fish and Game Commission (CFGC) to list the western Joshua tree (WJT) (*Yucca brevifolia*) as threatened under the California Endangered Species Act (CESA) (CBD 2019). CBD (2019) listed several factors that are "often related, synergistic, and collectively threaten the continued viability" of the WJT, including "predation, invasive species, wildfire, drought, climate change, and habitat loss". Further, CBD (2019) suggested that "climate change represents the single greatest threat to the continued existence" of the WJT.

In February 2020, the California Department of Fish and Wildlife (CDFW) completed a review of the petition and other scientific information, determined that the petitioned action may be warranted, and recommended the CFGC accept the petition for further consideration (CDFW 2020). In September 2020, the CFGC accepted the petition for consideration and the WJT became a candidate for listing as threatened or endangered (CFGC 2020).

Heritage Environmental Consultants (Heritage) previously reviewed the scientific basis for listing the WJT under the CESA (Heritage 2020), including studies identified in CBD's (2019) petition and CDFW's (2020) review. Heritage (2021) updated a portion of its earlier review by expanding the comparison of the WJT with other CESA-listed species.

Status Review

Following the CFGC's designation of the WJT as a candidate species, the CDFW began a status review to inform the CFGC's decision on whether listing the WJT as threatened under the CESA is warranted. The final status review (CDFW 2022) was released in March 2022. The final status review is based on the best available scientific information available to CDFW. It was informed by an independent peer review by experts in the scientific community with knowledge and expertise to critique the scientific validity of the draft status review. Peer review comments and CDFW's response to those comments were provided in an appendix to the final status review.

Comments on the Status Review

Heritage Environmental Consultants conducted a technical review of the final status review (CDFW 2022), including the content of the status review and the peer review comments and responses. Our technical review found that the status review provides an objective, thorough, and well-reasoned compilation of the best available science on the WJT. During our review, we identified two topics that, while adequately discussed in the status review, could benefit from additional comment here.

Distinction of YUBR North and South Metapopulations

The CBD (2019) petition requests listing of the WJT as a species, but also requests consideration for listing two occurrence groupings ("YUBR North" and "YUBR South") as separate "ecologically significant units". In our earlier review (Heritage 2020, pages 3 and 4), we discussed this concept, concluding that the best available information does not support the division of WJT into two distinct metapopulations or "ecologically significant units". The final status review (CDFW 2022) examines this same concept in detail on pages 10-12. Since our earlier review, new information has been developed on genetic diversity in the WJT, notably a recently published study by Smith and others (2021). This study (Smith et al. 2021) supports the concept of the WJT and eastern Joshua tree (*Yucca jaegeriana*) as two distinct species. Smith and others (2021) indicate there is genetic diversity between populations of WJT; however, genetic variation appears to be continuous across the range of the WJT and no populations appear to be sufficiently isolated to be recognized as evolutionarily significant units (ESUs). CDFW (2022) concludes that it does not consider populations of the WJT in the northern and southern portions of its range to be distinct for the purpose of listing under the CESA. We reviewed the work of Smith and other (2021) and agree with the conclusions of CDFW (2022).

Wildfire, Fire Return Intervals, and Recent Increases in Area Burned

The threat of wildfire to the WJT is thoroughly discussed in the final status review (CDFW 2022). One topic of concern is the increased area burned in recent decades, which is discussed on pages 83 and 85 of the final status review. The status review (page 83) cites Brooks and others (2018) as calculating a fire return interval of 687 years for middle elevations of the Mojave Desert, where the WJT is found at the highest density. We were not able to review Brooks and others (2018) directly, but assume the values reported in the status review are accurate. A fire return interval of 687 years translates to about 1.5% of an area burned per decade. Looking at Figure 10 (CDFW 2022, page 85), actual area burned was substantially below this value between 1900 and 1990, only increasing above this value in the decades after 1990. Over the entire period shown in Figure 10, it appears the average area burned per decade was about one percent, consistent with the expected value reported by Brooks and others (2018).

Peer Review Comments and Responses

The CDFW invited five independent experts familiar with the WJT and related topics to conduct a peer review of the draft status review. Peer review comments and the CDFW's responses to those comments, are included in Appendix B of the final status review. Heritage reviewed the peer review comments, CDFW's responses, and how the comments and responses were incorporated into the final status review. In the remainder of this section, we provide general comments on the peer review comments and responses, as well as comments specific to each peer review.

General Comments

In our review of the comments and responses, we noted several common themes that are summarized here, with additional detail provided in our comments on the individual peer reviews that follow.

Many recent studies of the WJT were conducted at Joshua Tree National Park (JTNP), which is located at the southern edge of the species' range. We do not question the results of the studies, or their utility in drawing conclusions specific to JTNP; however, several reviewers seemed to view results obtained here as valid across the entire range of the species. We do not support this view.

Similarly, several reviewers seemed to consider substantial risks documented in the southern part of the range, particularly climate change, wildfire, and development, as equally applicable across the entire range of the species. We do not question the documented risks to the WJT, but do not support application of these risks equally across the entire range.

Responses by CDFW to the peer review comments were generally well-reasoned and complete. We generally agree with the approach CDFW took in responding to the comments and support the edits made between draft and final documents. In our review, we noted several responses that would benefit from some additional discussion. **Appendix A** to this review contains five tables, one for each peer review. In these tables, we copied the peer review comments and CDFW responses and then added our own review comments. We recommend that any future revision of the status review consider our comments as a means of improving the completeness and quality of the document.

Comments on Peer Review by Dr. Cameron Barrows

Overall, Dr. Barrows' comments demonstrate a reasonable understanding of much of the current science and threats to the WJT. In our review, we noted that some of the reviewer's comments appear to take certain statements in the status review out of context, missing the point of the surrounding paragraph(s), and then using their interpretation to suggest flaws in the status review. The reviewer appears to focus on the results of studies at JTNP and does not adequately consider available information across the range of the WJT. This focus leads to a bias toward threats and potential decline of the species, which when extrapolated to the species across its range, suggest greater threats and risk of decline than may actually exist. Dr. Barrows does not explicitly state that the WJT should or should not be listed; however, many of his comments imply that sufficient evidence is available to suggest that listing may be warranted.

Responses by CDFW to Dr. Barrow's comments are generally adequate and well-reasoned; however, some additional nuance could be added per Heritage review comments provided in **Table A-1, Appendix A**. In particular, we believe that CDFW could more clearly acknowledge that climate change is likely to further reduce recruitment at the southern edge of the range of the WJT, while at the same time noting that this threat has not been demonstrated more broadly across the range.

Comments on Peer Review by Dr. Erica Fleishman

Overall, Dr. Fleishman's review was thorough and provided numerous comments that substantially improved the clarity and strength of the final status review. Several of the reviewer's comments were made from an academic perspective and, while accurate and appropriate for a scientific peer review, may not have considered that a large part of the audience for the status review is outside of the academic realm. This approach did not reduce the value of the comments. The responses to these comments indicate a clear understanding on the part of the CDFW that the audience for the status review is broader than the scientific community. We found that the reviewer's comments and CDFW's responses, while not necessarily coming from the same perspective, were both valid and appropriate. Dr. Fleishman explicitly agreed that the status review supports CDFW's recommendation that listing of the WJT as threatened is not warranted.

In most cases, CDFW responded to Dr. Fleishman's comments by modifying the status review; however, several suggestions were not incorporated in the final report. We believe that most of the comments that were not addressed were good suggestions and would have further strengthened the report. Please see **Table A-2, Appendix A** for our specific review responses. It appears that CDFW was not able to make these changes in the interest of time based on its need to complete the status review. We recommend that any future revision of the status review address these comments. We also noted that the reviewer identified several information gaps and suggested further research needs. We support these suggestions and recommend that CDFW address these gaps as time and funding allows.

Comments on Peer Review by Dr. Tim Krantz

Overall, Dr. Krantz's review was thorough and demonstrates understanding of the threats faced by the WJT. Dr. Krantz makes several management and research suggestions that help strengthen these sections of the status review. The reviewer clearly supports the concept of two separate and distinct populations of the WJT, "YUBR North" and "YUBR South". We note that the reviewer focused almost exclusively on YUBR South and threats in this portion of the species' range, while ignoring YUBR North. By asserting that YUBR North and YUBR South are distinct ESUs, and then focusing on threats to YUBR South, the reviewer comes to the conclusion that the best available science supports listing of the YUBR South population as threatened. This focus suggests bias toward listing based on the current information and threats to a limited portion of the entire range of the species. We believe this approach introduces a fundamental flaw into the peer review because the best available science does not support any distinction between these two alleged populations, and specifically does not support them as valid ESUs.

Responses by CDFW to Dr. Krantz's comments are generally adequate and well-reasoned. We support CDFW's conclusion that the range of the WJT cannot be divided into two separate and distinct metapopulations. Some nuance could be added to CDFW's responses per Heritage review comments provided in **Table A-3, Appendix A**. The reviewer makes some good recommendations regarding research needs and management options. We note that CDFW generally incorporated these recommendations into the final status review.

Comments on Peer Review by Dr. Lynn Sweet

Overall, Dr. Sweet's review was comprehensive, providing comments on many aspects of the best available science in an objective manner and substantially improving the clarity and strength of the final status review. The reviewer provided detailed comments on species distribution models, her particular area of expertise; however, we note the most recent and robust modeling generally only examined the southern part of the WJT's range and caution should be used in extrapolating results there across the entire range of the species. Dr. Sweet did not make a recommendation for or against listing the WJT as threatened under the CESA.

CDFW generally responded to Dr. Sweet's comments by modifying the status review as appropriate. In cases where CDFW did not directly incorporate the reviewer's comments in the final report, the responses generally provide adequate justification; however, some additional nuance could be added per Heritage review comments provided in **Table A-4, Appendix A**. In particular, we believe that CDFW could provide additional details on methods used to generate the range estimates.

Comments on Peer Review by Dr. Jeremy Yoder

Overall, Dr. Yoder's review was thorough and demonstrates understanding of the threats faced by the WJT, with particular attention to the potential for cumulative effects to pose a greater threat to the species than any individual effect. We acknowledge that the draft status review may have viewed effects that are not well understood in a more optimistic light, but suggest that the reviewer may have taken a more pessimistic approach in their comments. The final status review, in our opinion, presents a balanced view that is informed by both the best available science and reasoned comments from all reviewers.

The reviewer appears comfortable extrapolating from observations at JTNP or other local studies to broad-scale adverse effects at the species level, a position that is not necessarily supported by the best available science. For example, the reviewer suggests that lower population density in the southern portion of the range is an early indication of the effects of climate change. We acknowledge that climate change is a reality and is likely to reduce the quality of WJT habitat at the lower elevation, warmer southern edge of the range. We also acknowledge that lower population density could be an effect of climate change; however, we are not aware of any evidence that supports a cause-and-effect relationship as asserted by the reviewer.

Responses by CDFW to Dr. Yoder's comments are generally adequate and well-reasoned. Some nuance could be added to CDFW's responses per Heritage review comments provided in **Table A-5, Appendix A**.

Dr. Yoder agrees that the current range and abundance of the WJT are sufficient that listing the species as endangered under the CESA would not be appropriate; however, he is not convinced that evidence provided in the status review supports CDFW's recommendation that listing as threatened is not warranted.

Conclusion

We believe the peer review process in general and the combined comments from the five reviewers in particular contributed substantially to the quality of the status review. The comments were thorough, thoughtful, and led to an improved final status review.

The status review is a comprehensive look at the best available scientific information on the WJT. In addition, the status review objectively considers the risks to the species and presents a list of management recommendations and recovery measures, including elements of future research (CDFW 2022, pages 120-122). We support the management recommendations and recovery measures and note that all can be implemented regardless of whether the WJT is listed as threatened or not.

Finally, the status review recommends that the CFGC find the petitioned action to list WJT as a threatened species to be not warranted. This recommendation is based on the best scientific information available to the CDFW, which indicates that the WJT is not in danger of becoming extinct throughout all or a significant portion of its range because of one or more threats including loss of habitat, alteration of habitat, overexploitation, predation, competition, or disease, and is not likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts. We concur with this recommendation. We note that if the CFGC were to find that listing is not warranted at this time, nothing would prevent listing in the future if additional information were to be published that suggested greater threats or more imminent risk of the WJT becoming an endangered species.

References

Brooks, M. L. and R. A. Minnich. In Press. Fire in the Southeastern Deserts Bioregion. Chapter 16 in: Sugihara, N.G., J.W. van Wagtendonk, J. Fites-Kaufman, K.E. Shaffer, and A.E. Thode (eds.). Fire in California Ecosystems. University of California Press, Berkeley.

California Department of Fish and Wildlife. 2022. Report to the Fish and Game Commission. Status Review of Western Joshua Tree (*Yucca brevifolia*). March 2022.

California Department of Fish and Wildlife. 2020. Evaluation of a petition from the Center for Biological Diversity to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178625&inline. Accessed June 9, 2020.

California Fish and Game Commission. 2020. Notice of Findings. Western Joshua Tree (*Yucca brevifolia*). September 24, 2020. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=183565&inline. Accessed December 2, 2020.

Center for Biological Diversity. 2019. A petition to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175218&inline. Accessed June 3, 2020.

Heritage Environmental Consultants. 2021. Review of CESA-listed Species and Comparison with the Western Joshua Tree. Technical memorandum prepared for the County of San Bernardino. May 7, 2021.

Heritage Environmental Consultants. 2020. Review of scientific basis for listing the western Joshua tree as threatened under the California Endangered Species Act. Technical memorandum prepared for the County of San Bernardino. August 5, 2020.

Smith, C. I., M. R. McKain, A. Guimond, and R. Flatz. 2021. Genome-scale data resolves the timing of divergence in Joshua trees. American Journal of Botany 108(4): 647–663.

Appendix A Peer Review Comment Tables with CDFW Responses and Heritage Review Comments

Table A-1 Peer review comments from Dr. Cameron Barrows on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	Thank you for the opportunity to review and assess the Department's recommendations regarding the status of western Joshua trees. Overall, the report is comprehensive, delving into the relevant aspects of this species ecology. As requested, I will go through each point individually below, however, overall, it reads as an argument for not listing this species as threatened or endangered, not as an objective analysis of the existing data, and as a result is flawed, suffering from repeated confirmation bias. Whether or not listing Joshua trees as threatened or endangered under the CESA will do anything to ensure that this species will not go extinct is a point I can argue, but whether or not Joshua trees are at risk of being extirpated from most of their current range, based on the available data, is quite clear.	The Department has addressed multiple specific examples brought up by peer reviewers regarding uncertainty of scientific results being interpreted in a manner that minimizes those threats, and in response has included additional text to address the possibility that the severity of some threats may have been underestimated. The Department also added a paragraph in the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat to discuss uncertainty regarding the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review.	The response seems adequate, but without seeing exactly what changed it is hard to assess. Of note, the reviewer's comment as duplicated here seems moderately subjective and unsupported. For example, what evidence is given that the WJT is at risk of being extirpated from "most of their current range"?

Table A-1 Peer review comments from Dr. Cameron Barrows on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
209-214	"Predicted loss of areas of 20th century suitable climate conditions for western Joshua tree could result in an overall reduction in recruitment or increase in adult tree mortality, but the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts on existing populations that are severe enough to threaten to eliminate the species from a significant portion of its range by the end of the 21st century." This is an argument repeated throughout the document. The Department's argument being that yes, climate change is a threat to this species but because you can't quantify the impact range-wide, you discount this threat. Joshua trees have been studied with respect to climate change more than any other species in western North America. Every study has pointed to the same conclusion, that higher aridity constrains or eliminates recruitment. There is no controversy here, there is no wiggle room to say that the "jury is still out". The Sweet et al. (2019) paper demonstrates that both through state-of-the-art modeling and through empirical data. I am happy to acknowledge that models can be suspect when not validated, but this study did the validation and showed that everywhere the model indicated incrementally unsuitable habitat there was no recruitment. The adult trees looked fine, but without recruitment the stands were evolutionarily extinct. The Cole et al (2011) analysis was much coarser but showed that this was not an isolated phenomenon.	The Climate Change section discusses the high exposure of western Joshua tree to climate change, at length, and goes on to discuss the possibility that this climate exposure will have demographic effects, concluding that they are likely to result in population declines. Population declines are cause for substantial concern, but they do not mean that western Joshua tree will be in serious danger of becoming extinct in a significant portion of its range by the end of the 21st century. The reviewer mischaracterizes the results presented by Sweet et al. (2019). While both Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Barrows and Murphy-Mariscal (2012) incorporated demographic data by comparing a binary map product for adult trees with another for juvenile trees, which was useful in suggesting that a demographic link with climate change is present, but it is not an actual correlation. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of "High Recruiting" and "Low Recruiting" macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Both of these studies also examined the same area: Joshua Tree National Park, which is a small portion of western Joshua Tree's total range.	Generally agree with response. We do not question the potential correlation between climate change and loss of recruitment modelled in the referenced studies. But as noted in the response, these studies examined the same small area at the southern extent of the range of YUBR: Joshua Tree National Park. As we concluded in our 2020 review (page 9), "Climate change appears likely to reduce the range of YUBR, particularly at its southern edge; however, suitable habitats will remain in refugia and more broadly at its northern extent."

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Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
277	"Nevertheless, western Joshua tree is currently abundant and widespread, which lessens the overall relative impact of the threats to the species, and substantially lowers the threat of extinction within the foreseeable future." This appears to be the Department's primary, continually repeated, defense for their conclusion that Joshua trees do not warrant any additional state protection. It would be true if the threats were spatially constrained, but climate change is an existential threat, unconstrained by area, and so whether Joshua trees are currently abundant and widespread is a meaningless argument. Climate change is and will continue to impact all Joshua trees throughout their range. Many are already "evolutionarily extinct" populations of only mature adults, with no successful recruitment. Others will be unless we do something.	While all of the studies assessed by the Department come to similar conclusions that the areas with climate conditions that supported western Joshua tree during the 20th century are expected to contract substantially by the end of the 21st century, the negative effects are not expected to affect the range of the species evenly and a goal of both Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) was to identify areas of refugia. The Department does not agree that the abundance and widespread nature of western Joshua tree is meaningless when considering the extent to which it may be affected by climate change.	Generally agree with response. Climate change will affect the WJT across its range; however, the reviewer asserts lack of recruitment at the southern edge of the range (where loss of recruitment has been documented) demonstrates the potential for equivalent effects across the entire range (where recruitment has not been studied). We do not believe this assertion is valid because of the substantial differences in recruitment factors (for example, temperature, precipitation) across the range.
1301	"Figure 5: Average Deviation of Annual Precipitation in the Mojave Desert Region" Here the Department failed to include the most recent two decades of precipitation data which show the most significant and long-lasting drought, including three years of severe drought, over the past century. The best way to portray drought severity is with the SPI, (Standard Precipitation Index). Not including the last two decades is irresponsible and demonstrates the bias in presenting or emphasizing only those data that support a no additional protection needed conclusion.	The Department did not produce this figure, which was reproduced in the Status Review to illustrate multi-decadal precipitation patterns in the Mojave Desert region. To address the lack of data from the last 2 decades the Department added a reference to a 2021 study by Khatri- Chhetri et al. to the Precipitation and Climate Change sections of the Status Review to state that the Mojave Desert region has experienced more frequent and severe drought conditions in recent years.	Generally agree with response. Although not important to the response, it would have been nice to see an updated figure to help identify any change in trend or at least illustrate the recent drought period.

Table A-1 Peer review comments from Dr. Cameron Barrows on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1473	"Population trends can be an important predictor for extinction risk (O'Grady et al. 2004)." OK. Population trends, using those populations that continue to have successful recruitment as the baseline for populations that are not already evolutionarily extinct, show a distinct tread downward. So why conclude Joshua trees do not require some additional level of protection?	As discussed and illustrated in the Demographic Information section of the Status Review, the Department has evidence of recent recruitment at many populations throughout the range of the species, and demographic information from some populations appear consistent with negative population trends. As discussed in the Management Recommendations and Recovery Measures section, the Department also recognizes the value of additional protections for the species, however the purpose of this Status Review is to make a recommendation regarding whether western Joshua tree is likely to be in serious danger of becoming extinct in all or a significant portion of its range in the foreseeable future.	Generally agree with response. The Status Review contains substantial new demographic data that demonstrates variable recruitment across the range of the WJT. Most importantly, it does not demonstrate widespread decline.
1795	"Species with large ranges therefore tend to be less vulnerable to extinction from disturbances, environmental changes, random events, and other threats than species with more limited ranges (Purvis et al. 2000, Harris and Pimm 2007, Gaston and Fuller 2009, Pimm et al. 2014, Leão et al. 2014, Newbold et al. 2018, Silva et al. 2019, Enquist et al. 2019, Staude et al. 2020)." Less vulnerable does not mean that larger populations are not vulnerable. None of those citations refer to populations impacted by existential threats such as climate change.	The Status Review does not claim that larger populations are not vulnerable to extinction. The most recent article cited for this sentence in the Status Review is Staude et al. (2020), which is a global review of risk of local extinction that discusses climate change specifically and includes several citations. As stated in the Staude et al. (2020) article, empirical evidence for climate-driven global plant extinctions in recent centuries is very limited. However, the article acknowledges the increasing importance of climate change as a driver of plant extinctions.	Agree with response.

Table A-1 Peer review comments from Dr. Cameron Barrows on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1875	"Studies indicate that by the end of the 21st century California's climate will be considerably warmer than it is today, precipitation will become more variable, droughts will become more frequent, heavy precipitation events will become more intense, more winter precipitation will fall as rain instead of snow, snowpack will melt earlier in the year, and snowpack will be diminished (Leung et al. 2004, Hayhoe et al. 2004, Mote et 53 al. 2005, Knowles et al. 2006, Garfin et al. 2013, Bedsworth et al. 2018, He et al. 2018)." This document continually refers to climate change as if it is a future threat, something to deal with sometime in the future. It is here now and has been for decades. We can see the impacts on Joshua trees throughout their range. This is irresponsible. The only argument to be made is whether a CESU listing will alter that threat. I will argue that it will, if done with science and flexibility. It will increase public awareness and quit this misinformation of climate change only being a future threat (tell that to the drought-stricken southwest, flooding in the east and northwest, wildfires in the northwest, and sea-level rises along coastlines). Additionally, and specific to Joshua trees, it could fund research to identify climate refugia and genetic diversity within each population. With that information climate refugia that represent distinct genetic trajectories would be provided the highest levels of protection, while solar development could then be focused on those regions where the populations have been evolutionarily extinct for many years.	The first sentence of the Climate Change Direct Impacts section of the Status Review states that "The climatic conditions across western Joshua tree's range have already changed and will continue to change as a result of ongoing global carbon emissions." A primary purpose of this Status Review is to make a recommendation on the condition of western Joshua tree in the foreseeable future, which is defined in the Status Review to be the year 2100, and discussions in the Climate Change section therefore focus on that future. A discussion of climate conditions in the recent past to the present is provided in the Climate, Hydrology and Other Factors section of the Status Review, which serves as baseline for the comparison with future conditions provided here. Added a sentence to the Protection Afforded by Listing section of the Status Review to state that CESA listing of western Joshua tree could also increase public awareness of the conservation needs of the species and California desert ecosystems, and could lead to an increased interest in scientific research on the species.	Generally agree with response. As noted in the response, the reviewer took the cited section out of context. The response restores this context. We are concerned with the approach of using listing to increase awareness and funding for research. These changes could be made without listing, and without some of the adverse effects of listing, for example, curtailment of renewable energy development, which is one key to reducing future climate change.

Table A-1 Peer review comments from Dr. Cameron Barrows on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1990	"the Department does not possess a 1990 comprehensive random field sample of western Joshua tree demographic information in 1991 California" Having a "comprehensive random field sample" has never been the criteria for action. Using the best available science is that criteria. Using the best available science, there is no controversy here, there is no wiggle room to say that the "jury is still out".	A comprehensive random field sample is not a criteria for determining listing; this sentence was intended to highlight that the limitations of currently available demographic information limits the Department's ability to determine western Joshua tree's sensitivity to climate change. This sentence has been revised to be more specific and state that such a sample could be used to correlate declines in recruitment with areas most severely affected by climate warming that has already occurred, and the sentence now includes a reference to the work of Barrows and Murphy- Mariscal (2012) and Sweet et al. (2019).	Generally agree with response. Again, the reviewer took the cited sentence out of context. The response and edits to the status review restore and clarify the context.
2212	"how well their model accurately predicts the current distribution of Joshua tree, which calls into serious question the modeling methods used and therefore the accuracy of model predictions." This statement is a "red herring" and underlines the confirmation bias the Department has used in developing their conclusion. If the data indicate a conclusion that is at odds with what the Department wants, then challenge the accuracy of that data with no background or support as to why it should be questioned. Or use the best available science. Use science that has done what all science must do, undergo rigorous peer review. Show us where peer reviewed science is in disagreement, don't just question inconvenient truths.	Species distribution models have many limitations that are well acknowledged by the scientific community in peer- reviewed scientific literature. For these reasons, species distribution models should be credible, transparent, reproducible, and evaluated carefully to be used effectively for decision-making (Sofaer et al. 2019, Lee-Yaw et al.2021). Performing checks of model predictions is a common best practice for species distribution modeling efforts (see cited sources above) and pointing out this significant shortcoming in this very early species distribution modeling effort that also addressed 75 other plant species using the same methods is a valid criticism. Despite limitations, however, the Department clearly acknowledges the usefulness of species distribution models in the Status Review, concluding that western Joshua tree will experience a high level of exposure to climate change. The text was revised to remove the word serious from the sentence.	Generally agree with response. We are not sure if it is fair to question the methods (which are what they are), but without a check of predictions against data, it is fair to question the accuracy of the predictions. The reviewer is splitting hairs on the difference between highlighting disagreement vs. questioning the accuracy of results. The section in the status review does both, as appropriate for a review of best available data. By questioning accuracy, the status review highlights that the study in question may not be the best available science.

Table A-1 Peer review comments from Dr. Cameron Barrows on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
2313	"Continuation of western Joshua tree recruitment in areas of JTNP that Sweet et al. (2019) modeled as no longer containing suitable climate demonstrates that a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species." Another red herring. Rather that focus on the high level of congruence between the model and the patterns of recruitment on the ground, the Department has chosen to question the conclusions since they are not 100% accurate (they were closer to 95% accurate). The reality is that +70% of the Joshua trees within the park are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia. As aridity increases those refugia will incrementally become less and less suitable for the long-term sustainability of this species.	The reviewer did not provide data or cite a source for the claim that "+70% of the Joshua trees within the park are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia." While both Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Barrows and Murphy-Mariscal (2012) incorporated demographic data by comparing a binary map product for adult trees with another for juvenile trees, which was useful in suggesting that a demographic link with climate change is present, but it is not an actual correlation. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of "High Recruiting" and "Low Recruiting" macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Both of these studies also examined the same area: Joshua Tree National Park, which is a small portion of western Joshua Tree's total range. Sentence revised to add the modifier ", at least in the short term" at the end, and made it clear that the statement was in reference to the areas that Sweet et al. (2019) modeled as no longer containing suitable climate during the 1981–2010 climate period.	Generally agree with response. While current science may not show strong correlation between the effects of climate change and reduced WJT recruitment, we believe it is reasonable to assume such correlation. We also do not question reduced recruitment demonstrated by the cited studies, which as noted were limited to the southern (generally warmest, driest) edge of the WJT range. Statement in the status review is simply showing that the predictions are not 100% accurate, which is fair. There is recruitment, though whether it would lead to long-term persistence is unknown. Lack of support for the 70%+ statement indicates potential bias on the part of the reviewer for listing and against the overall conclusions of the status review.

Table A-1 Peer review comments from Dr. Cameron Barrows on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
2485	"but the Department does not have information indicating that western Joshua trees in the affected areas will likely die, or that populations are likely to cease reproducing or be no longer sustainable at the end of the 21st century" Yes, the department does have that information. Just use the best available science.	Sentence revised to include additional reasoning in response to this and other peer-reviewer comments. The Department also added a paragraph in the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat to discuss uncertainty regarding the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review.	Generally agree with response. The edits to the summary were important in identifying that significant range loss is not certain. Individual loss and population decline in certain areas is acknowledged.

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	Thank you for the opportunity to provide a scientific peer review of Status review of western Joshua tree (*Yucca brevifolia*). On the basis of the best scientific information available, I agree with the recommendation of the California Department of Fish and Game (Department) that listing western Joshua tree as a threatened species is not warranted. As detailed below, however, I believe that some elements of the Department's assessment are unclear, may be misleading, or could be strengthened.	Responses to specific comments on elements identified by the reviewer as unclear, possibly misleading, or that could be strengthened are provided below.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
N/A	The status review is intended to reflect the best scientific information available (see, e.g., line 310). In some cases, the status review appears to include a more comprehensive selection of the scientific information available—a subset of which, as suggested by the review itself, may not be highly reliable. The review would be more accessible to a diverse audience if it synthesized the best information and, if necessary, simply referenced other sources of information. I underscore synthesized because some sections of the status review are presented as summaries of the literature (whether high-quality or variable) rather than as syntheses. As one of many possible illustrations, the section on seed dispersal (768) would convey the best scientific information more effectively if it synthesized the species that are known to disperse seeds and the known dispersal distances. Instead, the section describes the methods and results of published studies sequentially, leaving it to readers to extract the primary inferences. As another illustration, the geology and soil section could begin with a statement that water availability likely limits survival and reproduction of Joshua trees, and therefore the water-retention capacity of the soil in a given area is relevant to the persistence of the species. The conclusions of some sections (e.g., 1064) could form the basis for such syntheses, much like introductions to high-quality, peer-reviewed scientific publications.	Additional synthesis text added near the beginnings of the Seed Dispersal and Geology and Soils sections of the Status Review per the reviewer's suggestion. The Status Review includes syntheses of information where appropriate, but also includes summaries of the literature when that is important because some of the details of the methods may be relevant to the study conclusions (such as the species and location of the work). The section on seed dispersal includes more detail because some of the information has been important for Department functions related to CESA including environmental review and permitting.	The reviewer's comment is valid, but the CDFW approach is equally valid. It may be important to summarize certain parts of the literature to show consideration and inform the intended audience, even for information that may not be peer-reviewed and published.

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	Throughout the review, the concept of habitat is misrepresented. Despite common misuse, habitat is not synonymous with location, vegetation type, or land-cover type. Instead, habitat is a species-specific construct. It encompasses the space within which a species (or other taxonomic entity) lives or can live and the abiotic and biotic elements in that space that generally are required for survival and persistence. The quality and configuration of a species' habitat affect its population dynamics and relations with other species and its connectivity, usually defined as the probability that genes or individuals move among patches of the species' habitat. Representation of the concept of habitat matters because at both the California and federal levels, most species-specific mitigation plans focus on acquiring areas that appear to function as habitat for the species or increasing the quality of the species' habitat. Descriptions and quantifications of habitat that fully reflect existing knowledge about the manner in which a given species interacts with its abiotic and biotic environment increase the feasibility of identifying the factors that limit survival and reproduction, the actions most likely to increase the species' survival and reproduction, and metrics of success. Moreover, habitat is suitable by definition. Suitable habitat is redundant, and unsuitable habitat is an oxymoron.	The document was searched for the word habitat and text updated where necessary.	Ok
N/A	There is some inconsistency with respect to topics for which background is provided, and the rationale for more or less explanation is unclear. For example, aspects of plant physiology are defined (e.g., lines 387-401, 414- 417), and diapause is explained briefly (750), but recruitment (e.g., 1539) and the El Niño–Southern Oscillation and the Pacific Decadal Oscillation (1281) are not.	Additional background added for the two examples identified by the reviewer: Added a definition of recruitment to the Establishment section of the Status Review and added background that El Niño, La Niña, and Pacific Decadal Oscillation are sea surface temperature conditions.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
185	The Mojave and Great Basin are deserts. Therefore, by definition, any vegetation (not habitat; see above) in these ecosystems is desert vegetation, and it is redundant to state that precipitation in these areas is low.	The word "habitat" was replaced to address another comment from this reviewer. Low precipitation is a characteristic of deserts, but this sentence describes fluctuations between wetter and drier conditions, so it is important context to initially state that precipitation is low so wetter and drier conditions can be put into context. The words "is low" were retained because they occupy little space and may help inform readers who are less familiar with the characteristics of deserts.	Ok
188	"obligate pollinating moth" implies that the moth must pollinate to survive, which is not correct. It would be more accurate to say that sexual reproduction of western Joshua trees appears to require pollination by this species of moth.	Text updated per suggestion	Ok
204	Remove "as refugia," given that the climate tolerances of the species are not well understood.	Text updated per suggestion	Ok
208	Change "climate disruption," which is not objective, to "climate change".	Text updated per suggestion	Ok
222-238	Lines 222–238 largely are redundant with the previous paragraph.	This is a summary of the primary reasoning in the executive summary and the document, and therefore must reference the key topics already discussed.	Ok
199, 230-232	It is true that the likely effects of climate change on the species (230-232) are not well understood. As a result, stating that climate change is the greatest threat to the species (199) seems inconsistent with the evidence and with the subsequent caveats.	Removed statement per suggestion	Ok
413	It would be helpful to provide the context about taxonomic criteria for legal protection at the start of this section rather than later in the section.	Moved the paragraph about taxonomic criteria for legal protection to the beginning of the section per suggestion	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
471	Note here that genetic distinctiveness was based on analysis of single nucleotide polymorphisms. Royer et al. (2016) hypothesized that selection in an intergrade zone operates on style length via the reproductive success of Tegeticula synthetica and T. antithetica; the paragraph does not clearly link information at lines 464-468 to this hypothesis. It also should be noted that although Smith et al. (2021) inferred that coevolution with Tegeticula might sustain taxonomic distinctiveness of Joshua trees, it likely was not the ultimate cause of divergence.	Added note on Royer et al. (2016) methods being based on analysis of single nucleotide polymorphisms. No additional changes were made in response to this comment because hybridization is not a threat to western Joshua tree and the selection pressures influencing the taxonomic distinctiveness of western and eastern Joshua tree are not important for the conclusions of the Status Review.	Ok. Reviewer makes good comments, but response is equally valid.
502-505 and beyond	The petition may abbreviate the species name, but this is distracting in the status review. When not quoting the petition, please simply refer to the southern and northern populations.	Text updated per suggestion	Ok
544	Cline should not be in quotation marks.	Text updated per suggestion	Ok
551	I very much hope that this project will improve scientific understanding. However, the cited work is the equivalent of a public relations piece on the project, and should be deleted.	Text updated per suggestion	Ok
554	Range and distribution are differentiated here, but the subsequent discussion sometimes confounds the two	Text checked and clarified per suggestion	Ok
593-596	Distribution or range?	Text changed to range per suggestion	Ok
606	This is somewhat ambiguous. Do you mean that over time, understanding of the species' distribution has improved, or that understanding of the temporal trajectory of the species' distribution has improved?	Text clarified per suggestion	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
615-618	The URL at line 4309 no longer is linked to the vegetation map. However, I found the map by searching on "Vegetation – Mojave Desert for DRECP." I cannot easily find the reference to 95% accuracy. Note here that the California Native Plant Society's description of the Yucca brevifolia vegetation alliance includes the membership (classification) rule that cover of Yucca brevifolia is even and ≥1%. Additionally, it is not clear whether the 95% accuracy refers to where the alliance is present or absent (binary) or whether it's a reference to the accuracy of the percent cover classifications. Is line 617 implying that absolute percent cover is estimated and then aggregated into classes? It it is unclear how figure 4 was derived, or whether and how the accuracy of the derived map was evaluated. Furthermore, at line 620, it is unclear whether there are areas within the range of western Joshua tree in which vegetation was not mapped.	Text updated to address reviewer comments, and clarify techniques and mapping methodology. Broken links updated.	Ok
621	The information is cover, not density.	Text updated per suggestion	Ok
623	These are cover classes, not absolute cover.	Text updated per suggestion	Ok
623-639	Why is this not in the range section rather than the distribution section?	This section discusses how distribution information was used to develop the range information shown in Figures 2 and 3. Text was added to the Range section stating that the range shown in Figures 2 and 3 was developed using distribution information as described in the Current Distribution section. The Range section is intended to be more general and the Current Distribution section is intended to contain more detailed and specific information.	Ok
628	Line 683 correctly notes that occurrence records from individuals without scientific training can be erroneous. This is all the more reason to fully describe the unpublished process used to estimate the range of western Joshua trees. For instance, how were observations deemed erroneous?	Added a sentence describing how observations were deemed erroneous and noted that the information used for mapping is publicly available.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
629	This description of methods is insufficient to facilitate replication. Additionally, dates of observations in other sources (e.g., herbarium records) may differ considerably, and may not reflect current distribution accurately. The analysis mentioned at line 637 is not detailed. Moreover, a mapping exercise is not necessarily synonymous with an analysis.	Added a sentence describing how observations were deemed erroneous and noted that the information used for mapping is publicly available. Added text stating that some observations used to produce the range map may be old. Changed the word "analysis" to "exercise" per suggestion.	Ok
631	Do you mean the extent of the presumed range of the species, rather than the map? The map includes areas that are outside the species' range.	Text updated per suggestion	Ok
634	Do some records include buffer distances, or were buffers added during the mapping process? If no buffers were used, why is this statement necessary?	Text updated to make it clear that buffers were used	Ok
640	This is confusing. I think you mean that the range is larger than the distribution. Again, the relevance of discussion of buffers is unclear if data were not buffered, and why 0.2 km versus any other distance? (Also, 643 should be "data are", not "data is").	Text updated to clarify that the area of range is larger than area of distribution. The 0.2 km distance was selected by the GIS analyst who performed these calculations based on prior experience with similar mapping exercises. Changed "data is" to "data are" per suggestion.	Ok
650	So what? Is the area of a particular state a criterion for listing?	The area of occupied habitat is important for assessing extinction risk. Areas represented as numbers of unit area are sometimes difficult to conceptualize. This sentence is meant to provide a more accessible and easy-to-conceptualize description of the area occupied by the species.	Ok. Agree with reviewer that this is a scientific "so what"; however, the response is also valid, considering the audience for the status review is likely larger than the scientific community.
658	Quite confusing here whether the references are to range or distribution.	Text updated to be more consistent with the terms range and distribution; however, the sources of information citied in this section may not follow the same conventions as the Status Review.	Ok
662	There is an abrupt shift here from range to distribution.	Previous section discusses how available information on distribution contributed to the range map provided in the Status Review. The subjects are not considered to be different enough to warrant an additional subheading.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
671	It would be helpful to indicate the breadth of spatial extents included in these occurrences, given that an occurrence could be an individual or a stand. Furthermore, the implication is unclear. Is this an estimate of the number of populations of the species, or an estimate of the number of potential records in the California Natural Diversity Database?	Text updated to clarify that separate element occurrences within the California Natural Diversity Database need to be separated by at least ¼ mile, and that this is in reference to the number of separate element occurrences.	Ok. Interestingly, CDFW predicted 840 EOs, slightly higher than our estimates of 480 and 620 in our May 2021 technical review, but within our 95% CI.
673, 689	The fact that the number of documented occurrences of western Joshua trees is greater than that of many other species that are tracked within the California Natural Diversity Database does not necessarily provide information about the status of western Joshua trees. For example, Joshua trees are easy to detect and relatively easy to identify. The same cannot be said for many of the other plant species that are tracked.	This information will be retained because it is informative to disclose how western Joshua tree compares with all other CNDDB-tracked plant species, because the current abundance and distribution of populations are important predictors of extinction risk. An implication of this comment is that the CNDDB would have a much larger number of element occurrences for the other plant species tracked in the database if they were as easy to detect as western Joshua tree. While it is true to an extent, most species tracked in the database are truly rare, and it is highly unlikely that hundreds of undiscovered occurrences are present. A caveat was added that the highest number of occurrences for a plant currently tracked by the Department in the CNDDB was for comparison.	Ok.
695	Does this mean that flowering occurs relatively early in the season (and move lines 707-710 here to provide context for early versus late season) as opposed to relatively late in the season? Or does it mean that during cold and dry years, flowering occurs and happens to be early, as opposed to not occurring? Also, what seasons correspond to a wet or dry year? For example, is this a reference to flowering in the spring following a wet winter? Could a wet summer followed by a dry winter prompt flowering?	Discussion of flowering months moved up per comment. Added text to clarify that the conditions that lead to flowering are not well known.	Ok

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Line	Reviewer Comment	Department Response	Heritage Review
711	Comparing height and age is confusing without data on heights at different ages; explain here the extent to which age can be inferred from height. Comparing height and latitude is confusing without data on heights at different latitudes.	Added a reference to the Growth and Longevity section of the Status Review where information on the relationship between plant height and age is discussed. There may be information on plant height at different latitudes within references cited in the Status Review, but that information was not considered to be important enough to include in the Status Review. The Department included information on height to first branching in the section referenced here because that information was available in Rowlands (1978) and branching is an indication of reproductive maturity, which may be important for understanding the demographics of the species.	Ok
720	All species are unique. Here I think you mean that western Joshua trees primarily are pollinated by T. synthetica; they also can be pollinated by T. antithetica.	Text updated for clarity	Ok
734	Why is this mouth part “special”? Delete that word.	Text updated per suggestion	Ok
739	Stigmas are not restricted to western Joshua trees. Rephrase.	Text updated per suggestion	Ok
746	The definition of a mutualism is that both species benefit—rephrase.	Text updated per suggestion. Definition of mutualism added earlier in the section.	Ok
762	Do you mean that transfer of pollen is limiting? Meaning of “greater sexual reproduction” is unclear. Do you mean that the proportion of sexual to asexual reproduction is greater?	The reference suggests that transfer of pollen could limit seed production. Text updated, and mention of greater sexual reproduction was removed.	Ok
764	Spell out Joshua Tree National Park. The authors may be familiar with this acronym, and the acronym is defined in a separate section of the document, but many readers won’t be familiar with it. The reference to detection of T. synthetica is accurate, but the implication that the moths do not occur in certain locations may be misleading given the duration and methods of the work by Harrower and Gilbert (2018).	JTNP abbreviation removed per suggestion. Changed to an in-line citation to emphasize that these results were from only one study.	Ok
778-779	And still may be important today, and still may occur today.	Text updated per suggestion	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
884	Please simply reference “seedling establishment.” If establishment, then successful. If no establishment, then not successful. The same comment is applicable elsewhere in the document, and to other concepts, such as recruitment (successful recruitment is redundant), e.g., lines 911, 923, 927, 1961; I suggest that you search on “successful” to identify all instances.	Text updated per suggestion	Ok
898	What does “satiate predation” mean, and is this is reference to mast years?	Text updated per suggestion	Ok
902	dispersed “in the wild”—as opposed to where?	Text updated per suggestion	Ok
932	These plants can’t really avoid anything—rephrase to “must not be consumed”	Text updated per suggestion	Ok
937	Is how much greater of a likelihood known?	Text updated to illustrate how much greater the likelihood is based on the study	Ok
943	Restate to “Many plants with which Joshua trees co-occur”	Text updated per suggestion	Ok
971	Restate to “a greater likelihood of survival,” and indicate how much greater.	Text updated per suggestion, however the source does not clearly describe how much greater this chance of survival is, so this information is not provided.	Ok
981	“carefully controlling”—as opposed to recklessly controlling? Just say “controlling”.	Text updated per suggestion	Ok
992	Plants cannot be frugal. However, they may be able to survive with limited water.	Text updated per suggestion	Ok
1019	What age would that be?	Text updated with the age of approximately three years	Ok
1087	The relevance of this section is unclear. I would hope that anyone trying to identify Joshua trees would use a field guide rather than this report. Would the section be better placed with discussion of potentially erroneous occurrence records?	If someone was unfamiliar with the desert flora, they may wonder how easy it would be to mis-identify western Joshua Tree and how physically distinct it is from eastern Joshua tree given that the two species have not always been recognized as distinct entities. A reference to this section was also added to the section of the Status Review that discusses misidentifications of the species submitted to databases such as iNaturalist.	Ok
1091	Co-occurrence by definition refers to the same location	Text updated per suggestion	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1116	Habitat that may be essential to the continued existence of the species usually is referenced with respect to critical habitat in the regulatory sense. There is no geographic information here. It is not possible that all locations where the species occurs are essential; if that was the case, the species should be listed. Habitat can't be located where the species occurs—that's circular— wherever the species occurs is habitat. Natural communities should not be confused with habitat given that habitat refers to the suite of biotic and abiotic attributes necessary for survival and reproduction, and it is unlikely that Joshua trees are dependent on all of the species with which they co-occur.	Department's preliminary identification of the habitat that may be essential to the continued existence of western Joshua tree updated in response to suggestion.	Ok
1141	Combine with 1132.	Text updated per suggestion	Ok
1143	Remove this sentence, which is confusing and redundant with the material above.	Sentence removed	Ok
1149	This is redundant with material above (551)	Redundant material removed and text edited.	Ok
1161	These are not habitats.	Exchanged the word "habitats" with "communities"	Ok
1163	What is meant by visually dominant? What is meant by other species being "more dominant"? Is this a reference to percent cover?	Text updated for clarity per suggestion	Ok
1165	This sentence is quite confusing.	Reduced and combined sentences for clarity	Ok
1181	Explain the difference in microhabitat among the cardinal directions.	The cited study does not provide information on differences in conditions between the cardinal directions but did suggest that microclimates are important. Updated the text to refer to microclimates.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1184	The dominant plant species should be listed in taxonomic rather than alphabetical order. Scientific name and common name generally refer to species rather than alliances—do you mean that these are the dominant species in the alliances, or that these are the names of the alliances? Especially with the inclusion of the Yucca brevifolia alliance, which of course supports Joshua trees, the caption might be more accurate as "Vegetation alliances in which Joshua trees occur or may occur," or something similar.	Table revised to list vegetation alliances in a more taxonomic order (of vegetation community), first by primary lifeform, then alphabetical by alliance scientific name.	Ok. We note that vegetation communities are typically listed as described in the response rather than taxonomic order as requested by the reviewer.
1203, 1205	If in the Mojave and Great Basin then the landforms and mountains are desert by definition; remove "desert".	Text updated per suggestion	Ok
1206	"may be", or "are"?	May be. Text retained.	Ok
1237	Does this mean "climate in the Mojave and southwestern Great Basin," or something similar?	Text updated per suggestion	Ok
1239	Is this a reference to climate at a given point in time, given that climate also varies as a function of topography and latitude?	Climate is the long term pattern of weather in an area, and therefore this is not intended to refer to a specific point in time. While latitude and topography also affect climate, this is intended to mean that local climate is most affected by elevation. Added the word "topography" and the word "local" to help clarify.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1243	It is worthwhile to discuss the fact that average climate may be associated with the physical condition, distributions, or population dynamics of many species, but extreme climate may be equally if not more relevant. For example, see the following. Germain SJ and Lutz JA. 2020. Climate extremes may be more important than climate means when predicting species range shifts. Climatic Change 163:579–598. Siegmund JF, Sanders TGM, Heinrich I, van der Maaten E, Simard S, Helle G and Donner RV. 2016. Meteorological drivers of extremes in daily stem radius variations of beech, oak, and pine in northeastern Germany: an event coincidence analysis. Frontiers in Plant Science 7:733. doi: 10.3389/fpls.2016.00733. Stewart SB et al. 2021. Climate extreme variables generated using monthly time-series data improve predicted distributions of plant species. Ecography 44:626–639. Zimmermann NE, Yoccoz NG, Edwards TC Jr, Meier ES, Thuiller W, Guisan A, Schmatz DR and Pearman PB. 2009. Climatic extremes improve predictions of spatial patterns of tree species. Proceedings of the National Academy of Sciences of the United States of America 106(Supplement 2):19723–19728.	Information and associated citations added per suggestion	Ok
1248	Change “it is unlikely” to “are not”	Text updated per suggestion	Ok
1268	Especially given that these citations do not include climate data from the past 20 years, I’m puzzled by why the authors of the status review did not compile climate data for the region from, say, the National Centers for Environmental Information or PRISM.	It would be a significant analysis beyond the scope of compiling existing information to re- compile precipitation data from the ~50 weather stations across the Mojave Desert and Great Basin similar to what was done by the reference that was cited to create a new figure. Added a reference to a 2021 study by Khatri-Chhetri et al. to the Precipitation and Climate Change Sections to state that the Mojave Desert region is experiencing more frequent and severe drought conditions in recent years.	Ok, but the reviewer makes a good point – the status review would be substantially strengthened by the addition suggested by the reviewer, in our opinion.
1277	As written, the sentence implies that the article’s authors completed their identification sometime during the past 108 years.	Text updated per suggestion	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1283	This section is not entirely clear, and may be confusing El Niño and La Niña with the weather patterns they sometimes produce. In essence, El Niño and La Niña are defined by sea surface temperatures, and those temperatures may or may not result in anomalously wet or dry conditions across the Mojave. See https://www.climate.gov/news-features/featured-images/howel-ni%C3%B1o-and-la-ni%C3%B1a-affect-winter-jet-stream- and-us-climate	Revised the text to be clearer about El Niño and La Niña sea surface temperatures and the weather patterns that they sometimes produce.	Ok
1308	Required for what life history elements? Germination, growth, survival, reproduction? Might precipitation requirements vary throughout the life cycle?	Text updated per suggestion	Ok
1310	What is meant by "extent of other plants"?	Text updated to "cover of other plants"	Ok
1317	This statement is somewhat misleading. Climate water deficit does not quantify slope and aspect, for example, although it may be affected by slope and aspect.	Text updated per suggestion	Ok
1343	The difference between averages and extremes is quite relevant here and likely should go beyond the simple mention of duration of high temperatures (1339).	Text updated per suggestion to emphasize the possible effects of high temperature extremes	Ok
1363	Provide some context here relating "elevated" to the concentrations of carbon dioxide projected under different scenarios by the Intergovernmental Panel on Climate Change or something similar.	Text updated per suggestion	Ok
1366	Recognize here that acclimation affects tolerances of many organisms to many extremes.	Text updated per suggestion	Ok
1373	Abundance and density are not synonyms. The section seems to use the concepts interchangeably, however.	A definition of both abundance and density was added. Abundance is defined as the number of individuals that are present, and density is the number of individuals that are present per unit of area.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1386	Is the intent here to imply that percent cover (which is not the same as abundance or density) of western Joshua trees is below a given threshold in some areas, but may be lower elsewhere?	Text updated for clarity per comment	Ok
1409	This is another section that would benefit from reorganization. Why not begin with a statement about the range of densities that have been estimated in the field, and then provide additional detail about whether the estimates were across extensive or limited areas?	Information on the range of localized population densities added to the first sentence of the paragraph to introduce and summarize the information presented, but the information on specific local densities was not removed because it may be informative.	Ok
1425	Data "were", not "was	Text updated per suggestion	Ok
1445	When did these wildfires occur?	Text updated to "within the previous 100 years"	Ok
1448	What was that resolution of these images? Were the estimates evaluated against ground data—how was 95% confidence estimated? Not enough information is provided here to support replication of the work.	Text updated to state that the resolution of imagery is not known, no ground truthing was conducted, and cite the statistical methods used for stratified random sampling.	Ok.
1471	Just "demographic information" One obviously cannot infer on the basis of unavailable information	Text updated per suggestion	Ok
1479	What do you mean by concerted population growth? Concerted doesn't seem like the correct word here.	Removed the word "concerted" which was from the cited source	Ok
1483	Range and abundance often are correlated, but not necessarily. I'm not convinced that a change in range can be interpreted as a change in abundance (1489).	Text updated per suggestion	Ok
1497	But maybe could estimate percentage of habitat as of some year that was developed	A rough estimate of 30 percent habitat loss is provided later in the paragraph.	Ok
1510, 1517, 1527	To what years does "historical" refer? What were the sources and resolution of the images?	The Department does not have a precise year that it considers to be the beginning of European settlement of the Mojave but added the phrase "during and before the 19th century". Added the general dates of the aerial images examined (mid 20th century) and added another citation to the source (it is cited earlier in the paragraph).	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1552	This is confusing. How large were the plots? What type of data were collected in the 1970s? I'm skeptical that it's not possible to make any type of comparison.	This information is not in the Department's possession. Based on personal communication with National Park Service staff serious attempts were made to make comparisons but it was not possible.	Ok. Old monitoring was likely documented poorly if at all, or documentation lost in the intervening years. Not really surprising, though unfortunate.
1554	Again a couple of synthetic sentences about trend would be quite useful rather than only summarizing a series of individual monitoring programs. The section seems to imply that across the species' range, trends are not uniform, which would not be surprising	Added a synthetic sentence to the opening paragraph per suggestion	Ok
1562	How many is several?	The researcher may have established plots that the Department is not aware of. Deleted the word "several".	Ok
1587	If there is "significant doubt," then why include the work in a review of the "best scientific information available"?	This source was submitted to the Department by Edwards Air Force Base during a call for information, and therefore the Department has analyzed it and included it for transparency.	Ok, and yes, correct response.
1607	Change "is" to "are" (data are)	Text updated per suggestion	Ok
1612	However, one could use simulation modeling to estimate the level of recruitment needed to sustain a population of a given size for a given period of time.	The Department does not currently have any data from simulation modeling or any other methods to estimate the level of recruitment needed to sustain a population of western Joshua tree at a given size for a given period of time.	Ok. But this seems like an obvious research need that should be addressed sooner than later.
1623	Seems like height measurements, not censuses. Census refers to an accounting of all individuals.	Changed "censuses" to "surveys"	Ok
1648	Here, summarize what reasonably can be inferred about persistence on the basis of multiple sources of information on height distributions. It is difficult for readers to synthesize the inferences from many summaries of individual articles or data-collection efforts. Perhaps move the paragraph starting at line 1751.	Moved paragraph up per suggestion	Ok
1703	Standardizing the range of values on the x-axes for figures 6, 7, and 8 would facilitate easier comparison	Comment noted. The Department will address this if possible within time constraints.	Apparently the suggested change was not made. It would have been nice, but not critical.

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1721	What was the source and resolution of the images?	The source reports that imagery was from the National Agriculture Imagery Program and the resolution was not reported. Text updated.	Ok, although approximate resolution of NAIP imagery is known and could have been reported.
1748	What aspect is being referenced here?	This is speculative. We don't know what aspect of life history may have been disrupted.	Ok
1801	Abundant populations can mean many populations, which is confusing. What you seem to mean here, and is clearer in the next sentence, is populations with a high number of individuals.	A definition of abundance was added in the Abundance section of the Status Review. Text updated for clarity per suggestion.	Ok
1807	Do you mean high-quality habitat? Habitat is favorable by definition.	Texted updated to "more suitable locations"	Ok
1820-1821	These are odd definitions of redundancy and representation. If they were included in the USFWS documents, they should be removed from the status review. Redundancy usually refers to function; for example, if many co-occurring bee species pollinate a given plant, there is some functional redundancy. Representation generally refers to a sample of natural variability rather than adaptive capacity.	Added a citation for the definition of those terms as they are used by the U.S. Fish and Wildlife Service.	Ok
1849	All of this is true. Nevertheless, some native and non-native species are likely to benefit from projected changes in climate, and this fact should be acknowledged. It is disingenuous to imply that climate change is a threat in all cases	Text updated to acknowledge that projected changes in climate may benefit some species.	Ok
1868	True, but not just "in the Department's possession," which sounds rather odd. Few scientific teams or individual scientists have made credible projections of climate change beyond 2100.	Text updated per suggestions	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1880	This is too broad of a statement, and as written is not true. Nor is it necessary—whether California is more or less affected by climate variability than other states is irrelevant to the status of Joshua trees. Also, be careful not to imply that all winter storms are caused by atmospheric rivers, although it is true that the strongest storms tend to be from atmospheric rivers. See, for example, https://climate.nasa.gov/news/2409/study-atmospheric-river-stormscan- reduce-sierra-snow/.	Text updated per suggestions	Ok
1890	Explain the range of values. I'm guessing it reflects different scenarios of emissions of greenhouse gases, but should be clarified.	Text updated per suggestion	Ok
1899	Yes, but the point should again be made here, or at 1892, that even if precipitation totals are consistent or increase somewhat, higher temperatures and more precipitation falling as rain than as snow may decrease water availability, especially during summer.	Text updated per suggestion	Ok
1910	True, but the number of ignitions may or may not be related to the size or intensity of wildfires.	Text updated per suggestion	Ok
1915	And ongoing emissions of other greenhouse gases (not restricted to carbon dioxide).	Text updated per suggestion	Ok
1916, 1922, 1923, etc.	As applicable, explicitly related these assumptions to other sections of the document.	Added references to other sections of the Status Review.	Ok
1944	What was the magnitude of warming?	Text updated with magnitude of warming per suggestion	Ok
1955	Climate is only one component of habitat. Soil type, presence of other species of plants and animals, and land use also affect likelihood of colonization.	Text updated per suggestion	Ok
1968	Assuming that survival of seedlings does not increase.	Text updated per suggestion	Ok
1993	Explain why – link to other sections of the document as applicable.	Text updated per suggestion	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2016	Explain why one might expect increases in atmospheric concentrations of carbon dioxide to affect temperature stress. Also, line 2055 seems to offer evidence to the contrary.	Added brief explanatory text. Line 2055 is about low temperature stress, not high temperature stress.	Ok, but the revised text is a little confusing – did they not find effects in WJT, or did they not study effects in WJT?
2028	These areas don't just appear to be occupied, they are occupied. As noted, the species may or may not persist in that location in the future.	Text updated per suggestion	Ok
2042	If Joshua trees could not survive and reproduce in these areas, then the areas were not habitat.	"habitats" changed to "areas"	Ok
2045-2052	Some redundancy here.	Reorganized portions of this section to reduce redundancy.	Ok
2064	The description of species distribution models could be updated and strengthened. For example, the description does not address the necessary data on response variables or trade-offs among different types of response-variable data (e.g., abundance, presence-absence, presence only). The description also seems to imply that the environmental variables entered into such models are restricted to climate data, whereas ideally one would include spatial data layers on a larger set of abiotic or biotic variables hypothesized to have a major effect on distribution. By extension, this section seems to imply, perhaps inadvertently, that a small set of climate variables are the primary factors that limit or predict species distributions. Some of these points are addressed at lines 2352-2374, but not all. Furthermore, those caveats should be presented at the start of the section so readers have the caveats in their mind while learning about species distribution models for Joshua trees.	Description updated per reviewer suggestions. This is complex subject matter for many readers of this document. We consider it better to first present basic information about species distribution models, then reference the limitations of the models without going into detail, and then discuss the results of the models that have been conducted for Joshua tree, with the more thorough discussion of the limitations of models at the end. This allows readers unfamiliar with models and their results to read about them first, before being presented with a complex critique of the models which are themselves also complex.	Ok, the response approach is reasonable, especially for non-academic readers.

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
2355	It would be more accurate to note that species distribution models are limited by the availability of spatially continuous data on variables of interest; by the capacity of the scientific community to make accurate measurements or projections of certain variables (e.g., projections of temperature generally are more feasible than projections of wind speed); and by the feasibility and reliability of downscaling or aggregating data to a common spatial and temporal resolution.	Text updated per suggestion	Ok.
2077	This sentence would benefit from clarification. If one wishes to identify areas where climate may change, there is no need to use a species distribution model. Additionally, it is preferable to use temporally matched data on species distributions and climate.	Sentence clarified per suggestion. Added mention of temporally matched data on species distributions and climate to the opening paragraph of this section.	Ok
2106-2112	It would be more accurate and streamlined to say that climate models suggest a shift in the potential range of the species, but effects on population dynamics, or current populations, are unknown (as recognized at line 2424).	Text updated per suggestion.	Ok
2110	Change to “data that show”	Text removed in response to previous comment	Ok
2116	It would be more accurate to say “information currently is insufficient to conclude” whether climate change is likely to threaten the species. The current texts suggests, perhaps inadvertently, that with more information, a conclusion that the species is threatened would be likely. At line 2119, change “yet” to “currently”.	Text updated per suggestion.	Ok
2126	The spatial resolution of climate variables is not necessarily an indication of the reliability of an analysis. Similarly, the most informative temporal resolution varies among species, locations, and analysis objectives.	While it is not necessarily an indication of the reliability of an analysis, higher resolution is more likely to identify smaller areas of climate refugia. Removed the word “because” in the sentence in response to this comment, to make the logic of the sentence less causal while retaining the descriptive information. Added mention of temporally matched data on species distributions and climate to the opening paragraph of this section.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2128	“endured” is not the best word choice here given that it implies hardship. Also, the twentieth century is not representative of the species’ evolutionary history.	Changed “endured” to “experienced”. Added text stating that the 20th century is not representative of the species’ evolutionary history in a paragraph later in the section.	Ok
2130	What is meant by “effectiveness”? Also, in and of itself, comparing multiple models does not render an analysis reliable.	Changed “effectiveness” to “results” and changed the beginning of the sentence in response to previous comment.	Ok
2132	Change to “how climate is correlated with”. These are not mechanistic models. Also, “relied on” is unclear. Are you trying to say that those variables were included in the models, or that among the variables included in the models, these were the most strongly correlated with the species’ current distribution?	Text updated per suggestion. The source implies that among the variables included in the models, these were the most strongly correlated with the species’ current distribution, but the source does not say this directly, so the text was changed to just that these variables were “included”.	Ok
2135	What is the difference between temperature and a temperature event?	Deleted the word “event.”	Ok
2142	Meaning that June drought and summer thunderstorms are not conducive to establishment and persistence of the species?	Revised the sentence to better match the source.	Ok
2157	What do you mean by “concordant demographic data”? It also would be good to mention that the uncertainty of model outputs increases when projected values of predictor variables are outside the range used to build the model.	Revised the sentence to remove the word “concordant,” and added sentence near the end of this section with suggested text.	Ok
2159	Change “that” to “whether”	Text updated per suggestion.	Ok
2164	Within the species’ current range, yes? Does “historically” mean “twentieth century”?	Text updated per suggestion.	Ok
2168	This is not clear. Do you mean that relative changes in precipitation were smaller than relative changes in temperature, or that correlations between precipitation and current presences were weaker than correlations between temperature and current presences?	This statement was from the abstract of the paper, but there is little information in the paper itself to justify or explain the statement. Sentence removed.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2175	This sentence is difficult to follow. Also, isn't warming a component of climate? Climate shifting after warming sounds odd. Additionally, it seems worthwhile to note that these models generally do not account for climate heterogeneity in complex terrain, such as mountains. Long-distance dispersal may not always be necessary to track climate.	Text updated per suggestions. Added sentence near the end of this section with suggested text.	Ok
2183	Clarify whether the work examined climate as forced by doubled carbon dioxide concentrations. Physiological responses to carbon dioxide per se may differ from responses to greenhouse gas-driven climate change.	Text updated per suggestion.	Ok
2185	What was the 30-year period?	This information was not provided by the information source. Added a note to the text to say this.	Ok
2193, 2209	If the Department has serious questions about methods or assumptions, why include a description of the analysis in a status review that is intended to reflect the best science available? It would be more informative to synthesize, rather than sequentially summarize, the model outputs for which the Department has reasonably high confidence (e.g., an expansion of the paragraph at lines 2470-2489, but not nine pages that amounts to summaries of the literature, including articles that likely would not be classified as the best science available). If you're trying to signal that you're aware of other work, then why not say something to the effect of "Others also have modeled the potential future range of Joshua tree on the basis of climate, but uncertainty in those outputs is high given poor fit to the species' current distribution or lack of model validation"?	Because climate change is one of the primary threats to the species, and species distribution models are a primary way of evaluating the possible effects of that threat, the Department thinks it is important to summarize all available species distribution modeling efforts for this Status Review. Information in early modeling efforts can still be useful and contribute to our understanding of the future distribution of western Joshua tree, and therefore still constitutes a portion of the best available science. Added additional subheadings to this section to help with organization and to break up this long section of the document.	Ok. Reviewer makes a good point; however, response is valid for the presumed intended audience for the status review.
2252	If including details about projected changes in temperature, then include details about projected changes in precipitation.	Added detail about different precipitation scenarios evaluated in the models.	Ok
2278	Above, lack of model validation was criticized strongly. Again, why detail this article if the Department does not have confidence in the outputs?	Addressed in above comment for lines 2193, 2209	Ok, same comment as above

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2286	Instead of explaining that Maxent is software, explain the major assumptions on which it is based. Also, either explain percent contribution and permutation importance, or summarize the results without using these terms. But again, if input values were not reported (2295), why is the work being included in the status review?	Added text explaining the major assumptions on which Maxent is based. Deleting text regarding percent contribution and permutation importance because they are not reported by source author, and uncertainty in model performance is discussed more generally under the Limitations of Models section of the Status review, to better organize the long Species Distribution Models section.	Ok
2346	This statement is misleading. These studies suggest that recruitment is decreasing in areas in which temperatures are increasing. There may be a mechanistic link, but other mechanisms also are possible	Text updated per suggestion to suggest that evidence would be of a correlation.	Ok
2350	This is incorrect. Such data would substantially improve ability to evaluate the predictive capacity of these models.	Text updated per suggestion	Ok
2399	True, but all models are highly sensitive to the data used for their construction	Text updated per suggestion to state that all species distribution models are sensitive to the climate data they are based on.	Ok
2510	As a result of climate change in general.	Text updated per suggestion	Ok
2402	Again, “endured” is not the correct word.	Text changed from “endured” to “experienced.”	Ok
2453	If confidence in this output is low—and I agree that it is low—why calculate the index, or include it in a report that aims to present the best science available?	Addressed in above comment for lines 2193, 2209. Text updated to provide more information on the meaning of a low confidence score.	Ok. Same comment as above.
2522	Does Prodoxus sp. parasitize Joshua trees? That is implied at line 2988, but not made explicit in either location.	Text updated per suggestion	Ok
2554	This statement is incorrect. Reduction of the contiguity of habitat indeed results in fragmentation. However, fragmentation can occur independent of changes in habitat area. See work by Fahrig and others on this topic.	Updated text per suggestion. Added citations to work by Fahrig and others, and work with opposing views by Fletcher and others in the following sentence, and replaced the word “can” with “may” in that sentence.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
2538-2559	Note, too, that some native species benefit from human activities or from creation of edges. As one of many examples, in arid ecosystems, residential and agricultural irrigation may benefit some native species. Joshua trees may not benefit from irrigation, but this paragraph is not specific to Joshua trees	Added sentence regarding possibility of positive benefits.	Ok
2579	Just “habitat” (delete “suitable”)	Text updated per suggestion	Ok
2601	Extensive experience with management of Department of Defense lands leads me to question the unreferenced statement that military activities are likely to lead to modification and destruction of habitat for Joshua trees. Native species tend to be conserved much more effectively on Department of Defense lands than on lands under other public jurisdictions.	Off road vehicle use alone is a modification of habitat, and there is a high likelihood of at least some construction or expansion of existing facilities (such as roads) on BLM and DOD lands by the year 2100. Two sentences in this paragraph already acknowledge that development on these lands may be limited. Minor revisions to the text were made for clarity and in response to reviewer comment.	Ok
2616	Dry conditions are not identified in Figure 5, although they may be illustrated in Figure 5.	Changed “identified” to “illustrated”.	Ok
2621	A need cannot be disrupted. Fulfillment of a need may be disrupted	Text updated per suggestion	Ok
2622	Change to “or as adults”. “Flight phase” doesn’t make sense.	Text updated per suggestion	Ok
2632-2634	Protection of habitat can be distinct from protection of individuals. My guess is that the development projects also would take habitat, but as written, the text references removal of individuals.	Text updated to include mention of protecting individuals	Ok
2687	How is severity being defined here?	Removed the word “severe.”	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2715	Moreover, livestock grazing and use of off-road vehicles, which can be extensive in the Mojave, generally are associated with expansion of non-native invasive grasses. Also see Curtis, C.A., and B.A. Bradley. 2015. Invasive Plant Science and Management 8:341–352 and Bradley, B.A., C.A. Curtis, and J.C. Chambers. 2016. Bromus response to climate and projected changes with climate change. Pages 257–274 in M.J. Germino, J.S. Chambers, and C.S. Brown, editors. Exotic brome-grasses in arid and semiarid ecosystems of the western US. Springer, Zurich.	Added sentence regarding livestock grazing and use of off-road vehicles. Added reference to suggested citation in the Climate Change Indirect Effects section of the Status Review.	Ok
2765	Correct that the Great Basin is a cold desert. How is that relevant here?	Cold desert province is mentioned here to contrast with Mojave Desert which is a warm desert province mentioned further down in the paragraph.	Ok
2772	The distribution and density of cheatgrass in the Great Basin also fluctuates considerably as a function of amount and timing of precipitation.	Made revisions in response to reviewer comment and moved a general sentence about invasive grass species fluctuating with precipitation to the first paragraph of this section.	Ok
2778	This is a statement about fire size rather than likelihood of fire per se.	Text updated per comment	Ok
2827-2844	Please synthesize.	Condensed some text in this section.	Ok
2878	This is not entirely true. Probability of fire is related to aridity, but aridity can increase even if precipitation amounts increase.	Changed the word “drive” in this sentence to the word “affect.”	Ok
2882, 2886	Okay, but not all invasive species increase fire likelihood appreciably.	Clarified that the sentence is referring to invasive species that contribute to wildfire risk	Ok
2911	Non-native is not synonymous with invasive. Native plants can be invasive, and not all non-native plants are invasive. This seems to be recognized starting at line 2939, but is not noted explicitly.	Added an explanation about non-native and invasive species.	Ok
2918	I assume you mean either changes to the natural fire frequency or simply changes in fire frequency. The latter is preferable given that fire frequency generally is quite variable.	Deleted the word “natural”	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2921, 2963	Use of "habitat" here is incorrect.	Replaced with "characteristics of the location"	Ok
2996	Remove "yet," which implies that an effect will be found in the future.	Text updated per comment	Ok
3084, 3085	Why are these terms in quotation marks? Either explain the terms or remove the quotation marks.	Quotation marks removed	Ok
3102.	This section describes petitions for listing, not protections under the law.	This section is titled "Regulatory Status and Legal Protections". Added an introductory sentence to indicate that western Joshua tree has no federal protections under the federal ESA.	Ok
3461	It is not immediately clear how this section relates to its headers, "Existing management" and "Regulatory status and legal protections". An explanation at the top of the section would be helpful.	Added an introduction at the beginning of the section.	Ok
3513	"found extensively" isn't quite correct. It seems more accurate to say that most of the known range of the species is under federal jurisdiction.	Text updated per suggestion	Ok
3530	Refugium (singular), not refugia (plural).	Text updated per suggestion	Ok
3751	Correct the tense here.	Changed "cannot be" to "is not"	Ok
3755	Do you mean that the area will decline? "areas . . . will decline" is unclear.	Text updated per suggestion	Ok
3791, 3803	Just "habitat" (delete "suitable")	Text updated per suggestion	Ok
3793	What about lands on which use of off-road vehicles is permitted or common, even if not permitted?	Habitat modification and destruction will occur in those areas as well, but it will not primarily be in those areas, and most off- road vehicle use is within the vicinity of roads that are used for access or to load and unload off-road vehicles.	Ok
3863	Revise to avoid the implication that large fires favor vegetation growth. The latter may be true in the case of non-native invasive bromes, but I don't think that's what you meant.	Added the word negative in two places to clarify.	Ok

Table A-2 Peer review comments from Dr. Erica Fleishman on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
3858	This statement seems inconsistent with 3781 and many statements throughout the document that the future demography of western Joshua trees cannot be projected with any appreciable degree of certainty.	Changed "is expected to" to "may".	Ok
4057	Completion of a conservation plan is a component of a preliminary conservation strategy (4045)? Is the intended emphasis here the partnerships rather than the conservation plan per se?	There is redundancy with the opening paragraph, but including it as a bullet point emphasizes it, and other reviewers have found the bullet point to be important.	Ok
4066	I think you mean "implement disincentives"	Text updated per suggestion	Ok
4071	This component must be accompanied by integration of scientific research into management. Knowledge in and of itself will not conserve the species.	Text updated per suggestion	Ok

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
539	As we will see in the discussion of endangerment factors, the levels of threat from land development, energy projects, wildfires and climate change are generally greater in the YUBR South range than the YUBR North range, thus warranting separate consideration of the appropriateness of listing under the CESA.	The Department recognizes that populations of western Joshua tree in the southern part of its range generally face more serious threats than populations in the northern part of its range, as described in the Factors Affecting the Ability to Survive and Reproduce section of the Status Review. Nevertheless, seriousness of threats is not a component of species concepts. As described in the Taxonomy section of the Status Review, the Department does not currently have evidence that would support the differentiation of southern and northern populations as separate and discrete evolutionary significant units that would qualify them as separate "species or subspecies" under CESA. Sentence added to the Taxonomy section of the Status Review about threats.	Agree with response. We agree with and support the discussion on pages 10-12 that reviews the asserted differences in the YUBR South and North occurrence groupings and concludes that there is no known basis, genetic or otherwise, for separating these groupings as ESUs.
2527	Thus, the environmental limits of the yucca moth have a direct bearing on the sexual reproduction of the WJT, and the lower elevation limitations for the moth—most likely reflecting a high temperature threshold and/or low soil moisture tolerance—may indicate that these low elevation WJT populations are already no longer viable and will, with increasing temperatures resultant to climate change, become locally extinct.	Lack of sexual reproduction reduces the ability of species to adapt, often reduces dispersal ability, and may present other serious challenges for population persistence, but it does not necessarily mean that a population of species that is capable of asexual reproduction will no longer be viable in the foreseeable future. The Department has very little information on the range of *T. synthetica*, however, any instance of non-clonal western Joshua tree recruitment is an indication that *T. synthetica* was present at the time the flower that produced the seed was pollinated. The potential for climate change to affect *T. synthetica* is discussed in the Climate Change Indirect Effects section of the status Review, and a discussion of the consequences of lack of sexual reproduction was added. Text also added to the Flowering, Pollination, and Fruit Production section.	Agree with response.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2536, 2559	Although asexual reproduction does occur in WJTs, particularly after fires and/or at higher elevations, sexual reproduction is essential for maintenance of genetic diversity of the species. Little is known about the life history or survival of yucca moths regarding their survival (or not) after fires, their environmental tolerances to extreme temperatures or moisture, or of their capabilities of locating host plants and dispersal in highly fragmented habitats, such as urbanized, low density WJT habitat in the YUBR South range. These potential endangerment factors relative to the *T. synthetica* moth are not addressed in the Status Review.	Information on survival of yucca moths following fire is discussed in the Wildfire section of the Status Review, and although the information is for eastern Joshua tree, it is the best information available to the Department. *T. synthetica* environmental tolerances are discussed in the Climate Change Indirect Impacts section. The reviewer is correct that little is known about environmental tolerances of *T. synthetica,* but this lack of knowledge is not, in and of itself, a threat to western Joshua tree. We added a statement to the Development and other Human Activities section to acknowledge how little is known, but that fragmentation may have negative effects on the moth. We added a discussion of the possible effects of lack of sexual reproduction on western Joshua tree due to climate change effects on *T. synthetica*. Lack of sexual reproduction does not necessarily mean that a population of species that is capable of asexual reproduction will no longer be viable in the foreseeable future.	Agree with response in general, but also agree with reviewer that sexual reproduction is essential. Reliance on asexual reproduction as one basis for not listing the WJT is not a particularly strong argument.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
623, 1914-1930, 1970-1972, 2018-2029	Lower elevation areas of the WJT range are already exhibiting lower absolute cover and reduced seedling germination and recruitment. (Lines 1970-1972). The compounding endangerment factors of climate change are described further by the Department (Lines 1914-1930). Furthermore, "There may be a time delay between the time when an area becomes no longer suitable for a species (crossing an extinction threshold) and when that species is no longer present, (Tilman et al. 1994, Kuussaari et al. 2009, van Mantgem et al. 2009, Svenning and Sandel 2013, Figueiredo et al. 2019). Extinction processes often occur with a time delay and populations living close to their extinction threshold might survive for long periods of time despite local extinction being inevitable (Hanski and Ovaskainen 2002, Lindborg and Eriksson 2004, Helm et al. 2006, Vellend et al. 2006, Malanson 2008, Cronk 2016). Because western Joshua tree is a long-lived species, adults could persist for decades or longer in areas that are no longer suitable for recruitment, or recruitment may continue, but at rates that are ultimately insufficient to maintain the species. Although these areas may appear occupied, the presence of western Joshua tree may merely represent a delayed local extinction. (Lines 2018-2029) Thus, when one re-examines the range of YUBR South as illustrated in Figure 4, one can see that fully half of the total YUBR South distribution may already be functionally extinct—that is, non-reproductive at rates that can sustain the population in those areas in the "foreseeable future" (the 21st century).	While the Department speculates that areas of western Joshua tree habitat could be subject to a delayed local extinction and acknowledges the possibility that this may occur by including the discussions referenced by the reviewer, the Department also states in the Status Review that local extinctions may be delayed for centuries or millennia, or that the species may be preserved as a relict from an earlier climate. The Department does not possess demographic information demonstrating that significant portions of the species range will be subject to a delayed local extinction in the foreseeable future.	Agree with response. We also need to acknowledge the existence of refugia even in the southern part of the range, such that while area of occupied habitat and overall density may decrease, it is unlikely that the WJT will entirely disappear from that area.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1519-1525	An unpublished recent study conducted by a Geographic Information Systems (GIS) research group under my direction at the University of Redlands found that 420 mi2/677 km2 of WJT habitat within the cities of Palmdale, Lancaster, Yucca Valley, Joshua Tree, Twentynine Palms, Victorville, Hesperia, and Apple Valley were developed within those jurisdictions between 1984 to 2021 (Krantz et al. 2021). This analysis examined decadal aerial photo imagery, identifying developed areas within those jurisdictions, but it did not include isolated blocks of open space that may represent occupied WJT habitat. In fact, the remaining undeveloped blocks within these cities are so highly fragmented that they likely no longer represent ecologically viable habitat. Given the extremely short distance dispersibility of WJT seeds and isolation from potential yucca moth pollinators, these remaining patches of WJT habitat should be considered ecologically unviable and essentially extirpated.	Text updated to include some of the details provided by the reviewer. The unpublished study cited by the reviewer was not provided to the Department, but an email from the reviewer was cited as a personal communication during preparation of the Status Review. The many effects of habitat modification and destruction including habitat fragmentation are discussed in the Development and other Human Activities section of the status review, however, the Department does not have information demonstrating that isolated blocks of habitat should be considered ecologically unviable and essentially extirpated. The Department does have information that suggests some populations near urban areas are declining (see Figure 8), but we don't know the cause of this decline and speculate in the Status Review that an important aspect of western Joshua tree life history may have been disrupted by environmental degradation related to urban and agricultural development.	Generally agree with response. But also, the reviewer makes a good point about the likely functional extirpation of WJT in isolated or fragmented habitat in developed areas. We believe this point is adequately addressed in the response and status review.
1519-1525	Within the foreseeable future (the year 2100), if not already, the undeveloped areas of these incorporated cities should be considered functionally extinct. Most of the smaller fragments of extant habitat are already ecologically unviable and would, therefore, meet the definition of functionally extinct, as described in the previous section of this peer review.	See response to previous comment.	See above response
	If one considers the incorporated cities within the YUBR South range as developed habitat within the foreseeable future, then a total habitat loss of 654.56 mi2 should be considered extirpated and functionally extinct.	See response to previous comment.	See above response
2810	The GIS study completed by Krantz et al. (unpublished, 2021), using the same CALFIRE database as cited in Figure 9, above, estimated that between 1980-2019 a total area of 950km2 of WJT habitat was burned within the YUBR South range, representing approximately 8% of total WJT habitat, but as much as 12.9% of YUBR South distribution.	Text updated with information from reviewer comment.	Ok

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2819	Smaller WJT plants (<0.5m) are almost entirely killed by fire, but even taller, mature trees are largely killed above ground. These may sprout vegetatively after fires, but these sprouts may take 30-50 years before reaching sexual maturity and producing flowers.	Text updated with detail from DeFalco et al. 2010.	Ok
N/A	With increasing fire frequency and intensity, vegetative sprouts of WJTs are largely eliminated from these areas if the subsequent fire occurs before the sprouts are more than 2-2.5m high—the height at which Southern WJTs first flower (Rowlands, 1978). Fires eliminate seed stock in the soils and remove potential nursery plants, further reducing the potential for flowering, seed production and seed germination for the "foreseeable future"—the end of this century. Finally, studies cited in the Status Review indicate that the yucca moth, upon which the WJT is dependent for pollination, is already rare at these higher elevations of the WJT range (Harrower and Gilbert 2018). With the elimination of flowering YUBR plants for 50+ years (before vegetative sprouts will flower again), these areas are essentially lost for their requisite pollinators.	Added two sentences to the Wildfire section of the Status Review on indirect effects of wildfire on *T. synthetica*. Wildfire effects on juvenile trees, nurse plants, seeds in the soil, and the long-lasting nature of impacts are all already discussed in the Wildfire section of the Status Review. Wildfire is a substantial threat to western Joshua tree but wildfire does not affect the entire range of the species evenly, does not necessarily burn through habitat in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. Also, see the results of Lybbert and St. Clair (2016).	Agree with response, which nicely summarizes the issue of extent, frequency, and intensity of wildfire effects.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	Furthermore, the focus of this Peer Review is on whether the southern extent of the populations of WJT (YUBR South) should be listed as Threatened "ecologically significant units" unto themselves. The conclusion of this Peer Review is that such a designation is appropriate because the YUBR South populations are subject to much greater threats than the northern WJT populations (YUBR North). The facts and research presented in this Status Review demonstrate that the potential for the YUBR South populations to become Endangered over a significant portion of their range (the YUBR South range) within the foreseeable future is very real. The primary threats to the YUBR South populations of WJT are three-fold: • Climate change • Urbanization and land development • and Wildfires	See response to comment from reviewer regarding line 539. Seriousness of threats is not a component of species concepts.	Agree with response. While we acknowledge greater threats as outlined by the reviewer, YUBR South has not been demonstrated to be an ESU.
N/A	It will be virtually impossible for WJT in the southern populations to disperse over these relatively few decades to the northern YUBR populations to adjust to climate change. As far as Southern YUBR plants are concerned, dispersal to newly suitable habitat in the YUBR North range is not possible. They will have to disperse/migrate to the higher elevation, cooler, moister habitats of the slopes along the southern edge of the YUBR South range, which we will see below, is also impossible.	The Status Review discusses and acknowledges that western Joshua tree has limited ability to disperse seed, and that it may take centuries or millennia for the species to naturally colonize areas of newly suitable climate. The Department's conclusions in the Status Review are not based on an assumption that any significant natural colonization will occur in the foreseeable future.	Agree with response.
N/A	To visualize the extent of the impact of climate change on the YUBR South metapopulation, the entire area shown as yellow on Figure 4 will be functionally extinct within the foreseeable future. Yes, there will be islands of refugia in the isolated mountains north of Barstow and northeast of Lancaster, but these islands will be reproductively and ecologically isolated to the extent that they are biologically doomed if current climate trends continue, as the climate models cited in the Status Review all predict.	The reviewer does not cite, and the Department does not possess any demographic or trend information to support the assertion that areas with >0-1% western Joshua tree cover will be functionally extinct within the foreseeable future. The Department does not possess information to conclude that reproductive and ecological isolation is necessarily a threat to species populations in the foreseeable future, even in the face of increasing threats.	Agree with response.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	Development and fragmentation within the incorporated city limits alone represent more than 650 square miles of habitat loss. This does not include the clearing and destruction of the 15 large-scale renewable energy projects that were granted §2084 take exemptions during the hearings to establish the WJT as a candidate species for listing under the CESA, nor does it include the expansive developments of rural "ranchettes" and other associated developments in the unincorporated communities of Phelan, Oak Hills, Baldy Mesa, Lucerne Valley, and Pioneertown, to name just a few. (See attached Image of the Unincorporated Communities)	Sentence added to the Development and Other Human Activities section of the Status Review regarding development within incorporated city limits and unincorporated areas.	Ok
N/A	Most of this development, from the Palmdale-Lancaster area in the western portion of the YUBR South range, to the cities of Yucca Valley and Joshua Tree at the eastern limit of the YUBR South range, extends across the middle elevations of the southern WJT habitat. Remaining fragments of occupied habitat within these city limits are, once again, functionally extinct. That is, extant WJTs on these remaining patches are now totally isolated, unable to disperse to higher ground in the face of warming temperatures and increasing drought. This isolation is compounded by the fact that they require the presence of yucca moths for pollination and production of viable seeds; and even if pollination is successful, the dispersal of seeds across the fragmented urban landscapes becomes increasingly unlikely, if not impossible. Furthermore, the development of the wide swath of the middle elevations across the southern flank of YUBR habitat effectively isolates the entire lower elevation populations from any chance of dispersal across the urban barrier to reach the cooler, moister suitable habitats in the face of climate change. This compounds the effective isolation of the lower elevation populations, reinforcing their functional extinction.	See Department responses to previous similar reviewer comments. The Department recognizes that habitat loss and fragmentation will occur in the Development and Other Human Activities section of the Status Review. The Department's conclusions in the Status Review are not based on an assumption that any significant natural colonization will occur in the foreseeable future.	Agree with response. Also note the reviewer makes several sweeping statements in their comment that are not supported by the best available science.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
N/A	Finally, we have the fact of increasing frequency, size and severity of wildfires in the southern WJT range. As noted in the Status Review (see Figures 9 and 10), the area burned by wildfires has more than doubled in the last three decades in comparison with the previous 90 years. Most of those fires and the largest of them have occurred in the higher elevations of the YUBR South range. For example, the Sawtooth Fire Complex near the community of Pioneertown (readily visible on Figure 9 in the southeast portion of the range), consumed 61,700 acres of high quality, high density WJT woodland habitat in 2006. Now, 15 years later, the area is still nearly devoid of WJT plants, with no mature Joshua trees in the burn area and very few vegetative sprouts. The area is essentially "dead" for many generations to come, with no flowering WJT plants. The lack of mature, flowering Joshua trees equates to no yucca moths. The absence of the flowering host plant will eliminate the yucca moths from the area for many moth generations, certainly for the "foreseeable future" through the Year 2100.	The Sawtooth Fire Complex is a large relatively recent wildfire that affected western Joshua tree, however the Status Review focuses discussion on the overall impact of wildfire across the species range, and therefore specific wildfires are not discussed individually. The effects of wildfire on adult and juvenile trees, nurse plants, seeds in the soil, and the long-lasting nature of impacts are all already discussed in the Wildfire section of the Status Review. Wildfire is a substantial threat to western Joshua tree but wildfire does not affect the entire range of the species evenly, does not necessarily burn through habitat in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. Also, see the results of Lybbert and St. Clair (2016).	Agree with response.
N/A	The WJT and yucca moth are obligate co-dependent species. This represents a significant and cumulative adverse impact, with very serious implications for WJT in wildfire areas. It means that these areas, even if they recover by vegetative reproduction from the fire, will remain without their obligate pollinators for many decades or even beyond 2100.	A sentence was added to the Summary of Listing Factors section of the status review to acknowledge that the cumulative impacts of climate change, wildfire, and the direct and indirect effects of development and other human activities may also affect populations of *T. synthetica*, reducing western Joshua tree's ability to sexually reproduce. Also see Department responses to previous comments.	Agree with response.
N/A	The fact that these wildfires are almost entirely in the higher elevations in the southernmost extent of the YUBR South range effectively removes the climate refugia that lower elevation populations will need, if they are capable of dispersal to these cooler, more hospitable habitats at all.	Sentence added to the Wildfire section of the Status Review to state that high-elevation areas of the Mojave Desert likely have the highest probability of retaining 20th century suitable climate conditions for western Joshua tree, however, these areas also have a high probability of wildfire, which means that wildfire may disproportionately affect areas of climate refugia for the species.	Agree with response.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
N/A	Thus, we find that the Southern WJT populations are faced with a triple cumulative threat: their lowermost populations are already functionally extinct due to climate change; even if they could disperse toward higher, more equable climate, they are blocked by sprawling development across their middle elevations; and finally, the remaining high ground along the south edge of the YUBR range is being consumed by wildfire and will be biologically non-functional for the foreseeable future and beyond.	Added text to the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat section of the Status Review to include a general statement that the southern portion of the species range faces greater threats than the northern portion of the species range. Also see Department responses to previous comments.	Agree with response. In a general sense, individuals in the southern occurrences do not need to disperse to ensure species survival, although some amount of gene flow would be good.
N/A	Together, these three impacts represent significant adverse cumulative impacts to the YUBR South populations *throughout their range.* Referring back to the definition of an Endangered species: one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range;" I find that the data and studies presented in this Status Review do, indeed, support a finding that the YUBR South population of WJT meets the definition of a Threatened species: one that, "although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA]."	See response to comment from reviewer regarding line 539. Seriousness of threats is not a component of species concepts, and the Department does not possess information to support a conclusion that the southern portion of western Joshua tree's range can be considered a "species or subspecies" under CESA.	Agree with response.
4057	The WJT Conservation Plan should include detailed protocols for environmental assessment and mitigation of proposed projects that have the potential to impact WJTs.	Text updated with new bullet point per suggestion.	Ok
4059	Dedicate State funds toward acquisition and protection of otherwise unprotected high-value WJT habitat.	Text updated to state that long-term conservation of the species is likely beyond the scope of any one government, agency, or organization, and could require *funding and* legislation.	Agree with response.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
4061	Would this mean weed-whacking non-native flash fuels over hundreds of square miles? Impractical.	Revised text for clarity. While landscape-scale invasive species management is impractical with current technology and resources, smaller-scale vegetation management to minimize wildfire risk in western Joshua tree woodland is already being implemented by Joshua Tree National Park, and the Department recently issued a scientific, educational, or management permit covering western Joshua tree for a project to remove non-native plants from large parcels to reduce wildfire risk.	Agree with response.
4064	Not practical.	Revised text to "Manage *active* fires aggressively…" for clarity. Full fire suppression is currently the policy of Joshua Tree National Park.	Agree with response, but this is going to run into trouble. In the long run, aggressive fire suppression is likely to exacerbate the risk of uncharacteristically frequent, widespread, and intense wildfires.
4066	What sort of "disincentives" are contemplated here? Not practical.	As stated in the Management Recommendations and Recovery Measures section of the Status Review, western Joshua tree faces serious challenges, and long-term conservation of the species is likely beyond the scope of any one government, agency, or organization, and could require funding and legislation. Disincentives could be implemented via legislation, and could take many forms, ranging from regulatory programs to financial incentives.	Agree with response.
4069	Not practical unless accompanied by enforceable, regulatory measures.	Text updated per suggestion to include enforcement.	Ok
4069	In this circumstance, it is my recommendation that the Department sanction the WJT in its YUBR South distribution as a Regulated species, like regulated game or fish animals.	The Fish and Game Commission is responsible for designating regulated species, not the Department. The Management Recommendations and Recovery Measures section of the Status Review already discusses implementation of disincentives and regulatory programs as recommended measures to protect western Joshua tree.	Agree with response.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
4071-4088	Of these last measures, all are necessary to provide basic baseline monitoring information for the WJT. Of particular importance would be to promote further investigations and biological research on the obligate pollinating moth, *Tegeticula synthetica*. The Status Review presents some basic information about the life history of the moths, but certain information pertinent to this Petition is lacking, such as: what are the temperature and moisture thresholds for the species? There is some indication that the moths are rare or absent at the lower and upper elevations of WJT. What are the limiting factors that determine its range? These are ***obligate***, co-dependent species. Therefore, the limiting environmental factors of one have direct consequences on the distribution of the other.	Text updated with bullet on investigating the life history, environmental tolerances, and distribution of *T. synthetica*.	Agree this is a critical research need.
4056-4088	One of the more practical measures, not mentioned above, would be to require consideration of projects within the YUBR South range to undertake environmental impact assessments in accordance with the CEQA guidelines. The Status Review describes this alternative (Lines 4007-4019), but, without formal listing, there would be no requirement that projects analyze potential impacts to WJT.	Impacts to western Joshua trees, alone, may not trigger the requirement for a lead agency to conduct an environmental review for a project under CEQA. Additionally, what is disclosed and mitigated under CEQA for unlisted species is largely determined by the lead agency. Changing this would require regulatory change or legislation, both of which are already mentioned in this section.	Agree with response.
N/A	If, however, the State designated the Southern WJT as a Regulated species, similar to other game and fish animals (§2116 *et seq.* of the Fish and Game Code), then CEQA review or at least regulatory review would be required, and permits would be necessary for removal of WJT plants on impacted properties. By this means, projects that have the potential to adversely impact WJTs would have to consider avoidance of WJTs to the extent possible and mitigation of impacts to WJTs in the case that Joshua trees cannot be avoided.	Changing section 2116 of the Fish and Game Code would require legislation which is already mentioned in this section.	Agree with response.

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
4087	Regarding mitigation for removal of WJT, the trees may be successfully transplanted. San Bernardino County enacted a Joshua tree policy in the late 1980s that required developers to avoid the trees if possible, translocate them or make them available for translocation if necessary. During this time and through the 1990s, I worked with a landscape company, *NativeScapes*, transplanting Joshua trees using a 24- inch and 36-inch hydraulic tree spade. Joshua trees have a fibrous root system, like palm trees, and they can be excavated and placed in 36-inch or 48-inch boxes for re-location to protected areas on- or off-site. Trees as tall as 10-12 feet with moderate branching can be transplanted. Once the trees are installed, larger trees must be tethered to stabilize the weight of the tree; and transplants must receive additional irrigation maintenance through the first two summer seasons until the fibrous root system is reestablished.	Added a sentence with details from this comment in the Management Efforts Other section of the Status Review.	Ok
4057, 4087	For this practice to be effective, it is essential that the State designate the WJT as a regulated species. Otherwise, if left to the individual county and city municipalities, the southern WJT would have only inconsistent standards for environmental review and mitigation. Standardized environmental assessment and mitigation measures may be included in the WJT Conservation Plan recommendations, described in #2 above.	Text updated with new bullet point per suggestion.	Ok

Table A-3 Peer review comments from Dr. Tim Krantz on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
4057	The WJT Conservation Plan may also identify conserved areas for translocation of Joshua trees in anticipation of climate change, such as the Pioneertown Preserve. The Pioneertown Preserve is a 25,500-acre natural preserve managed by The Wildlands Conservancy. The area was burned during the Sawtooth Complex Fire in 2006 and native WJT woodland habitat has been very slow to recover. Translocation from lower elevation sites in the cities of Yucca Valley and Joshua Tree to the Pioneertown Preserve would facilitate WJT recovery from the fire, as well as help with climate adaptation by moving plants to higher elevations. Such translocation sites would require long-term management for fire and fuel modification, non-native grass and fuels management around the base of the trees, and irrigation maintenance until such trees are reestablished.	Text revised to include identification and management as well as preservation of western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia. Text revised to clarify that results from investigations into the feasibility, practicality, and risks of implementing assisted migration and translocation should be integrated into management and conservation actions.	Agree with response.
4057	Other potential "climate refugia" may be identified in the Conservation Plan on State, Federal or private lands across the WJT range.	See response to previous comment.	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	The Department appears on the one hand to take seriously the threat of climate change and the many published studies detailing species distribution models that predict reductions in suitable habitat for the species. However, on the other hand, there is doubt cast on what the meaning is of these predictions, without an effective framework for evaluating such modeling.	The Department reviewed and added a citation to Sofaer et al. (2019) which provides an effective framework for evaluating the species distribution modeling efforts presented in the Status Review. As described in the Status Review, the loss of 20th century suitable climate conditions for western Joshua tree from some areas is expected to have negative effects on populations in the affected areas, but the Department does not have information indicating that western Joshua trees in the affected areas will likely die, or that populations are likely to cease reproducing or be no longer sustainable at the end of the 21st century.	Agree with response, although we believe there is likely to be some range contraction, or density reduction, in some portions of the southern edge of the range that was studied by the SDMs. That is, we do not question the results of the more recent and robust SDMs (for example, Sweet et al. 2019), but note that they are generally not broadly applicable across the range of the WJT.
N/A	The reason that the predictions of habitat loss (by the six models summarized) are discounted appears to be 1) the associated uncertainty in the models themselves (e.g. in model accuracy where there are differences in actual distribution differ from predictions, or criticisms of the data used), and 2) uncertainty about the species response. To this reviewer, there would seem to be less uncertainty about some substantial reduction in habitat in the foreseeable future, as predicted by all six models, and likely others, indicating strong predicted exposure to climate change. The uncertainty surrounding species response, or what this means for reductions in species abundance or range indicates sensitivity, or response to climate change. These need to be considered along with adaptive capacity, and the latter two may be questions that remain more unclear.	As stated in the Status Review, the degree to which climate change will affect western Joshua tree populations will depend on both the magnitude of climate change and the species' resilience to a changing climate. The Department acknowledges that species distribution modeling efforts produced for the species so far suggest that climate change will generally have negative effects on much of the current southern range of the species. The Department agrees that the response of the species to the effects of climate change is a greater uncertainty than whether or not climate change will affect large portions of the species range.	Agree with response and particularly note that models to date have examined the southern edge of the species range.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	However, several lines of evidence were presented that indicate sensitivity to e.g. decadal droughts, for populations of the species that are found to be unsustainable or declining in various parts of the range. This would seem to be in contrast to the assertion that unsuitable conditions over longer timescales, towards the end of century would not be predicted to impact the range of the species.	Information available to the Department regarding the negative effects of droughts on population abundance have been presented in the Status Review, however the Department does not currently have information demonstrating that loss of areas with 20th century suitable climate conditions will result in impacts on existing populations that are severe enough to threaten to eliminate the species from a significant portion of its range by the end of the 21st century.	Agree with response.
N/A	I found one of the main foundations of the argument, the paleoecological evidence that the species may take thousands of years to respond to a rapid change in climate to be poorly substantiated, as explained, although paleoecology is not my area of expertise.	Additional information from Cole et al. (2011) on this range shift was added to the Climate Change Direct Effects section of the Status Review.	Ok
N/A	It is true that there are some changes to vegetation that are not as linear as expected over the short term (for example, Abella et al. 2019), and this may be especially true in regions that are diverse topographically and with strong effects of insolation, soil moisture, texture and depth, etc., as well as with high exposure (due to low cloud cover and low humidity) to a highly variable short-term climate. This does not mean that long-term exposure and trends in increased warmth and decreased moisture availability will not impact vegetation over the long-term.	The Abella et al. 2019 source cited by the reviewer may be Abella, S.R., R.J. Guida, C.L. Roberts, C.M. Norman, and J.S. Holland. 2019. Persistence and turnover in desert plant communities during a 37-yr period of land use and climate change. Ecological Monographs 89:e01390. Comment noted.	Ok
N/A	In all, there is apparently a lack of systematic demographic data range-wide, although a meta-analysis could have been used to summarize these findings more effectively from the many small demographic studies described in text form. These need to be contextualized with respect to the position within the range, and this was difficult to properly contextualized as presented.	A subsection summarizing available demographic information was added at the end of the Demographic Information section of the Status Review. The Department agrees that there is a lack of systematic range-wide demographic data, which would be very useful for assessing the population trend of the species. Demographic data was to be compiled from available sources.	Agree with response.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
N/A	Please indicate why the following was not included: Thomas, K.A., Guertin, P.P., and Gass, L., 2012, Plant distributions in the southwestern United States; a scenario assessment of the modern-day and future distribution ranges of 166 species: U.S. Geological Survey Open-File Report 2012–1020, 83 p. and 166-page appendix, available at http://pubs.usgs.gov/of/2012/1020/. https://pubs.usgs.gov/of/2012/1020/ https://pubs.usgs.gov/of/2012/1020/of2012-1020_appendix_b/	Document reviewed, cited, and a discussion of it was added to the Species Distribution Models section of the Status Review.	Ok
195	Decline due "in part" to, lest it conflict with following sentence. I'm not aware of a study that has weighed all factors in a relative sense, including climate change, fire, habitat destruction and the impacts of invasive species together, other than this Review.	Added "largely" to the sentence because habitat modification and destruction in a broad sense that includes wildfire is considered to be the largest source of habitat loss and population decline, as discussed primarily in the Inferred Long-term Trends section of the Status Review.	Ok
368	Please clarify if this regarding "Yucca species"; it's not clear as written.	Text updated per suggestion.	Ok
374	This is an interesting note, but I find it to be speculative in the reference cited. This reference cited is a study on the Eastern tree in southwestern Utah. Although this study was primarily on blackbrush, they excavated a pit and noted the presence of a Joshua tree root 11m away; this was not conclusively tied to the individual measured, however, and could have been from an undetected Joshua tree seedling that was nearer by. For this reason, it would be important to add that while not impossible, there is no reason to think that this rooting radius is typical, and this may be relevant to protection measures. It's surprising that there is no better reference for rooting depth. At the very least, a description of what is seen here, which has been in the public domain, demonstrating what is seen along roadsides would be helpful to the reader: https://commons.wikimedia.org/wiki/File:Joshua_tree_(Yucca_bre vifolia)_roots;_Covington_Flat.jpg	Sentence edited to state that underground roots of eastern Joshua tree were observed 11 m (36 ft) away from *what appeared to be* the aboveground portion of the plant by Bowns (1973).	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
379-380	May be more common. I don't see evidence presented here to make this generalization. This is currently under study at Joshua Tree National Park.	Added citation to Rowlands (1978) to justify this sentence.	Ok
409	Because these numbers are relevant to the demographic information later stated to be needed, a citation is necessary here.	Added citation to Borchert (2021).	Ok
423	Earliest known, to whom? Please qualify that this is a statement about European settler accounts of the species, and there may be extensive Traditional Ecological Knowledge of the species that may not be recorded in a way accessible to this reviewer.	Text updated per suggestion.	Ok
470	To the degree I am familiar with both species, but as an ecologist and not a taxonomist, I concur with Smith et al. 2021 that they are distinct and it is therefore appropriate to treat this species separately.	Comment noted	Ok
637	Due to this method and the patchy distribution, this does represent the range as looking larger than it is, as you state in line 642. I believe there are more errors of commission here than omission per the range, due to the stature of the tree.	Text in this section has been updated for clarity in response to this and other peer review comments.	Ok
640-655	This all is highly speculative and while somewhat helpful to bookend the possibilities, detracts in its apparent precision (reporting decimals to the hundredth?).	The 0.2 km distance was selected by the GIS analyst who performed these calculations based on prior experience with producing similar map products. The decimals to the hundredth is a function of converting km to mi. The Department also wishes to be as transparent as possible regarding assumptions, because these range area estimates are also used for abundance estimates.	Agree with response, although additional justification for the 0.2km distance would be helpful. We note this is only 200 meters (~660 feet), so it should not make a big difference in the estimate range-wide.
672	While this could be, if accurate, a compelling illustration of the relatively large range of the species spatially and number of stands of trees, a reader unfamiliar with how these EA's are counted would be hard pressed to understand how the Department came to this conclusion. Please provide detail the qualifications of a locality to be counted as an EA.	Text updated with details of CNDDB mapping methodology.	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
766	Please note that this was a short-term study. We don't have evidence that moths are never found at these locations and although it is a significant trend and could indicate declines in pollination at these sites, this is likely a phenomenon that shifts in space and time year-to-year.	Added a sentence to clarify that these results were from one short-term study conducted within one continuous western Joshua tree population.	Agree with response.
803	I believe the name has changed to California scrub jay.	Text updated per suggestion	Ok
805	Agreed that the evidence is that rodents are a primary mode of dispersal, not wind, and within short distances. Second-caching is speculative and implies that territories would be extended in a linear manner further away.	Evidence of secondary caching was observed by Vander Wall et al. (2006) and is therefore not speculative. The text is speculative regarding maximum dispersal distance- making it clear what this additive distance is based on: "Assuming seeds are sometimes re-cached in the same direction away from the source tree".	Agree with response.
882	Germination and viability are different. It might be advantageous to mention this difference here for the reader to be clear. Out of the seeds formed, as mentioned earlier, many are consumed by larvae. Thus from the seeds formed within the fruit not all are viable and I would assume without descriptions that studies have used only the apparently viable seeds that are black in color. This is also important for a full life cycle assessment as it affects # effective genets that result from the fruit. Either way evidence is that both are fairly high. It's important to state whether this is out of selected viable seed. Kew: https://data.kew.org/sid/SidServlet?ID=24500&Num=DN5 88% germination.	Text updated to clarify that seed viability is the ability of a seed to germinate, and to mention that seeds used for studies were likely selected for apparent viability.	Ok
922	Establishment-stage bottlenecks for long-lived species are not unusual, as it takes very few successful seedlings to maintain communities of sparse and long-lived individuals. However, this also means that demography should be closely monitored. As suggested by studies on other species (e.g. oaks (Tyler et al. 2006 Quart Rev Bio ; Kwit et al 2004), conservation should focus on early stages prior to significant declines.	Sources provided by the reviewer were reviewed. According to Kwit et al. 2004, conservation efforts of long-lived slow-growing trees should focus on protecting established reproductive individuals as well as juveniles. The Management Recommendations section of the Status Review already includes "Identify, preserve, and manage western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia."	Agree with response.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
946	Cite Loik et al. Loik, M.E., Onge, C.D.S. and Rogers, J., 2000. Post-Fire Recruitment of Yucca brevifolia and Yucca schidigera in. *Open-file Report*, *2000*(62), p.79. Also, I have not seen a study definitively documenting this in natural systems (Brittingham and Walker looked at the Eastern tree. Many Joshua tree stands lack both extensive blackbrush and creosotebush, My impression is that there are many more species that act as nurse plants, including bunchgrasses, and occasionally juniper, or other sheltered sites including rocks and cacti.	Added citation per suggestion. The text already says that "Many plants in Joshua tree habitat… can act as nurse plants…" so the sentence is already acknowledging that these are just two examples. The paragraph also indicates the information is for Joshua tree and not specific to western Joshua tree.	Agree with response.
963	The paper referenced states Yucca Flat in Nevada as the location of the study.	Text updated per suggestion.	Ok
990	Leaf blades per plant? I suggest this be clarified as per growing tip	Text updated per suggestion.	Ok
998	While there is certainly variability in growth rates range-wide, rates within a smaller region are likely more uniform, so that relative heights of trees within a smaller regions ought to be more comparable when using this as a proxy for age.	Text updated per suggestion. A reference to the Demographic Information section of the Status Review was added later in this paragraph.	Ok
1039	The term "refugial" with respect to climate suggests suitable, or steady climate conditions with regard to the species environmental niche. I'm not sure it is used here to mean this unless the author means specifically all areas the species grows currently.	Removed "and refugial" from the sentence.	Ok
1085	Statement about minimum rate without specification very generic as to be not very useful here.	Revised sentence to state that this rate for western Joshua tree is not known.	Ok
1182	It is critical to note whether this mutualism appears to be required for germination and growth. Because these seeds are grown in sterilized conditions, I would assume that not for the former, but for restoration and to denote overall vulnerability, please state any evidence as to whether this is required for the trees to survive to reproductive age. The study cited may be the only study on this topic, and therefore the information is lacking.	Added a statement that it is not known whether mycorrhizal associations are required for western Joshua tree recruitment.	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1210	If the author does not mean to say that Joshua trees occur on dunes, then please rephrase. I am not familiar with that area, but I have never seen Joshua trees on active dunes, or sand fields. Here is must be meant that these are stabilized sand features that are supporting permanent vegetation?	This information is from the cited source.	Ok, but we agree with the reviewer that we have never observed the WJT (or EJT for that matter) on active dunes or sand sheets. Sandy soils, yes.
1230	Please note the scale they are indicating that these factors were not important, and relative to what. For instance, pH would certainly exclude the Joshua tree from some habitats globally, but I assume here this is *relative* to other factors, on a *regional* scale?	Text updated to make it clear that the statement was for within the study area near Riverside, California.	Ok
1258	I disagree; these plants are likely much more shallow-rooted than similar stature dicot trees and especially phreatophytes, which may be classically described as "deep rooted." Please provide the citation with evidence that the roots may be characterized as deep.	Changed text to "extensive" roots instead of "deep" per Gucker 2006. Citations for root structure are in the Species Description section of the Status Review.	Ok
1268	Relatively high precipitation for a desert or arid scrub system.	It is unclear what the reviewer is commenting on here.	Agree with response. This paragraph is clear about wet and dry years being relative to average for the Mojave Desert.
1308	Characterized as using the C3 photosynthetic pathway, this would be typical. However, since the trees are evergreen (where many desert plants are drought deciduous) the trees are losing water, and likely summer water prevents further water loss by decreasing soil evaporation and plant transpiration.	Updated text to remove an assumption of reliance, and only state that western Joshua trees in the western Mojave Desert receive a greater proportion of their annual precipitation in the winter.	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1438	The Sweet et al. 2019 peer-reviewed published study data is the same as cited here as Frakes 2017, after quality checks during analysis for publication. Although only summarized, unfortunately in the paper they are published as average densities on 14 300 x 300m plots within Joshua Tree National Park and one adjacent parcel in California. Quoting Sweet and others, page 7: "The total number of live Joshua trees per macroplot ranged from 48 to 562 trees per 9 ha (5.3-62.4 trees/ha). To be clear, the data used for this peer-reviewed published study is the same as that cited here as personal communication provided by Frakes et al. 2017, after quality control.	Text updated to reference Sweet et al. 2019, and density values changed.	Ok
1461	Confidence reported here appears to indicate the variation between plots (aka similar to precision), NOT the true confidence in the estimate (aka accuracy), which would have to be field verified. Please modify this phrase to indicate what this confidence refers to.	Text updated to state 95% statistical confidence based on the methods in Elzinga et al. (1998).	Ok
1475	Please note the period of time for which this decline is relevant. Note also any evidence of pre-settlement influence on Joshua tree patterns.	The Department does not have a precise year that it considers to be the beginning of European settlement of the Mojave but added the phrase "during and before the 19th century". Also added a sentence that says "Available information on Joshua trees population trends prior to European settlement is provided in the following section."	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1519-1524	This is a qualitative statement that is directly contradicted by the evidence presented in the last paragraph (Line 1504) stating that some portion of the apparent habitat of the tree had been lost to development. To say that this has not impacted the "range" of the tree is being arbitrary about the definition of "range" as the scale of the term in the usage here is not defined. If defined as the maximum area of a polygon simply drawn from the outermost individuals, the loss of any individual at the range edge therefore impacts the range of the species. Thus it is unclear at what scale the Department is setting the threshold for significant range loss, and this statement is not supported.	Added some clarifying words to further distinguish the two sentences that the Reviewer finds contradictory. Range is defined as "the general geographical area in which an organism occurs" in the Range and Distribution section of the Status Review, which also states: "Range is largely independent of species abundance, because population declines within an area do not necessarily change the overall geographical area in which an organism occurs." This definition of range is reiterated parenthetically here in response to the reviewer comment. "Significant range" is a subjective term that should be evaluated on a case-by-case basis based upon all relevant information, and was evaluated for western Joshua tree based on the information presented in the Status Review. The Department also added a paragraph in the Summary of Listing Factors Present or Threatened Modification or Destruction of Habitat to discuss uncertainty regarding the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review.	Agree with response. In a broad sense, range has not changed, although substantial habitat has been lost to development in certain areas as stated in the status review.
1538-1594	Direct population monitoring. While none of these is a complete analysis, taken together, there is noted either no recruitment over time spans of one to several decades, or declines in more studies: Comanor and Clark 2000 for Victorville; Comanor and Clark 2000 for JTNP; Cornett 2016; Cornett 2020, and Cornett 2009, 2012 and 2014 JTNP; DeFalco et al. 2010; Gilliland et al 2006. Whereas only one study mentioned any population increase (Cornett 2013). This was presented in a long section and this reviewer found it difficult to put this information together and into context.	Added a sentence to the first paragraph of this section to summarize. Also added more information on the limitations of the available direct population monitoring efforts.	Ok
1584	Agreed on this point. I do not have access to the report cited here, however as described, there is no way to possibly definitively identify changes in range or density using the different methodologies in different years. To boot, it is highly unlikely that this magnitude of change has occurred, and if so, would need to be field verified.	Comment noted	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1667	Any trends in population size should be with reference to the population's specific locality with respect to the range edge. Northern populations may be expected to be increasing. Southern or dry edge populations may be decreasing. As reported, this reviewer is not able to discern the meaning of all of this information in the time allotted and it should be summarized by geographic locality, source of information, and trend.	A subsection summarizing available demographic information was added at the end of the Demographic Information section of the Status Review. As stated in the Status Review, there does not appear to be a uniform range-wide trend.	Agree with response and incorporation of the summary in the status review.
1714, 1775	Esque et al. is a study by highly respected scientists, however, I do not have access to the paper, and no numbers are reported here. As stated in this review, demographic patterns may differ among areas of the species range and especially between two species. It seems that the data are being combined for consideration across localities, quoting lines 1652-1654, "aggregated among sampling locations within the range of both the western Joshua tree and eastern Joshua tree." Thus, I'm not sure why as a reviewer I can accept a broad statement indicating population stability based on the information solely presented here, to characterize entire Park Service units together. I would venture to guess that these authors placed those plots across spatial/environmental gradients exactly to study these differences. It could be that I misunderstand the statements here. Please clarify.	Esque et al. (2010) is a publicly available document, and the report does not isolate height data on western Joshua tree and eastern Joshua tree and does not isolate data by National Park Service Unit. The Department agrees that additional analysis of data used for this study would be useful, but the Department doesn't have access to this data. The Department is simply reporting the demographic data that is available. Minor revisions to text were made for clarity.	Agree with response.
1779	I believe a formal meta-analysis of effects detected and associated uncertainty is necessary to make a definitive statement here. I agree that there is a lack of range-wide data that is standardized and thorough enough to model population trends thoroughly. However many of the trends reported here are troubling in terms of population sustainability in some areas of the range.	A formal meta-analysis is beyond the scope of this Status Review. The Status Review acknowledges that some populations may decline, but current information taken together suggests that the species is not likely to disappear from a significant portion of its range in the foreseeable future.	Agree with response.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1812	Whether these climate variations occurred at the same temporal scale as is predicted for anthropogenic climate change in the industrial age, however, is relevant to this discussion. If there is evidence that these past changes are comparable, temporally or spatially as what climate scientists predict will occur, please state that here.	Added reference to discussions of previous climate variations in the Inferred Long-term Trends section of the Status Review.	Ok
1886	Cite Gonzalez et al. 2018 Env. Research Letters	This paper is about the relative impact of climate change within and outside of U.S. National Park Service lands and it is not specific to the Southwestern U.S. or the areas where Joshua trees occur. Joshua trees also occur both within and outside of National Park Service lands, making this paper not very relevant for a discussion of regional, direct, or indirect effects of climate change on the species.	While we have not read this paper, it appears that its omission is appropriate per the response.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1906	There is uncertainty with respect to the future climate scenarios; however, the way this is written incorrectly characterizes the prediction of an increase in precipitation in the region as the "current" model, which is misleading to the non-specialist reader. The simulations in the citation, Allen and Luptowitz do not represent all "current" climate models (as far as the CMIP5); only the subset that those authors chose that best simulate the observed El Nino, as I understand it, the CESM and GFDL from CMIP5. Looking at a range of scenarios from the CMIP5, Gonzalez 2019 (Anthropogenic Climate Change in Joshua Tree National Park, California, USA. US National Park Service) stated that half of the models predict increased precipitation and half predict a decrease for Joshua Tree National park, while thirty three predict an increase of 4.6 C in temperature, which would lead to an increase in aridity regardless. I appreciate the work of Allen and colleague, I'm simply pointing out that this is not all current scenarios, and among them there is much discussion due to the difference in effects on jet stream and storm tracks based by the scenario, the discussion of which is outside of my expertise. If the range and uncertainty of the predictions for the region are not going to be presented in a standardized manner here (see Neelin et al. 2013 J Climate), I would be satisfied if a qualifier is added here, "According to *some* current climate models," as many suggest warmer and drier, and it is to be determined which are in fact more accurate.	Changed the word "current" to "some" per reviewer suggestion. Added a sentence and reference to Gonzalez (2019) earlier in this paragraph for a statement regarding half of models projecting increased precipitation and half projecting decreased precipitation in Joshua Tree National Park.	Agree with response.
1933	Agreed.	Comment noted	Ok
1944	I do not know if this has been substantiated, and whether this precision is justified.	Another peer reviewer requested more detail on this statement, not less, and therefore additional information from Cole et al (2011) regarding the magnitude of warming was added to the Status Review here.	Agree with response.
1960-1972	Agreed, this seems supported by the evidence.	Comment noted	Ok
2025	Agreed that this is a possibility based on other scientific studies.	Comment noted	Ok

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
2065	I don't think this is intentional, however, this description of species distribution models seems odd, and implies that scientists performing these techniques modify variables or data manually and may detract from the perception of their objectivity unnecessarily. Perhaps there is a better description indicating that we "project" the species model on to new given conditions, e.g. those associated with future climates, as produced by climatologists. Try Franklin or Elith for better plain-terms descriptions.	Made revisions to this sentence to clarify, and removed the word "modifying" in response to the reviewer's concern.	Agree with response.
2080	This is the concept of sensitivity. Exposure is defined by the change in conditions experienced; sensitivity is the impact it may have on organisms, as defined by its biology and ecological relationships. See Dawson et al. 2011. Science.	Introduced the terms exposure and sensitivity in this sentence. Added citation to Dawson et al. (2011).	Ok
2123	It is unfortunate that this is the only range-wide study available, and it is significantly impacted by the inclusion of two species in the model, one of which is not being assessed here. Many efforts are currently underway by several entities to map the species distribution and model future distribution, mindfully and using data from the species separately. Relevant and not cited here is the model of Thomas et al. 2012 USGS (see above for reference) that shows substantial declines, and has updated information over Cole et al., which relied heavily on old, spatially-coarse and geo- referenced data, much of which was digitized from maps manually.	Added a discussion of Thomas et al. (2012) near the end of this section.	Agree with response.
2135-2144	There are some inherent limitations in the ability to infer biology using species and habitat distribution modeling because of the difficulty in isolating the effect of any one variable using these techniques without accounting for colinearity statistically. In other words, climate variables are often highly correlated, and assessing them independently requires further analysis. Inferring these relationships is more appropriate for models based on mechanistic understanding of species tolerances as opposed to correlations.	Updated text to recognize that models should be used with caution until tested with independent verification. Additional edits were made to this section in response to comments from other reviewers. Added citation to Lee-Yaw et al. (2021).	Agree with response.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2156	SDM's can certainly be improved by carefully choosing and vetting data inputs, variable choice, and even using advanced techniques as necessary, this statement is quite dismissive, if this is the only way to predict the threat of future climate change to the species. Predictions are always associated with a range of uncertainty. Invoking physics, Dr. Prescod-Weinstein (2021) explains that every scenario is possible, but each is associated with a probability. Here, if there is no acceptable probability defined, relying on models that have been peer-reviewed by the expert scientific community is probably the most reliable way to make predictions about changes in species ranges. The last 20 years have seen, as you state, at least 6 models of this species, each building upon the last to better use for each study aim. To dismiss this route of analysis on the basis of each shortcoming is shortsighted.	Removed much of the end of this sentence to avoid the implication that species distribution models cannot be useful.	Agree with response.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2315	I see this is an interpretation of Sweet et al. 2019. The difference between the two first models, for the historic 30 year periods, are based on the suitability using a historic or observed downscaled hydrologic gridded datasets from Flint and Flint as cited. The differences in temperature and precipitation between each of the climate datasets used is found within Table 3. As you can see, the 1981-2010 time stamp is the only time for which there was an increase in precipitation within the variable dataset from the historic period of 1951-1980 to that time period. In other words, the model is then projecting suitable area for the Joshua tree across space with an increase in precipitation and an increase in temperature, which resulted in a lower listed suitable area. As stated in this Review, climate is variable on shorter time periods especially in the Mojave Desert, and this variability has an impact on extrapolated estimates from measurement stations, especially in a topographically-complex and measurement-poor region (see Heintzman et al. 2022 J App Met and Clim), as you point out later in Line 2396. If the climate dataset as gridded accurately represents the climatic landscape during the second time step, this may support the proposal that the tree is able to weather shorter-term changes in climate, as the Department asserts. This time stamp was included to be fully transparent, using all time steps available. However, all future scenarios under MIROC listed show an increase in both min and max temperature, decreases in precipitation, and aridity (climatic water deficit), all of which demonstrate that this would reduce suitable habitat, which is logical and consistent with all other models. This would happen over a longer-term period, which is more likely to have consistent impacts on the species than changes from one 30 year period to the next.	Comment noted, and the Department points out later in this section that it may not be appropriate to use averages of narrow (30 to 40 year) timeframes to represent the climate conditions and climate variability that is suitable for western Joshua tree. Text also updated in response to reviewer comment to acknowledge that "…a departure from historical climate conditions does not necessarily mean that the new climate is no longer capable of supporting the species*, at least in the short term*."	Agree with response.

Table A-4 Peer review comments from Dr. Lynn Sweet on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2317	This was an oversight, I am happy to provide these data. I thought I had sent it, but I must have not, I do apologize. To answer the criticism here, any difference in the abundance of where seedlings may occur, similar to the Department's summary of the Barrows seedling habitat model, indicates a possible shift in where trees will occur into the future. I can confirm that the areas outside of refugia demonstrated demographic histogram patterns much more like those deemed stable or declining in previous sections than low recruiting plots. These are the same plots cited as Frakes et al 2017 in this Review.	Data were not provided to the Department with the reviewer's comments and therefore could not be included in this Status Review in time for completion, however comment indicates that demographic data used may be comparable with that reported by St. Clair and Hoines (2018) and illustrated in Figure 6 of the Status Review.	Agree with response.
2419	Sweet et al. reported an AUC for the model, which is often used as an indication of the sensitivity and specificity of the model. It should be listed here.	Reporting performance values under various metrics for the different models is likely too much detail for this report, however a citation to Sweet et al. 2019 was added to this section to indicate that performance of model results was evaluated with a single metric, like Cole et al. (2011) and Thomas et al. (2012). Added a sentence to indicate that Barrows and Murphy-Mariscal (2012) used two metrics to evaluate model performance.	Ok
2425	Again this refers to the sensitivity to the climate change exposure, consider citing Dawson et al. 2011 Science and utilizing this terminology.	Included additional use of the terms sensitivity and exposure in the Status Review per reviewer comment.	Ok
2989	However, given upward trend indicated, if larger and larger areas burn, that may have some impact that could start to shift the ability of populations to be sustainable long term and lead to range contraction eventually, as is stated later. I would put a slightly higher emphasis on this perhaps than the department, but agree that it would not be the sole factor in range decreases.	Comment probably intended for line 2889 or 2898. Edited text in the Summary of Wildfire Threat section to state that wildfire may negatively impact the species distribution.	Agree with response. But see our general note on the wildfire issue and interpretation of Figure 10.
3054	Small, but important and relevant to early seedling stages, which is relevant to restoration.	Added sentence to acknowledge that the early seedling stage is a vulnerable one. Added the word "overall" to the last sentence in this section to emphasize that the threat is evaluated in context of the entire species.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
N/A	Most substantively, although the draft Status Review details threats arising from changing climate, increasing frequency and extent of wildfires, and ongoing habitat losses to development, it does not substantially address how these threats may interact to rapidly endanger the survival of western Joshua tree throughout its range — and the CESA specifically notes that threats to a species may act in combination, per the California Code of Regulations, tit. 14, sect. 670.1, subd. 3709 (i)(1)(A).	The Department has little information on the degree to which threats may interact to rapidly endanger the survival of western Joshua tree throughout its range, but cumulative effects are discussed generally in the Summary of Listing Factors section of the Status Review, and cumulative threats are addressed throughout the Status Review when such information is available. In response to the reviewer's comment, the "Indirect Effects" section of the Status Review under Climate Change was renamed "Indirect and Cumulative Effects". A new paragraph discussing aspects of work by Sweet et al. (2019) regarding how climate change and historic wildfire may interact has been added to the renamed section. Additional sentences were also added to the Status Review to identify interconnected threats of development and other human activities and invasive plants and wildfire.	Agree with response.
N/A	This oversight is, perhaps, related to a second issue, that uncertainty in expected threats is consistently interpreted in a manner that minimizes those threats, particularly in the way that the text addresses uncertainties in habitat losses predicted by species distribution models.	A goal of the Status Review is to discuss the range of possibilities that may occur. A sentence was added to the Species Distribution Models section to acknowledge that the negative effects of western Joshua tree exposure to climate change within the foreseeable future could perhaps be very severe, resulting in a loss of significant range, or perhaps they will be less severe, resulting in lowered abundance without significant range loss. As discussed in the Status Review in detail, species distribution models can be useful, but they have significant inherent limitations, and exposure to climate change does not necessarily mean that there will be a loss of range. Specific comments from the reviewer related to this topic are addressed below.	Agree with response.
N/A	However, I am not convinced that the available evidence supports a recommendation against designating the species as "threatened." Current threats to western Joshua trees in California, considered in combination, mean that the species has very real potential to "become an endangered species in the foreseeable future" (again, per Fish and Game Code, sect. 2067).	See response to previous comment.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1402	The observation by WEST Inc that population density is lower in the southern range extent is in fact an early indication of climate-change impacts. Climate change that has occurred since pre-industrial times is expected to impact species at the warmest and driest parts of their ranges first, and reduced population density would be one sign of such an impact.	The text in the Status Review regarding the WEST Inc study was misleading as written and therefore was misunderstood by the reviewer. The text has been revised for clarity. The information from WEST Inc is therefore not evidence of the point being made by the reviewer here. WEST Inc did not compare the northern and southern portions of the species range and examined the entire perimeter of the portion of the species range analyzed (not just lower elevation and/or lower latitude areas of the range perimeter, but higher elevation and higher latitude areas as well). To the reviewer's point, it is noted in the Species Distribution Models section of the status review that lower recruitment in marginal habitats subject to climate change may be a sign that climatic warming is negatively influencing recruitment.	Agree with response, but it is easy to see how the reviewer was confused. It remains unclear to us what portion of the range was considered. "Southern" is not defined. The WEST study appears to have been conducted on a large portion of the southern extent of the range, although direct comparison with the range shown in Figure 3 was not possible.
1538-1598	The summation of long-term monitoring studies here seems to me to miss important overall trends. Multiple cited studies find population declines or lack of new recruitment in monitoring plots at relatively southern sites (Victorville, in the Comanor and Clark study; Saddleback Butte and Joshua Tree National Park, in the Cornett studies cited; other sites in the National Park in the DeFalco study). The text here correctly notes that this is limited data, but none of the direct studies discussed appear to have found substantial recruitment of juvenile trees into the populations being monitored.	Text in the opening paragraph of this section revised to state that "little recruitment in plots has been observed". A reference to the Demographic Information section was added for more information on recruitment trends.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1630-1632	The discussion here of limitations to existing population demographic data is correct to note the difficulty in surveying the abundance of Joshua tree seedlings, given their small size and their typical need of a sheltering nurse plant (discussed earlier in the text). However, the conclusion here appears to be that this should be read solely as a risk of *underestimating* the presence of seedlings; whereas it can just as easily mean that population demographic profiles with no data on seedling abundance will be unable to distinguish populations with no seedlings from populations that have them in abundance. The demographic data discussed in the text following this point should be understood in that light.	Added a sentence to further clarify that it is difficult to detect both periods of high seedling establishment and periods where little or no seedling establishment is taking place. Added similar text later in this section when discussing specific figures.	Agree with response.
1686-1720	The consideration here of demographic surveys by St Clair and Hoynes, published in 2018, correctly notes that this dataset is consistent with demographic declines. However, it is not correctly weighed against the older data published by Esque *et al*. in 2010. Esque *et al*. aggregate data from National Parks properties across the Mojave, while St Clair and Hoynes report data specifically from sites in Joshua Tree National Park. Given that the St Clair and Hoynes data are both more recent and more clearly attributable to specific populations, the balance of the evidence here is that populations in JTNP are declining. (This is consistent with results from modeling-based studies, discussed later in the text.)	The purpose of this section is to present the known (but limited) demographic information on the species, and Joshua Tree National Park is not being evaluated specifically. Nevertheless, a reference to the St. Clair and Hoines (2018) data was added in the section discussing the Esque 2010 data, and some additional detail on the St. Clair and Hoines (2018) data in Joshua Tree National Park was also added.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
1703-1712	Figures 6, 7, and 8: The demographic profiles displayed in these figures do not appear to be consistent with their descriptions in the text. (Notably, the histogram attributed to St. Clair and Hoynes in Figure 7 shows strong representation of trees in the smallest size class, consistent with good demographic health; while Figure 6 shows a striking lack of trees in the smallest class despite being described as "what would be expected for a sustainable or increasing population" on line 1665.) Regardless, two of the three demographic datasets presented here as figures are consistent with recent poor recruitment of juvenile Joshua trees, and these are specifically linked to sites in the southern part of the range — again, a potential early sign of impacts from warming climate.	Added additional text to emphasize that the relative amounts of shorter to taller plants is important in assessing whether the current number of taller plants can be replaced. Also added text discussing the smallest height class in Figure 6, and comparing height classes in Figure 7. While there are examples of recent poor recruitment at the southern portion of the species range, there are also examples of relatively high recruitment in the southern portion of the species range, and as described in the Life History section of the Status Review, recruitment for the species is episodic.	Agree with response. We suggest the lack of trees in the smallest size class in Figure 6 may also represent a period without substantial recruitment but that is also within the normal range of variability for recruitment events. There is clearly a large cohort in the 1m size class, likely from one or more past recruitment events. This cohort may be 25 to 35 years in age (based on average growth rates), so the lack of a large, younger cohort is not surprising given the rarity of large recruitment events.
1787	Factors affecting the ability to survive and reproduce: Throughout this section, the text emphasizes uncertainties inherent in SDM construction and the predictions derived from SDMs, but these uncertainties are consistently described in terms of their possibility to overestimate risk, never the possibility that they may *underestimate* risk.	The text does little to suggest that models are overestimating or underestimating risk and the reviewer does not cite any specific examples to address. A sentence was added near the beginning of this section to address this comment generally by pointing out that uncertainty in species distribution modeling results could mean that a species exposure to climate change is either higher or lower than models predict.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments			
Line	**Reviewer Comment**	**Department Response**	**Heritage Review**
1938	The statement here (repeated at line 2110 and line 3757) that the Department lacks data on the effects of climate change on the demography of western Joshua tree populations is contradicted by the extensive discussion later in the text of not one but two studies, by Barrows and Murphy-Mariscal (2012) and by Sweet *et al.* (2019), which use SDM methods informed by demographic data; and it further misses data on threats to juvenile Joshua trees that are highly likely to be exacerbated by changing climate. Most notably: findings by Esque *et al.* (2015) that establishment of Joshua tree seedlings may peak in rare years of higher than average rainfall, and that their survivorship is heavily reduced by herbivory in drought years. If climate change reduces the frequency of wet years and makes droughts both more frequent and longer, this study clearly indicates that seedlings will be less likely to establish and then less likely to survive to reproductive age as a result of climate change.	While Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Barrows and Murphy-Mariscal (2012) incorporated demographic data by comparing a binary map product for adult trees with another for juvenile trees, which is useful in suggesting that a demographic link with climate change is present, but it is not an actual correlation. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of “High Recruiting” and “Low Recruiting” macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Both of these studies also examined the same area: Joshua Tree National Park, which is a small portion of western Joshua Tree’s total range. Discussion of the vulnerability of early western Joshua tree life stages is discussed in the Establishment and Early Survival and Climate Change Direct Impacts sections of the Status Review. Added a sentence to the Direct Impacts section of the Status Review to state that seedlings and juveniles may be particularly vulnerable to warming and droughts from climate change. Added a new sentence with a reference to Esque et al. 2015 in the Herbivory and Predation section. Information available to the Department suggests that there will be more climate extremes, and that overall aridity will likely rise, but the Department does not have data that suggests the frequency of wet years will go down.	Generally agree with response. We believe it is safe to say that climate change will have some (mostly unknown) effect on WJT demography. We believe the reviewer is biased toward worse effects to the species as a whole, based on results of the studies from JTNP, which may not be representative and should not be extrapolated to the entire range of the species.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2035	The statement that the Department lacks data showing that western Joshua tree populations are experiencing "delayed local extinction" — in which populations of established adult trees are failing to recruit new seedlings — is contradicted by the earlier discussion of demographic studies showing that, at multiple sites in the Mojave, juvenile Joshua trees are sufficiently rare to be consistent with population declines. Such a demographic population decline is a "delayed local extinction" in a long-lived species such as western Joshua tree.	Population decline is not synonymous with delayed local extinction, and the reviewer does not provide justification for the assertion that a demographic population decline is a "delayed local extinction" in a long-lived species such as western Joshua tree. Due to the lack of basic demographic information such as long term recruitment and mortality rates and acceptable fluctuations of those rates over long timescales, the Department does not have a way to determine if populations are subject to a delayed local extinction or not.	Agree with response. Reviewer makes a leap from localized lack of recruitment to population decline to delayed local extinction (better phrased as extirpation).
2145-2161	The discussion of uncertainties in the SDM study by Cole *et al.* (2011) fails to acknowledge that these uncertainties cut two ways. Yes, it is possible the model may overestimate losses of suitable habitat by the end of the century; but by the same token the model may *underestimate* losses of suitable habitat. The model only considers climate, and cannot address reductions in population growth within regions that may remain suitable for mature trees but too harsh for seedlings to survive. Moreover, it makes deliberately optimistic assumptions about the trees' natural capacity for migration (Cole *et al.* 2011, page 145), the limitations of which are discussed earlier in the text. Thus, the dramatic estimate that only 10% of the current range may remain suitable by the end of this century is still in some respects a best-case scenario.	In response to the reviewer comment for line 1787 the Department added a sentence near the beginning of the Species Distribution Models section to say that uncertainty in species distribution modeling results could mean that a species exposure to climate change is either higher or lower than models predict. Text was revised in the Limitations of Models section to state that differences in how climate change exposure may affect seedling, juvenile, and adult trees is another uncertainty of species distribution models. Cole et al. (2011) provided relatively little explanation about how map products in the paper related to the conclusions in the text. It appears that Cole et al. (2011)'s optimistic migration capacity was used for the map product shown in Figure 5 of their paper, not for the "as little as 10%" conclusion that is illustrated by Figure 3 of their paper.	Agree with response.
2214-2240	Discussion here of the SDM study by Dole *et al.* (2003) appears to misunderstand the degree to which the top-line estimate of a 9% reduction in total suitable habitat relies on Joshua trees migrating to track suitable climates. Even under the modeled scenario in which elevated CO2 allows the trees to tolerate colder conditions, Dole *et al.* project that 71% of the current range will become unsuitable ("... 29% of cells from the current prediction remaining occupied", Dole et al 2003, page 142).	It is unclear what the reviewer is stating is incorrect or unclear. The Status Review already states that "The Dole et al. (2003) species distribution model broadly overestimates the ability of Joshua tree to disperse into new areas" and already states that 29% of grid cells would retain suitable climate conditions.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2241-2279	Discussion of the SDM study of mature and seedling western Joshua trees in Joshua Tree National Park by Barrows and Murphy-Mariscal (2012) assumes the high end of the range of uncertainty in the authors' projections. They find that up to 10% of the current habitat within the park will remain suitable by the end of the century, but it may be as little as 2%. This result must also be viewed in light of the results of the study by Sweet *et al*. (2019) discussed immediately following this work — that later work notes the risks to wildfire in the small climate refugia identified within the park.	Added sentence stating the Barrows and Murphy-Mariscal (2012) prediction for +3°C warming scenario with a 75 mm decrease in annual precipitation with the caveat that climate models do not agree that precipitation will decrease. A discussion of Sweet et al. (2019) noting the risks to climate refugia from wildfire was added to the Climate Change Indirect and Cumulative Effects section of the Status Review.	Agree with response.
2327	The finding by Sweet *et al*. (2019), that Joshua tree populations in study sites within future climate refugia are more demographically healthy (i.e., have higher density of juvenile trees) than populations outside of climate refugia is as close to demonstrating a demographic effect of climate change as anything short of long-term survey data tracking population declines over the rest of this century. It is particularly relevant because the region examined, Joshua Tree National Park, lies at the southern edge of the species range, where impacts of climate change are expected to manifest first.	While Barrows and Murphy-Mariscal (2012) and Sweet et al. (2019) are the first to associate western Joshua tree demographic data with predictions from species distribution models, they still do not provide a clear link between climate change effects and demographic trends. Sweet et al. (2019) correlated binary and somewhat arbitrary designations of "High Recruiting" and "Low Recruiting" macroplots with distance to a binary map product for refugia, which is a somewhat weak correlation between negative impacts from exposure to climate change and negative impacts on demographics. Text was added at the end of paragraph to acknowledge the correlation but point out that other possible explanations were not contemplated by Sweet et al. (2019). The last paragraph of this section already includes a discussion of the implication of this work for the trailing edge of the species range.	Generally agree with response, but we believe it is safe to say that climate change will have some (mostly unknown) effect on WJT demography. A clear link in not necessary to acknowledge that some level of effect on demographics, at least at the southern edge of the range, may be occurring.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2368	It is not entirely true that species distribution models cannot account for the "resilience" of "an abundant and widespread species." A widespread species necessarily occupies a wider range of habitats, and SDMs are fundamentally designed to account for variation in the habitats across which a species occurs. A rare, narrowly endemic species will occupy a narrower range of conditions, and an SDM would be more likely to find that its current range would become uninhabitable under climate change as a result. If a species occupies a wide range of climate conditions and those conditions remain present in the future, an SDM should show that the species will retain its extensive existing range; but this is not what we see for SDM studies of western Joshua tree	Revised the sentence to be less absolute and acknowledge that species distribution models are fundamentally designed to account for variation in the habitat in which a species occurs.	Agree with response.
2352-2373	Discussion of the limitations to SDM projections of habitat losses under climate change misses a key factor in evaluating SDM studies of Joshua tree: the species is in many respects an excellent candidate for SDM methods. Species distribution models gain power as they incorporate larger and larger sets of validated observations of a species' presence or absence from the landscape. Joshua tree, as the most visible member of most plant communities in which it occurs, is exceptionally well observed. Studies of Joshua trees using SDM methods routinely incorporate thousands of observations — Sweet *et al.* (2019) had 11,142 "presence" data-points in their most spatially extensive model. There certainly remain limitations on these data sets, but they are in many respects the ideal applications for SDM methods.	Added a sentence at the beginning of the species distribution modeling section to say that species distribution models gain power if they incorporate large sets of validated observations, and because western Joshua tree is so visually distinctive and well-observed it is a good species for species distribution modeling applications.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
2677	Wildfire: A substantial missed opportunity in the draft Status Review is serious consideration of the joint risks posed by climate change and the increasing frequency of wildfire in the Mojave, driven by the establishment of invasive fire-tolerant grasses. The Review correctly identifies the dramatic increase in burned area over recent decades (Figures 9 and 10), but does not systematically compare this to projected future refugia.	See response to first comment in this table. A new paragraph discussing how climate change and historic wildfire may interact has been added to the (renamed) Climate Change Indirect and Cumulative Effects section of the Status Review. This Status Review is based on the best scientific information available to the Department, and except as discussed in the newly-added paragraph, the Department is not in possession of a quantitative published analysis of the joint risks to western Joshua tree posed by climate change and the increasing frequency of wildfire.	Agree with response.
2819	As noted here, smaller trees are more likely to be killed in wildfires; this means that increasing frequency and severity of wildfires is a foreseeable risk to the demographic health of Joshua tree populations.	Additional detail was added to this sentence in response to a comment from another reviewer. Added a sentence saying: The severe effect of wildfire on shorter trees causes long- lasting negative effects on the demographic health of affected populations.	Agree with response.
2851-2859	Discussion of this study showing recovery of reproduction in a population of eastern Joshua trees after a burn is somewhat misleading, because it is impossible to assess flowering or fruit set in populations with no surviving trees after a burn — so the data is, by necessity, showing recovery of reproduction in populations that were less severely burned.	Added sentence that says: The study only examined areas where some eastern Joshua trees survived, because areas without surviving trees could not be assessed.	Agree with response.
2893-2907	Notably unmentioned in this section is the Cima Dome fire of 2020, perhaps because it impacted eastern Joshua tree. That event burned over 43,000 acres in Mojave National Preserve, a probable climate refuge, killing 1.3 million Joshua trees in the estimation of National Parks Service staff (NPS 2020). The Cima Dome fire demonstrates how rapidly a “stochastic” event can impact even a dense, demographically healthy population, and subsequent recovery efforts emphasize the substantial resources required to restore a Joshua tree population afterward.	Added a sentence at an appropriate location in the Wildfire section of the Status Review noting the Dome Fire as an example of how rapidly a wildfire can impact a dense Joshua tree population.	Agree with response.

Table A-5 Peer review comments from Dr. Jeremy Yoder on the WJT status review, with CDFW responses and Heritage review comments

Line	Reviewer Comment	Department Response	Heritage Review
3854-3867	The consideration here of the combined effects of threats to Joshua tree, particularly the joint impacts of climate change and increased wildfire frequency and severity, is really insufficient in considering their joint power. An example of how fire risk might be weighed in concert with climate change is the work by Sweet *et al.* (2019), which compares the extent of recent fires in Joshua Tree National Park to the extent of projected suitable habitat at the end of the century, and finds that up to 50% of the projected climate refuge area within the park has been burned. If western Joshua tree does indeed suffer predicted habitat losses as great as projected by even somewhat optimistic SDM studies, the remaining populations will be dramatically more vulnerable to stochastic losses, such as wildfires. It is unlikely that a single fire could substantially damage the survivability of currently extant Joshua tree populations, but losses on the scale of the Cima Dome fire could represent a large fraction of the populations remaining in climate refugia by the end of this century.	See response to first comment in this table. A new paragraph discussing how climate change and historic wildfire may interact has been added to the (renamed) Climate Change Indirect and Cumulative Effects section of the status review, which includes reference to the work by Sweet et al. (2019). This Status Review is based on the best scientific information available to the Department, and except as discussed in the newly-added paragraph, the Department is not in possession of a quantitative published analysis of the joint risks to western Joshua tree posed by climate change and the increasing frequency of wildfire. An additional paragraph regarding uncertainty was added to the Present or Threatened Modification or Destruction of Habitat section of the Status Review.	Agree with response.
N/A	In conclusion, it is undoubtably the case, as the draft Status Review concludes, that western Joshua tree currently remains widespread and abundant. However, I do not feel that the draft reflects a full assessment of the risk that this species “is likely to become an endangered species in the foreseeable future” as specified for assigning “threatened” status under the CESA (Fish and Game Code, sect. 2067.) As currently written, the draft Status Review interprets uncertainty in predicted threats in the most optimistic light, misses ways in which available data can answer questions that it poses, and does not seriously consider the joint effects of the interlocking threats to western Joshua tree.	See responses to previous comments. An additional paragraph regarding uncertainty in the ultimate effect of the combined and cumulative effects of the factors discussed in the Status Review was also added to the Present or Threatened Modification or Destruction of Habitat section of the Status Review.	Agree with response. We believe the reviewer is looking for a conclusion that is not supported by the best available science. While future studies will undoubtedly tease out more precise demographic effects of climate change, and more precisely describe the cumulative threats to the WJT, we believe the current status review discusses what is known and what is unknown without becoming speculative.

EXHIBIT 2

Technical Memorandum

Prepared For: County of San Bernardino

Prepared By: Heritage Environmental Consultants

Subject: Review of CESA-listed Species and Comparison with the Western Joshua Tree

Date: May 7, 2021

Background

In October 2019, the Center for Biological Diversity (CBD) submitted a petition to the California Fish and Game Commission (CFGC) to list the western Joshua tree (WJT) as threatened under the California Endangered Species Act (CESA) (CBD 2019). CBD (2019) listed several factors that are "often related, synergistic, and collectively threaten the continued viability" of the WJT, including "predation, invasive species, wildfire, drought, climate change, and habitat loss". Further, CBD (2019) suggested that "climate change represents the single greatest threat to the continued existence" of the WJT.

In February 2020, the California Department of Fish and Wildlife (CDFW) completed a review of the petition and other scientific information, determined that the petitioned action may be warranted, and recommended that the Commission accept the petition for further consideration (CDFW 2020a). In September 2020, the CFGC accepted the petition for consideration and the WJT became a candidate for listing as threatened or endangered (CFGC 2020). The CDFW is preparing a status review report for the WJT to determine whether the petitioned action is warranted.

Heritage Environmental Consultants (Heritage) previously reviewed the scientific basis for listing the WJT under the CESA (Heritage 2020), including studies identified in CBD's (2019) petition and CDFW's (2020) review. As part of this effort, we examined several recent status reviews and listing petitions, including those for Clara Hunt's milkvetch (*Astragalus claranus*) (CDFW 2019a), Shasta snow-wreath (*Neviusia cliftonii*) (Roche 2019), Lassics lupine (*Lupinus constancei*) (CBD 2016), and coast yellow leptosiphon (*Leptosiphon croceus*) (Corelli 2016). These species were selected because their petitions and supporting documentation were readily available on CDFW's web site (https://fgc.ca.gov/CESA).

While the documents for each of these species are variable in content, detailed information on distribution and abundance was provided. In every case, not only were data on population abundance and trends provided, but the species in question were limited in distribution, limited in the number of occurrences, and limited in abundance of individuals both within occurrences and range-wide. CDFW and the CFGC likely considered these factors, along with known and potential threats, in making their recent listing decisions.

This contrasts distinctly with the WJT, which lacks robust data on population abundance and trend, but is known to occur in large numbers across an extensive range. Our previous review concluded that the WJT is widespread and abundant relative to other plant species being considered for listing or already listed under the CESA. Given this contrast with other CESA-listed species, we concluded that it may not be appropriate to list the WJT as threatened under the CESA at this time.

Comparison with Recent CESA Actions

As a follow-up to our previous review, we expanded our comparison of the WJT with other CESA-listed species, an effort that is reported in the remainder of this memorandum. One purpose of this effort was to gather additional information on distribution and abundance of the WJT and compare it with other species subject to recent CESA listing actions. Another purpose was to examine the threats identified for each of these species and compare them with alleged threats to the WJT.

Since we completed our previous review, documents for several additional CESA-listed species, including Baker's larkspur (*Delphinium bakeri*) (CDFW 2019b), Kenwood Marsh checkerbloom (*Sidalcea oregana* ssp. *valida*) (CDFW 2020b), and Milo Baker's lupine (*Lupinus milo-bakeri*) (CDFW 2020c), were placed on CDFW's web site. For each of these three additional species, we reviewed data on range, abundance, distribution, trends, and threats. We also reviewed the threats that were described for the four original species (Clara Hunt's milkvetch, Shasta snow-wreath, Lassics lupine, and coast yellow leptosiphon) that we examined in our previous review.

Distribution and Abundance

The three additional species (Baker's larkspur, Kenwood Marsh checkerbloom, and Milo Baker's lupine) are extremely limited in distribution, number of occurrences, and abundance of individuals both within occurrences and range-wide. These findings are consistent with the other four species we previously examined and provide additional contrast with the WJT.

Relevant data from the status reviews and related documents were combined with information on the WJT to develop **Table 1**, which illustrates the differences between the WJT and other CESA-listed or candidate species, in terms of distribution and abundance. The remainder of this section discusses components of **Table 1** in detail.

The California Natural Diversity Database (CNDDB) (CDFW 2021a) lists the number of U. S. Geological Survey (USGS) 7.5-minute quadrangle (quad) maps in which each tracked species is known to occur. The CNDDB quad data are based on existing records and may not represent the entirety of a species' range. For example, a species may be present in additional quads, but has not yet been documented there. In addition, geographic data may not be sufficiently detailed, especially for older records, to determine exactly which quads are or are not occupied by a species. Nevertheless, quad data provide a rough surrogate for distribution (range) of a species – the more quads a species occupies, the broader its range. **Table 1** lists the number of quads within which the CNDDB data show presence of each species. Excluding the WJT, the average number of quads occupied by a species is 3.9, a statistically significant difference ($p < 0.0001$) from the 243 quads occupied by the WJT.

An Element Occurrence (EO) is defined as a group of individuals of a species found within 0.25 miles and not separated by substantial habitat discontinuities. Data on EOs were obtained from the California Native Plant Society (CNPS) Inventory of Rare and Endangered Plants of California (Inventory) (CNPS 2021). EOs are based on documented occurrences and may not represent all occurrences in existence. For example, unsurveyed portions of a species' range may support undocumented occurrences. EO data provide a rough surrogate for abundance – the more EOs are known for a species, the more abundant it generally is. **Table 1** lists the number of known EOs for each species except the WJT, because it is not included in the Inventory.

Table 1 Status and Occurrence for Recent CESA Listing Actions

Common Name	Scientific Name	Quads	EOs	Status*		CA Rare Plant Rank*	State Rank*	Global Rank*
				Federal	State			
Baker's larkspur	*Delphinium bakeri*	6	6	FE	SE	1B.1	S1	G1
Clara Hunt's milkvetch	*Astragalus claranus*	5	6	FE	ST (CE)[1]	1B.1	S1	G1
Coast yellow leptosiphon	*Leptosiphon croceus*	1	1	n/a	SE	1B.1	S1	G1
Kenwood Marsh checkerbloom	*Sidalcea oregana* ssp. *valida*	2	2	FE	SE	1B.1	S1	G5T1
Lassics lupine	*Lupinus constancei*	1	2	n/a	SE	1B.1	S1	G1
Milo Baker's lupine	*Lupinus milo-baker*	3	11	n/a	ST[2]	1B.1	S1	G1Q
Shasta snow-wreath	*Neviusia cliftonii*	9	26	n/a	CE[3]	1B.2	S2	G2
Western Joshua tree	*Yucca brevifolia*	243	n/a	n/a	CT[4]	CBR	SNR	G3

* See **Attachment A** for an explanation of codes for federal and state status and CA rare plant, state, and global ranks.

[1] Clara Hunt's milkvetch is currently listed as threatened under the CESA and is a candidate for up-listing to endangered.

[2] The CDFW has recommended that Milo-Baker's lupine be up-listed from threatened to endangered; however, the CFGC has not yet ruled on this recommendation.

[3] The Shasta snow-wreath is not currently listed under the CESA but is a candidate for listing as endangered.

[4] The WJT is not currently listed under the CESA but is a candidate for listing as threatened.

For the species listed in **Table 1**, with the exception of the WJT, it appears that extensive surveys have been conducted and few undocumented occurrences are anticipated; therefore, the number of EOs is likely a close representation of their abundance. Of these species, the average number of EOs is 7.7. While the WJT is not tracked at the EO level, it would be reasonable to assume that there are substantially more potential EOs, considering the relatively broad distribution and abundance of the WJT across its range. Based on the number of quads occupied by the WJT, we believe the number of potential EOs across its range is likely in the hundreds. To refine this approximation, we used the ratio of EOs to quads for the other species listed in **Table 1** (7.7 EOs per 3.9 quads, or 1.97 EOs per quad) multiplied by 243 quads to develop a theoretical estimate of 480 EOs for the WJT. Unfortunately, the small sample size and high variance mean that statistically this estimate could range from 49 to 2,082 EOs (95% confidence interval). Even though this estimate is far from definitive, it suggests that the abundance of WJT is at least an order of magnitude greater than for any of the other CESA-listed species in **Table 1**.

The CNPS (2021) established rare plant ranks for each species in the Inventory, based on factors including rarity, distribution, and threats. **Attachment A** contains a complete explanation of rare plant ranks. Each of the species in **Table 1** except the WJT has a rare plant rank of 1B.1 or 1B.2 (rare, threatened, or endangered in California and elsewhere, with moderate to serious threats). The WJT has a rare plant rank of CBR (Considered But Rejected) and was rejected as "too common".

Similar to the CNPS rare plant ranks, state and global ranks provide a measure of rarity and endangerment. The state rank refers to the imperilment status of a taxon only within California, while the global rank reflects the status of a taxon throughout its global range. **Attachment A** contains a complete explanation of state and global ranks. **Table 1** shows that each species other than the WJT is ranked as S1 or S2 (imperiled or critically imperiled in the state) and G1, G2, or T1 (imperiled or critically imperiled globally). The WJT has a global rank of G3 (vulnerable), but is not ranked at the state level, which is typical of G3, G4, and G5 ranked species.

The CNPS (2021) maintains a list of species that were considered for inclusion in the Inventory, but that were rejected for one reason or another. This list currently contains 862 species, including the WJT. Reasons for rejection typically include the species being too common, not occurring in California, or being taxonomically invalid. We conducted a cursory review of this list to identify any species that are comparable to the WJT. One species that is comparable to the WJT is the giant sequoia (*Sequoiadendron giganteum*).

Like the WJT, the giant sequoia was considered but rejected because it is too common, has a global rank of G3, and is not ranked in the state. It is also an easily recognizable and even iconic component of the ecosystem in which it appears, and is vulnerable to altered fire regimes and climate change, among other threats. In contrast with the WJT, the giant sequoia occupies a somewhat smaller and better mapped range and likely has a smaller number of EOs that are generally better documented. Despite the better understanding of its smaller range, lower abundance, and substantial threats, the giant sequoia has not been proposed for listing under the CESA. This comparison, combined with the information summarized in **Table 1**, suggests that the WJT has little in common with species that are truly threatened or endangered and much more in common with species that are more abundant, more widely distributed, and not under consideration for listing under the CESA.

Threats

The types of threats posed to a species and the magnitude of those threats should be among the primary factors in any listing consideration. Identified threats to one or more of the seven species subject to recent CESA listing actions that we reviewed include:

- Climate change (including increased temperature, drought)
- Habitat modification or loss
- Herbivory / predation (including livestock grazing)
- Human activities (herbicide use, mowing, recreation, water diversion / use)
- Inadequacy of existing regulatory mechanisms
- Invasive species (including management of invasive species)
- Life history traits (including slow reproduction)

* Over-collection / over-exploitation
* Small population size (loss of genetic diversity, risk of stochastic [random] extinction events)
* Vegetation community succession (including competition)
* Wildfire (primarily wildfire outside the historic range of variability)

This list encompasses all of the primary threats to the WJT, namely predation, invasive species, wildfire, drought, climate change, and habitat loss. This list also included threats that are unique to species with extremely limited distribution and abundance, unlike the WJT. Small populations are much more likely to be signficantly affected by single, stochastic events. For example, one wildfire can damage or destroy a significant portion of the individuals of a species with a small range. For the WJT, individual stochastic events may harm an occurrence, but the wide range and abundance of the species mean that small, local events are not relevant to the continued viability of the species.

Climate change, which CBD identifed as the single greatest threat to the WJT, is also a threat to almost every other plant species. Plants of all types across the world will be challenged to adapt to climate change. Plants with the smallest range, or most exacting habitat requirements will be the most threatened. The Lassics lupine, which only grows on two nearby mountain tops, is one example of a plant that is likely to be extremely threatened by climate change. Even slight warming or drying may render all of its current habitat unsuitable. And in the absence of assisted migration (human movement of the species), it has nowhere else to go. That is, it can't move up to a cooler, wetter elevation, since it is already growing on mountain tops. In contrast, the WJT occurs across a wide swath of desert, with substantial variation in temperature and precipitation across its range. While there are significant unknowns in the ability of the WJT to migrate with climate change, it appears to have more potential to survive than other truly rare CESA-listed species.

Comparison With All CESA-Listed Species

To expand on our comparison of the WJT with CESA-listed species, we analyzed data for all 219 plant species listed under CESA or the Native Plant Protection Act (NPPA). The purpose of this expansion was two-fold: 1) to increase sample size for statistical comparison; and 2) to determine if the recent CESA listing actions are for a group of rare species that differ significantly from those in earlier listing actions (that is, is the WJT similar to some previously-listed species, or does it remain an outlier when compared with all listed species?).

Table 2 provides a summary of this analysis. In general, the results of the expanded analysis are similar to the analysis of recent CESA listings actions summarized in **Table 1**. Similarities and differences in the two analyses are discussed in the remainder of this section.

Table 2 Comparison of CESA-listed species with the WJT

Parameter		State Status*				WJT
		SE	ST	SR	All	
Number of Species		133	22	64	219	1
Quads (average)		8.1	6.2	7.1	7.6	243
Quads (median)		4.0	6.0	4.5	5.0	
Quads (minimum-maximum)		1-57	1-17	1-63	1-63	
EOs (average)		20.6	13.8	18.7	19.4	n/a
EOs (median)		10.0	11.5	12.0	11.0	
EOs (minimum-maximum)		1-114	1-29	2-198	1-198	
Federal Status*	FE	72	9	11	92	
	FT	19	5	5	29	
	FC	1	0	0	1	
	FD	0	0	1	1	
	n/a	41	8	47	96	✔
CA Rare Plant Rank*	1A	2	0	0	2	
	1B.1	98	16	14	128	
	1B.2	23	6	37	66	
	1B.3	4	0	8	12	
	2B.1	3	0	1	4	
	2B.2	0	0	1	1	
	3.1	1	0	0	1	
	3.2	0	0	1	1	
	4.2	1	0	1	2	
	4.3	1	0	1	2	
	CBR	0	0	0	0	✔
State Rank*	S1	100	19	29	148	
	S2	24	3	28	55	
	S3	6	0	7	13	
	SNR	0	0	0	0	✔
	SX / SXC	3	0	0	3	
Global Rank*	G1	97	19	26	142	
	G2	25	2	30	57	
	G3	9	1	8	18	✔
	GX / GXQ	2	0	0	2	

* See **Attachment A** for an explanation of codes for federal and state status and CA rare plant, state, and global ranks.

The average number of EOs and occupied quads is noticeably higher for all CESA-listed species (**Table 2**) compared with recent listing actions (**Table 1**). This appears to be a function of species-specific details of the recent listing actions. In **Table 1**, two of the species are candidates for up-listing from threatened to endangered, while two species were recently listed as endangered, and status reviews confirmed endangered status for two other species. In each of these six cases, it appears that extreme rarity and impending threats led to the recent listing actions. The remaining species in **Table 1**, Shasta snow-wreath, has EO and quad numbers similar to the averages for the broader group of species in **Table 2**. It appears that the species subject to recent listing actions, other than the Shasta snow-wreath, are substantially less abundant and more narrowly distributed than CESA-listed species in general. Despite this difference, the WJT is significantly more abundant and more widely distributed than the entire group of CESA-listed species, confirming that it is not comparable to these species.

Table 2 provides the average and median number of EOs per species by CESA listing group. Both average and median are provided because EOs do not appear to be normally distributed among species. That is, most species have relatively few EOs, while a few species have a relatively high number of EOs. For example, 104 of the 219 species (47%) analyzed for **Table 2** are known from 10 or fewer EOs, while only 14 species are known from more than 50 EOs and only three are known from more than 100 EOs.

Table 2 also provides the average and median number of quads per species, again because the number of quads does not appear to be normally distributed among species. That is, most species are documented from a few quads, while a few species are documented from a relatively high number of quads. For example, 171 of the 219 species (78%) analyzed for **Table 2** are known from 10 or fewer quads, while only two species are known from more than 50 quads. **Figure 1** illustrates this distribution. The WJT is called out in this figure to show how much it is an outlier from the group of listed species.

With the larger sample size afforded by the entire group of CESA-listed species, we repeated our theoretical estimate of the potential number of EOs for the WJT. The ratio of EOs to quads was 19.4 EOs per 7.6 quads, or 2.55 EOs per quad. Multiplying this ratio by the 243 quads occupied by the WJT yields an estimate of 620 EOs for the WJT. Statistically, this estimate could range from 450 to 849 (95% confidence interval). This estimate is substantially higher and more precise than the estimate based on the smaller group of species in **Table 1**. Regardless of where the WJT might fall within this range, it is clear that the abundance of WJT (in terms of the number of potential EOs) is at least an order of magnitude greater than for any of the other CESA-listed species in **Table 2**.

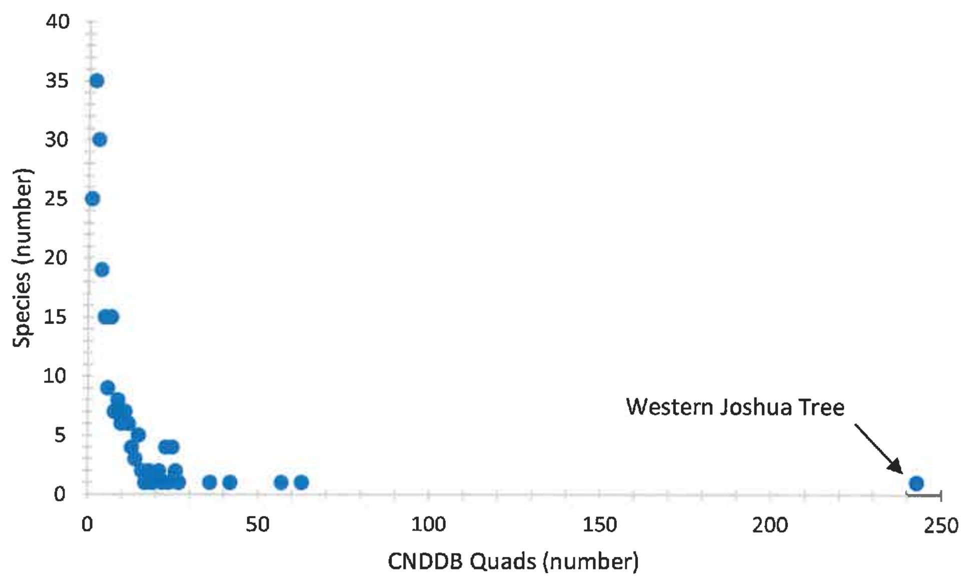
Almost half (44 percent) of CESA-listed species are not listed at the federal level (**Table 2**), likely reflecting differing priorities for listing at the state and federal levels. A similar case exists for the WJT, which the U. S. Fish and Wildlife Service (2019) declined to list, although the WJT is also substantially more abundant and widely distributed than many of the other CESA-listed species that are not federally-listed.

The majority (95%) of CESA-listed species are assigned CNPS rare plant ranks of 1A or 1B (**Table 2**). No CESA-listed species are on the CNPS (2021) CBR list. If it were listed under the CESA, the WJT would be the only species with a rare plant status of CBR.

The majority (93%) of CESA-listed species are assigned state ranks of 1 or 2 (**Table 2**). No CESA-listed species have state ranks of SNR. If it were listed under the CESA, the WJT would be the only species with a state rank of SNR; however, it is also likely that it would be ranked at the state level and by CNPS if it were listed.

The majority (91%) of CESA-listed species are assigned global ranks of 1 or 2 (**Table 2**). About 8% of CESA-listed species are assigned a global rank of 3, a group that would include the WJT if it were listed.

Figure 1 Quads Occupied by CESA-Listed Species



Conclusions

In our previous review of the scientific basis for listing the WJT, we concluded that the WJT is both widespread and abundant relative to other plants being considered for listing or already listed under the CESA. Our new analysis confirms that this conclusion is still valid, considering additional recent CESA-listing actions as well as the entire set of CESA-listed plants. The data shown in **Table 1**, **Table 2**, and **Figure 1**, as well as the discussion and references in this memo, support the following conclusions:

- The WJT is documented from a significantly larger area than CESA-listed species. This conclusion is based on the number of quads in the CNDDB for each species.

- The WJT is significantly more abundant than CESA-listed species. This conclusion is based on the estimated number of EOs of WJT, compared with the number of EOs in the CNDDB for each species.

- The WJT is substantially less rare than CESA-listed species. This conclusion is based on the CNPS rare plant, state, and global ranks for each species.

- The WJT shares many characteristics with plant species, such as the giant sequoia, that are not listed at the state or federal level, and that have been considered but rejected for inclusion in the CNPS Inventory, despite having limited ranges, limited population sizes, and being subject to current and future threats including climate change.

- The WJT is subject to some of the same threats as CESA-listed species; however, the WJT is not subject to threats that pose a high risk to species that have small population sizes or narrow distributions. That is, the WJT is not subject to potential extinction or significant loss of abundance or distribution caused by local, stochastic threats.

- Climate change is a threat to most plants, including the WJT and CESA-listed species; however, as an abundant and widespread species, the WJT is less threatened by climate change than species with small population sizes or narrow distributions (for example, CESA-listed species).

These conclusions reinforce our previous conclusion that it is not appropriate to list the WJT under the CESA at this time. There are 286 taxa of federally- and/or state-listed plants in California, including 100 taxa that are only listed by the state (CDFW 2021b). In addition, there are 173 taxa of federally- and/or state-listed wildlife in California, including 43 taxa that are only listed by the state (CDFW 2021c). The vast majority of these taxa are more rare and more likely to be threatened with extinction than the WJT.

Beyond currently listed species, there are 2,108 species of plants in the Inventory (CNPS 2021) that are not listed under either the CESA or the federal Endangered Species Act (ESA) (**Table 3**). These are species that the CNPS (2021) considered rare enough to rank (unlike the WJT, which was rejected as being too common), but that do not have any legal protections such as those provided by the ESA and CESA. Of these species, 285 are considered seriously threatened and should be the focus of upcoming CESA-listing actions, not the WJT, which is much more common and less threatened.

It is our opinion that a listing would divert staff time and funding toward special protection and management actions for the WJT and away from many other species that are more rare and more threatened, increasing their risk of extinction. We recommend that the CDFW prioritize conservation of plant and wildlife species that are already listed and focus future listing actions on species that are comparably rare and threatened.

Table 3 CNPS Rare Plant Ranks for Species Not Listed under the ESA and CESA

	Threat Rank				
Rare Plant Rank*	Not ranked	0.1 Seriously Threatened	0.2 Moderately Threatened	0.3 Not Very Threatened	Total
1A – Presumed extirpated in CA and either rare or extinct elsewhere	20	n/a	n/a	n/a	20
1B – Rare, threatened, or endangered in CA and elsewhere	n/a	200	501	214	915
2A – Presumed extirpated in CA, but common elsewhere	6	n/a	n/a	n/a	6

Table 3 CNPS Rare Plant Ranks for Species Not Listed under the ESA and CESA

Rare Plant Rank*	Threat Rank: Not ranked	Threat Rank: 0.1 Seriously Threatened	Threat Rank: 0.2 Moderately Threatened	Threat Rank: 0.3 Not Very Threatened	Total
2B – Rare, threatened, or endangered in CA, but more common elsewhere	n/a	75	211	216	502
3 – more information is needed – a review list	23	8	26	13	70
4 – Plants of limited distribution – a watch list	n/a	2	217	376	595
Total	49	285	955	819	2,108

* All species with a rare plant rank 1A, 1B, 2A, 2B are eligible for listing under the CESA. Many of the plants with a rare plant rank of 3 are also eligible for listing under the CESA, while few, if any, species with a rank of 4 are eligible for state listing (CNPS 2021).

References

California Department of Fish and Wildlife. 2021a. California Natural Diversity Database QuickView Tool. Available online at: https://apps.wildlife.ca.gov/bios/?tool=cnddbQuick. Accessed on February 23 to 25, 2021.

California Department of Fish and Wildlife. 2021b. State and Federally Listed Endangered, Threatened, and Rare Plants of California. January 2021.

California Department of Fish and Wildlife. 2021c. State and Federally Listed Endangered Threatened Animals of California. February 9, 2021.

California Department of Fish and Wildlife. 2020a. Evaluation of a petition from the Center for Biological Diversity to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178625&inline. Accessed June 9, 2020.

California Department of Fish and Wildlife. 2020b. Five-year status review of Kenwood Marsh checkerbloom (*Sidalcea oregana* ssp. *valida*). Report to the Fish and Game Commission. August 2020. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=184805&inline. Accessed February 26, 2021.

California Department of Fish and Wildlife. 2020c. Five-year status review of Milo Baker's lupine (*Lupinus milo-bakeri*). Report to the Fish and Game Commission. December 2020. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=187221&inline. Accessed February 23, 2021.

California Department of Fish and Wildlife. 2019a. Five-year status review of Clara Hunt's milkvetch (*Astragalus claranus*). Report to the Fish and Game Commission. September 2019. Available online at:

https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=177476&inline. Accessed July 22, 2020.

California Department of Fish and Wildlife. 2019b. Five-year status review of Baker's larkspur (*Delphinium bakeri*). Report to the Fish and Game Commission. December 2019. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=178637&inline. Accessed July 22, 2020.

California Fish and Game Commission. 2020. Notice of Findings. Western Joshua Tree (*Yucca brevifolia*). September 24, 2020. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=183565&inline. Accessed December 2, 2020.

California Native Plant Society. 2021. Inventory of Rare and Endangered Plants of California. Online edition. V8-03 0.39. Available online at: http://www.rareplants.cnps.org. Accessed February 23 to 25, 2021.

Center for Biological Diversity. 2019. A petition to list the western Joshua tree (*Yucca brevifolia*) as threatened under the California Endangered Species Act. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175218&inline. Accessed June 3, 2020.

Center for Biological Diversity. 2016. Petition to the State of California Fish and Game Commission to list the Lassics lupine (*Lupinus constancei*) as endangered under the California Endangered Species Act. July 14, 2016. Available online at: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165478&inline. Accessed July 22, 2020.

Corelli, T. 2016. A petition to the State of California Fish and Game Commission to list the coast yellow leptosiphon (*Leptosiphon croceus*) as endangered. May 23, 2016. Available online at: http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=165474&inline. Accessed July 22, 2020.

Heritage Environmental Consultants. 2020. Review of scientific basis for listing the western Joshua tree as threatened under the California Endangered Species Act. Technical memorandum prepared for the County of San Bernardino. August 5, 2020.

NatureServe. 2021. NatureServe Explorer. *Yucca brevifolia*. Western Joshua Tree. Available online at: https://explorer.natureserve.org/taxon/element_global.2.160735/yucca_brevifolia. Accessed on February 23, 2021.

Roche, K. S. 2019. Petition to the California Fish and Game Commission to list the Shasta snow-wreath (*Neviusia cliftonii*) as endangered under the California Endangered Species Act/ September 30, 2019. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175216&inline. Accessed July 22, 2020.

U. S. Fish and Wildlife Service. 2019. Endangered and threatened wildlife and plants; 12-month findings on petitions to list eight species as endangered or threatened species. Federal Register 84(158): 41694-41699.

Attachment A
Key to Status and Rank Codes

Federal Status

Provides official status under the federal Endangered Species Act (ESA), with definitions based on federal regulations. Data on federal status were obtained from the Inventory (CNPS 2021).

FC: Candidate for listing as threatened or endangered under the ESA.

FD: Previously listed as threatened or endangered under the ESA, but has been de-listed. These species have no current status under the ESA.

FE: Listed as endangered under the ESA.

FT: Listed as threatened under the ESA.

n/a: no status under the ESA.

State Status

Provides official status under the CESA or NPPA, with definitions based on state law. Data on state status were obtained from the Inventory (CNPS 2021), modified by recent listing decisions that are not reflected in the Inventory.

CE: Candidate for listing as endangered under the CESA.

CT: Candidate for listing as threatened under the CESA.

SE: Listed as endangered under the CESA.

SR: Listed as rare under the NPPA.

ST: Listed as threatened under the CESA.

n/a: no status under the CESA or NPPA.

CA Rare Plant Rank

Provides a rank for each species in the Inventory (CNPS 2021), based on factors including rarity, distribution, and threats.

<u>1A: Plants Presumed Extirpated in California and Either Rare or Extinct Elsewhere</u>

Plants with a rank of 1A are presumed extirpated or extinct because they have not been seen or collected in the wild in California for many years. A plant is extinct if it no longer occurs anywhere. A plant that is extirpated from California has been eliminated from California, but may still occur elsewhere in its range.

1B: Plants Rare, Threatened, or Endangered in California and Elsewhere

Plants with a rank of 1B are rare throughout their range with the majority of them endemic to California. Most of the plants that are ranked 1B have declined significantly over the last century. California Rare Plant Rank 1B plants constitute the majority of taxa in the CNPS Inventory, with more than 1,000 plants assigned to this category of rarity.

2A: Plants Presumed Extirpated in California, But Common Elsewhere

Plants with a rank of 2A are presumed extirpated because they have not been observed or documented in California for many years. This list only includes plants that are presumed extirpated in California, but more common elsewhere in their range.

2B: Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere

Except for being common beyond the boundaries of California, plants with a rank of 2B would have been ranked 1B. From the federal perspective, plants common in other states or countries are not eligible for consideration under the provisions of the Federal Endangered Species Act. With California Rare Plant Rank 2B, we recognize the importance of protecting the geographic range of widespread species. In this way we protect the diversity of our own state's flora and help maintain evolutionary processes and genetic diversity within species.

3: Plants About Which More Information is Needed - A Review List

Plants with a rank of 3 are united by one common theme - we lack the necessary information to assign them to one of the other ranks or to reject them. Nearly all of the plants constituting California Rare Plant Rank 3 are taxonomically problematic. For each California Rare Plant Rank 3 plant we have provided the known information and indicated in the "Notes" section of the CNPS Inventory record where assistance is needed.

4: Plants of Limited Distribution - A Watch List

Plants with a rank of 4 are of limited distribution or infrequent throughout a broader area in California, and their status should be monitored regularly. Should the degree of endangerment or rarity of a California Rare Plant Rank 4 plant change, we will transfer it to a more appropriate rank.

CBR: Considered But Rejected

Species that were considered for inclusion in the Inventory, but that were rejected (for one reason or another. This list currently contains 862 species. Reasons for rejection typically include the species being too common, not occurring in California, or being taxonomically invalid (CNPS 2021).

Threat Ranks

0.1-Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat)

0.2-Moderately threatened in California (20-80% occurrences threatened / moderate degree and immediacy of threat)

0.3-Not very threatened in California (less than 20% of occurrences threatened / low degree and immediacy of threat or no current threats known)

State Rank

Refers to the imperilment status of a taxon only within California's boundaries. Data on state ranks were obtained from the Inventory (CNPS 2021) except for the WJT, which was obtained from NatureServe (2021).

S1: Critically imperiled in the state because of extreme rarity (often five or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2: Imperiled in the state because of a very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

S3: Vulnerable in the state because of a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation from the state.

S4: Apparently secure, uncommon but not rare in the state; some cause for long-term concern because of declines or other factors.

S5: Secure, common, widespread, and abundant in the state.

S#?: Denotes inexact numeric rank, the rank listed is the best available estimate.

S#S#: A numeric range rank (for example, S1S2) is used to indicate any range of uncertainty about the status of the taxon.

SNR: Not ranked – a state conservation status has not been assessed.

SX: Presumed extirpated, the taxon is believed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

SXC: Presumed extirpated or eliminated in the wild in the state but is extant in cultivation, in captivity, as a naturalized population (or populations) outside its native range, or as a reintroduced population or ecosystem restoration, not yet established.

To simplify **Table 2**, several state ranks were combined as follows: S1 includes S1, S1?, and S1S2. S2 includes S2 and S2S3. S3 includes S3, S3?, and S3S4.

Global Rank

Reflects of the overall status of a taxon throughout its global range. Data on global ranks were obtained from the Inventory (CNPS 2021) except for the WJT, which was obtained from NatureServe (2021).

> G1: Critically imperiled, at very high risk of extinction due to extreme rarity (often five or fewer populations), very steep declines, or other factors.
>
> G2: Imperiled, at high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
>
> G3: Vulnerable, at moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
>
> G4: Apparently secure, uncommon but not rare; some cause for long-term concern because of declines or other factors.
>
> G5: Demonstrably secure, common, widespread, and abundant.
>
> G# ?: Denotes inexact numeric rank, the rank listed is the best available estimate.
>
> G#G#: A numeric range rank (for example, G1G2) is used to indicate any range of uncertainty about the status of the taxon.
>
> G#Q: Questionable taxonomy that may reduce conservation priority. Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank.
>
> G#T#: The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. Rules for assigning T-ranks follow the same principles for species. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1.
>
> GX: Presumed extinct. Not located despite intensive searches and virtually no likelihood of rediscovery.

To simplify **Table 2**, several global ranks were combined based on their taxon (T) rank as follows: G1 includes G1, G1?, G1G2, G1Q, G1T1, G2T1, G2T1T2, G3T1, G3G4T1, G4T1, G4?T1, G4G5T1, G4G5T1T2, and G5T1. G2 includes G2, G2G3, G2T2, G3T2, G3G4T2, G4T2, G4T2T3, G4?T2, G4?T2T3, G4G5T2, G5T2, G5T2Q, and G5T2T3. G3 contains G3, G3G4, G3Q, G4T3, G5T3, G5T3?, and G5T3Q.

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June 2, 2022

California Fish and Game Commission
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Sent by e-mail to: fgc@fgc.ca.gov

Re: Joshua Tree Working Group Comments on Western Joshua Tree Agenda Item (#5) at June 15-16, 2022 Meeting of the Fish and Game Commission

Dear President Murray and Members:

This firm represents 8minute Solar Energy, Terra-Gen, EDF Renewables, and Longroad Energy (together the Joshua Tree Working Group) with respect to the Commission's consideration of the Center for Biological Diversity's (CBD) petition to list the western Joshua tree (Joshua Tree) as a threatened species under the California Endangered Species Act (CESA).

Presentation to the Commission at June 15 Meeting

The Joshua Tree Working Group (Working Group) will submit written materials to the Commission prior to the Commission's taking up the Joshua Tree Agenda Item (#5) at its June 15 meeting, in accordance with CESA and 14 Cal. Code Regs. § 665. The Working Group looks forward to presenting a PowerPoint to the Commission at its June 15 meeting, as discussed with the Executive Director.

As the Members of the Commission know, the Working Group has participated extensively in the listing process over the past two years. It has funded a number of technical studies and reports concerning the Joshua Tree prepared by Western EcoSystems Technology, Inc. (WEST). These studies produced crucial data to understanding the current status of the Joshua Tree, including a population estimate of the species which was ground-truthed with field observations (data the Petition and subsequent submission by CBD notably lacked). Over the last eight months, the Working Group has submitted these technical reports and a synthesizing PowerPoint presentation to the Department of Fish and Wildlife (Department) to inform its Status Review and to the Commission to inform its consideration of the listing petition. These materials were contained in my e-mail of April 7, 2022, to the Commission, and are included as Exhibit 7 to the Staff Summary for the Joshua Tree Agenda Item (#19) for the Commission's April 20-21, 2022

Meeting (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=200677&inline). Those materials, reflecting the Working Group's considerable investment and expertise, necessarily pre-dated the publication of the Department Status Review for the Joshua Tree. The robust scientific information submitted by the Working Group concludes that more scientific study of the Joshua Tree is needed.

My request for extended time for the Working Group to present to the Commission explained that the Working Group's presentation would not reprise these materials, but would instead make a coordinated presentation addressing the Status Review and questions raised by Members during meetings with the Working Group. The Working Group's PowerPoint presentation will summarize and highlight points from the additional written materials the Working Group will provide the Commission.

Through the deployment of large-scale solar generation projects, the Working Group companies have been working to meet the challenges of climate change in a significant way. With respect to the Joshua Tree in particular, their projects represent the great majority of the megawatts of solar generation authorized under the Renewables 2084 Rule. (14 CCR § 749.10) Two of the Working Group companies intervened on the side of the Commission and the Department to successfully defend the candidacy determination and the Renewables 2084 Rule against lawsuits challenging them in the superior courts. And the Working Group companies continue to work with the Department and stakeholders on Joshua Tree conservation planning.

Threatened Legal Challenge to the Commission's Listing Determination

CBD has long been unabashed in filing suits to challenge the actions of the Commission and the Department. These threats come like the rain (at least before climate change exacerbated drought). Predictably, CBD has threatened to sue the Commission if it declines to list the Joshua Tree as a threatened species. But a suit by CBD would be unlikely to succeed.

The Commission is now at "Step Two" of the CESA listing process. Step Two requires the Commission to decide based on the record before it whether listing the Joshua Tree as a threatened species "is warranted" or "is not warranted." Fish and Game Code § 2075.5. In contrast, when the Commission made the Joshua Tree a candidate species at "Step One" of the listing process, the Commission merely had to find that CBD's petition "provide[d] sufficient information to indicate that [listing the Joshua Tree as a threatened species] may be warranted." Fish and Game Code § 2074.2 (emphasis added). This was a markedly lower bar than that presented now at Step Two, to say the least.

The question before the Commission at its June 15 meeting is whether the Joshua Tree is, in fact, "likely … in the foreseeable future" to become "endangered" – i.e., "in serious danger of becoming extinct throughout all, or a significant portion, of its range." Fish and Game Code §§ 2061 (definition of "endangered species") and 2067 (definition of "threatened species"). CESA and the Commission's regulations specify the factors (threats) to be considered in deciding whether listing the Joshua Tree is, in fact, warranted. Fish and Game Code § 2061 (enumerating factors); 14 Cal. Code Regs. § 670.1(i)(1)(A)(same).

Based on the information before the Commission, a determination that listing the Joshua Tree is not warranted would be eminently defensible against a lawsuit. In contrast, a decision to list the Joshua Tree would be highly vulnerable to a successful litigation challenge as an abuse of the Commission's discretion. A decision whether or not to list a candidate species is fundamentally driven by the scientific evidence (or lack thereof) regarding the species' status. This is apparent from the statutory and regulatory framework governing the listing process—the Commission cannot make a final listing determination until the Department has completed and submitted its Status Review (a process which takes 12 months or longer). Fish & G. Code § 2075; Cal. Code Regs. § 670.1.

The legal defensibility of a decision not to list the Joshua Tree is especially strong in this case based on the Status Review prepared by the Department and the lack of "… any data on the extent to which [] climate change[] will likely affect the demographics of the species (such as recruitment and mortality) in the foreseeable future." (Status Review at 113)

While courts "accord the Commission a degree of deference" in reviewing a listing decision because "the matters at issue are technical and scientific in nature," *Central Coast Forest Association v. Fish and Game Commission* (2018) 18 Cal.App.5th 1191, 1206, the discretion of the Commission in deciding whether to list (or delist) a species is far from unbounded. Among other limits on the Commission's discretion, the courts have explained:

> The Commission, in turn, <u>must accord substantial deference to the conclusions of the department staff</u>, as indicated by the structure of CESA, and the fact that the Commission's decision is ultimately a technical, scientific determination. The structure of the legislation governing the listing and delisting of species indicates the Legislature intended that the Commission <u>accord substantial deference to the recommendation of the department's staff</u>.

Id. (emphases added).

Here, the Department worked over the course of 18 months, drawing upon hundreds of sources, to comprehensively analyze the available information and prepare its 150-page Status Review.

Using, as it must, the best available science, the Department found the tree is "abundant and widespread, which lessens the overall relative impact of the threats to the species." (Status Review at 119) This is not surprising, as there are millions of Joshua Trees ranging across millions of acres. (Status Review at 39-42)

The Department also found that none of the primary threats to the species it identified – climate change, wildfire, or development – are likely (individually or cumulatively) to place the Joshua Tree in serious danger of becoming extinct throughout all, or a significant portion of its range, by 2100 (the foreseeable future). (Status Review at 112-117)

Throughout the Status Review, the Department correctly applied the legally required standard for showing that listing is warranted, both as to where that burden resides and what evidence is required to carry that burden. So, for example, the Department found that the Joshua Tree should not be listed as threatened on the basis of climate change "because the Department does not have demographic data showing that departures from 20th century suitable climate conditions will mean that the species will not be able to persist in significant portions of its range." (Status Review at 113 (emphases added)) So too, the Department found the development threat does not support listing the species because "scattered habitat loss is unlikely to result in a change in the overall range of the species, particularly when lost habitat continues to be surrounded by occupied habitat on protected lands and on occupied undeveloped lands that may be protected in the future." (Status Review at 114)

The Department's correct application of the standard for showing that listing is warranted is also reflected in its statement about the availability of the necessary scientific information: "The Department anticipates that the scientific information on the status of western Joshua tree will continue to improve in the coming years and decades, with demographic data and species distribution modeling eventually allowing for an analysis of the viability of western Joshua tree populations across their entire California range." (Status Review at 119)

As stated above, it is black-letter law that the Commission must accord substantial deference to the conclusions reached by the Department's expert staff about the Joshua Tree and the threats to it, as well as to its recommendations not to list the species. *Central Coast Forest Association*, 18 Cal.App.5th at 1206. A decision by the Commission to list the Joshua Tree as threatened, on the basis of the record before it, would be overreaching and outside the Commission's range of discretion under CESA. Such a decision is also unnecessary to protect the Joshua Tree from, in the foreseeable future, facing "serious danger of becoming extinct throughout all, or a significant portion, of its range." Moreover, if an abundant species, numbering in the millions, spread across millions of acres, when there is no scientific evidence of a negative population trend, is listed, the Commission will be setting a precedent that the threat of climate change ipso facto requires listing all of California's species of special concern. The Commission would also impermissibly be flipping the burden of proof under CESA. The threat of climate change as such cannot substitute for scientific evidence of a species' abundance and population trend.

There are millions of Joshua Trees spanning millions of acres, while there are no field-based, statistically robust Joshua Tree studies showing a negative population trend. Conservation planning efforts are under way that will benefit the Joshua Tree. Local governments are enacting laws that severely punish taking of Joshua Trees without required permits. CBD will, no doubt, itself police compliance with such laws, as well as participate in the CEQA and permitting processes for project development in the range of the Joshua Tree. Scientific study of the Joshua Tree is intensifying. When the scientific information on the status of the species starts to roll in, as anticipated by the Department, if that information shows a population trend that suggests the species in imperiled, CBD can surely be counted on to file another petition to list the Joshua Tree. And regardless of what CBD does, CESA authorizes the Commission and the Department to "review a species at any time based upon a petition or upon other data available to the department and the commission." Fish and Game Code § 2077(c). In other words, the Department can conduct another status review of the Joshua Tree, either on its own initiative or at the request of the Commission, in the absence of a petition, based on other available data.

The threat of climate change can only be addressed through reducing GHG emissions. Solar development is a necessary, indeed indispensable, component of the decarbonization that California has long shown leadership in implementing. A decision to list the Joshua Tree at this time would not only lack scientific basis, but would be unlawful and highly vulnerable to reversal when challenged and turn CESA into a weapon that threatens the ability of California to effectively fight climate change. Gone are the days when one can be for addressing climate change, but against the development of renewable energy projects where available interconnection capacity exists. Climate change will continue to advance and, in turn, potentially impact more sensitive plant and wildlife species throughout California if there is not immediate action taken to electrify our economy with renewable energy. If the Commission lists the Joshua Tree, it would impede California's energy security and imperil its climate leadership while exacerbating the impacts of climate change on Joshua Tree over the long term – all when CESA cannot be fairly said to compel it. That would be bad for the Joshua Tree, bad for the Commission, bad for CESA, bad for the State of California, and unlawful to wit.

Thank you for your consideration.

Chris Carr

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June 2, 2022

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VIA EMAIL ONLY

Re: Petition to List Western Joshua Tree As Threatened Under California Endangered Species Act

Dear President Murray and Members of the Commission:

On behalf of the California Construction and Industrial Materials Association ("CalCIMA"), we submit this letter to the California Fish and Game Commission ("Commission") in support of the recommendation of the California Department of Fish and Wildlife ("CDFW") in its *Status Review of Western Joshua Tree (*Yucca brevifolia*), March 2022* ("Status Review") that the western Joshua tree ("WJT") is not suitable for listing as "threatened" or "endangered" under the California Endangered Species Act ("CESA"), Fish & Game Code §§2050 *et seq*. We respectfully request that Commission not list the species.

Listing of the WJT is unwarranted, because:

(1) The "best available scientific information," as reviewed and presented by CDFW, in conjunction with the independent, range-wide population study commissioned by CalCIMA, provides substantial evidence that WJT is not likely be threatened (*i.e.*, to be in serious danger of extinction within the foreseeable future); and

(2) There is no evidence in the record, much less the "best available science" to contradict CDFW's recommendation, and the scientific information in the record (including peer review comments) cannot sustain a finding that the WJT, or any subpopulations thereof, is threatened.

Executive Summary

The Commission can only make a determination that the WJT is "threatened" under CESA if, using the "best available scientific information," there is sufficient evidence to demonstrate that the WJT is ***likely to become*** in ***serious danger*** of extinction within the ***foreseeable future***. Here, CDFW has completed its required Status Review and appropriately concluded that, based on the "best available scientific information," and accounting for the primary threats to WJT including habitat modification and destruction caused by climate change, development, and wildlife the widespread range and large population abundance of WJT mean that the WJT will not face a risk of extinction within the foreseeable future.

CDFW's conclusions are further substantiated by the "Population Viability Analysis of the Western Joshua Tree (*Yucca brevifolia*) ("Population Report"),[1] commissioned by CalCIMA as the first (and to-date, only), range-wide analysis of WJT population dynamics. The Population Report ***also*** analyzed the impacts of the identified key threats on WJT populations, and predicted that, within the foreseeable future, there is a ***zero percent risk*** of an extinction or subpopulation extirpation event. Between the Status Review and the Population Report, it is clear that the "best available scientific information" provides more than substantial evidence that listing is not warranted at this time.

Furthermore, while there is more than substantial evidence in the record to support a finding that listing is not warranted; there is ***no*** evidence in the record to support a contrary determination that listing is warranted. CDFW has evaluated the scope of scientific information available, analyzed that information in the context of CESA, and solicited and responded to the required peer review input. Even accounting for the range of opinion and discussion among the peer review comments regarding CDFW's conclusions, such divergent viewpoints, exist to ultimately make for a better, more informed Status Review rather than to constitute a basis to ignore CDFW's recommendation. Nor is CalCIMA aware of any asserted additional "best available scientific information" having been submitted to the Commission. To the extent that any such information is placed into the record between June 2, 2022 (the Comment deadline) and the hearing date on June 15, 2022, the Commission ***cannot*** support a determination that listing is warranted because (i) any additional scientific reports would be submitted after the statutory deadline; (ii) the Commission's statutorily designated expert agency – CDFW – has not reviewed such information to determine whether it actually constitutes the "best available scientific information;" and (iii) the public will not have had a chance to review and comment on such information.

Based on the forgoing, and as discussed in greater detail below, the record before the Commission can sustain only one finding: that listing WJT is not appropriate.

[1] Available at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=200624&inline (part 1) and https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=200625&inline (part 2).

Discussion

I. A Species Must Be "In Serious Danger of Extinction" within the "Foreseeable Future" to be Listed as "Threatened" Under CESA

CESA defines a "threatened species" as one that "although not presently threatened with extinction, ***is likely to become*** an endangered species in the ***foreseeable future*** in the absence of the special protection and management efforts required by this chapter."[2] As so defined, a "threatened species," is inextricably linked to the definition of "endangered species." CESA defines an "endangered species" as one that is "in ***serious danger*** of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease."[3] Thus, a "threatened species" is one that "***is likely to become***" "in ***serious danger***" of extinction "in the ***foreseeable future***. Under this definition, a proposed species is suitable for listing under CESA only if both prongs of the above criteria is met: (1) the species must be ***likely*** to face a serious risk of extinction and (2) the risk of facing the aforementioned serious danger must occur within the ***foreseeable future***. Here, the WJT cannot be a "threatened" species because, as demonstrated below, WJT does not face a serious danger of extinction within the foreseeable future.

A. First, a "Threatened" Species Must "Likely" Be In Serious Danger of Extinction

Although CESA does not define either "likely to become" or "serious danger," such CESA terms are interpreted by the Department to align with a given term's application under the Federal Endangered Species Act ("ESA").[4] Even so, the determination of whether a species is "threatened" is one of specific application.[5] Generally, a wildlife agency is not required to explicitly quantify (*i.e.*, establish a defined percentage) the likelihood that a species faces a serious danger of extinction; however, it must unequivocally determine that the risk of extinction is "more likely than not."[6] This requirement stems from the common definition of "likely" which is, generally, held to mean "more likely than not" and "[i]ndeed, most dictionaries define 'likely' to mean that an event, fact, or outcome is probable."[7]

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[2] Cal. Fish & G. Code § 2067.
[3] Cal Fish. & G. Code § 2062.
[4] *See* Tara L. Mueller, Guide to Federal and California Endangered Species Law 90 (1994); *see also* Bard D. Kern, "Permitting the Take: An Analysis of Section 2081 of the California Endangered Species Act," 102 N.Y.U Law Journal 74, 75-76.
[5] *See Center for Biological Diversity v. Everson*, 435 F.Supp.3d 69, 84-85 (D.C. Cir. 2020) (phrase "in danger of extinction" is "ambiguous" and wildlife agency's interpretation of that phrases in one listing decision (polar bear) which established a 60% likelihood; did not establish a universal standard that "threatened" means was not due deference in another listing decision (long-eared bat) if unsupported by the record).
[6] *Alaska Oil and Gas Ass'n v. Pritzker*, 840 F.3d 671, 684 (9th Cir. 2016).
[7] *Id.* (citing The Merriam-Webster Dictionary (new ed. 20160); Oxford English Dictionary Online (3d ed. 2016); Black's Law Dictionary (10th ed. 2014); and *Taniguchi v. Kan Pac. Saipan, Ltd.*, 566 U.S. 560, 565 (2012) (discussing the use of dictionaries to determine the ordinary or common meaning of a word).

Furthermore, in the context of a decision regarding whether the WJT is "threatened," any Commission findings must also be based on the "best available scientific information."[8] Thus, for the Commission to list the WJT, the "best available scientific information," as determined by CDFW and presented to the Commission in the Status Review,[9] must support a determination that it is probable (*i.e.*, more likely than not) that the WJT be in serious danger of extinction within the foreseeable future.[10] Other factors (such as population declines not resulting in a risk of extinction), sympathetic as they may be for ***other*** conservation actions, do not meet the legal standard for finding that species may be threatened. Indeed, using a standard that relies on speculation, rather than scientifically proven likelihood, would make it all but impossible to ***not*** list a species as threatened, unless there was absolute certainty that a species ***did not*** face any risk of extinction within the foreseeable future. This process would run contrary to CESA's purpose, which requires a serious risk of extinction before a species can be listed.

As will be discussed in greater detail below, even under an onerous (and legally dubious) standard, that would allow the Commission to determine a species is "threatened" based on any threat of extinction within the foreseeable future, the "best available scientific information" before the Commission would still not allow for such a finding because there is a ***zero percent risk*** of the WJT facing extinction within the foreseeable future and thus, by the plain terms of CESA, the WJT cannot be listed as "threatened."

B. Second, the Risk of Extinction for a "Threatened" Species Must Occur Within the "Foreseeable Future"

In order to be listed as "threatened," the risk of extinction facing the WJT (if there were a risk, which is refuted by the evidence here) must also occur within the "foreseeable future."

[8] Cal. Fish & G. Code § 2075.5(e).

[9] "Best available scientific information" means the information available to the agency and does not obligate the agency to conduct new independent studies (*i.e.*, the decision must be based on "the 'best scientific data ***available***,' not the best scientific data ***possible***"). *See N.M. Farm & Livestock Bureau v. U.S. Dep't of Interior*, 952 F.3d 1216, 1226-27 (10th Cir. 2020) (emphasis added); *see also San Luis & Delta-Mendota Water Auth. v. Locke*, 776 F.3d 971, 995 (9th Cir. 2014); *Ecology Ctr., Inc. v. U.S. Forest Serv.*, 451 F.3d 1183, 1194, n.4 (10th Cir. 2006); *Sw. Ctr. for Biological Diversity v. Babbitt*, 215 F.3d 58, 60 (D.C. Cir. 2000).

[10] It is also critical to note that here, the Commission owes significant deference to CDFW's determination of what constitutes the "best available science." *Central Coast Forest Ass'n v. Fish & Game Com.*, 18 Cal.App.5th 1191, 1206-07 (CDFW's determination of "best available scientific information" afforded deference based on agency's expertise and technical knowledge); *see also Marsh v. Or. Nat. Res. Council*, 490 U.S. 360, 378 ("[w]hen specialists express conflicting views, an agency must have discretion to rely on the reasonable opinions of ***its own qualified experts*** even if, as an original matter, a court might find contrary views more persuasive"); *San Luis & Delta-Mendota Water Auth. v. Jewell*, 747 F.3d 581, 602 (agency determinations regarding "best available scientific information" accorded deference because that decision is also a scientific determination due deference); *Utah Envt'l Cong. v. Bosworth*, 443 F.3d 732, 739 (10th Cir. 2006).

The term "foreseeable future" also is undefined by CESA and it too has been interpreted by the Department to align with the term's application under the Federal ESA.[11] Although foreseeable future," is a defined on a "case-by-case basis," it can only be so far into the future where the appropriate wildlife agency can reasonably determine both future threats and a species' likely (*i.e.*, more likely than not) response to those threats.[12] The "foreseeable future" must be based on facts found within the administrative record, and is the "timeframe over which the best available scientific data allow[s] [the wildlife agency] to reliably assess the effects of threats" on the species.[13]

Here, CDFW's Status Review established "the end of the 21st century (2100)" as the "'foreseeable future' for the WJT analysis."[14] CDFW, furthermore, recognizes that potential threats and impacts on the WJT, such as climate change, become highly uncertain past 2100.[15] CDFW appropriately and consistently reiterates throughout its discussion, that both uncertainty and the lack of scientific data prevent consideration of effects or impacts after 2100; and accordingly appropriately concludes that a determination as to whether the WJT may be "threatened" cannot be based on speculation, hypotheticals, or fear of impacts beyond that threshold. Thus, for purposes of the Commission's decision here, CDFW has appropriately set a time horizon for the foreseeable future and the Commission cannot look to threats, impacts, or speculation for what may happened beyond 2100 to justify listing WJT.

II. The Record Contains Substantial Evidence That Listing the WJT Is Not Warranted

As discussed above, the Commission's findings that listing is not warranted must be supported by the record before it and based on the "best available scientific information."[16] Here, CDFW has presented the Commission with what it, as the Commission's statutorily designated scientific experts, has determined constitutes the "best available scientific information," which unequivocally supports a decision to not list WJT.

A. CDFW's Status Review Evaluated All Necessary Factors and Appropriately Determined the Best Available Scientific Information Compelled Not Listing the WJT

CESA and its implementing regulations designate CDFW as the agency of expertise to (1) determine what constitutes the best available science regarding a species and (2) to prepare the

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[11] *See* Tara L. Mueller, Guide to Federal and California Endangered Species Law 90 (1994); *see also* Bard D. Kern, "Permitting the Take: An Analysis of Section 2081 of the California Endangered Species Act," 102 N.Y.U Law Journal 74, 75-76.
[12] 50 C.F.R. § 424.11(d).
[13] *In re Polar Bear Endangered Species Act Listing*, 794 F.Supp.2d 65, 93 (D.D.C. 2011).
[14] Status Review at 2.
[15] *See, e.g.*, *id.* at 55 ("Due to the high uncertainty in projecting the pace and magnitude of climate change other threats in the 22nd century (after 2100), and the lack of scientific information that contemplates such timeframes for the species, the Department cannot yet consider the range of the species in the 22nd century to be foreseeable")
[16] Cal. Fish & G. Code § 2075.5

Status Review.[17] In the Status Review, CDFW should evaluate six key criteria to determine whether listing is warranted: (1) present or threatened modification or destruction of habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; and (6) other natural occurrences or human-related activities.[18]

CDFW's Status Review thoroughly evaluated the scope, breadth, and depth-of-treatment for all of these factors, including significant analysis of key, identified threats to WJT habitat destruction or modification, including: (1) climate change, (2) development, and (3) wildfire. For each of the statutorily required threats, CDFW determined that the "best available scientific information" indicated that the above threats did not indicate that WJT is in significant danger of extinction within the foreseeable future.[19] In essence, the Status Review provides the substantial evidence in the record that compels the conclusion, based on the "best available scientific information," that listing is not warranted.

1. Impacts from Climate Change Do Not Pose a Significant Risk of Extinction in the Foreseeable Future

First, CDFW evaluated potential impacts of climate change on WJT habitat destruction and modification; and it did not shy away from the fact that WJT (and its habitat) "could be modified in a negative way or destroyed" by climate change impacts.[20] In fact, CDFW states that, "[b]ased on the best available science … direct and indirect effects of climate change will cause a reduction in the areas with 20th century suitable climate conditions for western Joshua tree by the end of the 21st century[.]"[21] However, these changes are insufficient to indicate that the WJT will face an existential threat in the foreseeable future, because "any changes will likely occur very slowly, perhaps over thousands of years … [and] there may be a long time delay between when an area becomes no longer suitable for sustaining western Joshua tree populations and when the species is no long present in the area." Accordingly, CDFW "does not foresee that the western Joshua tree is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range by the end of the 21st century (2100) due to climate change.[22]

These conclusions, in the context of CDFW's thorough review of the scientific literature and determination of what constitutes the "best available scientific information" make clear that that climate change impacts ***will not*** result in WJT being in serious danger of extinction within the foreseeable future. Accordingly, the Commission should recognize and defer to CDFW's conclusions and not list WJT based on purported climate change impacts.

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[17] Cal. Fish & G. Code § 2074.6.
[18] Cal. Fish & G. Code § 2074.6; *see also* 14 C.C.R. § 670.1(i)(1)(A).
[19] Status Review at pp. 112-117.
[20] *Id.* at p. 112.
[21] *Id.*
[22] *Id.* at p .113.

2. Impacts from Development Do Not Pose a Significant Risk of Extinction in the Foreseeable Future

Second, CDFW also evaluated potential impacts from development and found that "the direct and indirect effects of development and other human activities will cause negative modification and destruction of habitat for western Joshua tree in some areas by the end of the 21st century," but likely limited to private property, roads, existing development, and areas for renewable energy.[23] Despite evaluating the scenarios resulting in urban growth (and consequent loss of habitat), CDFW determined that "[w]hile habitat loss continues to be a substantial, ongoing threat, it does not necessarily mean that the species is likely to be at serious risk of extinction throughout all or a significant portion of its range."[24]

Again, these conclusions, in the context of CDFW's thorough review of the scientific literature and determination of what constitutes the "best available scientific information" make clear that that development impacts ***will not*** result in WJT being in serious danger of extinction within the foreseeable future. Accordingly, the Commission should recognize and defer to CDFW's conclusions and not list WJT based on purported development impacts.

3. Impacts from Wildfire Do Not Pose a Significant Risk of Extinction in the Foreseeable Future

Finally, CDFW evaluated the impacts of wildfire on WJT and determined that,

> "[b]ased on the current best available science, the Department expects that wildfire will continue to cause reductions in the population of western Joshua trees and will cause temporary modifications to habitat in burned areas that will reduce the ability of the species to recruit new individuals. ***However, because western Joshua tree is currently abundant and widespread***, it is inherently less vulnerable to extinction from the effects of stochastic and localized events such as wildfire. Furthermore, losses in abundance due to wildfire are not expected to change the species' range in the foreseeable future because some trees within burned areas survive, and occupied habitat remains outside of burned areas. The Department does not foresee that western Joshua tree is in serious danger of becoming extinct in a significant portion of its range by the end of the 21st century due to wildlife. The Department does not expect that the special protection and management efforts required

[23] *Id.* at p. 113.
[24] *Id.* at p. 114.

> by CESA would ameliorate the direct and indirect effects of wildlife on western Joshua tree."[25]

Yet again, these conclusions, in the context of CDFW's thorough review of the scientific literature and determination of what constitutes the "best available scientific information" make clear that that wildfire impacts ***will not*** result in WJT being in serious danger of extinction within the foreseeable future. Accordingly, the Commission should recognize and defer to CDFW's conclusions and not list WJT based on purported wildfire impacts.

Furthermore, taking these conclusions together, CDFW "[c]onsidered collectively, the direct and indirect effects of climate change, the direct and indirect effects of development and other human activities, and the direct and indirect effects of wildlife,"[26] and appropriately determined that while the "western Joshua tree will be subject to ongoing habitat modification and destruction through the end of the 21st century due to substantial threats from climate change, wildfire, development and other human activities, and the interconnected cumulative effects of some of these threats, particularly in the southern portion of its range, but western Joshua tree is also currently abundant and widespread, which lessens the overall relative impact of these threats to the species."[27] The Commission again should defer to CDFW's well-considered expertise and not list the WJT.[28]

B. CalCIMA Provided The Commission With the Only Scientific Report On Range-Wide WJT Population Dynamics, Which Constitutes the "Best Available Scientific Information" and Supports CDFW's Conclusions That Listing the WJT Is Not Warranted

Furthermore, CDFW's Status Review is not the only "best available scientific information" available to the Commission. CalCIMA's Population Report is also properly before the Commission as an independent scientific report submitted pursuant to Title 14, California Code of Regulations Section 670.1, subd. (h). The Population Report was prepared recognizing that CDFW did not have the time, resources, or obligation to undertake a full-scale population study when evaluating the "best available scientific information." However, the preparation and submission of the Population Report now ensures that such a full-scale study was conducted, that the Population Report underscores CDFW's conclusions, and when combined with CDFW's Status Review, undoubtedly presents the Commission with the "best available scientific information."

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[25] *Id.* at p. 115.
[26] *Id.*
[27] *Id.*
[28] Regarding the other statutory factors, CDFW determined that these factors, including overexploitation, predation, competition, and disease did not present significant threats to the WJT. *Id.* at p. 116. There is no evidence in the record that these factors present threats, and the Commission should defer to CDFW's determination that WJT is not subject to significant threat from these factors.

1. CalCIMA Commissioned the Population Report in Response to CDFW's Acknowledgement that Data on Population Abundance and Trend Was Missing, Thereby Ensuring the Commission has the "Best Available Scientific Information"

On October 9, 2020, the Commission formally approved the WJT as a "candidate species," pursuant to subdivision (e)(2) of Section 2074.2 of the Fish and Game Code.[29] The initial listing petition,[30] as evaluated by CDFW, acknowledged that scientific data regarding certain listing factors, primarily population abundance and trend, was missing from the petition or otherwise unavailable to CDFW.[31] Specifically, the Petition Evaluation states that "a reliable estimate of western Joshua tree population size is not available and that no range-wide population trends have been documented.[32] The Petition Evaluation further states that "the Petition does not present an estimate of Western Joshua Tree populations size, nor does it provide evidence of range-wide population trend…."[33] At that point in the listing process, the only scientific data available on either population abundance or trend was significantly limited to: (1) several small scale studies, on approximately 29.5 acres, localized at the extreme southern end of WJT range in Joshua Tree National Park (DeFalco et al. (2010); Harrower and Gilbert (2018); St. Clair and Hoines (2018); and Cornett (2014)); and (2) two population studies limited to Edwards Air Force Base (USAF (2017a) and USAF (2017b)).[34] Thus, as of the Commission's candidacy determination, population abundance and trend data was limited to less than 0.000007% of the WJT's 4.7-million-acre-range within California.

Given the limited scientific data on population trend and abundance, CalCIMA undertook to ensure that the Commission would have significantly more data on both population trend and abundance available before making any final listing decision. Accordingly, CalCIMA commissioned the Population Report, prepared by WestLand Engineering and Environmental Services, with review and contributions by Stantec. Inc. The Population Report was prepared in direct response to the dearth of scientific information previously available on WJT, and was designed to specifically address both the lack of, and/or limitations of, available scientific data. For example, a key issue with the limited scientific data on population abundance and trend is extrapolation of findings, based on data from a miniscule portion of the species' range, which is known to often result in biased results and inaccurate conclusions of biological processes and patterns.[35] Successful extrapolation of population dynamics, based on subsampling requires understanding and implementation of multiple procedures and ecological factors, including (1)

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[29] Office of Administrative Law, Register 2020, Number 41-Z, Oct. 9, 2020).
[30] "A Petition to List the Western Joshua Tree (*Yucca brevifolia*) as Threatened under the California Endangered Species Act (CESA)," Center for Biological Diversity (Oct. 15, 2019) ("WJT Listing Petition").
[31] "Evaluation of a Petition From the Center of Biological Diversity to List Western Joshua Tree (*Yucca Brevifolia*) as Threatened Under the California Endangered Species Act," California Department of Fish and Wildlife, February 2020 ("Petition Evaluation") at 8.
[32] *Id.*
[33] *Id.* at 9.
[34] *Id.* at pp. 8-9.
[35] *See* Population Study at p. 2.

intensity of the sampling effort; (2) spatial proximity of the sampled area to areas the data are extrapolated to; (3) variability of the ecological processes and population dynamics in questions, and (4) the similarity of the ecological and population variables evaluated within the sampled area to those across the range of the species.[36] Put simply, it would be scientifically inappropriate and factually dubious, to extrapolate data from the existing WJT studies ***without*** undertaking the multitude of steps necessary to verify such data can be properly extrapolated across the WJT's entire range. Unless CDFW, or the Commission, has undertaken the requisite scientific analysis to extrapolate the data from the population trend and abundance studies conducted within Joshua Tree National Park, those studies do not represent the "best available science" on population dynamics and ***are not*** and ***cannot be*** substantial evidence.

With these limitations in mind, the Population Report represents the first – and to-date only – comprehensive analysis of WJT population dynamics, representing data from across the entire California range of the WJT. Accordingly, on April 5, 2022, CalCIMA submitted the Population Report pursuant to Title 14, California Code of Regulations Section 670.1, subd. (h). This submission provides the Commission with the only range-wide data on WJT population dynamics and thus constitutes the "best available science."

2. The Population Report Supports CDFW's Conclusion That Listing WJT as "Threatened" is Not Warranted

The Population Report supplements CDFW's Status Review, and provides significant information on WJT range-wide population dynamics, thus presenting the Commission with more of the "best available scientific information" on which to base its decision. The Population Report ensures that the "best available scientific information" includes a range-wide population dynamics study; the conclusions of which underscore and reinforce CDFW's conclusions. When read in conjunction with CDFW's Status Review, the Population Report undoubtedly presents the Commission with the "best available scientific information" that listing the WJT is unwarranted.[37]

Importantly, the Population Review provides additional analysis to support CDFW's conclusion that listing the WJT is not warranted. Specifically, the Population Review incorporates predicted threats of increased drought and wildfire, both due to climate change. The Population Review models reductions of seedling recruitment and survival of pre-productive WJTs, explicitly integrating many of the concerns and comments made by peer reviewers. The PVA model

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[36] *Id.*; *see also* Conn, Paul B., Devin S. Johnson, and Peter L. Boweng, 2014. "On Extrapolating Past the Range of Observed Data When Making Statistical Predictions in Ecology." PLoS One 10(10).

[37] Furthermore, the Population Report and attendant PVA model is provided to the Commission and the public openly, in order for its results to both be reviewed and replicated, but also updated as new data becomes available. As the first, range-wide effort at modelling WJT population dynamics, there is now an actual starting point to continue building on the best available science for WJT. Providing this model provides a framework to ensure that improper extrapolation or uninformed inferences from prior, limited studies, are not the basis for speculative or scientifically dubious conclusions regarding WJT population abundance, trends, and WJT's response to potential threats.

predicts that, in part and as a result of these threats, the population of WJT is predicted to decline. However; despite the threats posed by climate change and increased urbanization, the model ***did not*** predict that WJT would face a serious danger of extinction in the foreseeable future. This modeling effort represents a comprehensive assessment of the population dynamics of WJT and serves as a framework for CDFW and others to update with new information and assess threats to WJT in the future.

Specifically, the Population Review provides fundamental evidence that listing WJT as "threatened" is not warranted at this time. The Population Review provides a comprehensive analysis of the population dynamics and predicted threats to the species that are incorporated into the PVA model, thereby demonstrating key pieces of evidence that further support CDFW's findings, including:

1) The PVA model was parameterized by demographic variables, using the most conservative values from a literature review, thus leading to predictions that were biased towards lower population growth rates;

2) The PVA model integrates estimates of threats to WJT that are "high" estimates, based on the available literature, thus leading to predictions that were biased towards greater threat impacts; and

3) Utilizes sensitivity analyses to explicitly inform the uncertainty inherent in population parameters and estimates of threats to the species.

Despite the conservative nature of the model framework and assumptions, while the PVA model predicts declines in WJT population, it ***did not*** predict extinction of WJT, or either the northern or southern populations of WJT.

C. Based on the Best Available Science, the Commission Cannot Make the Findings Necessary to List the WJT as Threatened

Based on the foregoing, we believe the record, and the "best available scientific information," cannot support a finding by the Commission that the WJT is a "threatened species." Conversely, the record compels a finding by the Commission that WJT is not "threatened," based on the "best available scientific information."[38] That information, as demonstrated at length above, and throughout both the Status Review and Population Report, is more than sufficient to support the required findings. Accordingly, the Commission ***can*** make the requisite findings, determine that the WJT is not threatened, and remove the WJT as a candidate species.

[38] Cal. Fish & G. Code §§ 2074.6, 2075.5(e); 14 C.C.R. § 6701.1(f).

III. The "Best Available Scientific Information" Provides No Evidence, Let Alone Substantial Evidence, to Support Listing WJT as "Threatened"

The above discussion focuses on the substantial evidence, based on the "best available scientific information," that should inform the Commission's determination and findings that a listing is not warranted. However, it is equally important that the Commission recognize what is ***not*** in the record, namely, substantial evidence that listing the WJT as "threatened" is warranted. Accordingly, the Commission simply ***cannot*** make the required findings to list the species.

A. The "Best Available Scientific Information" Does Not Support Listing Distinct Populations of WJT

1. The "Best Available Science" Does Not Support a Determination that Discrete Subpopulations of WJT Can Be Listed

First and foremost, the Commission should not list a portion or "subpopulation" (*i.e.*, the southern population and/or northern population) as a "threatened species." Neither CESA nor the Fish and Game Code generally define ***either*** "species" or "subspecies.'"[39] That is a determination vested in the sole discretion of CDFW during its evaluation of the "best available science" and whether a proposed listing qualifies as a "species or subspecies" for purposes of CESA protection.[40] A subpopulation can only be listed as a "species or subspecies," if, that subpopulation, based on the "best available scientific information," constitutes an "evolutionary significant unit" ("ESU").[41]

The WJT Listing Petition requests that the Commission consider potentially listing the northern and/or southern populations of WJT as distinct "species" or "subspecies."[42] However, utilizing the discretion granted to it by the courts, CDFW determined that these subpopulations are not

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[39] There is also the threshold matter regarding whether the record is sufficiently complete regarding whether WJT itself is actually a distinct species (*i.e. yucca brevifolia*) or a variety of species (*i.e. yucca brevifolia* var. *brevifolia*) which also encompasses the eastern Joshua tree (*yucca brevifolia* var. *jaegeriana*). As described by Heritage Environmental Consultants, "The current accepted taxonomy of the Joshua tree is a single species (*Yucca brevifolia*) with two varieties (*Y.b.* var. *brevifolia*, western Joshua tree) and (*Y.b.* var. *jaegeriana*, eastern Joshua tree)." (citing Integrated Taxonomic System 2020). *See* Technical Memorandum (Aug. 5, 2020) at 1. CDFW maintains in the Status Review that, in its discretion, it has determined WJT is a distinct species. *See* Status Review at 11-12. CalCIMA does not concede that WJT is a single species or subspecies, and simply points to the continuing disagreement regarding the WJT's taxonomic status as indicative that the record is insufficient to support a determination by the Commission that listing is appropriate.

[40] *See California Forestry Ass'n v. California Fish & G. Comm'n*, 156 Cal.App.4th 1535 (1458-59 (2007) ("Simply because the CESA does not include the definition of 'species or subspecies' provided in the FESA, the necessary conclusion is not that evolutionary significant units must be excluded for listing purposes under the CESA. More plausibly … the Legislature likely may have wanted to leave the interpretation of that term to the Department, which is responsible for providing the "best available scientific information[.]").

[41] *Id.*

[42] *See* WJT Listing Petition at 64.

ESUs and thus are not distinguishable species or subspecies suitable for listing under CESA, stating

> "[t]he genetic structure of western Joshua tree from north to south may instead be representative of a genetic cline, which is a continuous gradient of change in the genetic composition of populations within the range of the species that is associated with geography. Populations that are near each other are more genetically similar than populations that are farther away, but none appear fully isolated so as to be an evolutionary significant unit (Smith et al. 2021). Therefore, for purposes of this Status Review, the Department does not consider populations of western Joshua tree in the northern part of its range or the southern part of its range to be distinct 'species or subspecies' under CESA."[43]

Of note, the focus of one of the CDFW peer-reviewers was entirely on the question of whether the southern population of WJT "should be listed as [a] Threatened 'ecologically significant units' unto themselves."[44] However, this peer reviewer provided no data to support such a conclusion, which is particularly striking given:

1) CDFW has adopted the definition proposed by the National Marine Fisheries Service ("NMFS") for an ESU, which requires that a population meet two criteria:[45] (i) it must be reproductively isolated from other conspecific (*i.e.*, same species) population units and (ii) it must represent an important component of the evolutionary legacy of the species,[46] and

2) CDFW's Status Review explicitly analyzed and provided discussion on recent genetic findings to support its conclusion that WJT populations are not ESUs and thus not suitable for listing as "species or subspecies" under CESA.

In fact, none of the peer review comments, including one provided by a researcher that contributed substantially to the population genetics of WJT, provided additional genetic data ***or*** analyzes of existing data to support a conclusion that the southern population of WJT could be an ESU. Rather, the peer review comments focus ***solely*** on threats that the southern population of WJT may experience to suggest that the southern population of WJT should be listed under CESA. This approach fails to account for the "best available scientific information" discussed in the Status Review and is inconsistent with: (i) the statutory obligation of CDFW to assess distinct "species or subspecies" suitable for listing under CESA; (ii) the deference afforded to

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[43] Status Review at p. 12.
[44] Peer Review of CDFW Status Review, Dr. Timothy Krantz (April 2022).
[45] *See* CDFW 2015. Report to the Fish and Game Commission: A Status Review of the Fisher (*Pekania* [formerly Martes] *pennanti*) in California. Sacramento, CA, USA; California Department of Fish and Wildlife.
[46] Waples, Robin S., Definition of "Species" Under the Endangered Species Act: Application to Pacific Salmon. *NOAA Technical Memorandum, NMFS F/NWC-194*. Seattle WA: National Marine Fisheries Service. March 1991.

CDFW's technical determinations regarding potential species' listings under CESA; and (iii) CDFW's adopted definition of an ESU, which legally ***does not and cannot rest solely on a threats-analysis for listing purposes***, as the peer review commentators have suggested.

Accordingly, based on the best available science, as well as the determination by the agency charged by statute with evaluating what constitutes a "species or subspecies" suitable for listing, the multiple subpopulations of WJT do not, independently, constitute a species or subspecies.

2. Should the Commission Determine that Listing a Subpopulation is Warranted, It Must Reinitiate the Listing Process for that Subpopulation

Furthermore, if the Commission were to determine, against CDFW's designation to the contrary, that a subpopulation of the WJT should be listed, the public would be significantly deprived of a chance to comment on such a listing, particularly given CDFW's determination that such subpopulations are not "species or subspecies." In the event the Commission believes that a subpopulation should be listed, it must reinitiate the listing process for that distinct subpopulation because such a listing represents a significant change from the action currently before the Commission and as analyzed by CDFW's Status Review. This re-initiation would allow CDFW to conduct a one-year status review of that population segment, as required by regulation, and then to give the public ample opportunity to evaluate and comment on CDFW's evaluation of that subpopulation. Absent such a procedure, the Commission will have failed to comply with CESA, CESA's implementing regulations, and infringed on the public's due process rights.[47]

B. The "Best Available Scientific Information" Does Not Provide Substantial Evidence that Climate Change Impacts Warrant Listing WJT

Additionally, the Commission cannot justify a decision that ignores CDFW's recommendation based on the evidence within the record, including peer-review comments. Notwithstanding the fact that CDFW is the designated expert agency to determine what constitutes the "best available scientific information,"[48] there is ***no additional*** scientific information in the peer review comments that CDFW did not appropriately analyze and address.

Specifically, the majority of peer review comments that express contrary viewpoints to CDFW's conclusions do so on the purported basis that the risks of climate change warrant listing. Yet, as

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[47] *See* Cal. Fish & G. Code § 2074.6 (requiring CDFW analysis of "species or subspecies," to be listed, which includes an ESU designated as suitable for listing only if designated so by CDFW's review of the "best available scientific information); *see also Martis Camp Community Ass'n v. County of Placer*, 53 Cal.App.5th 569, 607 (2020) ("A failure to comply with mandatory procedures is presumptively prejudicial"); *see also Environmental Protection Information Ctr. v. Cal. Dept. of Forestry and Fire Protection*, 44 Cal.4th 459, 485 (2008) (review of agency action for failure to recirculate documents for public comment assess for whether or not "violation prevented informed decision making or informed public comment).

[48] *See Central Coast Forest Ass'n.*, 18 Cal.App.5th at 1206-07.

described above, climate change (as well as risks from development and wildfire) ***will not*** put WJT in serious danger of extinction within the foreseeable future and, indeed, impacts beyond 2100 ***cannot*** be considered because such impacts are too speculative and attenuated to be the considered as the "best available scientific information."

Moreover, and perhaps more importantly, the peer review comments provide no additional scientific information beyond that which is discussed and analyzed by the Status Review regarding the potential impacts of climate change, development, or wildlife (the three primary threats) on WJT. Specifically, the peer review comments focus, almost exclusively, on the issue of climate change.

In particular, the peer review comments suffer from the same limitations as the original Petition to list WJT under CESA, concentrating comments regarding predict impacts to WJT using results largely from studies that were conducted solely with Joshua Tree National Park. As correctly pointed out by CDFW's response to these comments, the peer review comments inappropriately extrapolate data from Joshua Tree National Park (which comprises less than 5% of the WJT's total range) and inappropriately infer that these data are representative of range-wide processes. This extrapolation is likely to produce spurious conclusions, as WJT occur in many different habitat types across their range that may influence local survival, reproduction, and other responses. Of note, one peer reviewer with substantial research on ecological responses to climate change and Director of the Oregon Climate Change Research Institute, found no fundamental issues with the Status Review's analysis of WJT's response to climate change and agreed that the "best available scientific information" did not indicate that listing WJT was warranted.

Accordingly, there is simply no new information in the peer review comments to support a determination listing the WJT as "threatened."

C. Additional Information Before the Commission Does Not Constitute the "Best Available Scientific Information"

Finally, to the extent that any new or additional scientific information enters the administrative record before the Commission's hearing on June 15, 2022, such information ***cannot*** form the basis for the Commission's conclusions. Critically, any independent scientific reports that are submitted are untimely. By statute, independent scientific reports that are submitted for the Commission to use in a listing decision ***must be*** submitted prior to the completion of CDFW's status review.[49] Here, no such independent reports have been submitted. Furthermore, and critically, this timing requirement is not frivolous. Rather, it exists for the simple reason both CDFW, as the statutorily designated expert agency, and the public, must have an opportunity to comment on any submitted reports. CDFW must be able to evaluate any submissions to determine both whether the study constitutes part of the "best available scientific information,"

[49] *See* Cal. Fish & G. Code § 2074.6 (requiring public review); 14 C.C.R. § 670.1(h) (requiring independent scientific reports be submitted before CDFW submits its status review).

and whether the study changes or modifies the conclusions in its status. Furthermore, the public ***must*** be afforded an opportunity to comment on the independent scientific reports; in the same manner that the public has an opportunity to comment on both timely-submitted reports ***and*** CDFW's status review.[50]

Accordingly, to the extent any new scientific information is submitted into the record and the Commission plans on using such information to support a listing decision, ***it cannot do so***. Indeed, if the Commission is to utilize any such information as the basis for its findings, it ***must*** provide the public sufficient opportunity to comment on any new scientific report.

IV. Conclusion

For the foregoing reasons, CalCIMA respectfully requests that the Commission determine that the WJT is not a "threatened species."

Respectfully submitted,

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cc: Chuck Bonham, Director
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[50] *Id.*

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Refer To File # 501803-0004

VIA EMAIL

June 2, 2022

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814
fgc@fgc.ca.gov

Re: California Fish and Game Commission Final Consideration of Petition to List Western Joshua Tree (Yucca brevifolia)

To Whom it May Concern:

This letter is submitted on behalf of QuadState Local Governments Authority ("QuadState")[1] in connection with the California Fish and Game Commission's ("Commission") final consideration of a petition ("Petition")[2] to list the Western Joshua tree (Yucca brevifolia) ("Joshua tree") as a threatened species under the California Endangered Species Act ("CESA"), which is scheduled for June 16, 2022. In March 2022, the California Department of Fish and Wildlife ("Department") completed a status review of the Joshua tree pursuant to California Fish & Game Code 2074.6 ("Status Review") and recommended the Commission find that listing the Joshua tree as a threatened species under CESA is not warranted.[3]

QuadState has reviewed the Status Review and supports the conclusions therein. The purpose of this letter is to provide additional support for the Department's determination that listing the Joshua tree is not warranted and to encourage the Commission to accept the Department's findings.

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[1] QuadState is a joint exercise of powers authority with seven members (six counties and one municipality) across four Western states. QuadState membership includes several desert counties in which the Joshua tree may be found.

[2] A Petition to List the Western Joshua Tree (*Yucca brevifolia*) as Threatened under the California Endangered Species Act (CESA) ("Petition"); *found at*: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=175218&inline.

[3] Status Review of Western Joshua Tree (*Yucca brevifolia*) ("Status Review"), Department of Fish and Wildlife, March 2022, at 2.

1. Department recommendation against listing set forth in the Status Review was reasonable, based on the best scientific information, and should be given due deference.

The Status Review does not paint a rosy picture for the long-term future of the Joshua tree. In its review, based on detailed analysis of the available scientific information during the year-long status review process, the Department recognized that the species—particularly in the southern portions of its range—faces threats from the direct and indirect effects of climate change and habitat destruction and modification and found these combined threats to be "cause for substantial concern."[4] Nevertheless, the Department appropriately considered these threats in the context of the listing criteria established by CESA and relevant regulations and recommended that the Commission decline to list the Joshua tree as threatened in the State of California.

a. Joshua tree is not likely to become an endangered species in the foreseeable future.

Pursuant to CESA, a species must be listed as endangered or threatened where "the Commission determines that its continued existence is in serious danger or is threatened by any one or any combination" of six factors:

- Present or threatened modification or destruction of its habitat
- Overexploitation
- Predation
- Competition
- Disease
- Other natural occurrences or human-related activities.[5]

The California Fish & Game Code defines an endangered species as one "in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes…" including those enumerated above.[6] A threatened species is one that does not presently meet the definition of an endangered species, but "is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]."[7] The best scientific information, set forth in the Status Review and supporting documentation, indicates the Joshua tree is not likely to be faced with imminent risk of extinction in the foreseeable future.

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[4] Status Review at 119.
[5] 14 Cal. Code Regs. 670.1(i)(1)(A).
[6] Calif. Fish & G. Code, § 2062.
[7] *Id*. at § 2067 (emphasis added).

While the Department explained in its Status Review that it anticipates a reduction in the abundance of Joshua trees by the end of the 21st century, it indicated that the range of the species into the 22nd century is beyond the bounds of foreseeability.[8] The Status Review does not indicate the Joshua tree will meet the definition of a threatened species under CESA in the 21st century, and even CBD's Petition acknowledged that the species is not faced with "imminent risk of extinction."[9]

That the species is not at imminent risk of extinction is unsurprising given the fact that the Joshua tree is "currently abundant and widespread," "likely has a high capacity to withstand or recover from stochastic…disturbance events,"[10] and has a range larger than the State of Connecticut.[11] Interestingly, the Status Review indicated that the Department tracks "most plant species of conservation concern" in its California Natural Diversity Database ("CNDDB"). Specifically, the CNDDB tracks "elements of occurrence," which are specific locations where a species is known to occur. Where two populations of a species (or element) are separated by more than a quarter mile, the two populations are considered separate occurrences. Prior to its designation as a candidate under CESA, Joshua trees were not considered plant species of concern and, thus, were not tracked in the CNDDB. The Department indicated in its status review that if the Joshua tree were tracked and mapped by the CNDDB using "standard methodology," Joshua tree occurrences could total 846. The Department currently tracks approximately 1,700 plant species of conservation concern in the CNDDB. The highest number of occurrences for any of those plant species is 249.[12]

Put simply, the Joshua tree currently is abundant, has an extensive range, and "has a high capacity to withstand or recover from stochastic…disturbance events."[13] The best available scientific information does not indicate that the species is at risk of extinction in the 21st century.

QuadState agrees with the assessment of the Department that the species is not likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by section 2067 of the California Fish & Game Code. The Commission has declined to list species as threatened where the best scientific information

[8] Status Review at 119.
[9] Petition at 32.
[10] Status Review at 113.
[11] Status Review at 12.
[12] *Id*. at 18-19.
[13] Status Review at 113.

indicates there is no serious danger of extinction in the next few decades,[14] and should decline to do so in this case.

b. Special protection and management is not likely to reduce threat of climate change on the Joshua tree.

Even if one were to assume the Joshua tree is in danger of extinction in the foreseeable future, the primary threat to the species, as alleged by the Petition is caused by climate change. As a result, there is no relevant special protection or management effort that the Commission could implement that would reverse the threat of climate change to the Joshua tree. The Department recognized this fact when it stated in the Status Review that it "does not expect that the special protection and management efforts required by CESA would ameliorate the direct and indirect effects of climate change on western Joshua tree."[15]

Likewise, CBD apparently recognized that tools available under CESA would not address the impact of climate change on the Joshua tree when it listed as the first suggested remedy to ameliorate threats to the Joshua tree a declaration of a climate state of emergency by the Governor of the State of California and subsequent implementation of "all necessary action" to achieve full de-carbonization of California's economy by 2045. And yet, the Petition failed to explain or substantiate how state-level action on climate change could result in a reduction of global greenhouse gas emissions at a level necessary to reduce the threats of climate change on Joshua trees located in California. Importantly, and a point ignored by the Petition, is that the California Fish & Game Code explicitly requires that any relevant management actions and protections required for CESA-listed species must be available under Chapter 1.5 of the Code itself and relate to regulating "take" of CESA-listed species rather than broad orders by the Governor.[16]

c. Joshua trees occur primarily on federal and other managed lands.

In addition to threats caused by climate change, the Status Review identified habitat modification and destruction—particularly in the species' southern range—as posing a significant threat to the species.[17] Nevertheless, the Status Review acknowledges that "most of the known range of the species is under federal jurisdiction" and, as a result, "the species receives some special protection and management by federal agencies.[18]

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[14] *See* Memorandum from Charlton H. Bonham, Director of California Dep't of Fish and wildlife to Sonke Mastrup, Exec. Director of Fish and Game Comm'n regarding American Pika Status Evaluation (March 5, 2013) at 1. On May 22, 2013, the Commission declined to list the American pika under CESA.
[15] Status Review at 113.
[16] Calif. Fish & G. Code § 2067.
[17] Status Review at 114.
[18] *Id*. at 105.

While QuadState was unable to find specific information in the Status Review indicating the percentage of Joshua trees that occur on federal lands, the Petition indicated that fully 96 percent of the Joshua tree population in the northern portion of the species' range occurs on federal lands protected under the California Desert Protection Act of 1994, with 10 percent of the species range occurring on National Park Service land that is "generally well-managed and should prevent significant habitat loss or degradation" from various activities.[19] Additionally, the Status Review points to a 2019 report by the U.S. Fish and Wildlife service that indicated approximately 48 percent of the species' range occurs on federal lands.[20]

Where the Joshua tree occurs on federal lands, it will not be subject to the kinds of development pressure typical of species that are threatened with habitat destruction or modification. While there may be some impacts to Joshua trees on federal lands (for example, those caused by grazing or mining), significant modification of the species' habitat is unlikely to occur as a result of traditional development activities.

In addition to the fact that a significant portion of the Joshua tree's range occurs on federally managed lands, it is also important to note that local jurisdictions also provide for protection for the species. For example, in San Bernardino County, Joshua trees are designated as Regulated Desert Native Plans and, as such, a permit must be obtained prior to removal of this species. Permits are issued only where the reviewer determines removal is justified based on one of a small number of factors, including a finding that there is no other feasible location for a given improvement.[21] And in Los Angeles County, Joshua trees located within Significant Ecological Areas designated as such by the Los Angeles General Plan receive significant protections.[22]

2. Peer reviewer input relative to ultimate listing recommendation should be treated carefully.

On January 29, 2021, QuadState submitted comments to the Commission in connection with the Commission's September 24, 2020 determination that a petition filed by the Center for Biological Diversity ("CBD") requesting the Joshua tree be listed as threatened under CESA and other related information "would lead a reasonable person to conclude that there is a substantial possibility the requested listing could occur."[23] In its January 2021 comments, attached as Exhibit 1 to this letter and incorporated herein, QuadState encouraged the Department to conduct a

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[19] Petition at 55.

[20] Status Review at 77, citing Joshua Tree Species Status Assessment (U.S. Fish and Wildlife Service 2018); *found at*: https://ecos.fws.gov/ServCat/DownloadFile/169734.

[21] County of San Bernardino Code, tit. 8, § 83.10.050.

[22] Los Angeles County Code of Ordinances, tit. 22, § 22.102.

[23] Commission Notice of Findings for Western Joshua Tree (Yucca brevifolia) (September 24, 2020); found at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=183565&inline.

rigorous and independent scientific review of information provided to the Department in connection with its Status Review, and to provide for rigorous peer review.

In connection with its Status Review, the Department solicited review from five experts in relevant fields. While QuadState recognizes that three of these peer reviewers questioned to one degree or another the ultimate recommendation of the Department that the Commission reject the Petition's request to list the Joshua tree as threatened under CESA, these same three reviewers also recognized that the draft Status Review provided to the peer reviewers (that was later revised to address their comments) was comprehensive, useful, and impressive.[24] Another peer reviewer, who has no discernible economic or other specific interest in the Joshua tree that could create the perception of bias agreed with the Department's recommendation that the Commission decide against listing the Joshua tree as threatened under CESA. A fifth reviewer declined to provide support for or opposition to Department's recommendation against listing the species.

The fact that the peer reviewers expressed divergent views should lead the Commission to defer to the Department's expertise on the question of whether or not the Commission should find the Joshua tree meets the definition of a threatened species under CESA. Peer reviewers were asked to provide analysis and input regarding a number of issues, including the "scientific validity" of the draft Status Review, and the assessments and conclusions regarding the status of the Joshua tree. While there is no doubt that the peer reviewers are qualified to provide input relative to the scientific information contained in the draft Status Report, the question of whether a species meets the definition of a threatened species under CESA is within the special expertise of the Department in light of its role in administering CESA.

Thus, when considering the input of the peer reviewers, it is important to keep in mind that even where a given peer reviewer did not agree with the ultimate recommendation of the Department, these same peer reviewers believed that, as a whole, the draft Status Review represented a comprehensive and useful analysis. It is reasonable to assume that changes made by the Department between the draft and final Status Review in response to the peer reviewers' comments likely served to strengthen the document.[25]

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[24] The draft Status Review "provides a comprehensive and detailed description of the biology of the [species]…its habitat and ecological parameters…its abundance/range and population trends…and endangerment factors…" (Krantz); "Having considered the draft Status Review in full, I am impressed by the thoroughness with which it enumerates the state of our knowledge about [Joshua trees]…and pleased to see that it cites the latest available data on the trees' demographic status and the threats faced by the species…" (Yoder); "Overall, the report is comprehensive, delving into the relevant aspects of this species ecology" (Barrows). April 21-22, 2022 Commission meeting packet ("April Meeting Packet") at 349-50/751.

[25] *See*, generally, Department's peer reviewer comment response logs in April 2022 Meeting Packet.

3. WestLand's Joshua tree population viability analysis should be accorded substantial weight in light of the quality of the analysis.

On April 5, 2022, WestLand Engineering & Environmental Services submitted to the Department a Population Viability Analysis of the Western Joshua Tree (*Yucca brevifolia*) ("WestLand Report"). The WestLand Report was prepared on behalf of CALCIMA and was intended to be considered by the Commission in connection with the Commission's Joshua tree status review. The WestLand Report explains that it uses conservative data inputs, and incorporates key threats to the species in order to evaluate various scenarios of Joshua tree population trends over the next 100 years. Ultimately, WestLand determined that "in no evaluated scenarios does the Western Joshua Tree face a threat of extinction or extirpation from the northern or southern portions of its range."[26] QuadState encourages the Commission to objectively review the WestLand Report and give it due consideration and weight in connection with the Commission's ultimate decision on whether to list the Joshua tree under CESA.

4. Conclusion

It is QuadState's position that the Joshua tree does not meet the definition of a threatened species under CESA because it is not likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by section 2067 of the California Fish & Game Code. Specifically, the best scientific information currently available, as set forth in the Department's Status Review, demonstrates that the species is not in serious danger of becoming extinct throughout all or a significant portion of its range within the next several decades. For that reason, the Commission should decline to list the species as threatened under CESA.

Sincerely,

Paul S. Weiland
Nossaman LLP

PSW/jm
Attachment

cc: Darrell Lacy, Executive Director, QuadState Local Governments Authority

[26] WestLand Report at 1.

CALIFORNIA CEMENT MANUFACTURERS ENVIRONMENTAL COALITION (CCMEC)

June 2, 2022

Samantha Murray
President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

Electronically Submitted To:
fgc@fgc.ca.gov

Re: California Fish and Game Commission June 15-16, 2022, Meeting
Agenda #5 – Petition to list the Western Joshua Tree

Dear President Murray:

Our organizations appreciate the opportunity to comment on the petition to list the Western Joshua Tree (WJT) and the accompanying California Department of Fish and Wildlife (Department) Status Review Report.

We have reviewed the petition to list the WJT, the Department's status review report, and additional information submitted by stakeholders including an extensive population viability analysis prepared by an independent third-party (Population Viability Analysis of the Western Joshua Tree prepared by WestLand Engineering and Environmental Services). We support the recommendation by the Department that the recommended action to list the WJT as threatened is not warranted and urge the California Fish and Game Commission (Commission) to deny the petition.

The Department's status review report is based on the best scientific information available to the Department on WJT and serves as the basis for the Department's recommendation to the Commission on whether to list the species as threatened under the California Endangered Species Act (CESA)

According to the Department as stated in its report, "The recent demographic trend information available to the Department suggests that density or extent of some populations may decline by the end of the 21st century (2100), but due to continuing recruitment, high abundance, widespread distribution, and the longevity of the species, the available demographic data does not currently suggest that western Joshua tree is likely to be at risk of disappearing from a significant portion of its range during this timeframe."

The Department's report further states that "the best scientific information available to the Department at this time indicates that western Joshua tree is not in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease, and is not likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by CESA."

In addition to the conclusions by the Department and its recommendation to not list the WJT, several noteworthy actions have been taken since the petition to list the WJT was submitted by California due to the leadership of the Newsom Administration that have provided the Department and other state agencies involved in California's natural resources new tools to advance regional conservation solutions.

For example, the Department's report points out that the California Desert Conservation Act (Fish & G. Code, § 1450 et seq.) became effective on January 1, 2022, and establishes a California Desert Conservation Program within the Wildlife Conservation Board with the goals of protecting habitat in California's Mojave and Colorado deserts by planning and implementing land acquisition and restoration projects. The California Desert Conservation Program could result in conservation or restoration of western Joshua tree habitat in California." To compliment this new program, the Governor's proposed 2022-23 budget includes $245 million to the Wildlife Conservation Board for nature-based solution programs including funding for the California Desert Conservation Program.

In addition to the California Desert Conservation Act, Governor Newsom issued the Nature-Based Solutions Executive Order N-82-20, advancing biodiversity conservation as an administration priority and elevating the role of nature in the fight against climate change in October 2020. As part of this Executive Order, California committed to the goal of conserving 30% of our lands and coastal waters by 2030 (30x30). In addition to the $245 million to the Wildlife Conservation Board for nature-based solution programs, an additional $523 million is being proposed to support programs including the Climate Smart Land Management Program, Local and Tribal Nature-Based Solutions Corps, and Nature-Based Solutions Partnerships and Improvements to name a few.

In addition to actions taken by California, local jurisdictions are also advancing measures to protect the WJT. For example, the San Bernardino County Board of Supervisors recently approved a new ordinance that increases the fine for unlawfully taking a WJT to up to $20,000 for a third conviction and up to six months in jail.

Our organizations opposed the petition when the Commission first considered whether the petitioned action "may be" warranted for several reasons including the lack of sufficient scientific data – specifically population and trend data - that was not included in the petition. We believe that the Department's conclusion based on what they believe is the best available scientific information along with the extensive data contained in the WestLand analysis coupled with the recent actions by the Newsom Administration leads to one answer regarding the western Joshua tree…it is not threatened in the foreseeable future from extinction.

For these reasons, our organizations respectfully request that the California Fish and Game Commission deny the petition to list the western Joshua tree as threatened.

Sincerely,

Jeff Montejano
CEO
Building Industry Association of Southern California

Michael Quigley
Executive Director
California Alliance for Jobs

Michael Miiler
Director of Government Relations
California Association of Winegrape Growers

Dan Dunmoyer
President & CEO
California Building Industry Association

Kirk Wilbur
VP of Government Affairs
California Cattlemen's Association

Frank T. Sheets, III
Chairman
California Cement Manufacturers Environmental Coalition (CCMEC)

Adam J. Regele
Senior Policy Advocate
California Chamber of Commerce

Robert Spiegel,
Senior Policy Director
California Manufacturers & Technology Association

Katie Little
Policy Advocate
California Farm Bureau Federation

Jon Switalski
Executive Director
Rebuild SoCal Partnership

Staci Heaton
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Rural County Representatives of California (RCRC)

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May 31, 2022

Via Email <fgc@fgc.ca.gov>

Samantha Murray
President, California Fish and Game Commission
P.O. Box 94409
Sacramento, CA 94244-2090

Re: Listing Petition for the Western Joshua Tree

Dear President Murray and Fellow Commissioners:

We appreciate the opportunity to comment on the Fish and Game Commission's ("Commission") pending decision on the petition to list western Joshua tree (*Yucca brevifolia*) as a threatened species ("Listing Petition"). During the candidacy period, the California Department of Fish and Wildlife ("Department") prepared a peer-reviewed Status Review of Western Joshua Tree ("Status Report") that analyzes whether the western Joshua tree should be listed as "threatened." The Status Report is based on the best science available to the Department, along with input from five independent peer reviewers with expertise on the western Joshua tree and interested members of the public. Based on the peer-reviewed best scientific evidence, the Department's Status Report concludes that listing western Joshua tree as threatened under the California Endangered Species Act ("CESA") is not warranted.

We urge the Commission to adopt the Department's recommendation because it is the only conclusion supported by substantial evidence in the record. The scientific experts selected to peer-review the Status Report uniformly agree that the report comprehensively and rigorously evaluates the best available science on western Joshua tree taxonomy, range and distribution, life cycle, habitat, population, and abundance. In summary, the Department's Status Report "acknowledges the significant threats western Joshua tree faces [and] ultimately concluded that the best available scientific evidence does not sufficiently demonstrate that populations of the species are negatively trending in a way that would show the species is likely to be in serious danger of becoming extinct throughout all of its range." (Memorandum from Charlton H. Bonham to Melissa Miller-Henson on Status Review of Western Joshua Tree, April 12, 2022, pg. 1.)

The Status Report relied on scientific studies conducted throughout the western Joshua tree's existing range. In contrast, data cited as evidence that the western Joshua tree will become endangered in the foreseeable future is speculatively based on findings from computer models ("Species Distribution Models") and isolated, small-scale studies. While certain peer reviewers suggest that the Status Report does not provide appropriate weight to Species Distribution Models, the Status Report concludes that these models are both highly variable and not supported by empirical data. The Status Report further demonstrates that there is no evidence of genetic variation that would qualify the southern population of western Joshua trees as separate species or subspecies under CESA.

The Commission is not faced with a decision where it must weigh competing evidence. Instead, the Status Report demonstrates that key data quantifying future threats to the western Joshua tree are too speculative to be relied upon as evidence to support listing. Key data regarding future threats to the western Joshua tree include:

(a) Findings from Species Distribution Models for the western Joshua tree which predict that increased temperatures associated with climate change will negatively impact western Joshua tree recruitment throughout its existing range;

(b) Projections that climate change will exacerbate wildfire conditions, resulting in more frequent and widespread wildfires within the existing western Joshua tree range; and,

(c) Projections that a significant amount of human development will occur on lands within the existing western Joshua tree range.

The Status Report evaluated this data and determined that:

(a) The Species Distribution Models that predict that increased temperatures associated with climate change will negatively impact western Joshua tree recruitment throughout its existing range have not been validated with observed demographic trends, meaning that there is no indication that the findings from these Species Distribution Models are reliable;

(b) Projections that climate change will exacerbate wildfire conditions are not supported by any studies or other evidence because no studies have been conducted that quantify the joint risks to western Joshua tree posed by climate change and the increasing frequency of wildfire; and,

(c) Projections that a significant amount of human development will occur on lands within the existing western Joshua tree range rely on estimated growth patterns that are inherently speculative and that vary widely.

As discussed in more detail below, the Status Report provides substantial evidence from empirical studies constituting the best scientific information that indicates that listing the western Joshua tree as threated is not warranted. The Status Report, moreover, demonstrates that data which indicates that the western Joshua tree is likely to become endangered in the foreseeable future is too speculative and cannot, as a matter of law, constitute substantial evidence under CESA.

A. The Status Report's Determination that the Western Joshua Tree is Unlikely to Become Endangered in the Foreseeable Future is Supported by Substantial Evidence

The Department's Status Report reviewed the best available science on the biological characteristics of the western Joshua tree and threats to the western Joshua tree to reach the determination that it is unlikely to become endangered in the foreseeable future. The Status Report is a comprehensive document that rigorously evaluates the best available science on the western Joshua tree's taxonomy, range and distribution, life cycle, habitat, population, and abundance. The Status Report examines findings from Species Distribution Models that project present and future climate change impacts to the western Joshua tree and contextualizes these findings based on empirical evidence. Overall, the Status Report determined that, even though some Species Distribution Models project that climate change will cause the western Joshua tree to become endangered in the foreseeable future, there is not reliable empirical evidence to support the findings in these models. Instead, the best available science indicates that the western Joshua tree's extensive range, pattern of adaption during past climate change events, and capacity for asexual reproduction decrease the likelihood that it will become endangered in the foreseeable future.

Unlike the "consideration" stage of the listing process for the western Joshua tree, which is governed by the "substantial possibility" standard, a decision by the Commission to list the western Joshua tree as threatened must be supported by "substantial evidence." (*Natural Resources Defense Council v. Fish & Game Commission* (1994) 28 Cal.App.4th 1104, 1125.) Substantial evidence is defined as evidence that is of ponderable legal significance, reasonable in nature, credible, and of solid value. (See *Stanislaus Audubon Society, Inc. v. County of Stanislaus* (1995) 33 Cal.App.4th 144; *Lucas Valley Homeowner's Assn. v. County of Marin* (1991) 233 Cal.App.3d 130, 142; *Bank of America v. State Water Resources Control Board* (1974) 42 Cal.App.3d 198, 213.) In general, substantial evidence means that a decision has "a reasonable factual basis." (*Bank of America*, *supra*, at 212 [applying substantial evidence test to water rights determinations].) Indeed, even when an expert provides an opinion, it will only constitute substantial evidence if it is based on facts that are proven. (*White v. State of California* (1971) 21 Cal.App.3d 738, 759-760; *San Diego Gas & Electric Co. v. Sinclair* (1963) 214 Cal.App.2d 778, 783.) As one court explained:

> The commission must be presumed to have a knowledge of the conditions which underlie and motivate its regulatory actions and unless it is demonstrated that those actions are not grounded upon any reasonable factual basis the courts should not interfere with the exercise of the discretion vested in it by the Legislature, nor lightly substitute their judgment for that of the commission.

(*Ferrante v. Fish & Game Commission* (1946) 29 Cal.2d 365, 374 [analyzing Commission's decision of whether to grant take permits].)

Substantial evidence in the record supports the Department's recommendation that listing western Joshua tree as threatened is not warranted. The best available science indicates the western Joshua tree is currently abundant and that species with large ranges, like western Joshua tree, are less vulnerable to extinction. The western Joshua tree experts who peer-reviewed the Status Report agreed with the Department's conclusion that the species has an extensive range, has adapted to past climate change events, and is capable of indefinite survival through asexual reproduction. The western Joshua tree's current range, distribution, and abundance are clear evidence that the species has adapted to climate variability that has occurred since the late Pleistocene period (22,000 to 13,000 years before present). (Status Report, pg. 54.)

By contrast, plants with the smallest range or most exacting habitat requirements (such as a single mountaintop) are the most threatened by climate change, wildfires, and human activities. The western Joshua tree occurs across a wide swath of desert, with substantial variation in temperature and precipitation, and, thus, more potential to survive than other truly rare CESA-listed species. Each of the preceding conclusions from the Status Report are based on peer-reviewed scientific evidence that has a reasonable factual basis. (See *Bank of America*, *supra*, at 212.) The Status Report, accordingly, fully considered existing threats to the western Joshua tree's survival and relied on substantial evidence to determine that it is not likely to become endangered in the foreseeable future.

This is not a case where the Department had to pick among competing scientific information. The Department exactingly reviewed data that quantifies future risks to the western Joshua tree and determined that information suggesting the species will be functionally extinct over large portions of its range by the end of the century is too speculative to meet the substantial evidence standard. For example, the Status Report states that:

> Even under baseline conditions, current species distribution models can only partially explain observed species distribution patterns and range. When species distribution models can only partially explain observed species distribution patterns and range, and are not strengthened with demographic data that agrees with model predictions, **predictions of species distributions in the future become very speculative**.

(Status Report, p. 64 [emphasis added].)

Species Distribution Models that project future risks to the western Joshua tree do provide meaningful information, but these tools cannot supplant empirical data which demonstrates the western Joshua tree has biological characteristics which make it uniquely suited to adapt to climate variability. The Department relied on undisputed evidence that the western Joshua tree is abundant across an extensive range, has adapted to episodic climate events over previous millennia, and is capable of indefinitely extending its lifespan through asexual reproduction to contextualize modeled risk projections. (*Bank of America*, *supra*, at 212.) In contrast, any conclusion that the western Joshua tree would become extinct across a significant portion of its range by the end of this century is based solely on Species Distribution Models that have not been validated by empirical studies. Absent verification of these theoretical models through observation or experience, these models cannot, as a matter of law, constitute substantial evidence that the western Joshua tree is likely to become extinct in the near future. (*White*, *supra*, at 759-760; *Sinclair*, *supra*, at 783.) As discussed in more detail below, the Status Report correctly analyzed the best available science and concluded that there is no substantial evidence that listing is warranted.

B. There is No Substantial Evidence that Western Joshua Tree is Presently at Risk of Becoming Extinct Throughout All or a Significant Portion of Its Range

Only one out of five peer reviewers, Dr. Cameron Barrows, stated that data on existing threats to the western Joshua tree demonstrate that it is currently in serious danger of becoming extinct. Dr. Barrows states that "70% of Joshua trees within [Joshua Tree National Park] are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia," but does not cite any data supporting that claim. (Peer Review Comments by Dr. Cameron Burrows on the Status Review and Department's Responses, at Line 2313.) Dr. Barrows then cites modeling results from Cole (2011)[1] to demonstrate that reduced western Joshua tree recruitment is "not an isolated phenomenon." (*Id*., Line 209-214.)

The Department evaluated Cole (2011) and identified the study as the "most useful range-wide species distribution modeling effort for this Status Review," however, the Department also noted that empirical observations of areas that were presently projected to have high or low suitability for western Joshua tree in the Cole (2011) study did not match projections. (Status Report, pgs. 63-64.) In other words, Cole (2011) attempted to project the current impacts of climate change on existing western Joshua tree habitat using a Species Distribution Model, however, the theoretical model projections could not be validated by empirical data. Because Dr. Barrow's opinion is based on theoretical modeling results that are not supported by empirical data, it is too speculative to be "substantial evidence" that the western Joshua tree should be listed as an endangered species as a matter of law. (*White*, *supra*, at 759-760; *Sinclair*, *supra*, at 783.)

C. There is No Substantial Evidence that Western Joshua Tree is Likely to Become an Endangered Species in the Foreseeable Future

The Listing Petition states that threats from climate change, wildfire, and human activity cumulatively make it likely that the western Joshua tree will become an endangered species in the foreseeable future. (Listing Petition, pg. 21.) Some of the peer reviewers stated that the Status Report did not give appropriate weight to studies that project how climate change, and its cumulative effect on the prevalence of wildfire, would eventually prevent large portions of western Joshua tree's existing range. (See, e.g., Peer Review Comments by Dr. Timothy Krantz (Jan. 15, 2022), pgs. 7, 10.) As discussed in detail below, existing data that quantifies how climate change, wildfire, and human development will impact western Joshua tree is highly speculative and is not of ponderable legal significance, reasonable in nature, credible, and of solid value. This data, accordingly, cannot constitute substantial evidence. (Compare *Bank of America*, *supra*, at 212 to *White*, *supra*, at 759-760.) The Department's Status Report correctly determined that this data is too speculative to constitute substantial evidence in support of a determination that listing the western Joshua tree as threatened is warranted.

1. There is No Substantial Evidence that Climate Change Will Cause the Western Joshua Tree to Become an Endangered Species in the Foreseeable Future

A significant portion of the Status Review and the comments by peer reviewers are dedicated to the interpretation of studies regarding the anticipated effects of climate change to the western Joshua tree. Two of the peer reviewers, Dr. Krantz and Dr. Yoder, stated that the effects of climate change may warrant listing of the western Joshua tree as "threatened" because Species Distribution Models predict that climate change will cause steep declines in western Joshua tree recruitment. The Status Report acknowledges that Species Distribution Models can be a useful tool for understanding threats to the species and agrees that certain models project that western Joshua tree will experience a high level of exposure to climate change. The Status Report concludes, however, that the Species Distribution Models that theorize there will be a significant decline in western Joshua tree recruitment are not substantial evidence that the species will become endangered in the near future.

[1] Cole, K.L., K. Ironside, J. Eischeid, G. Garfin, P.B. Duffy, and C. Toney. 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications 21(1):137–149.

Dr. Krantz and Dr. Yoder state that climate models demonstrating increased temperatures across the western Joshua tree's range mean it will become endangered by the end of the century. This conclusion, however, is not supported by substantial evidence because it relies on speculation regarding future precipitation trends. The undisputed empirical data demonstrates that western Joshua tree recruitment is negatively impacted by long term lack of rainfall, however, no studies have tied decreased recruitment to increased temperature alone. Because these climate models show that temperatures will increase throughout the region, Dr. Krantz and Dr. Yoder conclude that increased temperatures will result in increased aridity and, therefore, decreased recruitment. However, the Status Report concludes that existing studies do not indicate that increased temperatures alone will cause a widespread decline in recruitment because the primary factors affecting recruitment are precipitation and soil moisture retention. (Status Report, pgs. 71-74.)

Another peer reviewer, Dr. Sweet, who authored a study on the effects of climate change cited by Dr. Krantz and Dr. Yoder, agrees with Status Report's conclusion that existing models do not indicate a direct correlation between climate change and reduced precipitation. (Peer Review Comments by Dr. Lynn Sweet on the Status Review and Department's Responses, at Line 1906.)

Given the undisputed lack of direct, empirical data correlating increased temperatures with a decrease in precipitation and soil moisture retention, there is no substantial evidence supporting the theory that climate change will cause the western Joshua tree to become "functionally extinct" in large parts of its existing range. Any conclusion that increased temperature alone will result in decreased precipitation is an analytical leap from established facts that cannot be relied on as substantial evidence in support of the listing decision. (*White*, *supra*, at 759-760; *Sinclair*, *supra*, at 783.)

Even if the unproven assumption that increasing temperatures leads to reduced precipitation and soil moisture retention did constitute "substantial evidence," the Department's recommendation should be adopted because the best available scientific data supports the determination that listing is not warranted because specimens can reproduce asexually. As discussed extensively in the Status Review, the western Joshua tree can reproduce asexually, and no species-wide demographic studies have been conducted to determine if the lack of genetic diversity associated with asexual reproduction will have a negative impact on western Joshua tree's future survival. None of the studies that project future declines in western Joshua tree recruitment evaluate climate change impacts on asexual reproduction, which can permit a single specimen to survive indefinitely under appropriate conditions. (Status Report, pgs. 28-29, 117.) Species Distribution Models that do not evaluate recruitment through asexual reproduction are inherently speculative because they do not account for an alternate method of reproduction. Accordingly, the Department properly rejected the assertion that increased temperatures alone will result in significant threats to the western Joshua tree based on a lack of substantial evidence in the record.

2. **There is No Substantial Evidence that Wildfire Will Cause the Western Joshua Tree to Become an Endangered Species in the Foreseeable Future**

Certain peer reviewers evaluating the Status Report's treatment of threats associated with wildfire argue that the Department minimized the risk that climate change would cause an increase in wildfires and exacerbate the other negative effects of climate change on the western Joshua tree. The Status Report acknowledges that wildfire will continue to cause temporary modifications to habitat in burned areas, which will result in western Joshua tree mortality and reduce the ability of surviving specimens to recruit new individuals. The Department concludes, however, that because the western Joshua tree is currently abundant and widespread, it is inherently less vulnerable to extinction from the effects of stochastic and localized events such as wildfire. (Status Report, pg. 115.) A recent study,[2] reviewed fire records for the deserts of California and concluded that only 0.047% of the area in the Mojave Desert ecoregion, which encompasses all of the southern western Joshua tree population and part of the northern population, burned per year (a fire return interval of about 2,128 years). When the current threat posed by wildfire is considered in the context of the western Joshua tree's expansive range, there is substantial scientific evidence supporting the Department's conclusion that wildfire will not cause the western Joshua tree to become endangered in the foreseeable future. (*Bank of America*, *supra*, at 212.)

Projections that wildfire occurrence will increase dramatically from present conditions are not supported by substantial evidence. Some of the peer reviewers stated that the Status Report did not give appropriate weight to the cumulative risk associated with wildfire because of the likelihood that the frequency and intensity of wildfires would be exacerbated by climate change. The Status Report was updated to reflect the potential that wildfire risk will increase, but the Department also noted that there is not quantitative published analysis of the joint risks to western Joshua tree posed by climate change and the increasing frequency of wildfire. (Peer Review Comments by Dr. Jeremy Yoder on the Status Review and Department's Responses, at Line 3854-3867.) Again, data that is speculative and is not of ponderable legal significance, cannot, as a matter of law, constitute substantial evidence. (*White*, *supra*, at 759-760; *Sinclair*, *supra*, at 783.) Here, because of the absence of empirical scientific data quantifying the increased risk of wildfire associated with climate change, there is not substantial evidence in the record to support a claim that wildfire occurrence will represent a more-significant threat to the western Joshua tree in the future. (*Ibid*.)

3. There is No Substantial Evidence that Human Activities Will Cause the Western Joshua Tree to Become an Endangered Species in the Foreseeable Future

The Status Report evaluated threats associated with human activities and determined that these threats will not cause the western Joshua tree to become an endangered species in the foreseeable future because a significant portion of its range is on federal land and because extensive development is unlikely on private lands in the desert. The Listing Petition stated that the United States Fish and Wildlife Service ("USFWS") estimated 41.6% of suitable habitat in the western Joshua tree's southern population would be lost to development by 2095.[3] Another model from the same study, however, projected habitat loss of 21.7% in the southern population, and 0.6% or 0.7% in the northern population. In other words, habitat loss across the western Joshua trees range was estimated at 13.8% under Scenario 1 and 26.3% under Scenario 2. (Heritage Environmental Consultants, *supra*, pg. 7.)

Indeed, it is reasonable to expect more development will occur on private lands in the foreseeable future. Factors such as lack of water and distance from existing population centers, which play a key role in development, means, however, that projections of extensive development are too speculative to constitute substantial evidence. (*White*, *supra*, at 759-760; *Sinclair*, *supra*, at 783.) Additionally, 48% of the western Joshua tree's existing range is located on federal land, and 1.9% is

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[2] Technical Memorandum by Heritage Environmental Consultants dated Aug. 20, 2020, pg. 7 *citing* Brooks and Minnich (in press).
[3] U.S. Fish and Wildlife Service. USFWS. 2018. Joshua Tree Species Status Assessment. Dated July 20, 2018.

under State ownership. Given the wide range of predictions for the potential effects of human activities on the western Joshua tree, and the large portion of the existing range that is under federal and state jurisdiction, the Status Report correctly concluded that there is no substantial evidence that human activities will cause the western Joshua tree to become endangered in the foreseeable future. (*Ibid*.)

D. There is No Substantial Evidence to Support the Claim that the Southern Population of Western Joshua Tree Should be Considered a Separate Species or Subspecies

The Listing Petition requests that the Commission assess whether separate "population clusters" of the western Joshua tree, referred to as the southern population and the northern population, warrant listing separately as "ecologically significant units." In evaluating whether these populations warrant separate listing, the Department identified the relevant standard as follows:

> A population of organisms considered distinct for conservation purposes based on scientific analysis of the reproductive isolation and genetic differences between population groups is eligible for listing under CESA (see *Cal. Forestry Assn. v. Cal. Fish & G. Com.* (2007) 156 Cal.App.4th 1535, 1546-1547.)

(Status Report, pg. 11.)

In applying this standard, the Department reviewed existing studies on genetic distinctions between the northern and southern populations and determined that there is not sufficient evidence of a genetic subdivision between these two populations to qualify them as a separate species or subspecies under CESA. (Status Report, pgs. 11-12.) Neither the peer reviewers nor any public comments identified evidence of genetic variations to support listing the southern and northern populations separately. Because there is no scientific evidence of genetic differences between the southern and northern populations of western Joshua tree, there is not substantial evidence that the southern population should be listed separately from the northern population. (*White*, *supra*, at 759-760; *Sinclair*, *supra*, at 783.) The Department correctly concluded that listing the southern and northern populations of western Joshua tree as separate ecologically significant units was not warranted based on this lack of data.

E. Conclusion

We respectfully urge the Commission to adopt the Department's recommendation. The Status Report contains substantial evidence supporting the Commission's determination not to list the western Joshua tree as a threatened species under CESA. In contrast, the data cited to support the Listing Petition is based largely on speculation and conjecture and would not be considered as substantial evidence as a matter of law.

Very truly yours,
HARRISON, TEMBLADOR, HUNGERFORD & GUERNSEY

By

Russell Frink

June 1, 2022

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814
Via: fgc@fgc.ca.gov

RE: Western Joshua Tree - Support Newsom Administrations Scientific Study Recommendation – Listing not Warranted

Dear President Murray,

The California Construction and Industrial Materials Association (CalCIMA) thanks you for the opportunity to comment on your consideration of the listing of the western Joshua tree. We recognize that the decision now before the Fish and Game Commission ("Commission") is primarily based on science protection and conservation programs systems, and as such, we commissioned and have submitted a detailed "Population Viability Analysis of the Western Joshua Tree" ("PVA Report") We strongly believe a decision on the suitability of a species for listing as threatened depends on having such an analysis to inform decision makers and thus undertook the preparation of the PVA Report to ensure one was available to support your decision making. We are encouraged that our PVA Report both reinforces and supports the analysis of the Administration, and collectively provide compelling science that demonstrates listing is not warranted.

Rather than summarize the analysis and conclusions in the PVA Report, the focus of my letter today is on the changes in the regulatory and policy background, and management of climate change and species which have occurred since the Commission accepted the petition for candidacy in 2020. We believe these changes provide important context for evaluating the best available science now before you that demonstrates listing is not warranted, because international and domestic policy developments now also promise more support for conservation of species as well as aggressive global action against

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climate change. The prior Administration's rollbacks are now a footnote in world history that appears to have generated a vigorous counter-response from the world that heightened goals and objectives in the Paris Agreement. A unified 195 nations, including the United States of America, again, have recommitted to the Paris Climate Agreement. Further, a whole new conservation policy system focused on climate adaptation is emerging and being funded and supported in 30x30 programs.

CalCIMA is the statewide voice of the construction and industrial materials industry. With over 500 local plants and facilities throughout the state, producing aggregate, concrete, cement, asphalt, industrial minerals, and precast construction products, our members produce the materials that build our state's infrastructure, including public roads, rail, and water projects; homes, schools and hospitals; assist in growing crops and feeding livestock; and play a key role in manufacturing consumer products as well, including roofing, paint, low-energy light bulbs, and battery technology for electric cars and windmills. The continued availability of our members' materials is vital to California's economy, and local sources of these materials are vital to reducing the supply chain emissions of manufacturing and delivering the technologies we will need for a climate-smart future.

Landscape Scale Conservation Arrives

A significant new development is the emergence and implementation 30x30 conservation policy and goals by both the State of California and President Joe Biden through the America the Beautiful plan. These programs represent a significant expansion of conservation philosophy to broader nature-based solutions for climate change and conservation, including landscape scale conservation management and are part of a pattern of global action combatting climate change and it's impacts on habitat. Governor Newsom has directed substantial resources to these programs. Table 1 represents the budget funding of $768 million dollars over two years. It includes funds for the newly created, California Desert Conservation Program, authorized by the legislature in 2021 in AB 1183 (Ramos). As California Department of Fish & Wildlife Director Bonham noted in discussing the Governor's climate change investments the budget also includes $36 million for large scale habitat planning such as NCCP activities.

Nature-Based Solutions
(Dollars in Millions)

Investment Category	Department	Program	2022-23	2023-24	Total
Nature-Based Solutions Programs	Wildlife Conservation Board	Forest Conservation Program Oak Woodlands Conservation Program California Desert Conservation Program Rangeland, Grazing Land and Grassland Protection Program California Riparian Habitat Conservation Program Natural and Working Lands Climate Adaptation and Resiliency Program	$200	$45	$245
	Department of Fish & Wildlife	Nature-Based Solutions Wetlands Restoration Program	$54	$0	$54
	Delta Conservancy		$36	$0	$36
	Department of Conservation	Multi-benefit Land Repurposing Program	$0	$20	$20
	Department of Food & Agriculture	Healthy Soils Program	$0	$10	$10
	CAL FIRE	Wildland Grazing (Fire Prevention Grant Program)	$5	$5	$10
Supporting Regional Action	State Conservancies	Support for Nature-Based Solutions	$60	$60	$120
	Department of Fish and Wildlife & Santa Monica Mountains Conservancy	Wildlife Corridors (including Liberty Canyon)	$50	$0	$50
	Department of Fish and Wildlife	Natural Community Conservation Program Planning and Land Acquisition	$36	$0	$36
	Department of Conservation	Climate Smart Land Management Program	$14	$6	$20
	Wildlife Conservation Board	Resource Conservation Investments Strategies	$2	$3	$5
Expanding Educational and Economic Opportunities for Youth Climate Leaders	Conservation Corps	Local and Tribal Nature-Based Solutions Corps	$35	$17	$52
Partnering with California Native American Tribes	Natural Resources Agency	Tribal Nature-Based Solutions Program	$100	$0	$100
Additional Strategic Investments	CalRecycle	Compost Permitting Pilot Program	$0.5	$7	$7.5
	Natural Resources Agency	Nature-Based Solutions Partnerships and Improvements	$0.25	$1.75	$2
	Natural Resources Agency	CA Nature Support	$0.25	$0.25	$0.5
		Total	**$593**	**$175**	**$768**

Table 1: Nature Based Solutions
(Source: https://www.ebudget.ca.gov/2022-23/pdf/Revised/BudgetSummary/ClimateChange.pdf)

The additional importance of these large-scale efforts is they involve both the federal and state government leveraging additional funding and resources separate from permit and mitigation fees collected from development activities that traditionally fund conservation. They have expanded financing beyond limited funding pools of direct impact-based fees which are constitutionally limited in purpose and scope of use, to funds that can be spent as authorized in budgets based on broad objectives.

Recognizing that climate change is not caused by the local communities where species occur, but by the energy used to power the global economy, this expansion to broader revenue streams is important for promoting equity for the less developed rural and tribal communities where policies like CESA have only those responsible for direct impacts paying the price. When the bulldozer was the impact that's appropriate, when it's emissions from powerplants and transportation globally, a local fee to mitigate climate change impacts makes much less sense and is inherently unequitable. These programs can think broader and focus on the scale of the landscape not on individual species as a result.

Trump Climate Rollback is Over

In their listing petition, the Center for Biological Diversity called out the Trump Administration for their climate denialism, rejection of science, and abandonment of climate policy. But what was true then is not true now and the programs and targets rolled back by Trump have been replaced with equivalent and stronger commitments and targets going the other direction. A rubber band effect. The US clean energy plan Obama target included in our Paris targets was, "cut emissions 26% to 28% below 2005 levels by 2025" The target committed to by Biden, "U.S. economy-wide greenhouse gas (GHG) emissions by 50 to 52 percent below 2005 levels by 2030." Biden doubled the reductions sought only 5 years after the previous target. Fran Pavley introduced AB 32 in California in 2004, the Paris targets are to cut our emissions by 50% from that time by 2030, this is significant and meaningful action on climate change.

Biden also reset mileage standards but the larger development on transportation emissions started with news from China in 2020. China announced their vehicle New Energy Policy setting a new energy vehicle mandate by 2035 for manufacturers selling cars in China. The New Energy mandate which is largely being promoted and copied in the EU and California and elsewhere focuses on all electric by 2035 meaning zero emission and hybrid vehicles. Automakers are announcing all electric lineup changes and lobbying states to adopt similar standards as they move to position to provide cars to the largest auto markets in the world. The California Air Resources Board has already adopted several rules on zero emission vehicles and has draft regulations expected to be adopted later this year to early next which will require fleet vehicles purchased after 2024 be zero emission vehicles when such are available for the use. The electrification of transport is here and accelerating rapidly.

A vigorous global climate policy is being pursued by 195 nations of the world today along with corporations and people. Corporations are setting manufacturing policy investments for a rapid transition and additional events such as the California cement industry supporting legislation to set a pathway to carbon neutrality for cement by 2045 don't even make major headlines but have occurred. I guess if we aren't disagreeing, it isn't news. The science has been accepted and human society is evolving rapidly to address impacts and reduce and sequester emissions. That wasn't clear in 2019, it is in 2022.

The Science is in

Western Joshua tree science is also in, thanks to the Commission accepting the Center for Biologic Diversities petition. The Newsom Administration -- a fierce advocate for conservation species and climate change -- asked for 6 extra months and developed an important scientific report that found listing wasn't warranted.

CalCIMA opposed the petition because it lacked sufficient data and could impact a vast area. Knowing that the missing data was critical to making an informed decision CalCIMA also commissioned a study to fill in the known data gaps. There is a positive correlation between these independently developed scientific reviews of the literature and development of population trends showing roughly equivalent numbers and coming to the same conclusion. The western Joshua tree is not threatened for the foreseeable future. That is the best available science.

We hope the Commission has reached the same conclusion as all the scientific studies done to take the fragmentary science that existed previously and combine them into a larger review and population viability analysis for the species. We are aware of no study that combines the knowledge of the other Joshua Tree studies and differs in conclusion and the petition itself admitted it had no information on range and population trend when it was submitted and clearly lacks information to determine if the species is threatened as a result. The Administrations and CalCIMA's work fill that hole and provide population and trend modelling to develop a scientific answer.

We ask that the Commission accept the best available science developed as a result of the petition process and recognize that listing the western Joshua tree as threatened is not warranted.

Respectfully,

Robert Dugan
President/CEO

California Council for Environmental and Economic Balance
101 Mission Street, Suite 1440, San Francisco, California 94105
415-512-7890 phone, 415-512-7897 fax, www.cceeb.org

June 2, 2022

Samantha Murray
President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

Electronically Submitted To:
fgc@fgc.ca.gov

Re: California Fish and Game Commission June 15-16, 2022, Meeting
Agenda #5 – Petition to list the Western Joshua Tree

Dear President Murray:

The California Council for Environmental and Economic Balance (CCEEB) appreciates the opportunity to comment on the petition to list the Western Joshua Tree (WJT) and the accompanying California Department of Fish and Wildlife (Department) Status Review Report. CCEBB is a non-profit, non-partisan association of business, labor, and public leaders, which advances balanced policies for a strong economy and a healthy environment.

CCEEB has reviewed the petition to list the WJT, the Department's status review report, and additional information submitted by stakeholders including an extensive population viability analysis prepared by an independent third-party (Population Viability Analysis of the Western Joshua Tree prepared by WestLand Engineering and Environmental Services). Based on the scientific information provided as well as information obtained by our members, CCEEB supports the recommendation by the Department that the recommended action to list the WJT as threatened or endangered is NOT warranted and the California Fish and Game Commission (Commission) deny the petition.

The Department's status review report is based on the best scientific information available to the Department on WJT and serves as the basis for the Department's recommendation to the Commission on whether to list the species as threatened under the California Endangered Species Act (CESA)

According to the Department as stated in its report, "The recent demographic trend information available to the Department suggests that density or extent of some populations may decline by the end of the 21st century (2100), but due to continuing recruitment, high abundance, widespread distribution, and the longevity of the species, the available demographic data does not currently suggest that western Joshua tree is likely to be at risk of disappearing from a significant portion of its range during this timeframe."

The Department's report further states that "the best scientific information available to the Department at this time indicates that western Joshua tree is not in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease, and is not likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by CESA."

In addition to the conclusions by the Department and its recommendation to not list the WJT, several noteworthy actions have been taken since the petition to list the WJT was submitted by California due to the leadership of the Newsom Administration that have provided the Department and other state agencies involved in California's natural resources new tools to advance regional conservation solutions.

For example, the Department's report points out that the California Desert Conservation Act (Fish & G. Code, § 1450 et seq.) became effective on January 1, 2022, and establishes a California Desert Conservation Program within the Wildlife Conservation Board with the goals of protecting habitat in California's Mojave and Colorado deserts by planning and implementing land acquisition and restoration projects. The California Desert Conservation Program could result in conservation or restoration of western Joshua tree habitat in California." To compliment this new program, the Governor's proposed 2022-23 budget includes $245 million to the Wildlife Conservation Board for nature-based solution programs including funding for the California Desert Conservation Program.

In addition to the California Desert Conservation Act, Governor Newsom issued the Nature-Based Solutions Executive Order N-82-20, advancing biodiversity conservation as an administration priority and elevating the role of nature in the fight against climate change in October 2020. As part of this Executive Order, California committed to the goal of conserving 30% of our lands and coastal waters by 2030 (30x30). In addition to the $245 million to the Wildlife Conservation Board for nature-based solution programs, an additional $523 million is being proposed to support programs including the Climate Smart Land Management Program, Local and Tribal Nature-Based Solutions Corps, and Nature-Based Solutions Partnerships and Improvements to name a few.

Finally, the Department is recommending several actions to be conducted in coordination with a broad group of stakeholders including private citizens, scientists, and other local, state, and federal governments and organizations, consistent with California's goals of conserving biodiversity and preventing the extinction of rare, threatened, and endangered species. CCEEB is supportive of those recommendations that would directly benefit the conservation of the WJT while balancing the needs of a robust economy.

CCEEB respectfully requests that the California Fish and Game Commission deny the petition to list the Western Joshua Tree based on the recommendation by the Department to not list the Western Joshua Tree along with the scientific information prepared by WestLand Engineering and Environmental Services.

Please contact me or Jackson R. Gualco or Cliff Moriyama, CCEEB's governmental relations representatives at The Gualco Group, Inc. at (916) 441-1392.

Sincerely,

William J. Quinn

WILLIAM J. QUINN
President/CEO

Phelan Piñon Hills Community Services District

4176 Warbler Road • P. O. Box 294049 • Phelan, CA 92329-4049 • (760) 868-1212 • Fax (760) 868-2323

May 19, 2022

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

Subject: Listing of the Western Joshua Tree as a California Endangered Species – OPPOSE

Dear President Murray & Members of the Commission:

On behalf of the Phelan Piñon Hills Community Services District (District), I urge you to not list the western Joshua Tree as a California endangered species. The western Joshua tree is an iconic California native species and an important symbol of the Mojave Desert. We strongly believe that this special species should be protected and preserved for generations to come, and we appreciate the Commission's efforts to do so. However, a listing as an endangered species is not justified given the positive population trends of the Joshua tree.

The recently released Department of Fish and Wildlife Status Review Report (Report) found that the western Joshua tree is abundant and widespread, indicating that it faces a low threat of extinction. A central finding of the Status Review is that "the scientific evidence that is currently possessed by the Department does not demonstrate that populations of the species are negatively trending in a way that would lead the Department to believe that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future." This conclusion, drawing upon the best available scientific data, suggests that listing the Joshua tree as endangered is not justified by the evidence at hand. Furthermore, a listing would be a huge undertaking for the Department of Fish and Wildlife, requiring it to issue taking permits and regulate Joshua tree removal across the Mojave Desert, an area of roughly 25,000 square miles which is larger than the state of West Virginia. This heavy administrative burden would detract from the state's ability to protect other species that are at far greater risk of extinction.

From our logo, you can see that we acknowledge and represent that the western Joshua tree is a part of our community. We desire to protect the western Joshua tree, however, listing it as a California endangered species requires setbacks and relocation requirements that would substantially increase costs beyond what is necessary to protect them and incorporate them into projects. This includes projects such as wells, pipeline, and park development. Given that the Report found the Joshua tree to be widespread and abundant with heathy population trends for the foreseeable future, it does not seem warranted to list the western Joshua tree as endangered for protection purposes which would severely impact all essential projects for our community. We are in the process of a park expansion project for our underserved community. We have thoughtful mitigation measures in place for the Joshua trees which incorporate them into the design and landscape. We desire to protect and maintain as many trees as possible. We carefully designed our park elements to leave the trees as untouched as possible and continue to highlight their beauty and importance for our community.

Local governments in the region, both cities and counties, already have strict regulations to protect the Joshua tree in their planning codes. Generally, they require direct preservation and relocation along with stiff penalties for unpermitted removal and destruction of Joshua trees. These are powerful, effective measures that are in place and actively enforced. While we are grateful for the Commission's interest in protecting the western Joshua tree, given the tree's positive population trends and local protections, an endangered species listing is not warranted.

If you have any questions about our opposition to the listing of the Joshua tree, please contact Don Bartz at (760) 868-1212 or dbartz@pphcsd.org.

Sincerely,

Don Bartz
General Manager

HI-DESERT WATER DISTRICT

Samantha Murray, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

May 26, 2022

RE: Listing of the Western Joshua Tree as a California Endangered Species – OPPOSE

Dear President Murray and members of the Commission,

On behalf of Hi-Desert Water District, we urge you to not list the western Joshua tree as a California endangered species. The western Joshua tree is an iconic California native species and an important symbol of the Mojave Desert. We strongly believe that this special species should be protected and preserved for generations to come, and we appreciate the Commission's efforts to do so. However, at this time listing it as an endangered species is not justified given the positive population trends of the Joshua tree.

The recently released Department of Fish and Wildlife Status Review Report (Report) found that the western Joshua tree is abundant and widespread, indicating that it faces a low threat of extinction. A central finding of the Status Review is that "the scientific evidence that is currently possessed by the Department does not demonstrate that populations of the species are negatively trending in a way that would lead the Department to believe that the species is likely to be in serious danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future." This conclusion, drawing upon the best available scientific data, suggests that listing the Joshua tree as endangered is not justified by the evidence at hand. Furthermore, a listing would be a huge undertaking for the Department of Fish and Wildlife, requiring it to issue taking permits and regulate Joshua tree removal across the Mojave Desert, an area of roughly 25,000 square miles which is larger than the state of West Virginia. This heavy administrative burden would detract from the State's ability to protect other species that are at far greater risk of extinction.

The Joshua tree is part of our local and regional culture, it is part of who we are. We are also concerned about how climate change will affect the Joshua tree and our area in the future. We, the individuals in our community, agencies, and businesses have always and will continue to protect Joshua trees. We know the area, how to work around Joshua trees, and when necessary, relocate them to maximize their survival. As such, we have and will continue to work with local and county agencies to ensure protection and not only the long-term survival of the Joshua tree but to ensure it thrives.

To ensure the Joshua tree thrives, we prefer to see a long-term program developed, that is funded by those causing climate change, rather than isolate that cost to our severely disadvantaged and disadvantaged community. It appears evident that the most appropriate approach for accomplishing this goal should be based upon the findings in the Report. Taking such an approach would ensure the Joshua tree not only survives but thrives. As noted previously, the Report findings indicate that the Joshua tree is not in serious danger of becoming extinct in the foreseeable future. Thus, because the Joshua tree may become endangered from climate change in the future and thus over the longer term, the approach should align with those findings.

Without the survival of the Joshua tree, we would lose a foundational part of our local culture. This will not occur by a listing and the associated regulatory requirements at this time, but rather through the noted well thought out long-term programmatic approach that aligns with the Report's findings and the underlying science.

It is important to emphasize that our severely disadvantage community was required by the State to transition from individual septic systems to a sewer system. Using methods to protect and ensure the survival of the Joshua tree that are not aligned with the Report's findings and associated science currently conflict with the State's requirement and have caused and continue to cause unnecessary harm to our disadvantaged community. The candidate listing has placed our severely disadvantaged community in harm's way by unnecessarily extending a significant health and safety issue and associated water quality problem along with creating significant cost increases for our severely disadvantaged community.

Using means and methods that align with the Report's findings and science will help remove these unnecessary health and safety and cost burdens on both Phase I severely disadvantaged and Phase II disadvantaged community members. Not doing so makes the basic need for water and wastewater services unaffordable for many. None of these added costs has in any way helped in the protection, long-term survivability, and ability of the Joshua tree to thrive with respect to the Report's findings and the underlying science.

Local governments in the region, both cities, and counties, already have strict regulations to protect the Joshua tree in their planning codes. Generally, they require direct preservation and relocation along with stiff penalties for unpermitted removal and destruction of Joshua trees. These are powerful, effective measures that are in place and actively enforced. While we are grateful for the Commission's interest in protecting the western Joshua tree, given the tree's positive population trends and local protections, an endangered species listing is not warranted.

If you have any questions regarding our opposition to the listing of the Joshua tree, please contact me at 760-228-6269 or paulp@hdwd.com.

Sincerely,

Paul G. Peschel

Paul G. Peschel
General Manager

SOUTHERN CALIFORNIA
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June 2, 2022

Samantha Murry, President
California Fish and Game Commission
715 P Street, 16th Floor
Sacramento, CA 95814

Electronically Submitted To:
fgc@fgc.ca.gov

RE: California Fish and Game Commission June 15-16, 2022, Meeting Agenda #5 – Petition to list the Western Joshua Tree (*Yucca brevifolia*)

Dear President Murry,

Southern California Edison Company (SCE) appreciates the opportunity to submit comments on the California Fish and Game Commission's (Commission) decision whether to list the western Joshua tree (WJT) as threatened under the California Endangered Species Act (CESA). SCE agrees with and supports the California Department of Fish and Wildlife (CDFW) recommendation that the Commission find the action to list WJT as a threatened species to be *not* warranted, as stated in CDFW's March 2022 WJT Species Status Review (Status Review).

The CDFW Status Review recommendation is well-reasoned and is based on the best available science on the current status and projected population trends of the species as summarized in the report and in other information provided independently of the report. Based on the statutory requirement to list a species under CESA "based solely upon the best available scientific information" (Fish & Game Code §2070), the Commission should adopt CDFW's recommendation not to list WJT. As discussed below, critical electric utility work must occur in WJT habitat, WJT is widespread and abundant, WJT does not meet the CESA definition of endangered or threatened, SCE already takes actions to protect WJT, and listing WJT would be counterproductive to other important activities for the state.

SCE urges the Commission to follow the recommendation in the Species Review and *not* list WJT as threatened.

Critical Electric Utility Work Must Occur in WJT Habitat

SCE is an investor-owned electric utility responsible for the construction, operation, and maintenance of electric transmission, distribution, telecommunication, and generation facilities throughout a 50,000-square-mile service territory in central, coastal, and southern California. It is SCE's responsibility to provide safe, reliable, cost-effective service to its over 15 million customers as directed by or in coordination with numerous state and Federal agencies/entities including the California Public Utilities Commission (CPUC), the North American Energy

Reliability Corporation (NERC), the Federal Energy Regulatory Commission (FERC), the California Independent System Operator (CAISO), the California Department of Forestry and Fire Protection (CalFire), and the Governor's Office. SCE is also undertaking significant efforts to protect public safety and the environment by reducing the risk of potential wildfire-causing ignitions and the need for public safety power shutoffs through enhanced electrical infrastructure hardening, situational awareness, and operational practices.

Our existing transmission and distribution lines total more than 118,000 linear miles and consist of almost 1.5 million utility poles, as well as telecommunication facilities and interconnections to third-party renewable generation facilities. SCE is required to maintain and operate infrastructure, which requires frequent inspections and work on its structures and in areas adjacent to those structures. In some cases, SCE is required to make modifications to its existing electrical facilities to ensure the availability of safe, reliable, and cost-effective electric service. In other cases, SCE is performing work to reduce wildfire risk and/or to meet state and Federal regulations. In addition to ongoing maintenance activities, SCE's work activities include new projects to support consumer demand and to support the delivery of clean, renewable energy from third-party generators to SCE's electricity customers.

Our territory and infrastructure have a significant overlap with WJT habitat. A decision to list WJT will have a significant impact on SCE's inspections, repair, maintenance, and wildfire mitigation work. As explained more fully below, it is not feasible for SCE to avoid working around WJT or within WJT woodlands due to the wide range of the species and our extensive electrical infrastructure. However, we can and do take steps to protect the species as we work. SCE spends a considerable amount of time planning and engineering our projects to protect the diversity of habitats and species that occur within and near our facilities, including protecting WJT and other species that are not state or Federally listed.

WJT is Widespread and Abundant

As CDFW found through its comprehensive review of scientific data on the species, WJT is widespread and abundant in California. CDFW also noted that the abundance and widespread distribution of WJT within California are significant factors affecting the ability of the species to survive and reproduce. Species with large ranges and populations (like WJT) tend to be both more resilient to changing conditions and less vulnerable to extinction from disturbances, environmental changes, random events, and other threats.[1]

Moreover, listing a species that is as abundant as WJT would be unprecedented. As the County of San Bernardino pointed out in its May 11, 2021 letter to CDFW and accompanying Technical Memorandum, if WJT were to be listed it would be unique among all of the current listed plant species in that: (1) it would have a substantially more extensive range than any other listed species; (2) it would be significantly more abundant that any other listed species; and (3) it would be the only listed plant species with a California Native Plant Society (CNPS) rare plant rank of Considered But Rejected (CBR).

[1] Status Review, p. 53.

Two recent studies attempted to quantify the number of WJT currently in California using similar methodologies (tree counts obtained from digitized aerial imagery, confirmed by field observations, and then extrapolated to the full range). The Western Ecosystems Technology (WEST), Inc. study[2] estimated a total of roughly 8.5 million WJT (95% confidence interval: 6.5 – 10.6 million). CDFW had the benefit of utilizing this study while it was preparing its Status Review.

The WestLand Engineering and Environmental Services (WestLand) (with review and contributions by Stantec, Inc.) study[3] estimated a smaller number of WJT than the WEST Study (roughly 3.4 million), but it also looked at population dynamics and the effect of the likely known threats to the species over the next 100 years. In no scenario evaluated by WestLand, does WJT face a threat of extirpation or extinction in the foreseeable future. CDFW did not have the benefit of the WestLand study while it was preparing the Status Review, but it is available for the Commission to review prior to making a final listing decision.

All of this data provides strong support for CDFW's recommendation not to list WJT as threatened.

WJT Does Not Meet the CESA Definition of Endangered or Threatened

SCE cares about protecting California's natural resources and biodiversity, including sensitive and imperiled species; however, the status of WJT does not meet CESA requirements for listing. SCE encourages the Commission and CDFW to instead work with local governments, communities, conservation entities and environmental groups to protect WJT as part of their planning processes and conservation efforts to protect the species now and avoid the need to list the species in the future. SCE supports regional conservation efforts and believes that voluntary conservation and development planning partnerships are the best way to protect WJT and prevent the species from getting to the point that listing is warranted.

SCE Already Takes Actions to Protect WJT

As a steward of the environment with extensive land holdings and rights-of-ways, SCE sees itself as a valuable partner in protecting sensitive habitat and takes very seriously its obligation to comply with state and Federal environmental regulations. Accordingly, SCE takes steps to implement environmentally sustainable practices that protect the diversity of habitats and species that occur within and near our facilities, including protecting WJT and other species that are not state or Federally listed.

SCE has a robust environmental review process to identify sensitive resources, implement measures to avoid or minimize impacts to habitat and species, and consult with the appropriate agencies when impacts cannot be avoided. We work with multiple state and Federal land management agencies to ensure the protection of resources on public lands and to mitigate impacts through habitat restoration, land acquisition and preservation, or other conservation

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[2] Population Size Evaluation for the Western Joshua Tree, WEST, Inc., October 14, 2021 (West Study).
[3] Joshua Tree Population Viability Analysis, WestLand Engineering and Environmental Services, April 5, 2022 (WestLand Study).

mechanisms. SCE also supports and participates as a stakeholder in the development of state and regional conservation efforts such as the State Wildlife Action Plan, the Desert Renewable Energy Conservation Plan, and the Antelope Valley Regional Conservation Investment Strategy.

SCE's utility operations and maintenance (O&M) activities with the potential to impact WJT include inspections and patrols, vegetation management (e.g., vegetation trimming and removal), facility maintenance (e.g., pole replacements, equipment repairs, road maintenance), and overland travel to locations away from established roads. These activities typically have small ground or vegetation disturbance footprints and can avoid impacts to easily observed and slow-growing species such as WJT through pre-activity surveys to identify WJT (adult, juvenile, seedling, seed bank) for avoidance, by modifying and demarcating work areas and access routes, biological monitoring to ensure WJT avoidance measures are implemented, and by utilizing existing roads and disturbed areas.

Similarly, SCE's capital projects with larger impact areas, including those going through CEQA and NEPA processes, are reviewed for potential resources and the appropriate resource management and avoidance strategies are implemented to minimize impacts. Land management and resource agencies are engaged as needed for small and large projects alike depending on project and resource specifics, and the appropriate take authorizations are obtained when impacts cannot be avoided.

Listing WJT Will Be Counterproductive to Other Important Activities for the State

Given the abundance of WJT, it is not possible for SCE to avoid working around individual WJT or within their habitat. Approximately 10% of SCE's service territory falls within WJT habitat using CDFW's mid-range estimate of 5,360 square miles of WJT habitat. During the WJT candidacy period, SCE has gained valuable insight into buffer distances CDFW would likely impose to protect WJT seeds and the seed bank if WJT were listed. These buffer distances effectively preclude work absent a permit within areas occupied by WJT given the proximity of WJT to each other. As a result, much of SCE's critical repair, maintenance, and wildfire mitigation work would cease or be severely limited within WJT territory until SCE was able to secure Incidental Take Permits (ITPs) from CDFW.

To minimize the immediate delays to our work, SCE would likely seek many project-specific ITPs covering discrete pieces of work, while simultaneously pursuing a long-term ITP to cover all future repair, maintenance, and wildfire mitigation work under one permit. These steps would be time and work-intensive for both SCE and agency staff. Typically, obtaining an ITP is a lengthy process, taking one or more years to obtain a straightforward, project-specific ITP and long-term ITPs taking much longer. Other entities will likely do the same, leading to additional delays in moving forward with critical work for the state, work that ultimately protects WJT and its habitat.

Indeed, CDFW itself recognizes that efforts to minimize wildfire risk to WJT via vegetation management and to aggressively manage active fire in WJT woodlands are important to the long-term protection of the species.[4]

Another consequence of a delay in SCE completing its wildfire mitigation-related work is that SCE might not be able to reduce the number of public safety power shutoff (PSPS) events as quickly as it might otherwise have been able to if its work had not been delayed awaiting ITPs. PSPS events are very disruptive to the individuals who lose power. Given the minimal impact to WJT that SCE's work activities cause, it does not make sense to delay any work that would reduce the number and duration of PSPS events while waiting for CDFW to issue ITPs to SCE.

Conclusion

As the Status Review says, the best scientific information available today indicates that WJT is not currently in danger of becoming extinct throughout all, or a significant portion, of its range and is not likely to become threatened with extinction in the foreseeable future.[5] SCE urges the Commission to adopt CDFW's recommendation not to list WJT and also to consider implementing some of the other protection measures suggested by staff.[6]

SCE thanks the Commission for consideration of the above comments and looks forward to continuing its partnership with stakeholders to collaboratively advance the interests of the state. Please contact me at (626) 302-0905 with questions or concerns. I am available to discuss these matters further at your convenience.

Very truly yours,

/s/

Dawn Anaiscourt

cc: Charlton Bonham, director@wildlife.ca.gov

[4] Status Review, p. 121.
[5] Status Review, p. 120.
[6] Status Review, pp. 121 – 122.

FGC@FGC

From:	Lou L <[redacted]>
Sent:	Monday, May 23, 2022 9:26 AM
To:	FGC
Cc:	[redacted]
Subject:	Joshua Trees
Categories:	Exhibit

Hi,

I am writing again to make it known that the science should be the guiding factor on the Joshua Tree situation, not the public opinion of a few people.

The science was clear that the Joshua Tree is not endangered.

Yes, it should obviously be illegal to kill them, and anyone who does should be heavily fined and held to account. Other than that, there should be no silly building rules unless the science shows it is necessary…which it did not.

If building within 40 or 25 feet of a Joshua tree effected the tree, then you would not see hundreds of homes built in the 80's and 90's with very healthy Joshua trees all around them and very close. Some common sense could come in handy here.

Thanks,
Louis Litrenta
[redacted]

Joshua Tree — endangerment?

There is a critical housing shortage — a 'housing crisis', here in our state of California, and what we are discussing this morning is the stifling of development, in one of the few remaining affordable housing areas in California, the high-desert.
Millions of these Joshua Trees 'literally' grow like weeds throughout California's high-desert.
To illustrate my point, I have included recent photos from merely one community, Yucca Valley — 'one community out of the hundreds of California high-desert communities.'
Joshua Trees were no more endangered yesterday, or today, than dirt is!
So why not make 'dirt' endangered, and put an end to this debate?
The result would be the same.
'**NO MORE**' new ***affordable*** housing development.

And we're not talking downtown Los Angeles here, nor San Francisco, or even the town of Palm Springs. We are talking the sparsely populated high-desert, where other than Highways 62, 247, & 40, it is crisscrossed by a few unpaved roads per square mile.

Unfortunately, 'Climate Change' is not restricted to one or two living species, it effects us all, plant and animals alike. So Joshua Trees are not the endangered species — YOU & I are!

The next logical question is: if 'Climate Change' is the endangerment to Joshua Trees, will declaring Joshua Trees an endangered species reduce 'Climate Change'?

Yet the question remains — if Joshua Trees are not protected by the CESA, what effect would the infringement of man be on them and their environment over the next 100 years?
Well, I'll tell you!
Way, way less than a fraction of one percent.

Perhaps on your agenda, your commission should replace Joshua Trees, with Homo Sapiens. Because if 'Climate Change' continues unabated, you will not be concerned about where to park when coming to a meeting here — you will just need a boat.

Thank you for your time:

Charles A. Gabriels

CA licensed General Contractor #419564, & Real Estate Broker #00448129
cell & text [redacted]

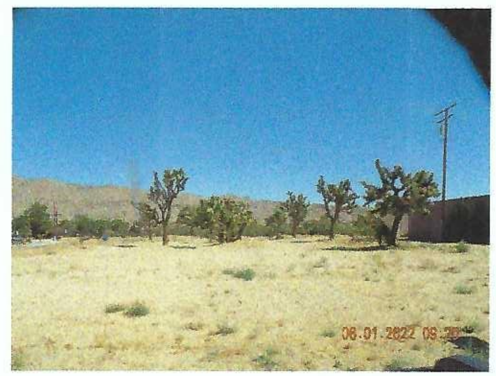
Along highway 247: Joshua Trees as far as the eye can see, in all directions, both sides of Hwy

Along highway 247: Joshua Trees as far as the eye can see, in all directions, both sides of Hwy

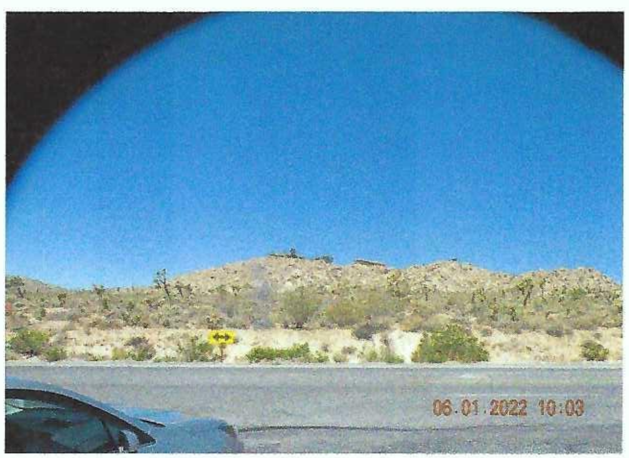
Yucca Valley Baseball field

Single family residence

Joshua Trees as far as the eye can see

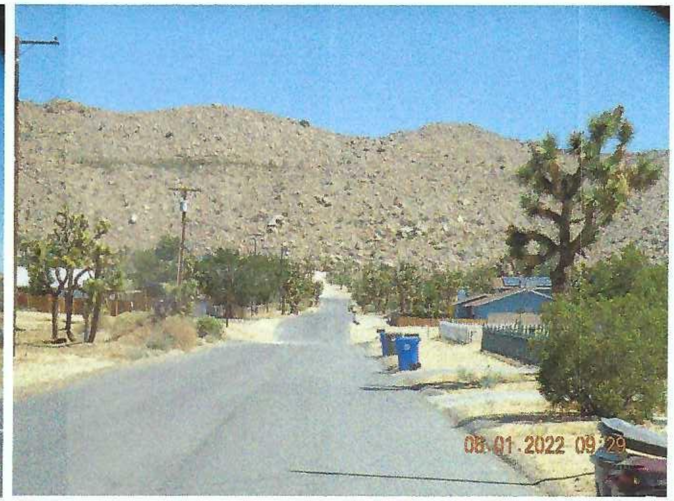


Hwy 247



State Highway 247

Highway 62, Yucca Valley, CA 92284



Neighborhood street

Neighborhood street

Neighborhood street

Neighborhood street

Neighborhood street

To the N. side of Highway 62, Yucca Valley
(the economic center of the Morongo Basin), CA


North side of Highway 62, Yucca Valley, CA

Off Highway 62, Yucca Valley, CA 92284

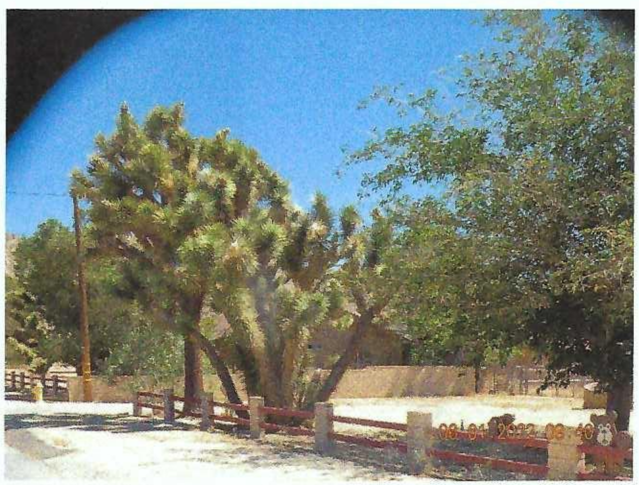
Off the main Highway

Off the main Highway

Off the main Highway

Highway 62 (main thoroughfare)
in Yucca Valley, CA 92284

Throughout the neighborhoods



Individual homes, where Joshua Trees are
revered, and are the 'center piece' of front yards.

Greaves, Jennifer@FGC

From: Cheryl Broadenax <user@votervoice.net>
Sent: Wednesday, May 25, 2022 1:36 PM
To: FGC
Subject: Western Joshua Tree Listing Unwarranted - Support Newsom Scientific Study Recommendation

WARNING: This message is from an external source. Verify the sender and exercise caution when clicking links or opening attachments.

Dear Executive Director Miller-Henson,

Limit land usage. Kill the baby but save the Joshua trees. Wow.

I want to thank the Commission and Newsom administration for their diligent work evaluating the well-being of the Western Joshua Tree and whether they should be considered for listing as a threatened species under the California Endangered Species Act. As a resident of the High Desert in California, I think it is important that we have a scientific report from a global climate leader like the Newsom Administration confirming that the species is not Threatened and should not be listed at this time. This is an important relief for all who love the species.

As a REALTOR® in California's desert, I am intrinsically aware of the importance of the western Joshua tree to defining the content and character of our communities. I know the tree is not just an iconic image on a calendar or post card, but a cherished part of our community. I am relieved to know the studies confirm it will continue to be a living part of our ecosystem with virtually no likelihood of extinction due to either direct or indirect effects of climate change, due to the abundant and widespread range of the species. This conclusion wasn't just found in the Newsom Administrations study but also in the CalCIMA scientific review and modeling efforts which clearly occurred as a result of your investigation.

I strongly urge the commission to accept the science presented by the Newsom Administration and confirmed by other analysis and studies presented. I know the decision before you today is about the science. I ask that the commission find the listing of the western Joshua tree is not warranted based upon the science.

Thank you.

Sincerely,

Cheryl Broadenax

CENTER for BIOLOGICAL DIVERSITY Because life is good.

Sent via email

June 2, 2022

California Fish and Game Commission
715 P Street, 16th floor
Sacramento, CA 95814

Submitted via email to fgc@fgc.ca.gov

Re: Agenda Item #5-Western Joshua Tree

Dear President Murray and Commissioners:

These comments are submitted on behalf of the Center for Biological Diversity regarding your upcoming decision as to whether listing western Joshua trees (*Yucca brevifolia*) as "threatened" under the California Endangered Species Act (CESA) is warranted (Cal. Fish & Game Code § 2075.5).

The Center believes that the information contained in our October 15, 2019 Petition, along with the supporting scientific studies submitted with it, clearly demonstrates not only that listing as threatened "may be warranted," but also that such listing "is warranted" (Fish & G. Code, § 2074.6). As such, we will not repeat the information and analysis contained in the Petition here. Instead, these comments are submitted to highlight additional information that has become available subsequent to the Petition, as well as to address arguments made by various parties against protection of the species, including those contained in the status review for the species that the California Department of Fish and Wildlife recently delivered to the Commission.

As summarized below, the best available scientific information demonstrates that threats to the species are ongoing, severe and certain to increase over time. While the species might not yet be "presently threatened with extinction" throughout it range, it certainly "is likely to become an endangered species in the foreseeable future" in, at a minimum, "a significant portion of its range," and consequently meets the statutory definition of a "threatened species" (Cal. Fish & Game Code § 2067).

<u>CESA Embodies the Precautionary Principle</u>

As the Commission weighs whether the western Joshua tree meets the definition of a "threatened species," it must heed the direction of the courts that "[l]aws providing for the conservation of natural resources are of great remedial and public importance and thus should be construed liberally." (*San Bernadino Valley Audubon Society v. City of Moreno Valley* (1996) 44 Cal.App.4th 593, 601; *California Forestry Assn. v. California Fish & Game Commission* (2007) 156 Cal.App.4th 1535, 1545 [same].) Moreover, just this week the California Court of Appeal for the Third District reaffirmed this important principle in upholding the Commission's broad authority to list species as threatened or endangered under CESA, stating that the "legislative history supports the liberal interpretation of the Act (the lens through which we are *required* to construe the Act)…" (*Almond Alliance of California v. Fish and Game Commission* (May 31, 2022) C093542) (emphasis added).

Like the courts, the Commission is *required* to construe CESA liberally to effectuate its purpose of protecting imperiled species. As explained below, the Department's status review ignores this directive and misinterprets the statutory definition of "threatened species" and CESA's "best available science" requirement in such a constrained way that it would all but preclude *ever* protecting any climate-threatened species or any currently widespread species no matter how great the threats. The Commission must not repeat the Department's mistake.

The Western Joshua Tree is Threatened by Climate Change, Fire and Development

In determining whether a species is threatened or endangered the Commission must access whether a species is threatened "by any one or any combination of" the relevant factors. 14 C.C.R. 670.1(i)(1)(A). As detailed in the Petition, the combined effects of climate change, increased fire, and poorly-regulated development individually and cumulatively threaten the continued existence of the western Joshua tree.

Climate Change

Climate change is undeniably the greatest threat to the western Joshua tree.[1] Since the Petition was filed, no information of any kind has come to light that would indicate that climate change represents less of a threat to the western Joshua tree than identified in the studies cited in the Petition. All such information serves only to reinforce the severity and imminence of the threat. The changing climate is already impacting the species across its range and this trajectory is expected to continue since current global policies are inadequate to prevent catastrophic global warming.

The IPCC Reports

Since the Petition, among the most important relevant new information regarding climate impacts is that contained in the recent IPCC Sixth Assessment Report, as well as studies documenting unprecedented drought in the range of the Joshua tree. The IPCC released the report of Working Group 1 (WG1) on the Physical Science Basis on August 2, 2021[2], and that of Working Group 2 (WG2) on Impacts, Adaptation and Vulnerability on February 28, 2022.[3]

The significance of the August 2021 IPCC WG1 report on the science underlying climate change is succinctly captured in the statement of the Secretary-General of the United Nations upon its release:

> Today's IPCC Working Group 1 Report is a code red for humanity. The alarm bells are deafening, and the evidence is irrefutable: greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet and putting billions of people at immediate risk. Global heating is affecting every region on Earth, with many of the changes becoming irreversible.
>
> The internationally agreed threshold of 1.5 degrees Celsius is perilously close.
>
> We are at imminent risk of hitting 1.5 degrees in the near term. The only way to prevent exceeding this threshold is by urgently stepping up our efforts, and pursuing the most

[1] Notably, the only outside peer reviewer to agree with the Department's recommendation discounted the threat of climate change on the species: ("stating that climate change is the greatest threat to the species (199) seems inconsistent with the evidence and with the subsequent caveats."). Peer review comments of Erica Fleishmann.

[2] https://www.ipcc.ch/report/ar6/wg1/

[3] https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/. Working Group 3's report on Mitigation was released in April 2022. https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/ As detailed in that report, current emissions trajectories are incompatible with avoiding catastrophic impacts of climate change. Similarly, California is also well behind on its climate goals with a recent report finding that at current rates of emissions reductions, the state will not reach its 2030 and 2050 goals until 2063 and 2111, respectively. https://www.next10.org/publications/2021-gii; see also https://calmatters.org/newsletters/whatmatters/2021/02/californias-climate-goals-unlikely/. We do not believe than any opponents of listing can credibly assert that greenhouse emissions are being adequately mitigated in California, the United States or globally such that the climate threats to the western Joshua tree are being sufficiently ameliorated.

> ambitious path.
>
> We must act decisively now to keep 1.5 alive.
>
> We are already at 1.2 degrees and rising. Warming has accelerated in recent decades. Every fraction of a degree counts. Greenhouse gas concentrations are at record levels. Extreme weather and climate disasters are increasing in frequency and intensity.[4]

The findings of the report[5] are made with increased certainty compared to previous reports and highlight the severity and, in many cases, irreversibility of the impacts that have already occurred and are certain to intensify even under the most optimistic emission scenarios:

> -It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred.
>
> -The scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years.
>
> -Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since the Fifth Assessment Report (AR5).
>
> -Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in carbon dioxide (CO2) and other greenhouse gas emissions occur in the coming decades.
>
> -Many changes in the climate system become larger in direct relation to increasing global warming. They include increases in the frequency and intensity of hot extremes… and ecological droughts in some regions.
>
> -Continued global warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events.
>
> -Many changes due to past and future greenhouse gas emissions are irreversible for centuries to millennia.

The WG1 report reinforces the fact that warming will inevitably continue, will cross the 1.5℃ threshold by 2040 if not before, and reach levels of at least 2.7℃ globally above pre-industrial averages by the end of the century, even if current climate pledges are met (and unfortunately, such pledges are nowhere near being met).

The more recent WG2 report looks at the actual impacts of this warming on global and regional scales, impacts which are severe globally, and even more pronounced in the range of the western Joshua tree. As with the WG1 report, the UN Secretary-General's statement regarding the WG2 report captures its significance:

> I have seen many scientific reports in my time, but nothing like this.

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[4] https://www.un.org/sg/en/content/secretary-generals-statement-the-ipcc-working-group-1-report-the-physical-science-basis-of-the-sixth-assessment

[5] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf

> Today's IPCC report is an atlas of human suffering and a damning indictment of failed climate leadership.
>
> With fact upon fact, this report reveals how people and the planet are getting clobbered by climate change.
>
> Nearly half of humanity is living in the danger zone – now.
>
> Many ecosystems are at the point of no return – now.
>
> Unchecked carbon pollution is forcing the world's most vulnerable on a frog march to destruction – now.
>
> The facts are undeniable.
>
> This abdication of leadership is criminal.[6]

The Chair of the IPCC similarly noted the importance of the report, including regarding the risk to biodiversity:

> The report is a dire warning about the consequences of inaction. It shows that climate change is a grave and mounting threat to our well-being and a healthy planet. It also shows that our actions today will shape how people adapt to climate change and how nature responds to increasing climate risks. Severe climate change impacts are already happening… there are limits to how much we and other species can adapt. Beyond certain temperatures, adaptation is no longer possible for some species.[7]

More specifically, the report reinforces the fact that the magnitude of climate-related impacts and threats facing species such as the western Joshua tree are greater than previously estimated:

> Climate change has caused substantial damages, and increasingly irreversible losses, in terrestrial, freshwater and coastal and open ocean marine ecosystems (high confidence). The extent and magnitude of climate change impacts are larger than estimated in previous assessments (high confidence). Widespread deterioration of ecosystem structure and function, resilience and natural adaptive capacity, as well as shifts in seasonal timing have occurred due to climate change (high confidence).[8]

Looking broadly at extinction risk, the report notes that "[e]xtinction of species is an irreversible impact of climate change, the risk of which increases steeply with rises in global temperature," and that "recent research predicts that one-third of all plant and animal species could be extinct by 2070 if climate change continues as it is." Even under more optimistic mid-level warming scenarios, 10% of flowering plants and 12% of pollinators will be at high risk of extinction.[9]

The western Joshua tree is restricted to a region at particular risk of warming. In the chapter focused on impacts to North America,[10] the report notes, *inter alia*, that "[s]ummertime daily maximum temperature is increasing in southwestern desert regions…Annual precipitation … has decreased across the western part of the continent…Extreme heat waves are projected to intensify, particularly in … US-SW… and become more frequent and longer in duration as average temperature rises across North America…Total precipitation is projected to… decrease in southwestern North America….Anthropogenic climate change has led to warmer and drier conditions (i.e., fire weather) that favour wildland fires in North America."

[6] https://media.un.org/en/asset/k1x/k1xcijxjhp
[7] https://www.ipcc.ch/2022/02/28/ipcc-chair-statement-wgii-ar6-press-conference/
[8] WG2 AR6 Report, Summary for Policymakers.
[9] WG2 AR6 Report, Chapter 2.
[10] WG2 AR6 Report, Chapter 14.

Notably, the WG2 report specifically addresses the western Joshua tree in a section discussing case studies of local climate adaptation measures.[11] The report focuses on the effort to identify and protect refugia in Joshua Tree National Park, noting that under scenarios of a local temperature increase of 4°C the species will likely be wholly extirpated from the park, but that refugia–if protected from fire–may persist for the species if warming is kept to lower levels. As discussed in the Petition and explained further below, we are not on a course to keep local temperatures in Joshua Tree National Park, or elsewhere in the range of the western Joshua tree to such levels. Moreover, the WG2 report, after its discussion of local adaptation measures such as those ongoing in Joshua Tree National Park, also recognizes their limitations under the emissions trajectories we are currently following:

> In general adaptation measures can substantially reduce the adverse impacts of 1-2°C of global temperature rise, but beyond this, losses will increase (IPCC, 2018b), including species extinctions and changes, such as major biome shifts which cannot be reversed on human timescales. Some adaptation measures will also become less effective at higher temperatures. Whilst adaptation is essential to reduce risks, it cannot be regarded as a substitute for effective climate change mitigation.[12]

In sum, the recent IPCC reports reinforce the severity of the threat climate change poses to biodiversity in general and the western Joshua tree in particular. We simply do not see how the Commission could reasonably conclude that listing the species as threatened is "not warranted" in light of these reports and the best available science more broadly.[13]

California also recognized the impending climate emergency recently. On April 5, 2022, California's nonpartisan Legislative Analyst Office issued a series of six reports on the ongoing and foreseeable impacts of climate change on the state.[14] And while the focus of these reports is not specific to biodiversity, they note the significant impacts of extreme temperature, drought and fire on the state's ecosystems, all of which are major threats to the Joshua tree.[15] Notably, the Crosscutting Issues report highlights that average maximum temperature will increase in the California Desert under "moderate" (i.e. highly optimistic) emissions scenarios by 5.4°F (3°C) as early as 2035 and by 7.2°F (4°C) by 2070.[16] As detailed in our Petition, studies carried out a decade ago in Joshua Tree National Park (Barrows and Murphy-Mariscal (2012)[17]) projected a 90-98% loss of the species under an "extreme" scenario of a 3°C rise in summer maximum temperature. That formerly "extreme" outcome is now likely to be upon us in less than two decades even under the most optimistic emissions reduction scenarios.

Drought Intensification

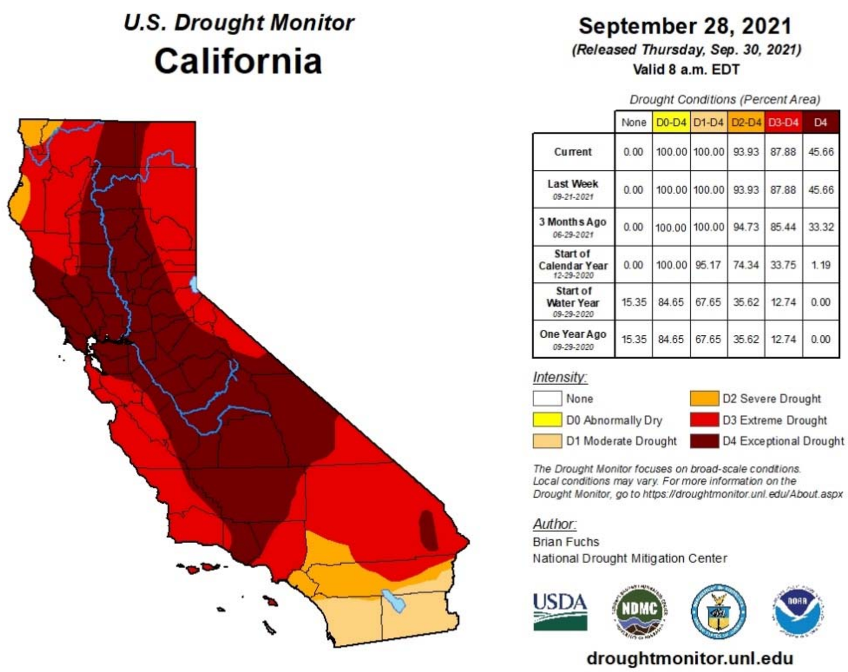
The western Joshua tree is currently subject to sustained drought conditions unlikely to have been experienced in over a millennium. In February 2022, Williams et al., published a study demonstrating that the current drought enveloping the southwestern United States is the most severe in at least 1200

[11] WG2 AR6 Report, Chapter 2 at 125.
[12] WG2 AR6 Report, Chapter 2 at 130.
[13] Notably, the Status Review makes only the most passing mention of the IPCC WG1 report and does not reference the WG2 report at all. Status Review at 55
[14] https://lao.ca.gov/Publications/Series/1
[15] A good summary of the finding of the reports can be found at: https://calmatters.org/environment/2022/04/california-climate-change-report-legislature/
[16] https://lao.ca.gov/reports/2022/4575/Climate-Change-Impacts-Crosscutting-Issues-040522.pdf
[17] Barrows, C.W. and M.L. Murphy-Mariscal. 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: How scale impacts predictions. Biological Conservation 152:29–36.

years (which is the limit of reconstructed drought data for the region).[18] According to the study, from 2000 to 2021, mean water-year (October–September) precipitation in the region was 8.3% below the 1950–1999 average and temperature was 0.91°C above average. Soil moisture in summer (June–August) was below average in 18 of the 22 years from 2000–2021 and the exceptionally dry soil in 2021 was nearly as dry as that of 2002, the driest year in the 1901–2021 observational record and notable for its severe impacts on forest ecosystems and wildfire, including on western Joshua trees.

The driving force of the prolonged drought is increased temperature brought on by climate change, which accelerates reduction of soil moisture. Since 2000, the average soil moisture deficit was twice as severe as any drought of the 1900s, and greater than it was during even the driest parts of the most severe megadroughts of the past 12 centuries. The authors attribute 19 percent of the severe 2021 drought, and 42 percent of the extended drought since the 21st century began, to human-caused climate change. Notably, Williams et al. (2022) ran simulations to determine the likelihood of the current drought continuing, and found that it did so through 2022 in 94%, and through 2030 in 75% of the simulations, respectively. They called this estimate "conservative" given it does not account for the additional warming and consequent drying that will occur over the remainder of the decade due to climate change.

While the Williams et al. (2022) study looked at the broader southwest, the portion of the southwest inhabited by western Joshua trees was not spared severe drought effects. By September 2021, the end of California's water year, the western Joshua tree's entire range had experienced prolonged Exceptional or Extreme Drought.[19]



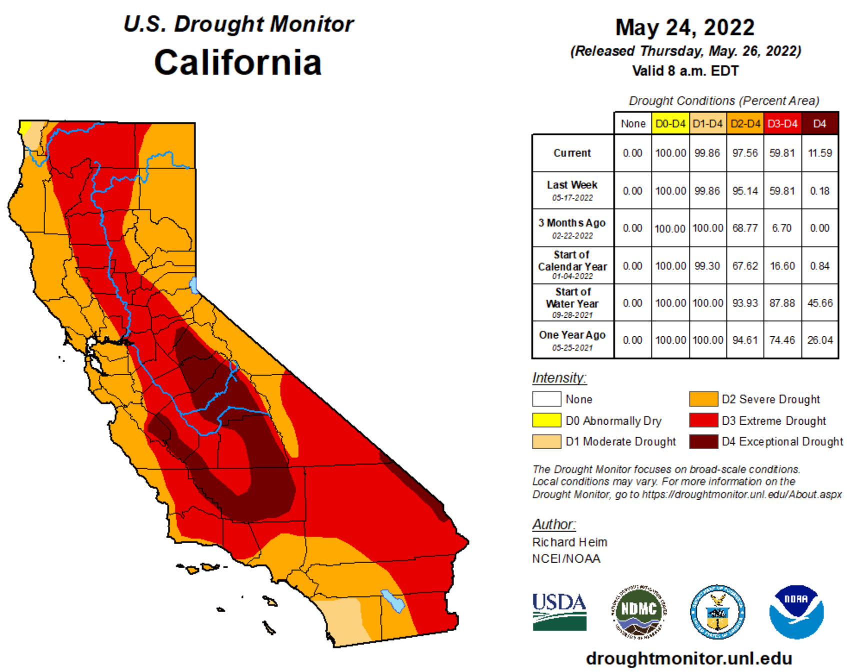
December 2021 rains and cooler winter temperatures have slightly ameliorated drought conditions in the Mojave, but as of late May 2022 the entire range of the western Joshua tree remains in Severe or Extreme Drought conditions. Moreover, the early months of 2022 have been exceptionally dry, congruent with predictions of Williams et al. (2022) that the drought would persist at least through the year.

[18] Williams, A.P., Cook, B.I. & Smerdon, J.E. Rapid intensification of the emerging southwestern North American megadrought in 2020–2021. Nat. Clim. Chang. 12, 232–234 (2022).
[19] https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

The current drought was driven by both severe lack of precipitation and by record high atmospheric evaporative demand (i.e. vapor pressure deficit; VPD) brought on by human-caused warming—an effect certain to continue and intensify over the coming decades (Ficklin & Novick, 2017; Mankin et al., 2021).[20] A 2021 report by NOAA's Drought Task Force predicted that drought such as experienced over the past decade will become the norm after 2030.

> By 2030 and with no climate mitigation, more than 1 in 10 years will have VPD values as high as 2020 and by 2030–2050, a decade with VPD as high as we have seen in the last decade (2011–2020) will be the norm. The magnitude and intensity of severe droughts in the region are projected to increase with greenhouse gas emissions (Mankin et al., 2021) (internal citations omitted).

Occasional wet months or years are unlikely to end drought conditions, as high temperatures and subsequent VPD levels can drive drought conditions, even if future years do not experience the same record low levels of precipitation of recent years (Hoerling et al., 2018)[21].



Prolonged severe, extreme and exceptional drought is not just a meteorological phenomenon; it represents an existential threat to the western Joshua tree. As described in the Petition (p. 45), drought limits western Joshua tree recruitment and leads to higher adult mortality, due to temperature and moisture stress or increased herbivory from hungry rodents lacking alternative forage. Seedlings and juveniles are thought to be most susceptible to drought impacts (DeFalco et al., 2010; Esque et al.,

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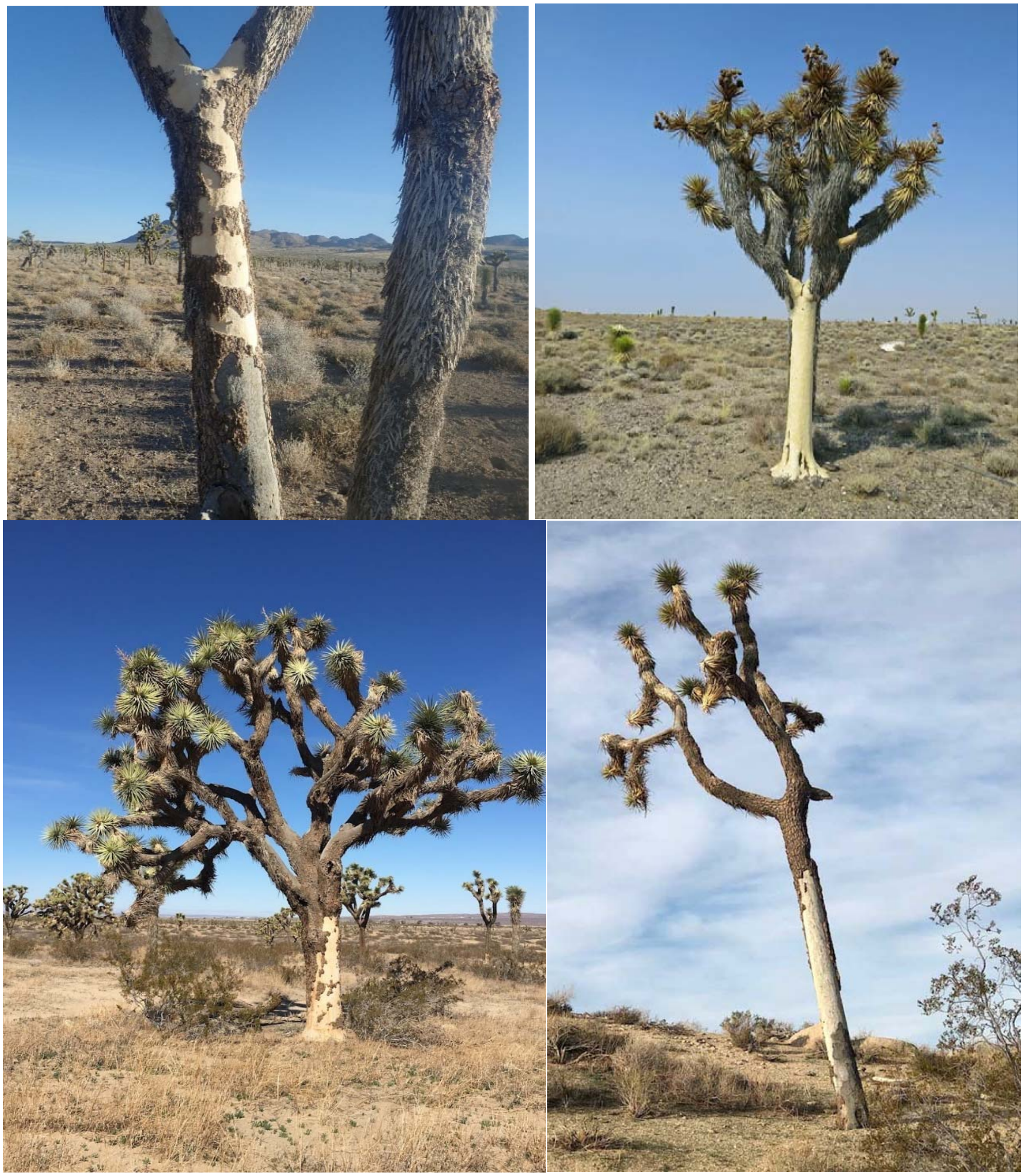
[20] Ficklin, D. L. and K.A. Novick. 2017. Historic and projected changes in vapor pressure deficit suggest a continental-scale drying of the United States atmosphere. Journal of Geophysical Research: Atmospheres 122(4):2061–2079. https://doi.org/10.1002/2016JD025855; Mankin, J. S., I. Simpson, A. Hoell, R. Fu, D. Barrie, and C. Byrd. 2021. NOAA Drought Task Force Report on the 2020 – 2021 Southwestern US Drought. NOAA Drought Trask Force, MAPP, and NIDIS. https://cpo.noaa.gov/MAPP/DTF4SWReport

[21] Hoerling, M. and et al. 2018. Temperature and Drought: A science assessment by a subgroup of the drought task force. https://cpo.noaa.gov/Portals/0/Docs/MAPP/Reports/2018/TemperatureDrought/Drought_TF_Temp_Drought_Final_Revised.pdf?ver=2018-07-31-104948-243

2015[22]), but adult trees are also at significant risk and can be killed by herbivory. The northern population cluster of *Y. brevifolia* is certainly not exempt from these effects as it experienced the most intense level of drought during the 2020–2021 water year.



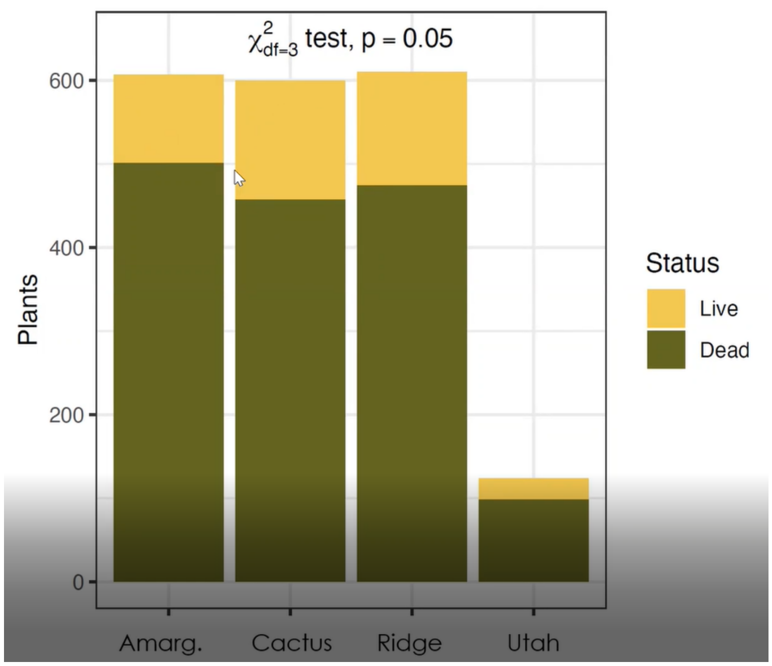
Examples of small rodent herbivory observed in April 2021 at Lee Flat, CA (upper left photo by botanist Maria Jesus), in October 2020 near Goldfield, NV (upper right photo by ecologist Jim Boone[23]), and in February 2022 near Lancaster, CA (bottom photos by Jeff Reno).

[22] DeFalco, L. A., T.C. Esque, S.J. Scoles-Sciulla, and J. Rodgers. 2010. Desert Wildfire and Severe Drought Diminish Survivorship of the Long-Lived Joshua Tree (Yucca brevifolia; Agavaceae). American Journal of Botany 97(2):243–250; Esque, T.C., P.A. Medica, D.F. Shrylock, L.A. DeFalco, R.H. Webb, and R.B. Hunter. 2015. Direct and indirect effects of environmental variability on growth and survivorship of pre-reproductive Joshua trees, *Yucca brevifolia* Engelm. (Agavaceae). American Journal of Botany 102(1):85–91.

[23] https://birdandhike.wordpress.com/2020/10/10/rodents-seek-moisture-from-sensitive-plants-during-a-severe-drought-year/

DeFalco et al. (2010) documented that over a quarter (26%) of unburned Joshua trees died in their study plots in Joshua Tree National Park over a 5-year period centered around the exceptional drought year of 2002. Given the 2021 drought year was similarly exceptional through much of the western Joshua tree's range, comparable impacts can reasonably be anticipated. While we are unaware of published studies similar to DeFalco et al. (2010) outside of Joshua Tree National Park and Red Rock Canyon State Park, widespread reports of herbivore damage throughout the range of the species are cause for great concern. Such impacts are known to currently be occurring in the southern end of the range in Joshua Tree National Park and on Mojave Desert Land Trust properties, in the western Mojave near Lancaster, as well as in Lee Flat in the northern edge of the range and Goldfield, Nevada on the northeastern edge.

And while western Joshua trees are declining due to climate change, a recent study by Riddell et al. (2021)[24] indicates small mammal populations in the Mojave Desert have remained stable over the last century of warming and drying, largely due to microhabitat buffering and behavioral adaptations (i.e. the ability to spend time underground). Given the likelihood of more frequent and intense droughts reducing alternative forage, mortality risk to adult trees due to small mammal predation should not be underestimated, as it is likely to become an ever-greater source of mortality to the species.



Source: Heyduk (2021)

In addition to causing increased herbivory, drought conditions can preclude western Joshua tree seedling survival directly due to heat and water stress. The historic drought conditions of 2021 likely precluded seedling survival in the wild; but even experimental seedlings buffered by common garden settings were impacted.[25] In spring 2021, thousands of individual *Y. brevifolia* and *Y. jaegeriana* seedlings were transplanted from a greenhouse into four separate common gardens as part of the Joshua Tree Genome Project's research (Heyduk, 2021).[26] Unfortunately, due to the record heat and drought, there was

[24] Riddell, E. A., K.J. Iknayan, L. Hargrove, S. Tremor, J.L. Patton, R. Ramirez, B.O. Wolf, and S.R. Beissinger. 2021. Exposure to climate change drives stability or collapse of desert mammal and bird communities. Science 371(6529):633–636. https://doi.org/10.1126/science.abd4605

[25] https://joshuatreegenome.org/archives/2021/07/field-season-physiology-joshua-tree-seedling/#more-505

[26] Heyduk, K. 2021. Local Adaptation in a Desert Perennial: Early Data from Joshua Tree Common Gardens. Presented at the 47th Annual Southern California Botanists Symposium, Virtual, October 16, 2021.

widespread mortality of seedlings across all gardens in the study. Very preliminary results indicate there was no effect of source climate (i.e. local adaptation) on the surviving seedlings. Overall, very strong garden effects were observed in terms of physiology and expression of genes associated with stress response (i.e. seedlings in the hottest garden grew much more slowly than those in a wetter, more northerly garden). While future study results may shed more light on the genetic variation underlying physiological tolerances, the high mortality already documented in the study demonstrates that current climate conditions, at least in drought years, are already largely unsuitable for seedling survival across the range of the species.

In sum, increased severity, frequency and duration of drought conditions is already resulting in reduced recruitment and increased mortality in western Joshua trees. Such conditions are virtually certain to continue and intensify over the coming decades, and when combined with increased temperatures will render much of the current range of the western Joshua tree unsuitable for the species. Even absent the additive impacts of fire and habitat loss to development, the impacts of climate change are such that the species is not just "likely" but almost certain to become an endangered species in the foreseeable future.

Fire

The increase of fire in the range of the western Joshua tree and the impacts it has on the species are significant and likely irreversible. As detailed in the Petition (p. 24-31) fire is one of the greatest threats to the continued persistence of the western Joshua tree. Since the Petition was filed, new information further substantiates the scale and immediacy of that threat.

In a large-scale long-duration study of 31 fire sites, Abella et al. (2020)[27] documented minimal recovery of Joshua trees and their host plants three decades post fire. Notably, in blackbrush (*Coleogyne*) dominated communities, the projected time to recovery to pre-burn species composition was 550 years. Given blackbrush is an important nurse plant for Joshua trees, this has obvious consequences for the species.

> In a 22-yr study, for example, 28% of *Y. brevifolia* seedlings survived below nurse plants in fertile islands, compared to zero survival for seedlings in interspaces. Burned areas likely select for species less dependent on nurse plants for recruitment, which may account for burned areas containing relatively small-statured perennial species capable of recruiting in open areas. (internal citations omitted).

Consistent with other studies (e.g. DeFalco et al. (2010), showing 64-95% post-fire mortality), limited resprouting of burned Joshua trees occurred, but minimal if any seedlings became established.

> Resprouting was less frequent for *Y. brevifolia*, but aided population persistence as the few resprouters constituted nearly all the species' live individuals on burned areas.

Abella et al. (2020) discussed the challenges facing Joshua trees recruiting into post-fire landscapes.

> Likely with similar challenges to recruitment, *Yucca brevifolia* forms a persistent but relatively short-lived soil seed bank (~4 yr) that is readily killed by temperatures sustained below shrubs during wildfire. Although the species can resprout at low frequencies,

[27] Abella, S. R., D. M. Gentilcore, and L. P. Chiquoine. 2020. Resilience and alternative stable states after desert wildfires. Ecological Monographs 00(00):e01432. 10.1002/ecm.1432

> resprouts may require over 30 yr to produce seeds, indicating that plants on even the oldest burns (36 yr) we studied may not yet be capable of reproduction. Furthermore, seeds typically disperse only short distances (<25 m) from adults via small mammals, and seedling establishment is contingent on availability of nurse plants, which are sparse on burns….Collectively, previous research suggests that sparse seed availability, limited seed dispersal, and lack of suitable regeneration microsites (nurse plants) hinder these species' recruitment. These limitations could form feedbacks deterring resilience and promoting alternative states with low densities of these species, consistent with our data (internal citations omitted).

These dynamics can also impact the persistence of the Joshua tree's obligate pollinators, as even when post-fire resprouting occurs, the area is rendered unsuitable to pollinating moths for decades.

> Although limited resprouting fostered minimal resilience of *Yucca* density in our study, stems sufficiently large to flower were largely absent from burns, and thus, *Yucca* flowers were unavailable to pollinators for decades. This highlights that some resilience may not translate to functional resilience and that recovery debts can accrue while limited resilience is occurring. Multi-decade absences of *Yucca* floral resources from extensive burned areas and potential influences on specialized pollinators could trigger alternative stable states in pollinator networks.

In sum, fire kills Joshua trees in all age classes, likely destroys the seed bank, and eliminates nurse plants that seedlings need to survive, while the few resprouting trees that survive take decades to flower, rendering the burn site inhospitable to pollinating moths. Given these challenges, burned Joshua tree woodlands are "entirely unlikely" to ever return to pre-fire densities or ecosystem function (Reynolds et al., 2012).[28]

While the Abella et al. (2020)[29] study reinforces the information provided in the Petition on the impacts of fire on Joshua trees, actual fires in the range of the species since the filing of the Petition further demonstrate the scale and immediacy of the threat.

Over the course of 2020 alone, many thousands of acres of Joshua tree habitat burned. These include very large fires in the range of the western Joshua tree such as the Lake and Bobcat fires, which collectively burned thousands of acres of Joshua tree habitat, as well as smaller fires that burned significant patches of such habitat.

The Lake Fire in August 2020 was noteworthy in that it burned a small state park designated to protect the western Joshua tree, a nearby county preserve, as well as private conservation lands acquired for the protection of Joshua trees. These areas are the Arthur B, Ripley Desert Woodlands State Park, the George R. Bones Wildlife Sanctuary operated by Los Angeles County, and conservation lands purchased and managed by Transition Habitat Conservancy, all of which lost significant portions of their holdings in

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[28] Reynolds, M.B.J., L.A. DeFalco, and T.C. Esque. 2012. Short seed longevity, variable germination conditions and infrequent establishment events provide a narrow window for *Yucca brevifolia* (Agavaceae) recruitment. American Journal of Botany 99(10):1647–1654.

[29] Abella et al. (2020) have not yet adopted the two-species taxonomy and refer to *Yucca brevifolia* throughout. Joshua trees in their study areas are likely *Y. jaegeriana*. Nevertheless, given no studies to date have demonstrated differing vulnerabilities or responses to fire between the eastern and western species, their findings are still highly informative to the fate of the western Joshua tree.

the fire. Additional private and public lands in the area containing Joshua trees also burned.

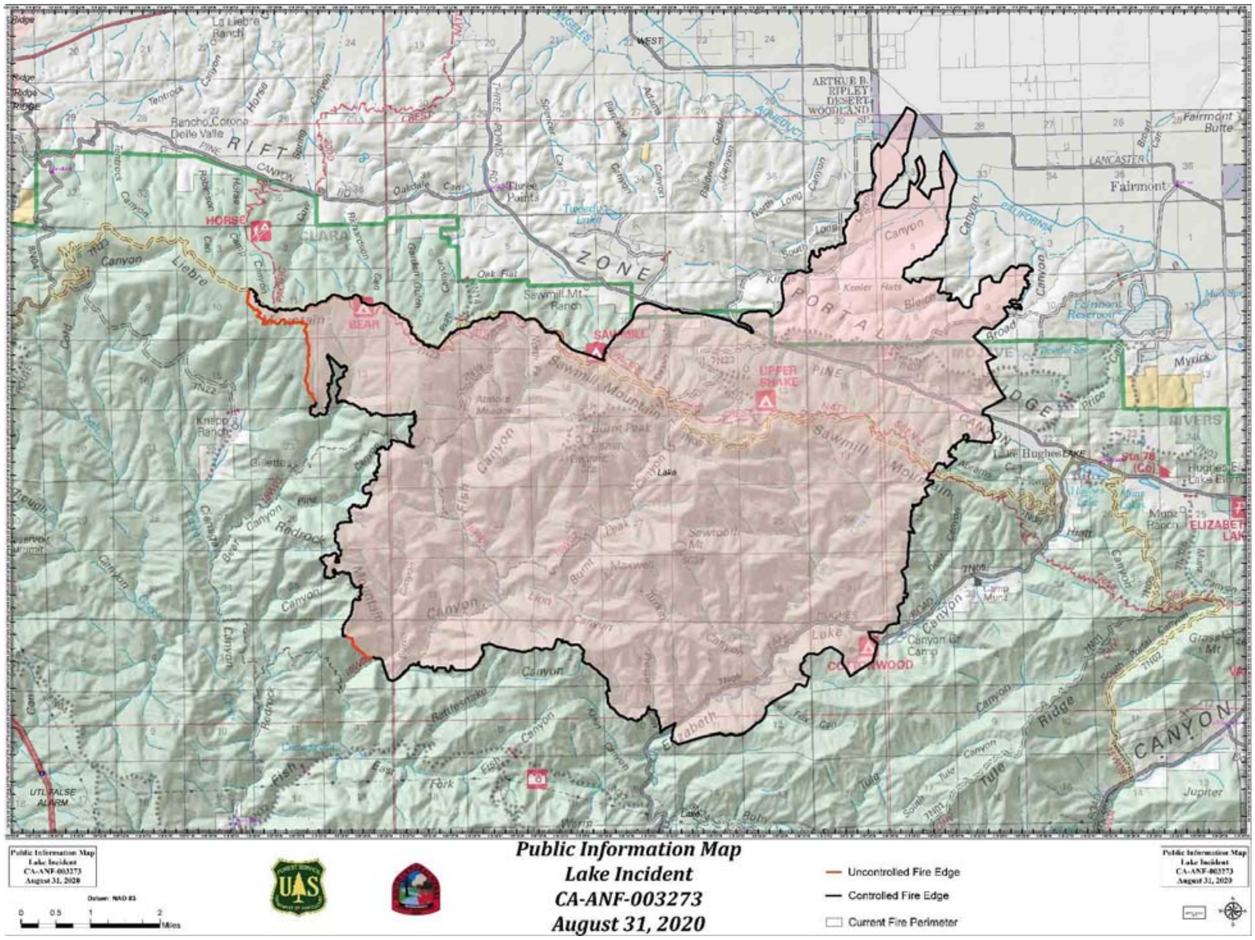


Photo of burned portion of Arthur B, Ripley Desert Woodlands State Park taken October 28, 2020.

Photo of burned portion of George R. Bones Wildlife Sanctuary taken October 28, 2020.

Photo of burned Transition Habitat Conservancy lands taken October 28, 2020.

These otherwise protected areas that burned in 2020 are roughly contiguous and represent the core of protected lands for Joshua trees in the western Antelope Valley, an area that has already lost most of its Joshua tree woodland to agricultural development and urban development.

Photo showing burned LA County preserve on right, burned THC lands on left and partially burned State Park lands in center. Solar projects visible in distance. Photo taken October 28, 2020.

As reflected in the photo above, remnant areas of Joshua tree woodland, visible as dark patches, represent a small fraction of land in the area. Much of the area was cleared for agriculture or pasture in the early 20^{th} Century. Other than the identified protected lands, all lands containing Joshua trees visible in this image are private with no long-term protections in place other than the temporary prohibition against take provided by candidacy status.

While the Lake Fire burned into the western Antelope Valley, the Bobcat Fire in September 2020 burned important Joshua tree habitat in the eastern Antelope Valley and along the northern slopes of the San Gabriel Mountains. This fire scorched over 115,000 acres, upwards of 10,000 of which contained Joshua trees. Among the burned areas were nominally protected areas such as the Devil's Punchbowl Natural Area and portions of the San Gabriel Mountains National Monument.

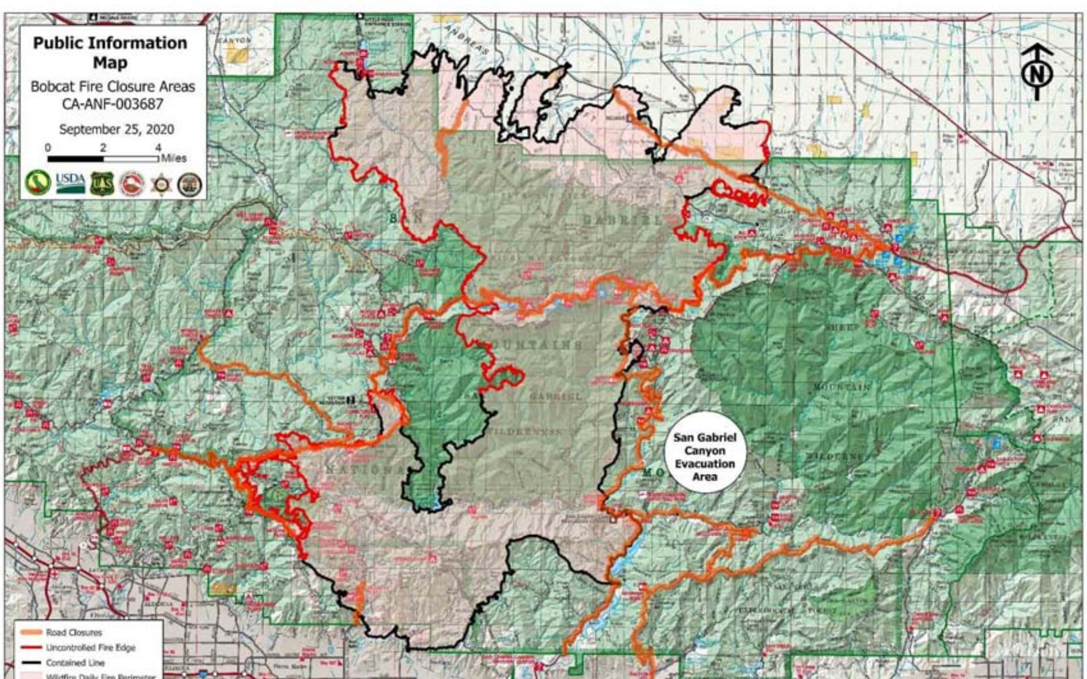


Photo of Bobcat Fire burning through Joshua tree habitat. Source CNN.

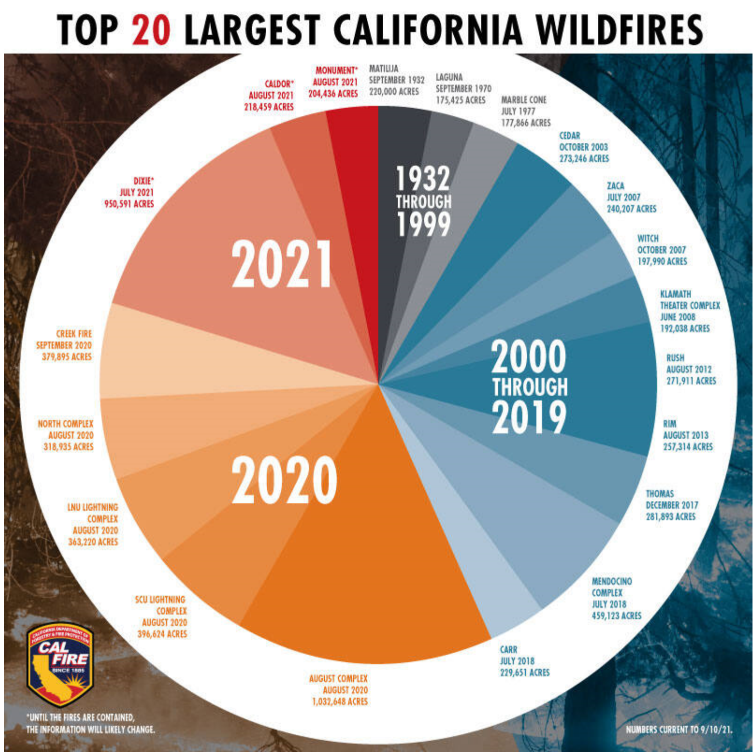
Another noteworthy fire of significant conservation impact occurred in May 2020 when a cigarette-caused fire burned over 150 acres of dense Joshua tree woodland on lands acquired for protection by the Mojave Desert Land Trust.

Photo showing boundary of burned area on MDLT land in Joshua Tree, CA. Photo taken May 20, 2020.

This fire, as with the Lake and Bobcat fires that followed it, demonstrate that even areas legally protected from development and otherwise managed for conservation, are not adequately protected from fire fueled by invasive grasses and the drought and heat conditions created by a changing climate.

While the Lake, Bobcat and MDLT fires all burned otherwise protected areas in the range of the western Joshua tree, perhaps the most noteworthy fire of 2020 was the Dome Fire that burned over 40 thousand acres of what is arguably the largest Joshua tree forest on earth. This fire killed an estimated 1.3 million eastern Joshua trees in the Mojave National Preserve. As acknowledged by the National Park Service, "since the Dome Fire fully scorched most of the plants it touched, it's unlikely that many of the 1.3 million Joshua trees will recover."[30]

Among the factors that led to the lightening caused Dome Fire were a combination of extreme heat, thunderstorms and other wildfires across parts of California that the National Weather Service described as an "extraordinary unprecedented historic event."[31] As noted by the Park Service, due to simultaneous fires burning elsewhere in the state, requests for additional firefighting resources to fight the Dome Fire were denied: "A desert wilderness fire, while recognized as being serious, was not given high priority for limited firefighting resources." With fires in California increasing in number and severity, and the majority of the state's largest ever fires occurring in recent years, similar dynamics where remote Joshua tree woodlands are allowed to burn while scarce firefighting resources are deployed elsewhere can be expected to become ever more common.



CALFIRE Chart of largest fires in recent California history.

[30] The National Park Service's description of the fire and the ecological impacts of its aftermath is available at https://www.nps.gov/moja/learn/nature/dome-fire.htm

[31] https://wsvn.com/news/us-world/a-heat-wave-in-california-is-fueling-more-than-30-wildfires-it-may-also-leave-millions-of-homes-without-power/

Photo of Dome Fire shortly after the fire was contained. Photo taken August 30, 2020.

While the Dome Fire devastated the eastern Joshua tree, the conditions that led to this unprecedented fire (e.g. carpets of invasive grasses, abnormally hot and dry climate conditions and widespread lightning strikes) are also prevalent in the range of the western species. The Dome Fire demonstrates that a significant portion of the species' range can be irrevocably devastated by fire over the course of a week due to a single incident. Even absent the impacts of climate change and habitat loss to development, fire is a widespread and imminent threat to the western Joshua tree.

Photo of Elk Fire prior to full containment. Photo taken May 27, 2022.

Moreover, while all the fires noted above occurred in a single year of high fire (2020), additional fires have continued to occur in the range of the western Joshua tree. Among these, just last week (May 26, 2022) a relatively "small" fire of 431 acres (the Elk Fire) burned through Joshua tree woodland in Yucca Valley and into Joshua Tree National Park, likely killing most of the trees in the burn area.

In sum, fire has already become a very significant threat to western Joshua trees. And fire is highly likely to increase in frequency and scale as climatic conditions contusive to fire become ever more prevalent across the range of the species. And even if fire acting in isolation may not yet render the western Joshua tree "likely to become an endangered species," as suitable habitat for the species contracts in the face of climate change, fire will kill increasingly greater percentages of a declining population, pushing the species ever closer to extinction.

Development

Habitat loss to development has been the greatest historic threat to the western Joshua tree and remains a significant obstacle to its conservation. Untold thousands of acres were lost to agricultural conversion and other forms of development in the Antelope Valley in the early 20th Century, while the growth of cities and towns in the Antelope Valley, West Mojave and Morongo Basin in more recent decades have resulted in the loss of thousands of additional acres.

As documented in the Petition (p. 46) over 50% of the land area comprising the YUBR South population is privately owned, with virtually no effective conservation measures for Joshua trees other than those provided by the interim take prohibition of candidacy. In 2018, USFWS projected that over 40% of suitable habitat in YUBR South would be lost to housing development absent changes in land-use protection. Other forms of additional habitat loss are also likely. For example, the pandemic-fueled growth of delivery entities such as Amazon has resulted in an ongoing boom in the construction of warehouses and related logistics facilities in the Victor Valley and Antelope Valley; these projects will result in the loss of hundreds, if not thousands, of acres of Joshua tree woodland in the westernmost part of its range.

Aerial imagery showing solar projects and other development fragmenting *Y. brevifolia* habitat.

As of 2018, USFWS estimated that 68,000 acres of Joshua tree habitat had been lost to renewable energy development. Enacted subsequent to candidacy, 14 C.C.R § 749.10 authorizes the loss of several tens of thousands of additional acres to 15 additional solar projects, primarily in Kern County. And while these projects will contribute to a mitigation fund that will ultimately be used to secure additional lands for protection, there can be no question that substantial amounts of irreplaceable occupied western Joshua tree habitat will be permanently lost.

Loss of habitat to renewable energy is likely to continue. While much of the western Joshua tree habitat lost to renewable energy development to date has been on private land, federal lands are increasingly at threat as well. In December 2020, as part of the COVID relief and omnibus spending bill, Congress passed, and President Trump signed into law, a provision mandating a five-fold increase of renewable energy on public lands with a goal of generating 25 gigawatts by 2025 (Section 3104 of the Consolidated Appropriations Act, 2021). Many of these areas contain intact western Joshua tree woodlands.

A recent report by the California Energy Commission, California Public Utilities Commission, and California Air Resources Board indicates an average of 2.7 GW/year of solar and 0.9 GW/year of wind will be needed to meet the state's renewable energy goals by 2045.[32] A study by Wu et al. (2019),[33] in alignment with these rates, projects California will develop between 939,000 and 2.6 million acres of utility-scale solar and wind projects by 2050. These estimates assume existing policies incentivizing distributed energy resources (DER), such as residential solar, remain constant. However, a proposed decision by the California Public Utilities Commission would discourage DER by charging a monthly solar penalty fee and drastically reducing incentives for residential solar, likely increasing the growth of utility-scale renewable projects on private and public lands.[34]

A portion of renewable energy development is expected to occur on Bureau of Land Management (BLM) lands in southern California under the Desert Renewable Energy Conservation Plan (DRECP) amendments to the California Desert Conservation Area (CDCA) Plan. Of the 388,000 acres of development focus areas subject to a streamlined review process to facilitate renewable energy development, approximately 50,000 acres fall within the mapped distribution for *Y. brevifolia*. The USFWS (2018) states the DRECP "contains measures to avoid removing individual plants by avoiding areas classified as Joshua Tree Woodland," but the protectiveness of these "measures" can be negligible in practice.[35] While a rapid transition to 100% renewable energy is an essential component of western Joshua tree recovery, it cannot be at the expense of losing tens of thousands of additional acres of Joshua tree habitat.

Habitat loss, whether historic, ongoing, or projected represents a significant threat to the continued viability of the western Joshua tree and is a factor dictating that the species be found to warrant listing as threatened. At the same time, it is also the threat that protection under CESA is most likely to ameliorate. CESA listing is both scientifically warranted, and prudent as a matter of good policy.

Western Joshua Tree Population Declines

Over the past century, hundreds of thousands of acres of western Joshua tree habitat have been lost to agricultural conversion and industrial and residential development (Petition, p. 19, 46-48). Over the past few decades, unprecedented fires fueled by invasive grasses have consumed many tens of thousands of

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[32] https://www.energy.ca.gov/publications/2021/2021-sb-100-joint-agency-report-achieving-100-percent-clean-electricity

[33] Wu, G. C., E. Leslie, D. Allen, O. Sawyerr, D. Richard, E. Brand, B. Cohen, M. Ochoa, and A. Olson. 2019. A Power of Place: Land Conservation and Clean Energy Pathways for California.

[34] https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M430/K903/430903088.PDF

[35] The Perdito Exploration Project Environmental Assessment, DOI-BLM-CA-D050-2017-0037-EA (EA), Finding of No Significant Impact (FONSI), and Decision Record did not apply the appropriate DRECP Conservation Management Actions to Joshua trees because the BLM failed to delineate the Joshua Tree Woodland vegetation type in the project area as detailed in a Request for State Director Review filed by the Center and other organizations.

additional acres, killing most of the Joshua trees within the burn areas. Even without accounting for climate change, it is clear that there are far fewer acres of intact western Joshua tree habitat today than in the recent past; consequently, the species has undeniably declined in range and abundance. And of course, climate change must be considered. Increasing temperatures have already resulted in reduced reproduction and increased mortality in the lower and hotter portions of the western Joshua tree's range (p. 19-20). Over time, as temperatures continue to rise, these effects will manifest at higher elevations and latitudes. Even under the most optimistic climate scenarios, the species will be reduced over the next fifty or so years to a small fraction of its historic distribution (p. 32-45).

Opponents of listing have made much of a statement in the Petition that "no range-wide population trends have been documented" (p. 19). The Petition's statement regarding "range-wide population trends" reflects that outside of Joshua Tree National Park, much of the currently existing intact habitat for the species remains unstudied and therefore the question of whether or not trees are *already* declining in these areas due to climate change has yet to be answered. However, given hundreds of thousands of acres of formerly occupied habitat have been lost to development while fires have killed scores of trees in other areas, there can be no doubt that overall there are fewer Joshua trees today than existed only a few decades ago. In that sense there has been a range-wide population decline of the species that is ongoing.

Since the filing of the Petition, at least one additional study has been made public regarding the status of Joshua tree populations outside of Joshua Tree National Park. Cornett (2020) reported on a long-term study plot in Red Rock Canyon State Park, which is located near the northern edge of the southern population (YUBR South). The number of trees declined by 46% over the 21-year study period, with young trees (<1m) declining at a greater rate than older trees (>1m). Tree vigor, measured by comparing ratio of live to dead rosettes of trees larger than 1m, also declined from 0.97 in 1995 to 0.63 in 2016, suggesting surviving trees were more stressed at the end of the study than at the start. The time-period of the study corresponded with an increase in temperature and a decline in precipitation in the region. Non-quantitative observations outside the study plot indicated similar declines in abundance and vigor were occurring throughout the park. Cornett concluded that the population in the park may have reached "a tipping point where it may no longer be self-sustaining."

The threats of climate change, as well as of fire and habitat loss to development, collectively would be sufficient to warrant protection of the western Joshua tree as a threatened species even in the absence of already observed declines (by way of analogy, when a ship starts taking on water, you don't have to wait until the first passenger drowns before calling in a Mayday). The fact that the species is already declining on otherwise protected habitat in widely separately portions of its range as a result of the limited warming that has occurred to date, serves to validate the dire projections of the various climate modeling studies of the species.

The Department's Flawed Status Review

Notwithstanding the overwhelming information contained in the Petition, the studies cited in it, or the subsequent information referenced above, the Department's Status Review ultimately recommended that listing is "not warranted." While we recognize that Department staff clearly put a significant amount of time into drafting the status review, we agree with one of the peer reviewers that the document "reads as an argument for not listing this species as threatened or endangered, not as an objective analysis of the existing data, and as a result is flawed, suffering from repeated confirmation bias."[36] Similarly, as another peer reviewer noted, "the draft Status Review interprets uncertainty in predicted threats in the most optimistic light, misses ways in which available data can answer questions that it poses, and does not

[36] Peer review comments of Cameron Barrows.

seriously consider the joint effects of the interlocking threats to western Joshua tree."[37] This consistent pattern of underestimating risk and overstating resilience is also noted by two additional peer reviewers and renders the status review's "not warranted" recommendation wholly unreliable.

Among the many specific problems with the status review are the following:

- It disregards the input of the independent peer reviewers. Four of the five peer reviewers disagreed in whole are in part with the recommendation against threatened listing and/or the rationale against listing.[38]

- It completely discounts the findings of the published, peer-reviewed studies that modeled the fate of Joshua trees under various climate scenarios. These studies (e.g., Cole et al. 2011 (range-wide) and Barrows and Murphy-Mariscal 2012 and Sweet et al. 2019 (Joshua Tree National Park)) predict the near complete loss of suitable habitat for the species in their respective study areas. The status review's rationale for dismissal of these studies (e.g., general unreliability of species distribution models (SDMs), purported lack of demographic data, climate data too short-term, etc.) is nearly identical to that used by the U.S. Fish and Wildlife Service under the Trump administration to deny federal listing of Joshua trees. That finding was recently overturned by a federal court. See *WildEarth Guardians v. Haaland*, C.D. Cal. Sep. 20, 2021, No. 2:19-cv-09473-ODW (KSx), 2021 U.S.Dist.LEXIS 179024).

- It repeatedly states that there is no information on how climate change will actually impact Joshua trees, ignoring the well-documented impacts already occurring. For example, the review states "the Department does not have information indicating that modeled exposure to climate change will mean that there will be a serious risk that western Joshua trees will likely die, or that populations are likely to cease reproducing and no longer be sustainable at the end of the 21st century." (Status Review at 73). As one peer reviewer bluntly stated in refuting this assertion: "Yes, the department does have that information. Just use the best available science."[39]

- It largely ignores recent climate related changes to Joshua tree habitat, citing recruitment that occurred in the 1990s as evidence that populations are currently stable (Status Review at 49). Numerous studies demonstrate reduced or no recruitment in many areas since that time. Again, a peer reviewer pointed out, this assertion conflicts with actual field data in published studies: "The reality is that +70% of the Joshua trees within the park are already either not recruiting seedlings or are showing reduced recruitment compared to identified, putative climate refugia." [40]

- It describes multiple study plots across broad areas of the species range that *all* (with the

[37] Peer review comments of Jeremy Yoder.
[38] The only peer reviewer to support the Department's recommendation was the reviewer recommended to the Department by San Bernardino County, an entity that has vigorously opposed listing. See Appendix B, page 347 of meeting materials (describing process by which this peer reviewer was chosen). Support from this reviewer for DFW's conclusion comes in a single conclusory sentence ("On the basis of the best scientific information available, I agree with the recommendation of the California Department of Fish and Game (Department) that listing western Joshua tree as a threatened species is not warranted."). Peer review comments of Erica Fleishmann.
[39] Peer review comments of Cameron Barrows.
[40] Peer review comments of Cameron Barrows.

exception of one at Edwards Air Force Base that it acknowledges is unreliable) demonstrate a decline in the number of adults trees and/or a lack of recruitment, but then discounts all these studies as not being of sufficient duration (more than 30 years) or of significant scope to be relied upon (Status Review at 44-46). The law requires the use of the "best *available* science," not the hypothetical science that the Department would prefer exist, but that would take additional decades to complete.

- It profoundly misunderstands and misstates the speed at which anthropogenic climate change impacts are being felt, stating that "Based on fossil records following climate changes approximately 11,700 years ago, the Department expects that any changes in the range of western Joshua tree that are ultimately caused by climate change will likely occur very slowly, perhaps over thousands of years." (Status Review at 113). This is completely at odds with consensus climate science. See, e.g., NASA's climate portal: https://climate.nasa.gov/evidence/ ("ancient, or paleoclimate, evidence reveals that current warming is occurring roughly ten times faster than the average rate of ice-age-recovery warming").

- It completely fails to account for the findings in the recent IPCC reports documenting the severe and accelerating impacts of climate change, or the fact that the range of the western Joshua tree in California is experiencing a prolonged drought that is unprecedented in a millennium and that such droughts will become the norm going forward.

- It downplays the risk of fire to the species, repeatedly declaring the impacts of such fire on Joshua tree habitat to be "temporary" (e.g., Status Review at 115) notwithstanding the fact that numerous studies conclude that post-fire recovery is "entirely unlikely, especially in light of potential changes to regional desert climate in combination with plant invasions and the potential for recurrence of subsequent fires" (Reynolds et al. 2012).

- It downplays the impacts of drought-related herbivory on Joshua trees, finding that "Herbivory and predation result in relatively minor negative impacts overall to western Joshua tree." (Status Review at 92). This conclusion is at odds with the studies it cites showing high mortality (over 50%) of trees damaged from herbivory in drought years, and that such herbivory can affect significant portions of a population (14-28% in one study). Nor does it address the widespread herbivory event that is currently underway across the range of the species that will almost certainly result in large-scale mortality of the species.

- If fails to meaningfully assess whether historic (approximately 30%) and projected (42%) loss of habitat to development would render the species threatened in a significant portion of its range. The status review acknowledges that the majority (50-65%) of habitat for the species in the southern half of its range is on private property, and recognizes that "western Joshua trees and habitats on private property have been very vulnerable to habitat modification and destruction" and that such areas are "at a high risk of habitat modification and destruction in the foreseeable future, and this threat is highest in the southern and western part of western Joshua tree's range, where most of the western Joshua trees on private property occur." It even concludes that "Present or threatened modification or destruction of habitat is a substantial threat to western Joshua tree in California, particularly at renewable energy development sites, on private property, and within the vicinity of existing urban areas in the southern part of western Joshua tree's range." (Status Review at 77-80). Nevertheless, such threats (as are all others) are summarily dismissed because the species is "widespread and abundant." The development threat to the southern portion of the range, when combined with climate and fire, was the basis for one peer reviewer recommending that the southern populations of the species be listed as a threatened ESU.[41]

- It almost completely ignores the combined impacts of the threats facing the species, notwithstanding CESA's requirement to consider whether a species is threatened "by any one *or any combination of*" the relevant factors. 14 C.C.R. 670.1(i)(1)(A). In the status review, this cumulative analysis is relegated to less than a page with no attempt to actually assess how these threats might be additive to each other. (Status Review at 115).

- It sets a standard for "threatened" that completely eliminates the precautionary principal and is at odds with the purposes of CESA. As the courts have repeatedly found, "'[l]aws providing for the conservation of natural resources' such as the CESA are of great remedial and public importance and thus should be construed liberally." (*California Forestry Association v. California Fish and Game Commission* (2007) 156 Cal. App.4th 1535, 1545-1546) Consistent with this mandate, listing decisions should always provide the benefit of the doubt in favor of increased rather than reduced protection. Here, the status review requires near certainty of extinction rather than such risk becoming "likely" in the foreseeable future. Under CESA, a threatened species is one "likely to become an *endangered* species" in the foreseeable future, not one that is "likely to become an *extinct* species" in that timeframe (Cal. Fish & Game Code § 2067). Not only does the Department unlawfully redefine a "threatened species" inconsistent with clear statutory language, if adopted, this standard would all but preclude ever listing a species due to the threat of climate change.

The above examples are only a subset of the flaws with the conclusion of the status review. Fundamentally, the Department appears to believe that a species that is currently "widespread and abundant" can never be considered threatened under CESA, because its numbers and range render it resilient to any threat. This position is simply untenable in a changing climate. One of the foremost Joshua tree researchers and a peer reviewer of the status review succinctly articulated the flaw with Department's position:

> This appears to be the Department's primary, continually repeated, defense for their conclusion that Joshua trees do not warrant any additional state protection. It would be true if the threats were spatially constrained, but climate change is an existential threat, unconstrained by area, and so whether Joshua trees are currently abundant and widespread is a meaningless argument. Climate change is and will continue to impact all Joshua trees throughout their range. Many are already "evolutionarily extinct" populations of only mature adults, with no successful recruitment. Others will be unless we do something.[42]

In sum, the "not warranted" recommendation contained in the Status Review is at odds with the plain language and statutory purposes of CESA, effectively reads the "threatened" category out of the statute, contradicts the input of the majority of independent peer reviewers and fails to comport with the "best available science" standard required by law. Perhaps most importantly, it reflects a profound failure to seriously grapple with the ongoing and certain impacts that climate change is already having on the species.

[41] Peer review comments of Timothy Kranz.
[42] Peer review comments of Cameron Barrows.

We encourage the Commission to review our Petition and previous letters, as well as the peer review comments, which along with other information in the record, clearly demonstrate that the western Joshua trees warrants protection as a "threatened species". The Commission must, in the exercise of its independent obligations under CESA, follow the science and the law, demonstrate true climate leadership, and list the western Joshua tree as a threatened species.

Sincerely,

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UNIVERSITY OF Redlands
CENTER FOR ENVIRONMENTAL STUDIES

June 2, 2022

Samantha Murray, President
California Fish and Game Commission
1416 Ninth Street, Suite1320
Sacramento, CA 95814

Dr. Timothy Krantz, Chair
Environmental Studies Program
University of Redlands
1200 E. Colton Avenue, Lewis Hall 121
Redlands, CA 92373

RE: Agenda Item 5: Petition to list the Western Joshua Tree as a Threatened Species in accordance with the California Endangered Species Act – Support "Threatened" Listing
Submitted via email to fgc@fgc.ca.gov

Dear President Murray and Commissioners:

Thank you for this opportunity to provide these comments regarding the petition to list the Western Joshua Tree as a Threatened species under the auspices of the California Endangered Species Act. I submit these comments in addition to my comments submitted to the California Department of Fish and Wildlife (CDFW) as one of their peer reviewers (Peer Review Comments attached).

The scientific data presented by the CDFW in their Status Review of Western Joshua Tree (*Yucca brevifolia*), dated March 2022, is very good and comprehensive. Yet, contrary to four out of the five peer reviewers, they come to the wrong conclusion when they summarily state that, "The Department recommends that the Commission find the petitioned action to list western Joshua tree as a threatened species to be not warranted." This conclusion, limited to a very brief two paragraph statement, flies in the face of the facts the Status Review so painstakingly presents in the previous 125 pages.

My own peer review focused on the Department's lack of consideration of the appropriateness of listing the WJT as Threatened in its Southern Population—the WJT distribution extending from Palmdale-Lancaster on the west to Joshua Tree National Park to the east (Fig. 4, pg. 17). The Southern Population of WJT should be considered an "Evolutionarily Significant Unit" unto itself, considered separately from the Northern Population extending from Lone Pine-Bishop, northwards along the Eastern Sierra range.

Within the Southern Population, a Threatened species designation, according to the definition under the CESA, is well warranted. The lower elevation portions of the WJT range in the south (northeast of Lancaster, extending to Barstow) already exhibit only 0-1% cover and very sparse distributions. The obligate pollinating moth, *Tegeticula synthetica*, is not present at these lower elevations (Webber 1953, Rowlands 1978, Harrower and Gilbert 2018), indicating that sexual reproduction (plants from seeds) is no longer occurring in this portion of the WJT range and the surviving plants are doomed within their generation lifetimes—within the "foreseeable future" of the Year 2100. The intermediate elevations within the Southern Population have been highly fragmented and cleared within the cities of Palmdale-Lancaster, Hesperia-Adelanto-Victorville-Apple Valley, and Joshua Tree-Yucca Valley-Twentynine Palms. The remaining fragments of habitat across this broad sweep of WJT habitat have been so highly subdivided that the pollinating moths may no longer be able to sustain themselves in such small patches; and the prospects of seed dispersal (measured in meters) is nil. Finally, at the upper elevations of the Southern WJT range, the habitat has been decimated by increasingly large and frequent wildfires. Although the Department states that these wildfires remove just 2.5% of the overall WJT habitat per decade, if one considers these wildfires within just the higher elevation portions of the Southern WJT range, they easily represent 7.5-10% of remaining habitat per decade—such that more than half of this remaining habitat will have been burned by the year 2050. Recovery of these Joshua tree woodlands will require more than a century.

The Status Review itself summarizes the situation: "Considered collectively, the direct and indirect effects of climate change, the direct and indirect effects of [urban] development and other human activities, and the direct and indirect effects of wildfire are interconnected and will affect different portions [the Southern population] of western Joshua tree's range in different ways [very severely], sometimes cumulatively." [Insertions by me]

The Status Review continues with the summary that, "Climate change may reduce recruitment and abundance in southern and lower elevation portions of the [WJT] range, development and other human activities are expected to destroy and modify habitat [in the middle elevations of the Southern WJT range], and fire is expected to kill a [substantial] proportion of trees in [the higher elevation areas of the Southern WJT range]."

Together, climate change has already reduced or eliminated reproduction of WJTs at the lower elevations of their range. Urbanization has already developed and highly fragmented the middle elevations of the WJT range; and wildfires have decimated hundreds of thousands of acres of WJT habitat in the higher elevation portions of their range. These three factors alone, not to mention large-scale solar arrays, invasive species and the lack of the obligate pollinating moths, represent significant adverse cumulative impacts on the WJT.

One does not need to look into the foreseeable future to see if the WJT is, indeed, "threatened". These threats are all occurring now.

Given these facts, as presented in the Department's own Status Review, I urge the Commission to arrive at their own conclusion: that the Western Joshua Tree meets the definition of a Threatened species, as defined according to the California Endangered Species Act, and that they deserve the protections and regulatory safeguards that the CESA affords.

We cannot afford to "wait and see" as these iconic trees continue to decline over the next several decades until there are none. We/You—the Commission must act now to ensure that Joshua trees may continue to exist in their namesake National Park and on other protected lands in California.

Respectfully submitted,

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UNIVERSITY OF Redlands
CENTER FOR ENVIRONMENTAL STUDIES

January 15, 2022

Subject: Peer Review of the California Department of Fish and Wildlife Status Review of Western Joshua Tree

To Whom It May Concern:

Thank you for this opportunity to provide these peer review comments relative to the Draft Status Review of the Petition to List the Western Joshua Tree (WJT) as a Threatened species under the auspices of the California Endangered Species Act (CESA).

The primary purpose of the Status Review is to evaluate the appropriateness of listing the WJT as a Threatened species. According to the CESA, "An endangered species under CESA is one 'which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease' (Fish & G. Code, § 2062). A threatened species under CESA is one 'that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [CESA]' (*Id.*, § 2067). A species' range for CESA purposes is the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com*. (2007) 156 Cal.App.4th 1535, 1551). (Lines 3710-3719)

Given the extent of the range of WJT (10,160 km^2 (3,920 mi^2) to 13,880 km^2 (5,360 mi^2), Lines 1382-1385), and the distribution of WJT within that range (3.1 million and 4.9 million adult western Joshua trees in California, Lines 1459-1465), the designation of WJT as an Endangered species, according to the definition under the CESA, is inappropriate at his time. The appropriateness of listing the WJT as a Threatened species, however, requires further definition of what is meant by the "foreseeable future". As described in the Status Review, the "foreseeable future" with regard to the Threatened species definition is considered to be the 21st century, or by the year 2100.

The California Department of Fish and Wildlife (the Department) Draft Status Review provides a comprehensive and detailed description of the biology of the WJT (pages 5-29), its habitat and ecological parameters (pp. 30-37), its abundance/range and population trends (pp. 38-49), and endangerment factors (pp. 50-85).

These comments address each of these topics as they are presented in the Draft Status Review, with numeric line citations and quotations for reference, as necessary. Finally, I will review the Department's conclusions and recommendations for the Petitioned Action, with my own suggestions as to the appropriateness or not of listing the WJT as a Threatened species under CESA.

Biology of the WJT

The Status Review provides an excellent synopsis of the taxonomy and biology of the WJT. For this peer review, I will limit my comments and analysis to the WJT—

Yucca brevifolia—as opposed to the Eastern Joshua Tree, *Yucca jaegeriana*. (Page 9, Lines 452-457).

The Petition states that the WJT warrants listing as a Threatened species throughout its range in California; but requests the Department consider listing the southern population (YUBR South) as "ecologically significant units", as opposed to the northern extension of WJT (YUBR North)—generally the range of WJT from Inyo County, northward into Nevada and the Great Basin Floristic Province (Page 10-11, Lines 498-508 and Figure 3: Joshua Tree Range in California). As we will see in the discussion of endangerment factors, the levels of threat from land development, energy projects, wildfires and climate change are generally greater in the YUBR South range than the YUBR North range, thus warranting separate consideration of the appropriateness of listing under the CESA.

A key biological factor for the WJT is its obligate pollination mutualism with the yucca moth, *Tegeticula synthetica* (Page 19, Lines 719-730). The yucca moth and WJT are co-evolved to the degree that the WJT is dependent on the moth for sexual reproduction and the moth is dependent on the WJT for its own reproduction. Thus, it is not surprising that, "greater sexual reproduction tends to occur in areas with more *T. synthetica* moths (Harrower and Gilbert 2018). Within the vicinity of JTNP, *T. synthetica* moths were found at elevations ranging from 1,049 m (3,442 ft) to 2,076 m (6,811 ft), but not at the lowest elevation study site that had western Joshua trees at 1,004 m (3,294 ft) or the highest elevation study site with western Joshua trees at 2,212 m (7,257 ft) (Harrower and Gilbert 2018)." (Page 20, Lines 761-767)

Thus, the environmental limits of the yucca moth have a direct bearing on the sexual reproduction of the WJT, and the lower elevation limitations for the moth—most likely reflecting a high temperature threshold and/or low soil moisture tolerance—may indicate that these low elevation WJT populations are already no longer viable and will, with increasing temperatures resultant to climate change, become locally extinct.

Once fertilization of the WJT flowers has occurred and the moth larvae mature, they "fall to the ground below the tree, burrow into the ground, create a cocoon, and enter a period of suspended development called diapause (Pellmyr 2003). Yucca moth larvae are likely able to remain in diapause for several years before pupating into moths; the environmental or other cues that trigger this pupation are currently unknown (Riley 1892, Pellmyr 2003)" (Page 20, Lines 749-753).

Although asexual reproduction does occur in WJTs, particularly after fires and/or at higher elevations, sexual reproduction is essential for maintenance of genetic diversity of the species. Little is known about the life history or survival of yucca moths regarding their survival (or not) after fires, their environmental tolerances to extreme temperatures or moisture, or of their capabilities of locating host plants and dispersal in highly fragmented habitats, such as urbanized, low density WJT habitat in the YUBR South range. These potential endangerment factors relative to the *T. synthetica* moth are not addressed in the Status Review.

Other biological factors that are of critical importance in consideration of the endangerment of the WJT are summarized herein:

- Seed dispersal is very limited: average seed dispersal is ~30m (Lines 805-825)
- Seed germination requires periods of cooler, moist conditions for several years following mast seeding events. "After burial of seeds, several successive years of sufficiently wet and/or cool conditions are likely required to ensure that seeds germinate, and that seedlings reach a sufficiently large size (perhaps at least 25 cm) before the arrival of a period of hotter and/or drier conditions. This period of several successive years of sufficiently wet and/or

cool conditions must occur relatively soon after a mast seeding event, because western Joshua tree seeds do not remain viable in the soil for long periods of time." (Lines 1077-1085)

- After germination takes place, seedlings require long periods of time, perhaps as much as 30-50 years, to reach reproductive maturity. "After a seedling has become established, it must survive a long period of time (perhaps 30-50+ years) to reach reproductive maturity. A minimum rate of recruitment is necessary to keep populations from declining (Wiegand et al. 2004)." (Lines 1083-1086)

These three biological factors all conspire to create a cumulative adverse impact on WJT health and viability in the face of the impacts of climate change: 1) that WJT seed dispersal is extremely limited and that dispersal to more northerly or higher elevation potential habitat will not keep pace with increasingly extreme high temperatures and drought; 2) the conditions of higher temperatures and drought at lower elevation WJT locations will adversely impact seed germination; and 3) the time from germination to reproductive maturity will be very slow, especially given the likelihood of increasingly severe heat and drought episodes, and the increasing frequency and severity of fires in the higher elevation populations.

Thus, just based on these biological requirements alone (not considering the impacts of land development in the middle elevation populations of the YUBR South range), we can expect the continuing loss of sexual reproduction in the lower and upper elevation populations of WJT; and an inability of WJT to adapt to these environmental extremes by dispersal to more northerly or higher elevation potential habitat.

WJT Habitat, Range and Ecological Parameters

The Status Review describes the pre-historic range of WJT: "Fossil evidence indicates that Joshua tree was more widespread during the late Pleistocene period (22,000 to 13,000 years before present) than it is today, with its range at that time extending south of its present range farther into southern California and Arizona, and likely also into northwestern Mexico (Rowlands 1978, Holmgren et al. 2010, Cole et al. 2011, Smith et al. 2011). The apparent reduction in Joshua tree range from the late Pleistocene period to modern times suggests the population trend of Joshua tree across its entire range has been in decline." (Lines 1483-1488)

The contraction of WJT range in post-Pleistocene times has seen some expansion of WJTs to the north and into the Great Basin, and into higher elevation habitats on the southeastern Sierra Nevada slopes and the northern slopes of the Transverse Mountains and Little San Bernardino Mountains (Joshua Tree National Park). These transmigrations of the species have taken place over several thousands of years.

The Status Review states in its Executive Summary that, "Predicted suitable habitat for western Joshua tree based on 20th century climate conditions will likely remain in some areas at the end of the 21st century as refugia, and newly appear to the north and in higher elevation areas, although western Joshua tree is unlikely to colonize areas with newly suitable climate conditions quickly." (Lines 202-206)

Record high summer temperatures in recent years are already being measured in the lower elevations of the WJT range and increasing temperatures and overall reductions in precipitation will lessen recruitment of WJTs in those areas. For WJTs to "newly appear" to the north and in higher elevation areas implies that there would be some means of long-distance dispersal. During Pleistocene times, with much more temperate conditions than present, WJTs were dispersed over significant distances by giant ground sloths (Lines 857-878), whereas dispersal distances by desert packrats and other rodents is measured in meters and would be ineffective for WJTs to adjust to rapid climate change.

This Peer Review finds that the total range estimate of 10,160 km^2 (3,920 mi^2) to 13,880 km^2 (5,360 mi^2) for the WJT is reasonably accurate. Using the Department's WJT range map (Figure 4. Joshua Tree Absolute Cover), one can readily see that the higher WJT cover estimates (>1-5% and >5%) are all in the upper elevation range of the species, extending from the southeast Sierra Nevada slopes, the extreme western edge of the Mojave Desert west of Palmdale-Lancaster (where there is some supplemental precipitation through the Tehachapi Pass), and along the north aspect slopes of the San Gabriel, San Bernardino and Little San Bernardino Mountains.

Lower elevation areas of the WJT range are already exhibiting lower absolute cover and reduced seedling germination and recruitment. As the Status Review summarizes:

Declines due to reduced seedling recruitment will likely be most severe in areas of western Joshua tree's range that are already near the thermal and water stress tolerance limits for recruitment, such as at hotter, low-elevation areas. (Lines 1970-1972)

The compounding endangerment factors of climate change are described further by the Department: "The climatic conditions across western Joshua tree's range have already changed and will continue to change as a result of ongoing global carbon emissions. The Department expects that the direct effects of climate change (e.g., increased temperatures and decreased total water availability locally) will likely contribute to a decline in populations of [WJT] within California through the end of the 21st century… The primary reasons for the decline of populations of [WJT} within California may be the incremental contribution of climate change to high intensity and longer duration droughts, coupled with extreme high temperatures during summer months, which may have direct physiological effects on [WJT] plants. These effects of climate change will likely reduce [WJT] seedling recruitment, and to a lesser extent also increase adult [WJT] mortality, leading to population declines as recruitment does not keep pace with mortality. Climate change may also contribute to the decline of populations of [WJT] via other more indirect mechanisms, including increased impacts from small mammals during drought, reduced growth due to lack of low winter temperatures, increases in fire activity, or effects on pollinating moths…" (Lines 1914-1930).

Furthermore, "There may be a time delay between the time when an area becomes no longer suitable for a species (crossing an extinction threshold) and when that species is no longer present, (Tilman et al. 1994, Kuussaari et al. 2009, van Mantgem et al. 2009, Svenning and Sandel 2013, Figueiredo et al. 2019). Extinction processes often occur with a time delay and populations living close to their extinction threshold might survive for long periods of time despite local extinction being inevitable (Hanski and Ovaskainen 2002, Lindborg and Eriksson 2004, Helm et al. 2006, Vellend et al. 2006, Malanson 2008, Cronk 2016). Because western Joshua tree is a long-lived species, adults could persist for decades or longer in areas that are no longer suitable for recruitment, or recruitment may continue, but at rates that are ultimately insufficient to maintain the species. Although these areas may appear occupied, the presence of western Joshua tree may merely represent a delayed local extinction. (Lines 2018-2029)

Thus, when one re-examines the range of YUBR South as illustrated in Figure 4, one can see that fully half of the total YUBR South distribution may already be functionally extinct—that is, non-reproductive at rates that can sustain the population in those areas in the "foreseeable future" (the 21st century).

<u>Endangerment Factors</u>

The Status Review examines three primary factors affecting the survival and reproduction of the WJT: climate change, [land] development and other human activities, and wildfire. Other factors, including invasive plants, herbivory and predation, and human use and vandalism are not considered to be significant endangerment factors unto themselves and are not discussed further in this Peer Review.

Climate—

The potential impacts of climate change have been described in the previous section of this peer review. Several climate models are presented in the Status Review: Thompson et al. 1998, Shafer et al. 2001, Dole et al. 2003, Cole et al. 2011, Barrows and Murphy-Mariscal 2012, and Sweet et al. 2019. The first four models evaluate both Eastern and Western Joshua Tree species; and the last two are focused on WJT population models for JTNP and vicinity.

The Status Review summarizes the models' findings: "The species distribution modeling efforts that have been conducted for Joshua tree suggest that climate change could cause substantial reductions in areas with 20th century suitable climate conditions for the species at the southern parts of western Joshua tree's range, including within JTNP. These species distribution modeling efforts also suggest that substantial additional areas of 20th century suitable climate conditions may become available for western Joshua tree to the north, particularly in Nevada (outside of the scope of CESA) but also in some parts of eastern California, although **the species is unlikely to naturally colonize these areas in the foreseeable future.**" [Bold highlight added by the Peer Reviewer]

The models all indicate a contraction of WJT range from lower elevation slopes, where extreme summer high temperatures and increasing drought will cause those areas to become locally extinct, toward higher elevation or northerly areas characterized by cooler temperatures and more precipitation. The Status Review is correct, however, in qualifying that "the species is unlikely to naturally colonize these areas in the foreseeable future," because of its inability to disperse such long distances over inhospitable terrain, given the species' short dispersal range (~30m, op.cit. under Biology of the WJT).

Land Development—

Land development in the form of clearing the land for agriculture, housing and urban development, or energy projects represents a direct and permanent loss of WJT habitat. Most land development in the Mojave Desert region occurs on private land in the YUBR South range.

The Status Review mentions large-scale clearing of land in the western Mojave Desert portion of the range for dry farming and agriculture during the early 1900s and how these areas have shown little or no WJT recruitment since those times. Much of that area has since been developed for housing and urban development in the cities of Palmdale and Lancaster.

The Status Review reports that, "Much of the recent western Joshua tree habitat modification and destruction has been the result of ongoing urban development, typically on private property within the general vicinity of existing developed areas. The USFWS (2019) reported that approximately 50% of the southern part of western Joshua tree's range (YUBR South) is on private property, 2% of the northern part of western Joshua tree's range (YUBR North) is on private property, with the remainder predominately on federal land. WEST Inc. (2021b) found a higher percentage of western Joshua tree's range on private property than the USFWS did, with approximately 65% of the southern range on private property…" (Lines 2562-2570)

An unpublished recent study conducted by a Geographic Information Systems (GIS) research group under my direction at the University of Redlands found that 420 mi^2/677 km^2 of WJT habitat within the cities of Palmdale, Lancaster, Yucca Valley, Joshua Tree, Twentynine Palms, Victorville, Hesperia, and Apple Valley were developed within those jurisdictions between 1984 to 2021 (Krantz et al. 2021). This analysis examined decadal aerial photo imagery, identifying developed areas within those jurisdictions, but it did not include isolated blocks of open space that may represent occupied WJT habitat. In fact, the remaining undeveloped blocks within these cities are so highly fragmented that they likely no longer represent ecologically viable habitat. Given the extremely short distance dispersibility of WJT seeds and isolation from potential yucca moth pollinators, these remaining patches of WJT habitat should be considered ecologically unviable and essentially extirpated.

Within the foreseeable future (the year 2100), if not already, the undeveloped areas of these incorporated cities should be considered functionally extinct. Most of the smaller fragments of extant habitat are already ecologically unviable and would, therefore, meet the definition of functionally extinct, as described in the previous section of this peer review.

City	Area (mi^2)
Palmdale	106.3
Lancaster	94.54
Victorville	74.01
Hesperia	72.78
Adelanto	52.88
Apple Valley	77.08
Joshua Tree	37.04
Yucca Valley	39.83
Barstow	41.34
Twenty-nine Palms	58.76
	654.56 mi^2

If one considers the incorporated cities within the YUBR South range as developed habitat within the foreseeable future, then a total habitat loss of 654.56 mi^2 should be considered extirpated and functionally extinct.

Fifteen renewable energy projects were granted §2084 take exemptions during the hearings to establish the WJT as a candidate species for listing under the CESA. According to an analysis done by the USFWS using U.S. Environmental Protection Agency Integrated Climate and Land Use Scenarios projections, between 22% and 42% of the habitat within the southern part of western Joshua tree's range may be lost by the year 2095 due to urban growth and renewable energy development. (Lines 2641-2645)

Wildfire

Wildfire, although a defining component in many of California's ecosystems, is a relatively rare phenomenon in the Mojave Desert, but fire frequency and intensity has increased dramatically in recent decades, especially in the period from 2001-2020, as illustrated in *Figure 9: Fires within the California Range of Western Joshua Tree, 1900-2020* (CALFIRE 2021) of the Status Review.

Within the WJT range, "Fire is unevenly distributed in the Mojave Desert, and fire occurrence tends to align with distinct precipitation regime boundaries, with most large and recurring fires occurring in areas that have a relatively high amount of precipitation in summer (Tagestad et al. 2016). Fuels tend to be more available, and fires tend to be more frequent and severe at higher-elevation areas of the Mojave Desert, and the availability of fuels and frequency of fires is somewhat lower at middle elevation areas, and still lower at the low elevation areas of the Mojave Desert (Brooks et al. 2018). (Lines 2683-2690)

The size, intensity and frequency of fires in the YUBR South range are the result of higher fuel loads in the higher elevation portions of the species' range and increasing drought and higher summer temperatures—characteristics of climate change. The GIS study completed by Krantz et al. (unpublished, 2021), using the same CALFIRE database as cited in Figure 9, above, estimated that between 1980-2019 a total area of 950km^2 of WJT habitat was burned within the YUBR South range, representing approximately 8% of total WJT habitat, but as much as 12.9% of YUBR South distribution.

Wildfire impacts on YUBR habitat are severe. As cited in the Status Review, "Western Joshua tree populations are very slow to recover from fire. Minnich (1995) observed a 47 year chronological sequence of 13 burned Joshua tree woodland sites within JTNP that were similar, but that had burned at different times in the past. Minnich (1995) found that 64% to 95% of western Joshua tree stems were fatally damaged in all but one of the sample sites, and western Joshua tree cover and density remained low in burned sites compared with unburned sites, even 47 years after burning."

Smaller WJT plants (<0.5m) are almost entirely killed by fire, but even taller, mature trees are largely killed above ground. These may sprout vegetatively after fires, but these sprouts may take 30-50 years before reaching sexual maturity and producing flowers.

The Department summarizes the impacts of wildfire on the WJT as follows: "Wildfire is a substantial threat to western Joshua tree and invasive plants contribute to that threat, but wildfire does not affect the entire range of the species evenly, does not necessarily burn through habitat in a uniform, high-intensity way, and does not typically result in the complete elimination of western Joshua tree from burned areas. For these reasons, wildfire is likely to reduce the abundance of the species, but it is unlikely to result in a serious danger of elimination of the species throughout a significant portion of its range. Nevertheless, because western Joshua tree recruitment from seed is rare, and because the species takes a long time to reestablish in burned areas, wildfire causes long-lasting negative effects in burned areas. The Department expects that the impacts from continuing and increasing wildfire activity in the Mojave Desert and surrounding areas will cause ongoing gradual reductions in the size of at-risk populations of western Joshua tree within California, but the range of the species is unlikely to be affected by wildfire in the foreseeable future, because western Joshua tree is unlikely to be completely eliminated from affected areas due to its high abundance and widespread distribution." (Lines 2893-2907)

This conclusion fails to account for several factors. With increasing fire frequency and intensity, vegetative sprouts of WJTs are largely eliminated from these areas if the subsequent fire occurs before the sprouts are more than 2-2.5m high—the height at which Southern WJTs first flower (Rowlands, 1978). Fires eliminate seed stock in the soils and remove potential nursery plants, further reducing the potential for flowering, seed production and seed germination for the "foreseeable future"—the end of this century. Finally, studies cited in the Status Review indicate that the yucca moth, upon which the WJT is dependent for pollination, is already rare at these higher elevations of the WJT range (Harrower and Gilbert 2018). With the elimination of flowering YUBR plants for 50+ years (before vegetative sprouts will flower again), these areas are essentially lost for their requisite pollinators.

Conclusions Regarding Listing the WJT as a Threatened or Endangered Species

It is clear that the Western Joshua Tree does not meet the definition of an Endangered species in accordance with the CESA: a species "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range." The question before the Department and the focus of this Status Review is whether the WJT meets the definition of a Threatened species, a species "that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA]." In this Status Review, the foreseeable future is considered to be the 21st century, or through the year 2100.

Furthermore, the focus of this Peer Review is on whether the southern extent of the populations of WJT (YUBR South) should be listed as Threatened "ecologically significant units" unto themselves. The conclusion of this Peer Review is that such a designation is appropriate because the YUBR South populations are subject to much greater threats than the northern WJT populations (YUBR North). The facts and research presented in this Status Review demonstrate that the potential for the YUBR South populations to become Endangered over a significant portion of their range (the YUBR South range) within the foreseeable future is very real.

The primary threats to the YUBR South populations of WJT are three-fold:

- Climate change
- Urbanization and land development
- and Wildfires

Each of these endangerment factors will be discussed briefly and summarized below.

Climate Change

The impacts of climate change are already manifest in the YUBR South populations, with higher summer temperatures and more extreme drought, particularly in the lower elevations of the YUBR South range. As stated in this Status Review, "climate change could cause substantial reductions in areas with 20th century suitable climate conditions for the species at the southern parts of western Joshua tree's range, including within JTNP."

As the climate models cited in this Review have found, the impacts of increasing heat and drought will be most severe at the lower elevations of the YUBR South range.

The Status Review goes on to state that, "These species distribution modeling efforts also suggest that substantial additional areas of 20th century suitable climate conditions may become available for western Joshua tree to the north, particularly in Nevada (outside of the scope of CESA) but also in some parts of eastern California, although the species is unlikely to naturally colonize these areas in the foreseeable future."

The Department is correct in noting that as the climate warms and low elevation areas of the WJT become uninhabitable for the species, other areas to the north and at higher elevations may develop suitable climate conditions; but the Department is also correct in stating that the species is unlikely to naturally colonize these areas in the foreseeable future (by the Year 2021) due to its very limited dispersibility (~30m).

It will be virtually impossible for WJT in the southern populations to disperse over these relatively few decades to the northern YUBR populations to adjust to climate change. As far as Southern YUBR plants are concerned, dispersal to newly suitable habitat in the YUBR North range is not possible. They will have to disperse/migrate to the higher elevation, cooler, moister habitats of the slopes along the southern edge of the YUBR South range, which we will see below, is also impossible.

In fact, the lower elevation populations of southern WJT are already experiencing very low reproduction rates and those individuals are not maturing to achieve mature flowering plant status, as illustrated in Figure 4 of the Status Review. Furthermore, there is evidence that the obligate pollinator, *T. synthetica*, may already be declining or absent from the lower elevation WJT populations, implying that these areas cannot sexually reproduce (Harrower and Gilbert 2018) and, therefore, cannot produce viable seeds for dispersal. The lower elevation portions of YUBR South should already be considered ecologically and functionally extinct.

To visualize the extent of the impact of climate change on the YUBR South metapopulation, the entire area shown as yellow on Figure 4 will be functionally extinct within the foreseeable future. Yes, there will be islands of refugia in the isolated mountains north of Barstow and northeast of Lancaster, but these islands will be reproductively and ecologically isolated to the extent that they are biologically doomed if current climate trends continue, as the climate models cited in the Status Review all predict.

Urbanization and Land Development

As described earlier in this Peer Review, urbanization and land development in the desert cities of the southern Mojave Desert represent an enormous and permanent conversion of WJT habitat. Development and fragmentation within the incorporated city limits alone represent more than 650 square miles of habitat loss. This does not include the clearing and destruction of the 15 large-scale renewable energy projects that were granted §2084 take exemptions during the hearings to establish the WJT as a candidate species for listing under the CESA, nor does it include the expansive developments of rural "ranchettes" and other associated developments in the unincorporated communities of Phelan, Oak Hills, Baldy Mesa, Lucerne Valley, and Pioneertown, to name just a few. (See attached Image of the Unincorporated Communities)

Most of this development, from the Palmdale-Lancaster area in the western portion of the YUBR South range, to the cities of Yucca Valley and Joshua Tree at the eastern limit of the YUBR South range, extends across the middle elevations of the southern WJT habitat. Remaining fragments of occupied habitat within these city limits are, once again, functionally extinct. That is, extant WJTs on these remaining patches are now totally isolated, unable to disperse to higher ground in the face of warming temperatures and increasing drought. This isolation is compounded by the fact that they require the presence of yucca moths for pollination and production of viable seeds; and even if pollination is successful, the dispersal of seeds across the fragmented urban landscapes becomes increasingly unlikely, if not impossible.

Furthermore, the development of the wide swath of the middle elevations across the southern flank of YUBR habitat effectively isolates the entire lower elevation populations from any chance of dispersal across the urban barrier to reach the cooler, moister suitable habitats in the face of climate change. This compounds the effective isolation of the lower elevation populations, reinforcing their functional extinction.

Wildfires

Finally, we have the fact of increasing frequency, size and severity of wildfires in the southern WJT range. As noted in the Status Review (see Figures 9 and 10), the area burned by wildfires has more than doubled in the last three decades in comparison with the previous 90 years. Most of those fires and the largest of them have occurred in the higher elevations of the YUBR South range.

For example, the Sawtooth Fire Complex near the community of Pioneertown (readily visible on Figure 9 in the southeast portion of the range), consumed 61,700 acres of high quality, high density WJT woodland habitat in 2006. Now, 15 years later, the area is still nearly devoid of WJT plants, with no mature Joshua trees in the burn area and very few vegetative sprouts. The area is essentially "dead" for many generations to come, with no flowering WJT plants. The lack of mature, flowering Joshua trees equates to no yucca moths. The absence of the flowering host plant will eliminate the yucca moths from the area for many moth generations, certainly for the "foreseeable future" through the Year 2100.

The WJT and yucca moth are obligate co-dependent species. This represents a significant and cumulative adverse impact, with very serious implications for WJT in wildfire areas. It means that these areas, even if they recover by vegetative reproduction from the fire, will remain without their obligate pollinators for many decades or even beyond 2100.

The fact that these wildfires are almost entirely in the higher elevations in the southernmost extent of the YUBR South range effectively removes the climate refugia that lower elevation populations will need, if they are capable of dispersal to these cooler, more hospitable habitats at all.

Final Peer Review Recommendation

Thus, we find that the Southern WJT populations are faced with a triple cumulative threat: their lowermost populations are already functionally extinct due to climate change; even if they could disperse toward higher, more equable climate, they are blocked by sprawling development across their middle elevations; and finally, the remaining high ground along the south edge of the YUBR range is being consumed by wildfire and will be biologically non-functional for the foreseeable future and beyond.

Together, these three impacts represent significant adverse cumulative impacts to the YUBR South populations ***throughout their range.*** Referring back to the definition of an Endangered species: one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range;" I find that the data and studies presented in this Status Review do, indeed, support a finding that the YUBR South population of WJT meets the definition of a Threatened species: one that, "although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts required by [the CESA]."

Management Recommendations and Recovery Measures

If the Department finds that the WJT does not warrant protection as a Threatened species under the CESA, then other regulatory and recovery measures shall be necessary to ensure that the species does not become a Threatened species.

The Department lists a range of management recommendations and recovery measures (Lines 4056-4088). A few of these measures are practical and may be implemented, while many are vague, impractical and unenforceable. I will briefly review the recommendations below.

1) Continue efforts to drastically reduce greenhouse gas emissions. Of course!

2) Complete a western Joshua tree conservation plan in collaboration with partners and stakeholders. The WJT Conservation Plan should include detailed protocols for environmental assessment and mitigation of proposed projects that have the potential to impact WJTs.

3) Preserve western Joshua tree habitat in areas with high recruitment and areas projected to be climate refugia. Dedicate State funds toward acquisition and protection of otherwise unprotected high-value WJT habitat.

4) Minimize wildfire risk to western Joshua tree woodlands, particularly following one or more years of high precipitation, and particularly in areas with high recruitment and areas projected to be climate refugia.

Would this mean weed-whacking non-native flash fuels over hundreds of square miles? Impractical.

5) Manage fires aggressively to protect Joshua tree woodlands, particularly in areas with high recruitment and areas projected to be climate refugia. Not practical.

6) Implement ways to disincentivize destruction of western Joshua tree habitat, particularly in areas with high recruitment and areas projected to be climate refugia. What sort of "disincentives" are contemplated here? Not practical.

7) Implement state and/or local laws and regulations that limit unmitigated impacts to high quality western Joshua tree habitat. Not practical unless accompanied by enforceable, regulatory measures. In this circumstance, it is my recommendation that the Department sanction the WJT in its YUBR South distribution as a Regulated species, like regulated game or fish animals.

8) Continue scientific investigations into the biology, ecology and genetics of western Joshua tree and the species and habitats upon which it depends:

- o Collect and analyze range-wide demographic information to detect baseline population trends and identify populations that do not appear to be recruiting new individuals at sustainable levels.
- o Implement long-term range-wide direct population monitoring and vegetation monitoring with emphasis on leading and trailing edges and highest and lowest elevations of the species' range.
- o Produce and improve upon range-wide species distribution models for western Joshua tree.
- o Produce range-wide species distribution models for western Joshua tree's obligate pollinating moth.
- o Investigate the significance of multi-year and multi-decade climate variability patterns for western Joshua tree recruitment.
- o Investigate ways to control the spread and abundance of invasive plant species to reduce wildfire risk.
- o Investigate the feasibility, practicality, and risks of implementing assisted migration and translocation.

Of these last measures, all are necessary to provide basic baseline monitoring information for the WJT. Of particular importance would be to promote further investigations and biological research on the obligate pollinating moth, *Tegeticula synthetica*. The Status Review presents some basic information about the life history of the moths, but certain information pertinent to this Petition is lacking, such as: what are the temperature and moisture thresholds for the species? There is some indication that the moths are rare or absent at the lower and upper elevations of WJT. What are the limiting factors that determine its range? These are ***obligate***, co-dependent species. Therefore, the limiting environmental factors of one have direct consequences on the distribution of the other.

One of the more practical measures, not mentioned above, would be to require consideration of projects within the YUBR South range to undertake environmental impact assessments in accordance with the CEQA guidelines. The Status Review describes this alternative (Lines 4007-4019), but, without formal listing, there would be no requirement that projects analyze potential impacts to WJT.

If, however, the State designated the Southern WJT as a Regulated species, similar to other game and fish animals (§2116 *et seq.* of the Fish and Game Code), then CEQA review or at least regulatory review would be required, and permits would be necessary for removal of WJT plants on impacted properties. By this means, projects that have the potential to adversely impact WJTs would have to consider avoidance of WJTs to the extent possible and mitigation of impacts to WJTs in the case that Joshua trees cannot be avoided.

Regarding mitigation for removal of WJT, the trees may be successfully transplanted. San Bernardino County enacted a Joshua tree policy in the late 1980s that required developers to avoid the trees if possible, translocate them or make them available for translocation if necessary. During this time and through the 1990s, I worked with a landscape company, *NativeScapes*, transplanting Joshua trees using a 24-inch and

36-inch hydraulic tree spade. Joshua trees have a fibrous root system, like palm trees, and they can be excavated and placed in 36-inch or 48-inch boxes for re-location to protected areas on- or off-site. Trees as tall as 10-12 feet with moderate branching can be transplanted.

Once the trees are installed, larger trees must be tethered to stabilize the weight of the tree; and transplants must receive additional irrigation maintenance through the first two summer seasons until the fibrous root system is reestablished.

For this practice to be effective, it is essential that the State designate the WJT as a regulated species. Otherwise, if left to the individual county and city municipalities, the southern WJT would have only inconsistent standards for environmental review and mitigation. Standardized environmental assessment and mitigation measures may be included in the WJT Conservation Plan recommendations, described in #2 above.

The WJT Conservation Plan may also identify conserved areas for translocation of Joshua trees in anticipation of climate change, such as the Pioneertown Preserve. The Pioneertown Preserve is a 25,500-acre natural preserve managed by The Wildlands Conservancy. The area was burned during the Sawtooth Complex Fire in 2006 and native WJT woodland habitat has been very slow to recover. Translocation from lower elevation sites in the cities of Yucca Valley and Joshua Tree to the Pioneertown Preserve would facilitate WJT recovery from the fire, as well as help with climate adaptation by moving plants to higher elevations. Such translocation sites would require long-term management for fire and fuel modification, non-native grass and fuels management around the base of the trees, and irrigation maintenance until such trees are re-established.

Other potential "climate refugia" may be identified in the Conservation Plan on State, Federal or private lands across the WJT range.

This concludes my Peer Review comments on the Status Review of the Petition to List the Western Joshua Tree. Thank you again for the opportunity to provide these comments. If the Department has any further questions in these regards, please do not hesitate to reach out to me at the numbers/email below.

Sincerely,

Dr. Timothy Krantz
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[redacted]

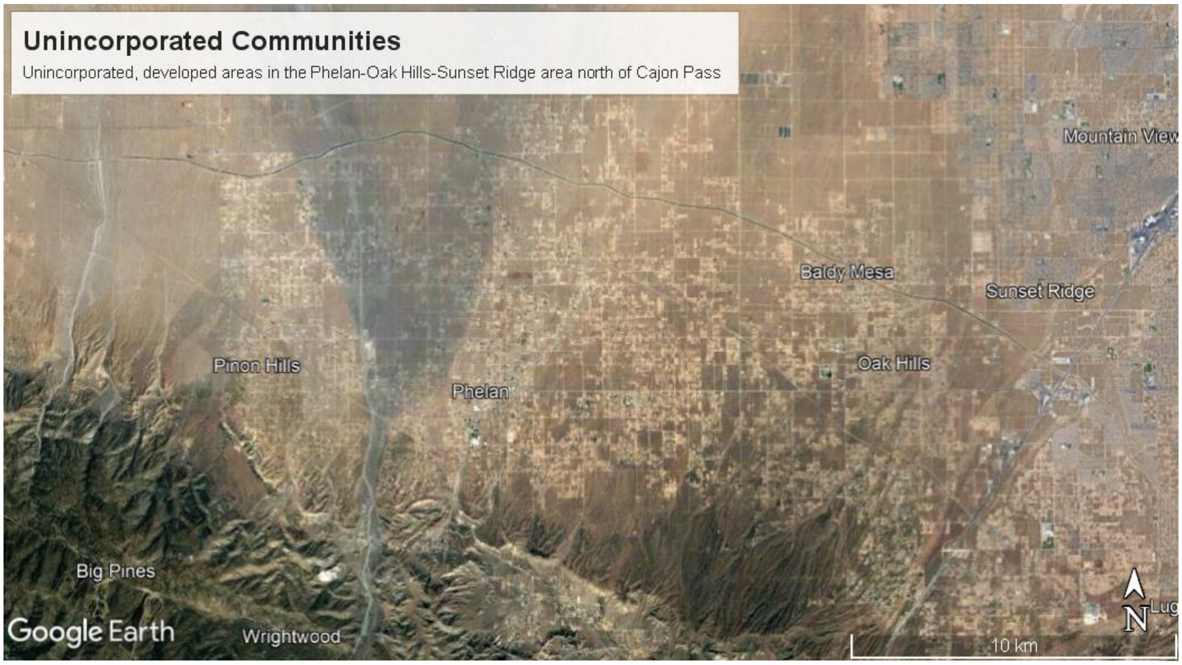

Figure: Unincorporated Communities in the Phelan-Baldy Mesa Area.

Note the extensive land clearance for small ranches and rural residential development. These communities are entirely within high density WJT woodland habitat. Estimated WJT habitat loss just within this image is approximately 300 km^2. The even more densely developed cities of Hesperia and Adelanto are immediately east of the image.

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Kenneth S. Norris Center for Natural History
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California Fish and Game Commission June 2, 2022
Re: Western Joshua tree status review

Dear President Murray and Commissioners:

Thank you for granting Joshua trees interim protection in 2020. With the boom in development and solar industry, this was a key decision towards securing Joshua tree populations. The continued protection of Joshua trees is very important if we want to maintain population viability moving forwards.

I am a Joshua tree climate change ecologist and I disagree with the recent status review by the CADFW which concluded that protections are not warranted. I agree with one of the reviewers who stated that the review reads as an argument for not listing the species as threatened as opposed to an objective analysis of the science. There is an underestimation of risk throughout the report as well as missed opportunities to answer questions posed by the department with scientific data that is already available.

Firstly, numerous peer-reviewed climate modeling studies of Joshua tree distribution were largely dismissed because they were species distribution models, which in fact do provide very useful predictive ecological data (this was a similar issue in the federal status review which denied Joshua trees listing, and was actually overturned). The report continually states that there is no information on how climate change will actually impact Joshua trees or that populations may cease to be reproducing in certain locations. The status review also claimed a lack of demographic and climate data, however, they cited my peer-reviewed Joshua tree climate demography research over 20 times in the report. This is confusing as my work directly demonstrates these impacts.

In my research[1] I found no pollinators or seedling recruitment at either the hottest/driest location or the coolest locations along a climate gradient at the southern-most range for Joshua trees. This suggests that the southern range edge of Joshua trees is contracting but also not shifting upwards into higher elevation. I also found high tree mortality at both locations. Perhaps climate change will make those higher locations more hospitable to future Joshua trees, but they are also locations of high fire threat due to invasive grass species. Regardless, seedlings and their obligate pollinators are not currently moving upslope into those areas. In my recent research on Joshua trees and their soil mycorrhizal symbionts[2], I found that fungal species change along an elevation gradient and that these different species interactions may have significant consequences for Joshua drought tolerance and seedling recruitment at range edges. These studies document important components of Joshua tree ecology that are compromised under climate conditions and will only multiply with largescale tree removal on private lands across CA.

The status review ignores these and other recent data on climate related impacts to Joshua tree habitat, instead utilizing recruitment data from the 1990's as a basis to assert that Joshua tree populations are healthy and stable, assertions that conflict with more recent data from myself and others that show

[1] Harrower, J. and G. S. Gilbert. 2018. Context-dependent mutualisms in the Joshua tree–yucca moth system shift along a climate gradient. Ecosphere 9(9): e02439. 10.1002/ecs2.2439.
[2] Harrower, J.T. and G.S. Gilbert. 2021. Parasitism to mutualism continuum for Joshua trees inoculated with different communities of arbuscular mycorrhizal fungi from a desert elevation gradient. PLOS ONE. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0256068

that the majority of Joshua trees at their southernmost ranges (hottest and driest) are either not recruiting seedlings or have reduced recruitment.

Overall, throughout the report, there is a pattern of refuting or misunderstanding solid data. The requirement is for the state to use the best available science to base its recommendations for listing as opposed to putting off protections for future decades until more data can be collected. The profound understatement of the impact of climate threats as summarized by the department is concerning and is not representative of actual climate science (for example the recent findings in the IPCC report). There is also no discussion of the combined and additive impacts of the many threats that are listed. The general dismissal argument that Joshua trees are widespread and abundant and thus not warranting protection is a severe short sight by the department and a meaningless argument.

I was born in the Mojave and have spent over a decade researching Joshua tree habitat within or near the national park. My family lives locally, and I have experienced firsthand how bad the local management of Joshua trees is by the town of Yucca Valley and San Bernardino County. With the booming Airbnb economy (Joshua tree is one of the top 2 fastest growing markets in CA) we need to effectively manage Joshua tree habitat given the increased interest in development. While I am happy to see that San Bernardino passed an ordinance in March 2022 which raises the fines for illegally removing Joshua trees, I suspect that this has more to do with an attempt at demonstrating that the county is now attempting to protect Joshua trees and that they are hoping that this will convince the commission that there is no need for continued state protection. It is worth noting that this doesn't change the exemptions for permit issuance, and regardless, enforcement by the county has always been very low. Additionally, this also does nothing to address the severe climate change and fire threats to Joshua tree populations.

Maintaining healthy Joshua tree populations is also an important aspect of the tourism economy. I have given numerous public talks on Joshua tree ecology around the country to thousands of people, many whom have visited or plan to visit the Mojave Desert. The typical stated reason that people want to visit the area is their desire to see actual living Joshua trees.

Joshua trees would be the first species protected in California due to climate change. It is important that California continues in its legacy of true climate leadership - we don't have the time to wait for more data to protect these species. As a majority of the Joshua tree habitat in the southern half of its range is on private property in CA, it is vulnerable to threats by largescale development projects. I hope that you follow the best available science with your decision and choose to prioritize the protection of this iconic species for our future generations.

Sincerely,

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San Bernardino Valley
Audubon Society

June 2, 2022

Samantha Murray, President
California Fish and Game Commission
1416 Ninth Street, Suite1320
Sacramento, CA 95814

Submitted via email to fgc@fgc.ca.gov

RE: Agenda Item 5: Petition to list Western Joshua Trees as threatened under the California Endangered Species Act – Support "Threatened" Listing

Dear President Murray and Commissioners:

Thank you for the opportunity to provide comments on your upcoming decision as to whether listing western Joshua trees as "threatened" under the California Endangered Species Act (CESA) is warranted (Fish & G. Code, § 2075.5).

The undersigned organizations, which represent hundreds of thousands of people throughout California, strongly support continued state protection of the western Joshua tree. We urge the Commission to adopt a finding that listing of the species *is* warranted and officially add the species to the list of Threatened Species. Doing so would be a demonstration of true climate leadership, as the western Joshua tree would become the first species protected under CESA primarily due to the threat of climate change.

Our state's western Joshua trees are being profoundly impacted by human activity, most directly from climate change and habitat loss, but also from wildfire, drought and invasive species, each of which are exacerbated by climate change. Protections under CESA would greatly help protect western Joshua trees from direct habitat loss as well as foster recovery actions by the California Department of Fish and Wildlife (DFW) and other state and local agencies. These protections are necessary to ensure that this iconic species continues to inhabit California and inspire future generations.

While much of the western Joshua tree's range is on public lands, over 40% of its California range is on private land, of which only a tiny fraction is protected from development. Outside of Joshua Tree National Park, areas of federal land that are home to the species are subject to poorly regulated activities including off-road vehicle use, cattle grazing, power and pipeline rights-of-way and large-scale energy projects that consume or degrade habitat.

The Joshua tree's ability to colonize new habitat at higher elevations or latitudes is extremely limited and no such range expansion is yet occurring, even as the lower elevation and southern edge of its range is already contracting in the face of a warming climate. The convergence of factors necessary for recruitment results in successful establishment of new Joshua tree seedlings only a few times a century. Such recruitment has already largely stopped at the drier, lower limits of the species' range.

In this context, climate change represents an existential threat to western Joshua trees. The western Joshua tree in California will lose upwards of 90% of its range under likely climate scenarios. There is no safe refuge for western Joshua trees, as the higher elevation areas in which Joshua trees are projected to best be able to survive increasing temperatures and drying conditions are at great risk of fire due to the prevalence of invasive non-native grasses. Prolonged droughts, which are projected to occur with greater frequency and intensity over the coming decades, will not only preclude recruitment across ever-greater areas of the species' range, but will lead to higher adult mortality, either directly due to temperature and moisture stress or indirectly due to increased herbivory from hungry rodents lacking alternative forage. Further, it is uncertain whether the western Joshua tree's pollinating moth will be able to keep pace with a changing climate. Absent the pollinating moth, Joshua trees will not be able to produce seeds, meaning there will be no juvenile trees to replace older trees as they die off.

Additionally, the western Joshua tree is further threatened by direct habitat loss. Development has already consumed vast swaths of habitat in the range of the western Joshua tree. Over the coming decades, over a million additional acres are projected to be destroyed or degraded from development. This large-scale loss or severe degradation of habitat would be of conservation concern for the species even ignoring the threats posed by climate change. Taking climate change into account, such loss of habitat and the genetic resiliency and connectivity it provides will further push the species towards extinction in California.

Without rapid and substantial reductions in greenhouse gas emissions and protection of habitat, the western Joshua tree will likely be extirpated from most if not all of its range in California by the end of the century. It therefore clearly meets the definition of a "threatened species" under state law and must be protected as such.

While the threats facing the western Joshua tree in the coming decades are dire, they are not insurmountable. If the species and its habitat are protected early, and with active management to enhance recruitment and survival, and potentially dispersal, the western Joshua tree has a realistic chance of persisting in the wild over the coming decades. CESA listing, and the consequent development and implementation of a recovery plan and local or regional Natural Communities Conservation Plans (NCCPs), would help ensure the survival of this iconic species of the Mojave.

We recognize that recognizing a species as warranting protection under CESA primarily due to the threat of climate change is something that DFW and the Commission have never done. We also recognize that DFW recommended against listing the western Joshua tree, and voting to protect a species notwithstanding an adverse recommendation of DFW is not a decision to be made lightly. Nevertheless, given that four of the five independent peer reviews (the same four peer-reviewers who have actually studied the species) disagreed either with DFW's recommendation or with the rationale behind it, we believe that the overwhelming weight of the science still supports listing.

Rather than becoming yet another tragic symbol of our political leaders' failure to adequately respond to the climate crisis, protection under CESA would allow the western Joshua tree to serve as a symbol of California's climate leadership. We look forward to you demonstrating such leadership and making the legally and scientifically necessary finding that listing the western Joshua tree as a threatened species *is* warranted.

Sincerely,

lleene Anderson
Senior Scientist/Public Lands Deserts Director
Center for Biological Diversity

Michael Madrigal (Cahuilla)
President
Native American Land Conservancy

Nicolas Jensen, PhD
Conservation Program Director
California Native Plants Society

Maria Jesus
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Lucinda A. McDade, Ph.D.
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Erin Woolley
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Janessa Goldbeck
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Jocelyn Silverlight
Executive Director
Friends of Big Morongo Canyon Preserve

Mason Voehl
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Amargosa Conservancy

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Transition Habitat Conservancy

Jora Fogg
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Steve Bardwell
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Chris Clarke
Ruth Hammett Associate Director
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Kelly Herbinson
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Jack Thompson
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June 2, 2022

Samantha Murray, President
California Fish and Game Commission
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Sacramento, CA 95814

Submitted via email to: fgc@fgc.ca.gov
CC: Jennifer.Greaves@FGC.ca.gov

Re: Agenda Item 5: Petition to List Western Joshua Trees as Threatened Under the California Endangered Species Act - Support "Threatened" Listing

Dear President Murray and Commissioners:

Thank you for the opportunity to comment on the upcoming decision regarding listing the western Joshua tree (*Yucca brevifolia*) as "threatened" under the California Endangered Species Act (CESA). The following comments are submitted on behalf of the California Native Plant Society (CNPS), a non-profit environmental organization with over 11,000 members in 35 Chapters across California and Baja California, Mexico. CNPS's mission is to protect California's native plant heritage and preserve it for future generations through the application of science, research, education, and conservation. We work closely with decision-makers, scientists, and local planners to advocate for well-informed policies, regulations, and land management practices. Acknowledging the negative effects of climate change on the western Joshua tree, we urge the Commission to formally designate this iconic species as "threatened" under CESA.

Four of the five peer reviews were conducted by reviewers who have studied *Yucca brevifolia*, and all four disagreed with either the Department of Fish and Wildlife's recommendation or the rationale behind the recommendation. The consensus of scientific evidence supports the listing of the western Joshua tree as "threatened." Importantly, this is an opportunity for our policy makers to respond to climate change proactively by applying the protections of CESA to species like the western Joshua tree that are facing decline in the face of the current climate crisis.

One peer reviewer noted, "I am not convinced that the available evidence supports a recommendation against designating the species as 'threatened.' Current threats to western Joshua trees in California, considered in combination, mean that the species has very real potential to 'become an endangered species in the foreseeable future' (again, per Fish and Game Code, sect. 2067)."[1]

Ample scientific evidence demonstrates that the species meets the criteria for listing as "threatened." Though there is some uncertainty regarding how western Joshua trees will be affected in the future by increasing temperatures and changes in the timing and abundance of precipitation, it is well documented that climate change is already impacting this species. Range wide studies[2] and studies in Joshua Tree National Park[3] predict near complete loss of suitable habitat for this species due to climate change. The status review document cites recruitment from the 1990s as evidence that populations are stable, but this evidence conflicts with field data in published studies showing that certain Joshua tree populations have reached a mature age and are no longer producing offspring to keep the populations stable. Without proper protection and management other populations will also become extirpated in the foreseeable future.

This led another peer reviewer to conclude that, "many are already 'evolutionarily extinct' populations of only mature adults, with no successful recruitment. Others will be unless we do something."[4]

Another factor influencing recruitment is the western Joshua tree's sole pollinator, *Tegeticula synthetica*, a species of yucca moth. Western Joshua trees at the edge of their range at higher elevations produce fewer viable seeds than populations at intermediate elevations, probably due to lower numbers of pollinators.[5] This suggests that as populations are pushed beyond the northernmost and highest elevation portions of their range, pollinators may not follow. The loss of this pollinator or a decoupling of the timing of flowering and the activity of yucca moths due to climate change would effectively halt the reproduction of the western Joshua tree.

The effects of fire and herbivory both have been shown to have a significant impact on

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[1] Peer review comments of Jeremy Yoder.

[2] Cole, K.L., Ironside, K., Eischeid, J., Garfin, G., Duffy, P.B. and Toney, C., 2011. Past and ongoing shifts in Joshua tree distribution support future modeled range contraction. Ecological Applications, vol. 21, no. 1, pp.137-149.

[3] Barrows, C.W. and Murphy-Mariscal, M.L., 2012. Modeling impacts of climate change on Joshua trees at their southern boundary: how scale impacts predictions. Biological Conservation, vol. 152, pp.29-36; Sweet, L.C., Green, T., Heintz, J.G., Frakes, N., Graver, N., Rangitsch, J.S., Rodgers, J.E., Heacox, S. and Barrows, C.W., 2019. Congruence between future distribution models and empirical data for an iconic species at Joshua Tree National Park. Ecosphere, vol. 10, no. 6, p.e02763.

[4] Peer review comments of Cameron Barrows.

[5] Harrower, J. and G. S. Gilbert. 2018. Context-dependent mutualisms in the Joshua tree–yucca moth system shift along a climate gradient. Ecosphere vol. 9, no 9, pp. e02439. 10.1002/ecs2.2439

the recruitment and recovery of western Joshua tree populations. Blackbrush and Joshua tree communities typically convert to plant communities dominated by non-native annuals after fire and the recruitment of native shrubs and Joshua trees can take decades, if this happens at all.[6] Additionally, annual dominated ecosystems are more likely to have more frequent fires,[7] which can leave seed banks empty if subsequent fires occur before native shrubs and Joshua trees reach reproductive maturity. Joshua tree seedlings are typically found in the protected understory of shrubs,[8] called nurse plants. Studies on saguaro cactus, a species that also requires nurse plants for recruitment, show that recovery of nurse plants to the point that they can support seedlings can take ten years after the cessation of grazing.[9] This is likely true for areas recovering from wildfire as well.

Using fossil records as an indicator of the expected speed at which the range of Joshua trees can change is not reliable, as evidence suggests that current warming is happening approximately ten times faster than the rate of ice-age-recovery warming.[10] As a result, we are concerned that western Joshua tree's ability to adapt/move will be far outpaced by the current rate of environmental change. This is likely to lead to extirpation of western Joshua trees in many locations.

Over 40% of the western Joshua tree's range in California is on private land, of which only a small percentage is protected from development and land management/use that is inconsistent with conservation. Federal lands that are home to populations of western Joshua tree are subject to a variety of threats including off-road vehicle use, cattle grazing, the spread of invasive annual plants, electrical transmission line and gas pipeline construction and maintenance, and large-scale energy projects. These threats are expected to become amplified in the coming decades. However, if the species and its habitats are protected and active management to enhance recruitment, survival, and distribution is employed, these threats are not insurmountable. Listing the western Joshua tree as "threatened" will help to alleviate some of these threats.

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[6] Hughes, L.E., 2002. Is there recovery after fire, drought, and overgrazing?. Rangelands Archives, vol. 24, no. 4, pp. 26-30.

[7] Davies, K.W., Wollstein, K., Dragt, B. and O'Connor, C., 2022, Grazing management to reduce wildfire risk in invasive annual grass prone sagebrush communities, Rangelands, https://doi.org/10.1016/j.rala.2022.02.001

[8] Brittingham, S.B., 1998. Facilitation of Yucca brevifolia recruitment by Mojave Desert shrubs (Doctoral dissertation, University of Nevada, Las Vegas).

[9] Hall, J.A., S. Weinstein, and C.L. McIntyre. 2005. The Impacts of Livestock Grazing in the Sonoran Desert: A Literature Review and Synthesis. The Nature Conservancy in Arizona, Tucson

[10] https://climate.nasa.gov/evidence/

Thank you for the opportunity to comment on this decision. Please don't hesitate to contact me if you have any questions.

Sincerely,

Nick Jensen, PhD
Conservation Program Director
California Native Plant Society
njensen@cnps.org

MOJAVE DESERT LAND TRUST
P.O. Box 1544
Joshua Tree, California 92252
760.366.5440 • MDLT.org

California Fish and Game Commission

fgc@fgc.ca.gov

Subject: Western Joshua Tree Listing

June 2, 2022

Dear Members of the Fish and Game Commission,

We are writing to you to express our strong support for permanent listing of the western Joshua tree as a threatened species under CESA.

The Mojave Desert Land Trust is a 501c3 nonprofit organization dedicated to the conservation of the California desert ecosystem. Since our inception in 2006, we've protected more than 100,000 acres of desert habitat. We've conveyed a large percentage of those lands to national parks, wilderness areas and monuments, and currently hold more than 40,000 acres of desert with ecological significance, including riparian areas, springs, and wildlife corridors, much of which contain Joshua trees. As one of the largest land conservancies in the California desert, we have a significant stake in the fate of the western Joshua tree and its habitat.

In response to a large outpouring of support for greater protection for the western Joshua tree, we hosted a public rally in May that was enthusiastically attended by 110 concerned community members. Their messages of support and comments have been shared with the Commission.

As long-term landowners we clean up, restore, conduct research on and steward our lands, making us acutely tuned in to the threats the western Joshua tree faces. Climate change combined with drought, invasive species and human encroachment are taking a visible toll on the species.

In the last three years, we've had four major fires burn our lands, including one that ignited last week. This is a significant increase since our inception in 2006, and since fires have been reliably documented in the desert over the last 100 years. Proliferation of non-native plants has contributed to these increasingly frequent wildfires across desert lands, including devastating losses within western Joshua tree habitat. The convergence of increasing temperatures, invasive species, drought conditions, and a lengthier fire season are advancing both frequency and intensity of wildfires within Joshua tree habitat. This reality has forced us to take on a new role in fire restoration and management, and we are currently conducting research in conjunction with the BLM looking at Joshua tree recruitment post-fire in one of our parcels that recently burned near Joshua Tree National Park.

Climate change threats to the western Joshua tree are exacerbated by intense development pressure on western Joshua tree habitat that accounts for 40% of its range on private land. Residential, commercial, and more recently, poorly sited large-scale renewable energy projects have already impacted thousands of acres of western Joshua tree woodlands with no indications of decline. Indeed, as the popularity of the desert region grows in leaps and bounds, with the western Joshua tree as a signature species and tourist attractant, we can anticipate ever expanding development pressure. Development projections are particularly pronounced in the southern range region. EPA's Integrated Climate and Land-Use Scenarios (ICLUS) modeling tool projected that 41.6% of suitable habitat in the southern habitat region would be lost to housing development by 2095.

MDLT's position in support of permanent protection for the western Joshua tree does not exist within a conservation-focused bubble. We recognize the economic context in which protections take place. The real estate market in the Joshua tree region has exploded. According to Redfin, home values in the Joshua Tree community skyrocketed by almost 69% between 2020 and 2022, in part because of its proximity to the National Park and the growing AirBnB market. The popularity of California's desert region has translated into clear beneficial economic metrics. Employment opportunities often cited by development projects tend to be short-term and limited, whereas tourism employment sparked by the public's interest in the western Joshua tree is expansive and long-term. In 2018, 2.9 million visitors to Joshua Tree National Park created a total economic benefit to the local region of $196 million – that's $68 million more than in 2015. For the local communities adjacent to the park, 1,823 jobs were related to Joshua Tree National Park visitation.

The western Joshua tree is much more than a spectacular desert plant. The identities of gateway communities to Joshua Tree National Park and much of the California desert region are intrinsically tied to the existence and perpetuity of this iconic plant. Visitors are attracted from around the world. In 2020, Joshua Tree National Park was the most visited park in the state of California, outperforming even Yosemite National Park – and the 10th most visited park in the entire United States.

The merging of conservation interests with development/economic considerations has the opportunity to be mutually beneficial. Proven success stories abound within Regional Habitat Conservation Plans and Natural Community Conservation Plans which allow for smart growth that streamlines development and permitting: this is the win-win situation we hope to see once permanent listing is secured.

The scientific community specializing in western Joshua tree research has left little doubt that the western Joshua tree is at tremendous risk, as noted in their peer reviews of the CDFW recommendation. We need our leaders to take bold action now if we are going to be able to protect the desert ecosystem and its ability to function for the biodiversity it contains, including us. As a keystone species, the western Joshua tree is the glue that holds the entire ecosystem together. Please consider the weight of this moment for the western Joshua tree, and for the ongoing conservation of the desert for generations to come.

We thank the Commission members for their integrity and leadership in voting for interim protections for the western Joshua tree during the 18-month review period. We hope that California can serve as a national example by voting for permanent listing of the western Joshua tree as a threatened species under CESA.

Sincerely,

Kelly Herbinson
Cody Hanford
Joint Executive Directors
Mojave Desert Land Trust

RECEIVED
CALIFORNIA
FISH AND GAME
COMMISSION

2022 MAY 11 AM 8:21

Attention:Fish and Game Commission:

Hello. My name is Wendy Schiff, and I live in Palmdale, California, at the western end of the Mojave Desert. I've lived here most of my life and have witnessed the ongoing destruction of the Joshua tree and native desert habitat for over 30 years. Our desert land and Joshua trees are being torn down and clear-cut at record speed, all in the name of endless real estate development, industrial projects, strip malls, solar farms and wind farms. It has caused a massive scale die off in the desert, and it is absolutely heartbreaking to witness. In addition to large-scale destruction of the Joshua tree, other forms of desert plants and animals are disappearing from where I live as well; namely, quail, cottontail rabbits, jackrabbits, Fremont Cottonwood trees, Juniper trees and sagebrush.

Cities are finding loopholes in order to get around protective laws for Joshua trees by allowing companies to use "emergency take "permits to clear the land legally. These emergency take permits are being taken advantage of in the worst and most widespread way where I live and present an ongoing threat to the land. Cities claim to transplant the trees, but 60% die after transplantation.

In addition to killing the Joshua trees, animals will die off permanently in certain areas due to ongoing habitat destruction and land fragmentation. Ecosystems should be protected and not destroyed in the name of greed - in the ongoing quest to build tract homes, strip malls and solar farms.

Drought and fires are another major threat to the Joshua tree. I hike often, and constantly come across areas of burnt down Joshua trees. It is a sad sight. They need a chance to replenish their population. Many Joshua trees that have been burned and appear to be dead can possibly regenerate after 20 years or so. I've seen it with my own eyes.

If protections are lifted, Phase 1 of the massive, large-scale destruction of our deserts will begin immediately, mostly in the name of solar farms producing electricity for humans. This is incredibly self-serving and greedy on the part of human beings. From what I understand, the land traps carbon underground, but all of that carbon gets kicked back up into the atmosphere when land is developed. This makes pollution even worse and hurts the environment more. The government should require commercial buildings in the city to have solar panels on the roofs, and the government should also pay for it since they are pushing it so hard, and the number of solar farms allowed to be constructed should be limited by law.

Solar farms are a scam in the sense that they are not capable of providing electricity to the vast majority of people unless we clear upwards of 70% of natural desert land and replace it all with solar panels. What an awful idea for the future! What's more, a new form of technology will surely come along and replace solar panels in about five to ten years (think of a solar "prism"), but, by then, the damage will be done by the solar farm industry. The land will be dead and bare. I have serious questions as to why the California Department of Fish and Wildlife deemed that the Joshua tree should not be protected a week before the Commission is holding a meeting regarding Joshua trees being potentially listed as an endangered species. It seems rather odd that an agency serving to protect nature is giving the green light to have it destroyed. I wonder who could have influenced their decision in that regard.

Americans have a long history of looking at land through the lens of how it can benefit them and what kind of resources they can derive from it. For example, how many crops someone can grow on several acres, how much money can be made from logging the trees and selling the wood, the sale of luxury fur coats, etc. But a new way of thinking is emerging in various countries in which people are beginning to believe that nature has its own rights and has a right to exist independent of what type of resources it can offer people. It is called the "Rights of Nature" movement, and some countries are beginning to grant certain natural areas the right to be left alone and untouched. However, when it comes to resources, perhaps the Joshua tree could provide us with a needed resource in the future, like medicine. There's a popular chemo drug called Taxol, which is derived from the bark of the Pacific yew tree.

In summary, I would urge you to think about everything I've stated in this letter. I am just an everyday layperson who cannot make any money from the development of open land. I want to preserve the Joshua tree and its habitat and the animals that utilize it from the goodness of my heart and for future generations to experience it. People love the desert and this iconic tree. Think of the popularity of Palm Springs and Joshua Tree State Park. Please put this ancient, mysterious and well-loved tree on the endangered species list permanently. It is the right thing to do.

Thank you very much for your time.

Sincerely,
Wendy Schiff
[redacted]

[redacted]

Fish and Game Commission
California Department of Transportation
Conference Room 1.040 (1st Floor)
100 S. Main Street
Los Angeles, CA 90012

RE: Agenda Item 5: Western Joshua tree
June 15, 2022

Dear Commissioners,

I am writing this statement as testament on the necessity for state protection of the Western Joshua tree (Yucca brevifolia). I have lived in San Bernardino County most of my adult life, including 17 years in the Mojave Desert communities of Victorville and Hesperia. As a registered voter and former resident, I have witnessed vandalism, negligence, and the destructive process of urban development in Hesperia for quite some time.

In 2016, I began to photographically document the mistreatment of Western Joshua trees that were under the protection of the county of San Bernardino and the city of Hesperia. My images provide evidence that the laws in place at the county and city level are not enough to protect the Western Joshua tree from systematic eradication due to urban development. The following pages contain images that provide support on why state protection is needed.

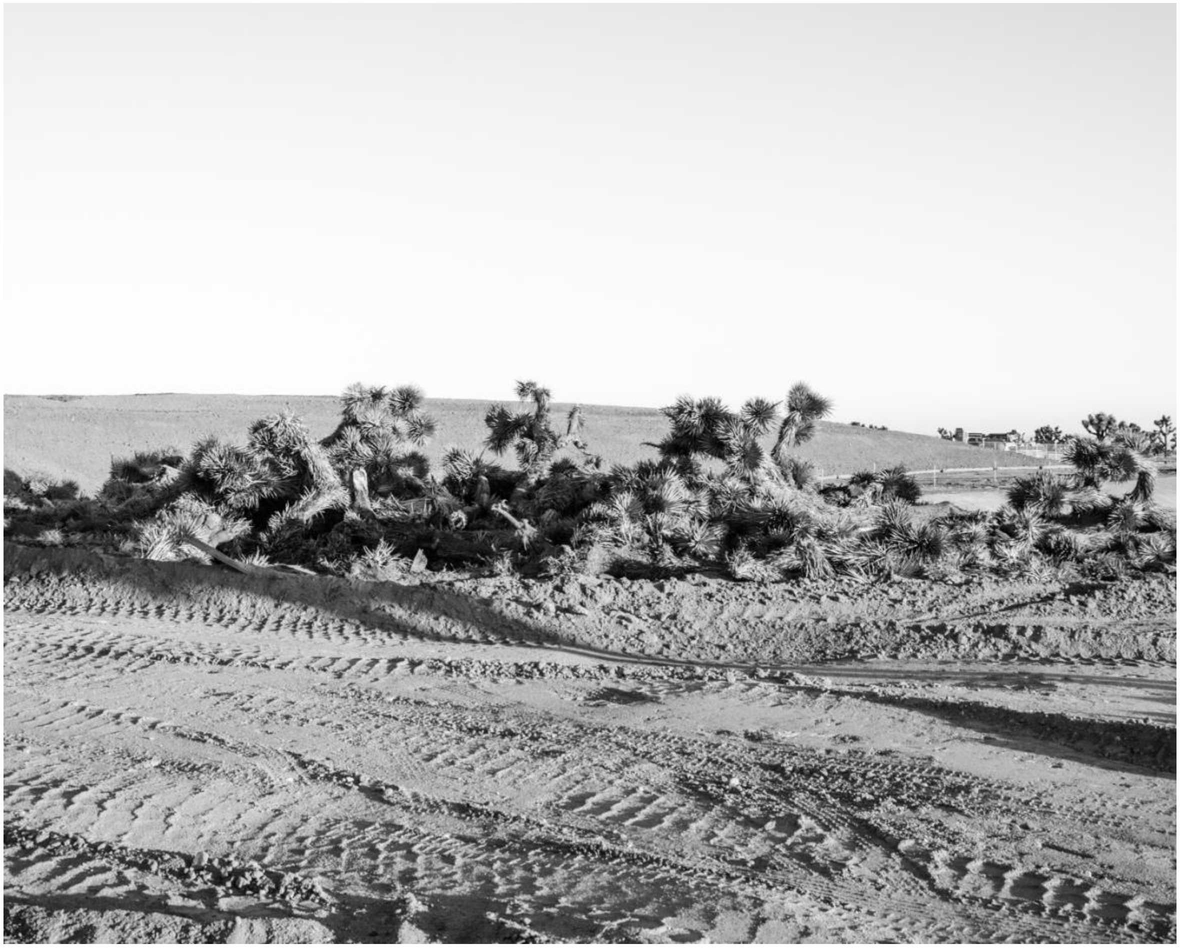
Image 1

Vacant lot, east of hwy. 395, north of Poplar St, Hesperia, CA. 2017. Vandalized tree cut down.
No construction in the area at the time.

Image 2

South of 11510 Fashion Ct. Hesperia. 2018. Frozen Joshua tree from sprinklers. Water is often applied to help loosen the soil before the development of a construction site. Tree was not saved. Lot is still vacant as of May 27,2022.

Image 3



Adjacent to 8770 Caliente Rd, Oak Hills, CA. 2018. Pile of uprooted Joshua trees due to construction. No trees were saved.

Image 4

8770 Caliente Rd, Oak Hills, CA. 2018. Another pile of uprooted Joshua trees due to construction. No trees were saved.

Images 5 and 6

Joshua tree 164, South of 11412 Fashion Ct. Hesperia, CA. 2019. For monitoring and protection, local officials tag trees before the development of a specific site for construction.

Images 7, 8, 9

Even though it was tagged, Joshua tree 164 was broken at the trunk base and tossed into the surrounding juniper shrub during the development of vacant lot, south of 11412 Fashion Ct. Hesperia, CA. 2019. Tree was destroyed. Lot still vacant as of May 27,2022.

With the presented photographic evidence, city and county officials are not capable of ensuring that Western Joshua trees will be protected under their supervision. Without state protection, more Joshua trees will be lost due to negligence and urban development. With the effects of climate change, increased fire behavior, and a hotter, drier climate already taking their toll; urban development could be the biggest contribution to the systematic eradication of an endemic species unique to the Mojave Desert. I implore the State of California Fish and Game Commission to act now and protect the Western Joshua tree species before it is too late.

Thank you.

Sincerely,

Frederick James Brashear Jr, M.F.A.
Artist & Educator

FGC@FGC

From:	Mitch Miller <[redacted]>
Sent:	Wednesday, May 25, 2022 11:54 AM
To:	FGC
Subject:	Protection for Western Joshua Trees
Categories:	Exhibit

Ms. Samantha Murray, President California Fish and Game Commission

I am a Joshua Tree-based photographer. I've explored Joshua Tree National Monument/Park since Memorial Day 1980. My wife and I were married in the Park in 1999, moved here in 2017 and have seen changes. There are more drying, dying, withering, and generally sickly-looking Joshua trees as a result of climate change-induced drought and air pollution.

As an art show vendor, I've seen many travelers enjoy my photographs of pinyon pine, ocotillo, cholla, rocks, smoke trees and yucca. But it is the iconic Joshua tree in which they are most interested. Many, many people, from the maintenance personnel at the national park, to the barista at the local coffee shop, local bakers, convenience store cashiers, artists, restaurant servers and more rely on that very interest in this unique plant for their livelihood.

But despite the Joshua tree's amazing survivability it is under constant threat from climate change, drought, vandalism and development. If we can't protect this tourism magnet for its own sake (and we should), we must protect it for our own economic survival.

They are gravitating towards "refugios" on north-facing slopes at higher elevations, but that's a slow process and visitors won't see that. If we don't act now to protect Joshua trees we might as well change the name of the park to Creosote Bush National Park, and that doesn't have quite the same allure.

Please act now to give Joshua trees across their much-shrunken range the maximum protection possible under state law.

Thank You

Mitch Miller
Joshua Tree, CA

SAVE THE WESTERN JOSHUA TREE!

Write a message for the California Fish and Game Commission here. It will be sent to the Commission ahead of its June 15 and 16 meeting.

Name/Address	Personal Comment
J.E. Tucker [redacted]	These trees need our protection NOW!
JASON DUDLEY [redacted]	Proactively SAVE OUR JTREES Before it's too LATE!!!
MATTHEW CASE [redacted]	THE WESTERN JOSHUA TREE WILL NOT SURVIVE THE CENTURY WITHOUT OUR HELP. DO THE RIGHT THING FOR OUR AREA'S FUTURE AND LIST THE WJT.
Nelda McCulloch [redacted]	Please Save the Joshua Tree!

SAVE THE WESTERN JOSHUA TREE!

Write a message for the California Fish and Game Commission here. It will be sent to the Commission ahead of its June 15 and 16 meeting.

Brenda Estrada

[redacted]

As a Mojave Resident for over half my life (Since 2) I am 32
I have Personally witnessed the horible
decline of western Joshua Trees. It is very
horribly sad. The beauty of this Desert and the
wildness of nature Should be Protected!!!!

The world is at a Climate Crises that
will take effect on the
Younger generations to come. We need
to think about all our actions and
the thing we can do to improve the
future. Please understand we the
People are noticing what is happening.
You can be the first state to
improve the wild habbitats that
Make California, CALIFORNIA!

Please be the First 1st
to Make this
Change!

thank You.

Brenda

SAVE THE WESTERN JOSHUA TREE!

Write a message for the California Fish and Game Commission here. It will be sent to the Commission ahead of its June 15 and 16 meeting.

Name/Address	Personal Comment
Joseph Bottari [redacted]	Climate change is hurting these ancient trees. Please save them -
Jon Bottari [redacted]	Please save our Joshua trees
Margaret Strachan [redacted]	Please protect the Joshua Trees. Allowing towns to rubber stamp take permits violates statute.
NOEL RHODES [redacted]	PLEASE PROTECT OUR PRECIOUS JOSHUA TREES

SAVE THE WESTERN JOSHUA TREE!

Write a message for the California Fish and Game Commission here. It will be sent to the Commission ahead of its June 15 and 16 meeting.

Name/Address	Personal Comment
ARCH McCULLOCH [redacted]	CLIMATE CHANGE IS IMPACTING THE ENTIRE DESERT. PROTECTING WESTERN JOSHUA TREES HABITAT WILL PROTECT MANY OTHER SPECIES OF PLANTS AND ANIMALS.
VERA TOPINKA [redacted]	Our climate change is effecting the entire desert. We need to help the joshua trees, the western joshua trees! ♡
Sarah Kennington [redacted]	
NOREEN LAWLOR [redacted]	Please save our Joshua trees

SAVE THE WESTERN JOSHUA TREE!

Write a message for the California Fish and Game Commission here. It will be sent to the Commission ahead of its June 15 and 16 meeting.

Deble Savitt
[redacted]

I read the 158 page Joshua tree report and it was, really has so many mixed opinions, and different/conflicting reports about the survival of the Joshua trees. How could you possibly make any decision based on conflicting scientific reports? I think it is obvious it's getting hotter & that the Joshua Trees and all plant species are at a greater risk of extinction. If anything the status should remain "threatened" to continue the study as there appears no conclusive results. Please save the Joshua Trees.

SAVE THE WESTERN JOSHUA TREE!

Write a message for the California Fish and Game Commission here. It will be sent to the Commission ahead of its June 15 and 16 meeting.

Name/Address	Personal Comment
Siyan Goldfarb	Development is not needed to save the Joshua Tree. There is plenty of desert without Joshua Trees where development can happen without harming the Joshua Trees. Please save the Joshua Trees.
Crystal Watson [redacted]	Please save our iconic prehistoric Joshua Tree. Be on the right side of history!
Doria Greenland [redacted]	Change the distance that homes can Be Built to enable housing & Please Protect the Joshua Trees ~~Bec~~ & our economy (Residents) need these iconic trees
DAMARIS ZATARAIN	THE WESTERN JOSHUA TREE IS IN DANGER OF EXTINCTION DUE TO DEVELOPMENTS THAT ARE BEING BUILT AROUND AN IDEA THAT THE TREES WILL STICK AROUND FOR PEOPLE + THE ENVIRONMENT TO ENJOY. PLEASE HELP US.

SAVE THE WESTERN JOSHUA TREE!

Write a message for the California Fish and Game Commission here. It will be sent to the Commission ahead of its June 15 and 16 meeting.

Name/Address	Personal Comment
CONRAD LAMBER [redacted]	PLEASE err on the side of CAUTION. THE WORLD loves JOSHUA TREE + its Yucca brevifolia + jaegeriana

June 2, 2022

Samantha Murray, President
California Fish and Game Commission
1416 Ninth Street, Suite 1320
Sacramento, CA 95814

Submitted via email to fgc@fgc.ca.gov

RE: Petition to list western Joshua Tree as threatened under the California Endangered Species Act

Dear President Murray and Commissioners:

Thank you for the opportunity to submit comments regarding your upcoming decision to list the western Joshua tree (Yucca brevifolia) as “threatened” under the California Endangered Species Act.

Over the last several years, my botanical research and work required frequent visits to the Inyo Mountains, a site of potential climate refugia for *Yucca brevifolia* identified by Cole et al. 2011. As far as I am aware, there relatively little demography data on the northern populations of *Y. brevifolia* which mostly occur on federal lands. While my hope is that quantitative demography data will eventually be available for these northern populations, observational data may be of use in the Commission’s upcoming vote.

Following the onset of exceptional drought in Inyo County (2021 to present), I observed a rapid increase in mortality of many large Joshua trees due to small mammal herbivory (see photos below). The mortality appears to be localized in the southern portion of Lee Flat (Death Valley National Park) and has impacted several hundred mature trees in the area I observed. While the species is widespread and abundant in the northern part of its range, I find the rapid demise of mature trees at relatively high elevations (ca. 5,500’) cause for concern. These biotic interactions are not accounted for in the models predicting the future range of *Y. brevifolia* cited in the Center for Biological Diversity’s listing petition.

Given the likelihood that very few climate refugia exist in California (Cole et al. 2011; Sweet et al. 2019), it follows that protecting habitat in these areas will be necessary for the continuation of the species. However, if *Y. brevifolia* loses protective status, it is possible that some of these places will be lost to development, leaving the refugia that remain more vulnerable to stochastic loss. For instance, candidacy status was cited as one of the reasons the Bureau of Land Management required an Environmental Impact Statement (see attached letter from BLM) in response to a mining company’s request to develop an exploratory drilling project in the southern Inyo Mountains – a high-elevation climate refugia that could be lost forever if the mining project continues on its trajectory leading to an open-pit gold mine.

I urge you to consider the long-standing impacts the listing decision will have on the future viability of *Yucca brevifolia* and the integrity of its habitat in the Mojave Desert.

Respectfully,

Maria Jesus
Bishop, CA

Attachment 1: Photos of Joshua tree herbivory and mortality at Lee Flat, Death Valley National Park,

Attachment 2 from Maria Jesus

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Ridgecrest Field Office
300 S. Richmond Road
Ridgecrest, CA 93555
www.ca.blm.gov/ridgecrest

In Reply Refer To:
CACA-56495
3809(P)
LLCAD05000.51

March 09, 2022

Mojave Precious Metals, Inc.
Attn: Steven Swatton
1020-800 Pender Street W
Vancouver, BC V6C 2VC

Dear Mr. Swatton,

After a thorough review of the Plan of Operations modification that you submitted on behalf of Mojave Precious Metals, Inc. (MPM), the BLM has determined that it will analyze the potential impacts in accordance with the National Environmental Policy Act by preparing an Environmental Impact Statement (EIS). The EIS will analyze the following resources in detail: wildlife, vegetation, special status species, noxious weeds, cultural and Native American resources, special land use designations, recreation, water, soil, and visual resources (and potentially transportation and access). MPM's original Plan of Operations was analyzed in an Environmental Assessment (EA) and the BLM issued its Finding of No Significant Impact (FONSI) and Decision Record in May 2018. In that decision, the BLM approved the alternative that authorized access via helicopter only and created a surface disturbance of 0.2 acres. The current proposed plan modification calls for access via overland travel and road construction and could disturb over 12 acres. Based on the resource concerns expressed by the public, Tribes, and agencies during scoping, the increased surface disturbance of the proposed plan modification, and the increase to 30 drill locations with a total of 120 hole, the BLM has determined that an EIS is warranted.

The BLM also considered the following factors when determining that it will prepare an EIS for the proposed plan modification:

1. The Joshua Tree is now a candidate species under the California Endangered Species Act.
2. The area is considered to be Lands with Wilderness Characteristics (WIU #124-1).
3. Red Ochre clay for which the Timbisha Tribe is named was unearthed during the first drilling project.
4. The largest known population of Inyo thread plant (*Nemacladus inyoensis*) in the southern Inyo Mountains was observed growing in and adjacent to the reclaimed access road. This plant species is new to science as of 2020 and is currently undergoing a California Rare Plant Rank status review (proposed status 1B.2).

5. On a field visit to engage in government-to-government consultation, Tribes told the BLM that the proposed plan modification could impact the holistic value of the area. Tribes explained that the area contains historic trails and sites where men of the tribe would gather for various reasons.
6. Under the Desert Renewable Energy Conservation Plan, portions of the area are designated as Areas of Critical Environmental Concern and California Desert National Conservation Lands.
7. The proposed plan modification would cause an increase in water use, which may result in potential impacts on quantity and quality to water supplies, seeps, springs, streams or water reservoirs. There could also be indirect impacts from water withdrawal, transport, and storage on air quality, dust generation, and traffic.

If you have any questions, please contact me at (760)384-5400 or Randy Porter at (760)384-5452 and rporter@blm.gov.

Respectfully,

CARL SYMONS

Digitally signed by CARL SYMONS
Date: 2022.03.09 10:16:34 -08'00'

Carl Symons
Ridgecrest Field Manager

Protect California's Western Joshua Trees

June 2, 2022

We, the 6,210 undersigned, urge you to give western Joshua trees full protection as “threatened” under the California Endangered Species Act. Climate change and fire are pushing this iconic species toward extinction. Recent studies show these fragile trees are already dying off because of hotter, drier conditions, with very few young trees becoming established — and even greater climatic changes are projected over the coming decades.

In 2019 scientists projected that Joshua trees will be largely gone from their namesake national park by the end of the century. An earlier study projected the species will be lost from virtually its entire range in California.

Prolonged droughts are expected to be more frequent and intense over the coming decades, shrinking the species’ range and leading to more tree deaths. Higher elevations, where Joshua trees might survive increasing temperatures and drying conditions, are at risk of fire because of invasive non-native grasses.

About 40% of the western Joshua tree’s range in California is on private land, with only a tiny fraction protected from development. Virtually all this habitat will be lost without legal protection for the trees.

We're in the midst of climate and extinction crises. We can’t afford to deny or delay protection for climate-imperiled species like Joshua trees. It’s time to demonstrate true climate leadership and protect this irreplaceable part of California’s natural heritage.

Larry Dinger, Rocklin, CA, 95677
Suzanne Jones, Moraga, CA, 94556
Elizabeth Bortolotto, Santa Rosa, CA, 95405
Susan Yewell, Cool, CA, 95614
Doug and Karen Lenier, Van Nuys, CA, 91401
Cindy Zacks, Joshua Tree, CA, 92252
Chris Rose, Petaluma, CA, 94952
Geness Lorien, Santa Barbara, CA, 93101
Steven Kapchinske, San Diego, CA, 92115
Karen Evans, Woodacre, CA, 94973
Susan Hayes-Tripp, Placerville, CA, 95667
Jared Laiti, Sacramento, CA, 95818
Mary Proteau, Los Angeles, CA, 90036
Anita Pereira, Richmond, CA, 94804
Lorna Paisley, Van Nuys, CA, 91406
Ralph Sanchez, Carmel Valley, CA, 93924
Susan Stover, Sebastopol, CA, 95472
Meg Foley, Morongo Valley, CA, 92256
Martha Sherman, Santa Clara, CA, 95054
Dr. John D. Stickle D.C., Kelseyville, CA, 95451
Ann Carranza, Healdsburg, CA, 95448
Mika Stonehawk, Tustin, CA, 92782
Constance Walsh, Pioneertown, CA, 92268
Barry Fass-Holmes, San Diego, CA, 92108
Antoinette Anderson, Rancho Cucamonga, CA, 91730
Mary Jean Pramik, San Francisco, CA, 94115
Thomas Proett, Valley Springs, CA, 95252
Christine Berger, Oakland, CA, 94610
Corinne London, Santa Clara, CA, 95050
John Van Straalen, Petaluma, CA, 94952
Eric Richter, Soquel, CA, 95073
Jessica Wilson, Petaluma, CA, 94952
Marguerite Dessornes, Pasadena, CA, 91104
Mildred Sondermann, Camarillo, CA, 93010
Leora Feeney, Alameda, CA, 94501
Dudley and Candace Campbell, Van Nuys, CA, 91401
Cinda Johansen, Folsom, CA, 95630
Tom Pohorsky, Soquel, CA, 95073
Douglas Emery, Sebastopol, CA, 95472
Julie Beer, Palo Alto, CA, 94306
Henry Boyle, Berkeley, CA, 94702
Dana Troia, South San Francisco, CA, 94080
Galen Reid, Ramona, CA, 92065
Laura Brody, Monrovia, CA, 91016
Cindy Dupray, Escondido, CA, 92025
Cindy Stein, Newbury Park, CA, 91320
Sharon Ponsford, Santa Rosa, CA, 95409
Victoria Silver, Irvine, CA, 92617
Polly D Pitsker, Huntington Beach, CA, 92648
Miranda Stewart, Pasadena, CA, 91106
Michael Koterba, Redding, CA, 96001
Linda Riebel, Lafayette, CA, 94549
Kathleen Keenan, Aptos, CA, 95003
Alexis Morris, San Francisco, CA, 94122
Ilene Mandelbaum, Lee Vining, CA, 93541
Holly Harris, Mill Valley, CA, 94941
Sally McKay, Reseda, CA, 91335
Aaron Saffa, Agoura Hills, CA, 91301

SEAN MCADAM, Santa Cruz, CA, 95062
Debbie Kennedy, Solvang, CA, 93463
Heather Brophy, Santa Barbara, CA, 93109
Constance Mills, Menlo Park, CA, 94025
Bob Kvaas, Goleta, CA, 93117
Sharon Morris, San Leandro, CA, 94577
Jim Jung, Merced, CA, 95340
Nina Jones, Oakhurst, CA, 93644
Priya Ganguli, Van Nuys, CA, 91411
Benjamin Zumeta, Crescent City, CA, 95531
Jacquolyn Duerr, Sacramento, CA, 95831
John and Katrina Lee, Elk Grove, CA, 95757
Simone St Clare, Martinez, CA, 94553
Linda Malone, Santa Rosa, CA, 95403
Anastasia Yovanopoulos, San Francisco, CA, 94114
Nelda McCulloch, Morongo Valley, CA, 92256
Kayla Fitzgerald, Joshua Tree, CA, 92252
Heather Etchevers, Berkeley, CA, 94709
Mark Palmer, Los Angeles, CA, 90026
Gregg Eisman, Valley Center, CA, 92082
Robert Knight, San Pablo, CA, 94806
Caroline Kim, Oakland, CA, 94610
Chrissy Cronin, San Francisco, CA, 94114
Lynne Goldsmith, Sacramento, CA, 95825
Peter M Sloman, Pasadena, CA, 91104
Janice E. Beyer, Stockton, CA, 95203
Vicki S, Mckinleyville, CA, 95519
Alexis Barton, Davis, CA, 95618
Nina Burr Esq., Forestville, CA, 95436
Alejandra Escobar, Yucca Valley, CA, 92284
Pat Doherty, Beaumont, CA, 92223
Deborah Williams, Goleta, CA, 93117
Christine Troche, Fremont, CA, 94555
William J. Schmidt, Wilton, CA, 95693
Rinnie Perry, Twentynine Palms, CA, 92277
Diane Ryerson, Arcata, CA, 95521
David Field, Santa Cruz, CA, 95060
Jensen Fiskin, Palm Desert, CA, 92260
Ron Holman, Cloverdale, CA, 95425
Rosa M Vasquez, Mariposa, CA, 95338
Paul Brigham, Fairfax, CA, 94930
Dan Stone, Carmichael, CA, 95608
Jack Litewka, Berkeley, CA, 94710
Yvonne Cabrales, Arcata, CA, 95521
Jennifer Sowle, Mckinleyville, CA, 95519
Deborah Young MD, Encinitas, CA, 92024
Ronald Sardarian, Joshua Tree, CA, 92252
ann henderling, Valencia, CA, 91355
Michelle Bowles, Los Angeles, CA, 90019
Cecilia Marzullo, San Diego, CA, 92130
Elizabeth Moreno, San Jose, CA, 95117
Stacy Spence, San Jose, CA, 95123
Kayla Lee, Fresno, CA, 93704
Scott Johnson, Auburn, CA, 95602
Shirley Perl, Los Angeles, CA, 90035
Ellen Oh, Los Angeles, CA, 90027
Miriam Martin, San Jose, CA, 95127
Doria Greenland, Yucca Valley, CA, 92284
Lynn DuPratt, Lancaster, CA, 93536
Danielle Wallis, Redlands, CA, 92373
Diana T., Berkeley, CA, 94709
Richard Payne, Los Gatos, CA, 95032
Dianna Sahhar, Corona Del Mar, CA, 92625
phyllis chu, San Francisco, CA, 94134
J Eiser, Long Beach, CA, 90803
Mark Johnston, Joshua Tree, CA, 92252
Lara Rozzell, Twentynine Palms, CA, 92277
Bryan Goldfarb, Joshua Tree, CA, 92252
Licia Judd, Yucca Valley, CA, 92284
Amber Bansak, Los Angeles, CA, 90042
Caroline Hamel, Berkeley, CA, 94705
Britt Carr, , CA, 90877
Lynda Caesara, Berkeley, CA, 94703
Robert Deloyd, Joshua Tree, CA, 92252
Theresa Brady, Moorpark, CA, 93021
Christina Nelson, Healdsburg, CA, 95448
Lena Nilsson, Laguna Beach, CA, 92651
Geralyn Gulseth, Alameda, CA, 94502
Virginia Clarke, Pasadena, CA, 91101
Michael McKibben, Moreno Valley, CA, 92557
Nita Winter, Sausalito, CA, 94965
Benjamin Billhardt, Fontana, CA, 92336
A Burk, Redlands, CA, 92373
John Miller, Ducor, CA, 93218
Sharon Ellis, Yucca Valley, CA, 92284
Carolyn Barkow, San Diego, CA, 92119
Judy Chew, San Francisco, CA, 94122
Melanie Rocks, San Diego, CA, 92110
Myphon Hunt, Yuba City, CA, 95991
Nancy Hiestand, Davis, CA, 95616
Catherine Krueger, El Cerrito, CA, 94530
Tori Coto, Santa Rosa, CA, 95409
norma campbell, Campbell, CA, 95008
Angel La Canfora, Torrance, CA, 90503
Harold Tipping, San Jose, CA, 95121
Louise Denish, Santa Rosa, CA, 95404
Dawn Williamson, Corte Madera, CA, 94925
Linda Novy, Fairfax, CA, 94978
Sheilah Cummings, Santa Cruz, CA, 95060
Becky Cunningham, Napa, CA, 94558
Ray Min, San Francisco, CA, 94131
Dorothy Brown, San Francisco, CA, 94110
todd Steiner, Forest Knolls, CA, 94933
Christine Russell, Los Gatos, CA, 95032
Margaret Adam, Corona, CA, 92877
Roz Schneider, San Anselmo, CA, 94960
Sandra Rakestraw, Atascadero, CA, 93422
Kara Ayik, Merced, CA, 95340
Stacie Wolny, Campbell, CA, 95008
Joanne Vinton, Sacramento, CA, 95818
Claude Rush, Los Angeles, CA, 90077

Petition to protect the western Joshua tree

We support listing the western Joshua tree as a threatened species. We call on the California Fish and Game Commission to do the right thing in listing the western Joshua tree under the Californi Endangered Species Act. Scientific findings show the species is already suffering from habitat loss. Within the next 50 years, the range of western Joshua tree habitat within Joshua Tree National Park will be dramatically reduced by climate change. Outside the National Park, 40% of its range falls on private land without protections that address long-term threats. The California Fish and Game Commission should show real climate leadership and list the western Joshua tree as a threatened species.

Contact Name	Date Submitted	Form Name
JOHNSTON, STEPHEN MARK	6/2/2022	Petition to protect the western Joshua tree
Burnett, Sandra	5/16/2022	Petition to protect the western Joshua tree
Garnier, Jean-Paul	5/16/2022	Petition to protect the western Joshua tree
Taylor, Sarah	5/26/2022	Petition to protect the western Joshua tree
Von Halle, Cynthia	5/17/2022	Petition to protect the western Joshua tree
Amdur, Louis	6/1/2022	Petition to protect the western Joshua tree
Weber, Samantha	6/1/2022	Petition to protect the western Joshua tree
Gadsden, David	6/1/2022	Petition to protect the western Joshua tree
Grad, Robert	6/1/2022	Petition to protect the western Joshua tree
Unbehand, Kendall	6/2/2022	Petition to protect the western Joshua tree
Mancuso, Brian	6/1/2022	Petition to protect the western Joshua tree
Acosta, Teo	6/1/2022	Petition to protect the western Joshua tree
Laudy, Robert	6/1/2022	Petition to protect the western Joshua tree
Adams, Ashley	6/1/2022	Petition to protect the western Joshua tree
Donovan, Daniel	6/1/2022	Petition to protect the western Joshua tree
Goodwin, Karen	6/1/2022	Petition to protect the western Joshua tree
Wray-Kirk, Ally	5/30/2022	Petition to protect the western Joshua tree
Francis, Lindsey	5/30/2022	Petition to protect the western Joshua tree
Loperena, Andrea	5/31/2022	Petition to protect the western Joshua tree
BAKER, JOHN H	5/31/2022	Petition to protect the western Joshua tree
Le, Jenny	6/1/2022	Petition to protect the western Joshua tree
Rovzar, Lani	6/1/2022	Petition to protect the western Joshua tree
Hinterman, Kevin	6/2/2022	Petition to protect the western Joshua tree
Wire, Emily	5/28/2022	Petition to protect the western Joshua tree
Bird, Sabrina	5/28/2022	Petition to protect the western Joshua tree
McMurry, Hannah	5/29/2022	Petition to protect the western Joshua tree
Ramos, Natalie	5/30/2022	Petition to protect the western Joshua tree
Bogner, Laura	5/30/2022	Petition to protect the western Joshua tree
Ogata, Christine	6/1/2022	Petition to protect the western Joshua tree
Woodward, Nancy	6/1/2022	Petition to protect the western Joshua tree
Geukens, Christopher	6/1/2022	Petition to protect the western Joshua tree
Miller, Kossen	6/1/2022	Petition to protect the western Joshua tree
Thorpe, Jessica	6/1/2022	Petition to protect the western Joshua tree
Sutton-Long, Michael	6/2/2022	Petition to protect the western Joshua tree

June 2, 2022

Re: Agenda Item 5 - western Joshua tree listing

For the attention of California Fish and Game Commission Members and Staff:

Sierra Club collected 3,907 public comments from our members and supporters throughout the state urging the California Fish and Game Commission to list the western Joshua tree as threatened under the California Endangered Species Act.

The names of the individuals submitting comments are listed in the rest of this document. Each of the individuals signed onto the following text:

> *In 2020, this Commission granted temporary protections to the western Joshua Tree as a candidate species under the California Endangered Species Act (CESA). Now you have an opportunity to permanently protect the western Joshua Tree and prevent cumulative harms from eradicating this iconic species.*
>
> *The western Joshua Tree is long-lived, with individuals surviving upwards of 100 years. However, they are also slow to reproduce. Juvenile trees require wetter conditions than their adult counterparts, and can take decades to reach maturity.*
>
> *Climate change impacts have already reduced the western Joshua Tree's current range and population density, particularly at lower elevations. At the same time, rising temperatures and declining precipitation have functionally eliminated the species' ability to reproduce in some areas. Studies show that climate change will outpace the western Joshua Tree's limited ability to expand its range to higher elevations.*
>
> *Additionally, more frequent wildfires and development in the region threaten the remaining adult population. Without immediate action, the western Joshua Tree will be eradicated from the majority of its current habitat by the end of the century.*
>
> *California cannot afford to downplay the present-day impacts of climate change at this critical moment.*
>
> *We applaud the Commission for pursuing the appropriate path towards protecting the western Joshua Tree and ask that you complete the trajectory you are on and provide CESA safeguards to prevent this iconic species from being further compromised.*

Thank you for considering this public input as you decide whether California will be a leader in fighting the climate and biodiversity crises by listing the western Joshua tree as threatened under the California Endangered Species Act, a critical action for ensuring we meet our state’s goal of protecting 30% of lands and waters in California by 2030.

Sincerely,

Erin Woolley
Sierra Club California

First Name	Last Name	Address	City	Postal Code
Sally	Marone	[redacted]	Livermore	94550
Charesa	Harper	[redacted]	Napa	94558
Brad	Nelson	[redacted]	Oxnard	93035
Petra	Boardman	[redacted]	Healdsburg	95448
Janet	Graham	[redacted]	Santa Barbara	93111
Albert	Acosta	[redacted]	Barstow	92311
Jacqueline	Ortega	[redacted]	San Francisco	94110
Stephen	Falgout	[redacted]	Murrieta	92563
Steven	Bal	[redacted]	San Diego	92108
Bonny	Davis	[redacted]	Grass Valley	95949
C	Swenning	[redacted]	Richmond	94805
Colleen	Harrison	[redacted]	Rancho Cordova	95670
Nancy	Robinson	[redacted]	Ridgecrest	93555
Mary	Franz	[redacted]	Laguna Beach	92651
Christopher	Hadley	[redacted]	Albany	94706
Elizabeth	Van Zandt	[redacted]	Palm Desert	92211
Rachel	Prandini	[redacted]	Sebastopol	95472
Nina	Greenberg	[redacted]	Los Angeles	90039
J.	Angell	[redacted]	Rescue	95672
Camille	Atwood	[redacted]	Richmond	94801
George	Grace	[redacted]	Los Angeles	90027
Kevin	Schader	[redacted]	Pleasant Hill	94523
Sally	Beer	[redacted]	Altadena	91001
Jackie	Leighton	[redacted]	Vacaville	95688
Grace	Morsberger	[redacted]	mont	91711
Daniel	Cooney	[redacted]	od	92397
Karen	Gerst	[redacted]		91505
Jud	Woodard	[redacted]	reek	95685
Tyler	Fitzgerald	[redacted]		92081
Abra	Rider	[redacted]		92029
Martha	Rossman	[redacted]	d	94602
Margot	Gorske	[redacted]		94510
David	Eisenman	[redacted]	Del Rey	90292
David	Mintz	[redacted]		95060
Carmen	Jurado	[redacted]		92656
Alison	Hill	[redacted]		94549
Judith	Baker	[redacted]	aks	91423
Michael	Agliardo	[redacted]	ncisco	94116
Ivan	Cunningham	[redacted]	ersfield	93311
George	Lewis	[redacted]		93402
Linda	Wallace	[redacted]		95616
Jeffrey	Hurwitz	[redacted]	cisco	94121

FGC@FGC

From: Chelsie Colombini <[redacted]>
Sent: Monday, April 25, 2022 9:52 PM
To: FGC
Subject: Western Joshua Tree CESA protection

Categories: Exhibit

Dear President Murray:

I am writing today in support of listing the Western Joshua Tree as a threatened species and giving it full protection under the California Endangered Species Act (CESA).
The range of the Western Joshua Tree has been shrinking because of climate change, wildfires, and mass clearing by the solar energy and construction industries. Extended periods of extreme heat and prolonged drought are affecting the health of Joshua Trees such that their ability to bloom and successfully reproduce is also imperiled. Additionally, the Western Joshua Tree can only be pollinated by a specific yucca moth that co-evolved with it. Literally: one can't exist without the other.
The elevation range where the Western Joshua Tree currently lives and where its scientifically projected climate refugia are located are very limited. Large fields of solar panels can go anywhere—they are not limited to a narrow elevation range. Renewable energy like solar power is very important to combat anthropogenic climate change, but it can't be at the expense of the keystone Western Joshua Tree species and its co-dependent yucca moth. In this case, we have a single chance to save our beautiful desert sentinels, known and loved the world round: our Western Joshua Trees. So, too, can solar energy thrive and grow as it absolutely should, but without impacting the Western Joshua Tree.

Understandably, the California Fish and Game Commission must weigh the decisions it makes, taking into consideration the impact on all parties involved. I ask you to please embrace this singular opportunity to protect the Western Joshua Tree and its mutually dependent Yucca moth.

Respectfully,
Chelsie Colombini

FGC@FGC

From: Ashley Lungwitz [redacted]
Sent: Thursday, May 26, 2022 12:47 PM
To: FGC
Subject: Add the Joshua Tree to the Endangered Species Act

Dear Commissioners,

I urge you to permanently protect Joshua Trees under the California Endangered Species Act. Stronger legal protections for the trees are necessary, not only because of the threat of a changing climate but because of the immediate threat from developers.

While the killing of western Joshua trees by developers is the most visible threat, climate change and fire are also pushing the species towards extinction. Recent studies show Joshua trees are dying off because of hotter, drier conditions, with very few younger trees becoming established. Even greater changes are projected over the coming decades. Scientists in 2019 projected that the Joshua tree will be largely gone from its namesake national park by the end of the century.

Prolonged droughts are projected to be more frequent and intense over the coming decades, shrinking the species' range and leading to more tree deaths. Higher elevations, where Joshua trees might survive increasing temperatures and drying conditions, are at risk of fire because of invasive non-native grasses.

Approximately 40% of the western Joshua tree's range in California is on private land, with only a tiny fraction protected from development. Current projections show that virtually all this habitat will be lost without stronger legal protections for the trees.

Joshua trees face extinction in the wild and there's not much time left to save them. Human-caused climate change is making matters worse. It's critical that the state stood up for these spectacular trees, because the federal government, local officials and for-profit corporations are facilitating their destruction.

Habitat loss and degradation are also major threats. Outside of Joshua Tree National Park, off-road vehicle use, cattle grazing, powerlines and pipelines and large-scale energy projects are destroying habitat. Approximately 40% of the western Joshua tree's range in California is on private land, with only a tiny fraction protected from development. Current projections show that virtually all of this habitat will be lost without stronger legal protections for the trees.

Developers are bulldozing Joshua trees every day to build roads, powerlines, strip malls and vacation rentals. If these beautiful plants are to have any hope of surviving in a warming world, we have to stop killing them. The California Endangered Species Act may be the only hope for saving these iconic symbols of the Mojave Desert.

Without strong legal protections, one of California's most unique landscapes will cease to exist. Without strong legal protections, current and future generations will not get to experience the beauty and magic of desert life. We must be aware of the long-term consequences of our actions if we do not protect the natural world that supports us.

For these reasons, I urge you to protect Joshua Trees under the California Endangered Species Act.

Thank you,

Ashley Lungwitz.

FGC@FGC

From: Cindy Ferguson <[redacted]>
Sent: Friday, May 27, 2022 8:02 AM
To: FGC
Subject: Western Joshua trees need full protection.

Dear Staff California Fish and Game Commission ,

I urge you to give western Joshua trees full protection as “threatened” under the California Endangered Species Act. Studies show these fragile trees are already dying off because of climate change and wildfires, with very few young trees becoming established — with even more climate change to come.

In 2019 scientists projected that Joshua trees will be largely gone from Joshua Tree National Park by the end of the century. An earlier study projected the species will be lost from virtually its entire range in California. About 40% of the western Joshua tree’s range in California is on private land, with only a tiny fraction protected from development. Virtually all this habitat will be lost without legal protection for the trees.

We are in the midst of climate and extinction crises. We cannot afford to deny or delay protection for climate-imperiled species like Joshua trees.

It is time to demonstrate true climate leadership and protect this irreplaceable part of California’s natural heritage.

Thank you,
Cindy Ferguson
[redacted]