Russell, Daniel <daniel_russell@fws.gov>

[EXTERNAL] Beach Layia SSA Peer Review

1 message

David Imper <dimper@suddenlink.net> Tue, Apr 3, 2018 at 10:54 AM
To: daniel_russell@fws.gov

Dear Mr. Russell:

Thank you for the opportunity to review the Beach Layia Draft Species Status Assessment. It is an exceedingly well written document, and a great contribution to future management of this species. I attached my review document herein, and I will send the conflict of interest form directly to you by mail.

David Imper

(Ecologist retired; USFWS Arcata, Ca Office)

Eureka, CA

Beach Layia SSA Peer Review - David Imper.docx
19K

April 3, 2018

Daniel Russell – Regional Listing Coordinator
Pacific Southwest Regional Office, Region 8
US Fish and Wildlife Service
Sacramento, California 95825

Subject: Beach Layia SSA Peer Review

Dear Mr. Russell:

Having prepared the 2011 USFWS status review for beach layia, a somewhat less rigorous review than this effort, I am painfully aware of how much effort went into preparing this very impressive document. The draft review is thorough, well organized and well thought out. It is an excellent summation of what is known about the beach layia, and presents good rationale for predicting the future threats to the species. I have very little in the way of suggestions to make this a better document.

First, a minor format suggestion regarding the use of the "3Rs" acronym (I assume this is standard agency jargon?) to help avoid confusion, particularly for those that choose to skim-read this rather lengthy document, or those that focus on particular sections beyond the first few pages. While it is a simple acronym, and seldom used in the document, it was poorly defined in the first usage. You might consider adding clarification, and reminding readers what it refers to each time it is used in the document.

My only significant concern had to do with the manner in which the impact of sea level -rise on beach layia was analyzed. Prediction of this threat is obviously highly speculative, and subject to a great many factors, both geophysical (changes in ocean currents, wave action, availability of new sand deposition, redistribution of current sand , etc.) and biological (primarily the character and redistribution of habitats and plant communities that establish over time). My own analysis made for the 2011 status review was quite basic, focused primarily on 1) the elevation distribution (in one foot increments) of the existing beach layia occupied habitat at Humboldt Bay, and 2) the relative availability of dune habitat (of any kind) at higher elevation in close proximity to the current populations, assuming that even unsuitable habitat could be the focus of restoration to make it suitable for beach layia.

The analysis of sea level-rise in this draft review, if I understand it correctly, is primarily limited to the extent and probability that current occupied habitat will be directly inundated in the future. Thus, based on the sea level-rise model used and elevation data for beach layia occurrence at Humboldt Bay, Tables 5 and 7 indicate that mean high-high water (MHHW) is predicted to rise between 1.4 and 1.9 feet by 2050, and 4.3 and 5.4 feet by 2100. As a result, no existing beach layia habitat is predicted to be inundated by 2050, while between 1 and 15 percent of its habitat is predicted to be inundated by 2100. While this is one metric that can be used to describe *just the direct* impact of rising water (ignoring the complexity of factors suggested above), I believe a more contextual assessment, based on the relative proximity of current beach layia to the MHHW line might be more indicative.

Based on the 2011 LACA Status Review analysis (Figures 3 and 4), and using the South Spit of Humboldt Bay as an example, the current distribution of beach layia there ranges between roughly 9.5 feet elevation (NAVD88) and just over 20 feet elevation, with approximately 77 percent of its habitat below 20 feet. The MHHW for Humboldt Bay overall appears to be roughly 6.5 feet NAVG88. The approximate three foot elevation gap between the MHHW and the lowest occurrence of beach layia is likely caused by many factors, the most important of which probably include frequency of wave run-up, salt concentrations, high water table, and other factors that influence the quality and structure of the dominant vegetation (e.g., deflation plains dominated by salt rush, densely vegetated swales, excessive competition, etc.). While the elevation span in the Layia gap above the MHHW could easily differ in 2050, either increasing or decreasing over time due to changes in ocean currents and wave action, re-contouring of the spit due to sand redistribution and/or availability of new sand for deposition, and other factors beyond my understanding, for the purpose of predicting future *direct* sea level-rise impact on beach layia, it seems to me we must assume some "occupancy gap" will remain. Lacking more specific data, we might also assume the gap will more or less be similar to the current gap between MHHW and beach layia occurrence.

Following the above argument, a projected 1.9 foot rise in MHHW by 2050 on the South Spit would cause the "occupancy gap" to rise and eliminate up to 7 percent of the currently occupied beach layia habitat (Figure 3; 2011 LACA Status Review), and a 5.2 foot rise by 2100 would similarly eliminate more than 30 percent. Whether or not beach layia is able to move to higher ground is one of the many unknowns not factored into this *direct impact* analysis, making this simply a gross estimate of impact, and not in any way a best or worst case scenario. However, recognizing the continuing gap between MHHW and the ability of beach layia to establish I believe provides a better approximation of direct impact.

I'll also mention the few typos noted: pg12/ln37 chapter "12" rather than "13"; pg87/ln14 "in the future".

Regarding the requested findings, the sea level assessment notwithstanding, I can easily say:

1) You have assembled and considered the best available scientific and commercial information relevant to this species;
2) You have analyzed the information correctly;
3) Your scientific conclusions are reasonable in light of this information.

Many thanks for the opportunity to review this fine document.

David Imper
(Ecologist retired; USFWS Arcata, Ca Office)
Eureka, CA

BISON CONNECT

Russell, Daniel <daniel_russell@fws.gov>

Re: [EXTERNAL] Re: Request for Peer Review - Beach Layia

Peter Alpert <palpert@bio.umass.edu> Sun, Apr 8, 2018 at 1:32 PM
To: "Russell, Daniel" <daniel_russell@fws.gov>

Dear Dan,

Please find attached my review, COI form, and short CV. Please let me know if you need anything else.

Regards,
Peter

On 3/26/2018 3:50 PM, Russell, Daniel wrote:

Excellent, thanks very much for your quick reply, and your willingness to take this on.

If you have any questions, please don't hesitate to contact me.
Dan

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Daniel Russell - Regional Listing Coordinator
Pacific Southwest Regional Office, Region 8
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2606
Sacramento, CA 95825
Office (916) 978-6191
Cell (916) 335-9060
****

On Mon, Mar 26, 2018 at 10:04 AM, Peter Alpert <palpert@bio.umass.edu> wrote:

Dear Mr. Russell,

I am willing to review and should be able to send comments by April 8.

Regards,
Peter

On 3/26/2018 11:00 AM, Russell, Daniel wrote:

Dear Dr. Alpert:

The U.S. Fish and Wildlife Service (Service) is soliciting independent scientific reviews of the information contained in our 2018 Draft Species Status Assessment for Beach Layia (Layia carnosa). Once finalized, this Species Status Assessment report (SSA report) will provide the underlying science on which we will base our decision on whether the species should be reclassified from an endangered species to a threatened species, under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.). You were identified by our Arcata Fish and Wildlife Office as a potential peer reviewer based on your area of expertise.

This request is provided in accordance with our July 1, 1994, peer review policy (USFWS 1994, p. 34270) and our current internal guidance. This request also satisfies the peer review requirements of the Office of Management and Budget's "Final Information Quality Bulletin for Peer Review." The purpose of seeking independent peer review of the SSA is to ensure use of the best scientific and commercial information available; to ensure and maximize the quality, objectivity, utility, and integrity of the information upon which we base listing and recovery actions; and to ensure that reviews by recognized experts are incorporated into our final rulemaking processes. Please let us know if you would like us to provide any of the referenced materials to help facilitate your review.

Please note that we are not seeking advice on policy or recommendations on the legal status of the species. Rather, we request that peer reviewers focus their review on identifying and characterizing scientific uncertainties, and on ensuring the accuracy of the biological and land and water use information in the SSA. Specifically, we ask peer reviewers to focus their comments on the following:

(1) Have we assembled and considered the best available scientific and commercial information relevant to this species?

(2) Is our analysis of this information correct?

(3) Are our scientific conclusions reasonable in light of this information?

Our updated peer review guidelines also require that all peer reviewers fill out a conflict of interest form. We will carefully assess any potential conflict of interest or bias using applicable standards issued by the Office of Government Ethics and the prevailing practices of the National Academy of Sciences (http://www.nationalacademies.org/coi/index.html). Divulging a conflict does not invalidate the comments of the reviewer; however, it will allow for transparency to the public regarding the reviewer's possible biases or associations. If we receive comments from a reviewer that we deem to have a substantial conflict of interest, we will evaluate the comments in light of those conflicts, and may choose not to give weight to those comments if the conflict is viewed as problematic. You may return the completed conflict of interest form either prior to or with your peer review.

So that we may fully consider any input and coordinate other peer review comments as we develop the final SSA report, and ensure adequate time to complete our reclassification finding, we are requesting written peer review comments by letter or email by April 8th, 2018. If you are willing to peer review but are unable to complete your assessment during this time period, please let me know when we may anticipate receiving your comments. We will summarize and respond to the substantive comments raised by all peer reviewers and use the information, as appropriate, in the final SSA report.

Please provide your written response to us by email or by letter. We would also appreciate receiving a copy of your Curriculum Vitae for our records. Please be aware that your completed review of the draft SSA report, including your name and affiliation, will be included in the administrative record for this evaluation and will be available to interested parties upon request.

If you have any questions about the draft SSA report, or our listing policies in general, please feel free to contact me at any time at (916) 978-6191. Please submit your comments and associated materials to the contact information below.

Thank you for your consideration.

Sincerely,
Dan Russell

****
Daniel Russell - Regional Listing Coordinator
Pacific Southwest Regional Office, Region 8
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2606
Sacramento, CA 95825
Office (916) 978-6191
Cell (916) 335-9060
****

3 attachments

Alpert COI form.pdf
76K

beach layia review Alpert.docx
16K

Alpert short curriculum vitae.pdf
37K

Review of the fourth draft of the 2018 Species Status Assessment Report for Beach L
ayia (*Layia carnosa*)

Peter Alpert, Biology Department, University of Massachusetts, Amherst, MA 01003

General comments

This report presents very good information on the distribution, abundance, protection of, and threats to the study species. It seems likely that all sizable populations have been identified and that the estimate of the abundance of the species is accurate to within an order of magnitude as of 2017, though likely to vary by an order of magnitude between years and to have been especially high in 2017. The information on management at the various sites is particularly detailed. There is apparently little information available on genetic diversity or differentiation (p 13 par 2). Information on threat due to the spread of introduced species is extensive. There is good evidence for correlation between abundance and rainfall (e.g., Figs. 18 and 19) and thus for threat due to drought. Information on effect of habitat disturbance due to human activity is limited.

The analysis of likely effects of sea level rise seems strong (e.g., p 11 last par) but could be strengthened by consideration of storm surge. The analysis of precipitation used to classify populations into ecoregions seems weak; a clustering algorithm would likely do a better job than the ANOVA used. The use of habitat to infer genetic differentiation between populations is not appropriate (p 54).

The conclusion that spread of introduced species and increase in drought are the principle threats to the species seems warranted. The conclusions with regard to the individual downlisting and delisting criteria likewise seem warranted, although the downlisting criteria are very lax, requiring in some cases only that some action have been taken or some change have been observed (p 64-65). The division of populations into ecoregions seems questionable; using mean annual precipitation as a basis is weak and precipitation at Point Reyes itself is less than at Monterey, suggesting that Point Reyes should be placed in the central region not the northern one. Whether the species is endangered seems to depend partly on whether loss of the populations in the southern half of the range is considered a danger.

The text is generally quite clear. There are a number of typographical errors and errors in style or grammar; I have not commented on these in the specific comments below. Is "pers. comm." really "unpublished data" in some cases? "Nutall" should be "Nuttall", and "arboreous" should be "arboreus".

Specific comments

P 7 l 17. This statement seems misleading, since the populations at Point Reyes and Monterey are more than 70 miles from other populations.

P 8 l 15-16. This statement that there is no reason to expect a change in commitment to control of threats if the species is downlisted seems contradicted in the text below.

P 9 l 9. I do not find a basis in the data presented for this figure of a minimum of 10 million individuals even in the least favorable years. The data on variation in abundance between years suggest at least 6-fold fluctuation between years (p 30 par 4, Figs. 15 and 16). If there were 30 million individuals in 2017, a highly favorable year, this suggests a minimum of about 5 million individuals.

P 9 l 14-15. This conclusion does not seem well supported.

P 9 l 16-18. The relevant analysis shows this for permanent inundation but not for impact due to storm surge.

P 9 l 19-22. This conclusion is not well supported by the information presented. The only information seems to be that in Table 1.

P 11 par 2. Explain how these populations correspond to those shown in Fig. 2?

P 11 par 4. It would help to describe how population data were analyzed in relation to habitat and climate.

P 12 par 2. "Resilience" seems to be used to mean "stability". The definition of "viability" is vague; it would be better to use a given risk of extinction in a given number of years.

P 14. The descriptions of the species and habitat are good.

P 15 l 7. The definition of achene is too broad.

P 16 par 1. Is this based only on areas that did have the species? I do not agree that dune perennials generally die back in winter in this region.

P 16 l 29. There seems no basis for this statement in regard to the study species.

Fig. 5. A frequency diagram would be better. This graph actually shows open sand as a function of presence of the species, not the reverse as stated.

Fig. 6. This is good and persuasive.

P 19 last par. It might be worth noting that the total area occupied by the species is less than one square mile.

P 31 l 18-21. Does this suggest that long-term persistence of species on sand spits or at river mouths is uncertain?

P 32. This information on land ownership and management is very detailed.

P 33 l 6. Does "stable" mean not likely to go extinct? Fig. 6 shows no evidence for stable population size.

P 34-35. This strongly supports the conclusion that spread of introduced species is a threat. The monitoring data from Humboldt Bay are strong.

Fig. 21. This figure seems to characterize properties of individuals more than of populations. Some likely effect are missing, such as of fecundity on abundance.

P 45-46. The conclusions on threats of development and disease seem sound.

P 46 l 21. It is not clear why stabilization due to native species and stabilization due to introduced ones are different ecological processes.

P 47-48. This review of introduced species seems sound, except for calling perennials annuals.

P 50-51. This analysis of disturbance seems all right.

P 52 l 38. "incredibly steep" is an exaggeration.

P 53 last par. The conclusion that increase in drought associated with change in climate is one of the two most important threats seems warranted but appears to contradict p 50 par 2.

P 54 last par. Catastrophe is said to be unlikely here, but possibility of a tsunami is noted on p 63 par 1.

P 62 par 3. Evidence for benefit of light disturbance seems weak.

P 67 l 10-12. These percentages seem to have been derived by adding the proportions in Table 7, which is only valid if the different areas are the same size.

P 67 l 31-33. This point is important.

BISON CONNECT

Russell, Daniel <daniel_russell@fws.gov>

[EXTERNAL] Re: Request for Peer Review - Beach Layia

Erik S Jules <erik.jules@humboldt.edu> Wed, Apr 11, 2018 at 10:49 AM
To: "Russell, Daniel" <daniel_russell@fws.gov>

Hi Dan,

Please find my comments on the beach layia status report attached. Also, I've attached the conflict of interests form, but I'm unsure how you'd like me to sign it electronically?

Thanks, Erik

Erik S. Jules
Department of Biological Sciences
Humboldt State University
Arcata, CA 95521
707-826-3346

On Mon, Mar 26, 2018 at 7:58 AM, Russell, Daniel <daniel_russell@fws.gov> wrote:

Dear Dr. Jules:

The U.S. Fish and Wildlife Service (Service) is soliciting independent scientific reviews of the information contained in our 2018 Draft Species Status Assessment for Beach Layia (*Layia carnosa*). Once finalized, this Species Status Assessment report (SSA report) will provide the underlying science on which we will base our decision on whether the species should be reclassified from an endangered species to a threatened species, under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.). You were identified by our Arcata Fish and Wildlife Office as a potential peer reviewer based on your area of expertise.

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Please provide your written response to us by email or by letter. We would also appreciate receiving a copy of your Curriculum Vitae for our records. Please be aware that your completed review of the draft SSA report, including your name and affiliation, will be included in the administrative record for this evaluation and will be available to interested parties upon request.

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Thank you for your consideration.

Sincerely,
Dan Russell

****
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U.S. Fish and Wildlife Service
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Sacramento, CA 95825
Office (916) 978-6191
Cell (916) 335-9060
****

2 attachments

20180323_BeachLayiaSSA_Draft#4 ESJ Edits.docx
8102K

Conflict of Interest Disclosure Form_template.pdf
63K

Species Status Assessment Report for

Beach Layia (*Layia carnosa*)

Month 2018 – Version xx

U.S. Fish and Wildlife Service

Region 8

ACKNOWLEDGEMENTS *(author, peer reviewers, agency reviewers & contributors)*

SUGGESTED LITERATURE CITATION OF THIS DOCUMENT:

U.S. Fish and Wildlife Service. 2018. Species Status Assessment Report for Beach Layia (*Layia carnosa*) (Month dd, 2018 version). U.S. Fish and Wildlife Service, Pacific Southwest Region, Arcata, California. xx pp.

EXECUTIVE SUMMARY

We, the U.S. Fish and Wildlife Service (Service) concluded in our last 5-year review (2011) that there was evidence to support a decision to reclassify beach layia (*Layia carnosa*) from an endangered species to a threatened species, under the Endangered Species Act (Act). For this current analysis, in order to assess the resiliency of the populations of beach layia across the range of the species, we conducted a mapping and sampling effort in the Humboldt Bay area, the largest population center, and requested information regarding abundance and habitat qualities from land managers in order to summarize the current state of the species. We found that 2017 was a year of high abundance for the species and that population estimates generated that year were higher than had ever been recorded for many, though not all, populations. This high abundance was correlated with high amounts of rainfall and an increased survey effort. We identified potential threats that are known to or reasonably likely to negatively affect beach layia individuals and thus pose a risk to the recovery of the species and found that dune overstabilization associated with the presence of invasive species and changing climate conditions, specifically the increased likelihood of multi-year droughts and rising sea levels, are the most significant threats.

Given that populations of this species are known to fluctuate largely based on environmental factors (such as, but not limited to, competition with invasive species and amount of rainfall), it is hard to predict ~~what the~~future population sizes~~ might be in the future~~. Regardless, drought was identified as a threat that could depress populations throughout the range of the species and have significant impacts on the species as a whole. Overstabilization of dunes and sea level rise, on the other hand, were found to be ~~more of~~ a threat only for specific populations. We assessed differences in genetics, phenology, and demography to ~~try to find~~assess patterns that could help group populations for comparing factors that influence those populations; however, we found no reasonable grouping. Therefore, we grouped the populations by ecoregions based on average annual rainfall since precipitation is a species need that is directly correlated with abundance. The ***North Coast Ecoregion*** contains the largest and most resilient populations, receives the highest average annual rainfall, and is the most susceptible to the risk of sea level rise. The ***Central Coast Ecoregion***, which receives less rain than the North Coast and more than the South Coast, is? less vulnerable to changing sea levels and is comprised of three small populations on the Monterey peninsula that are less resilient due to low abundance, though habitat quality is high at two of the sites. The ***South Coast Ecoregion***, both historically and currently, consists of a single population on the Vandenberg Air Force Base (AFB). This Ecoregion is less resilient than the other Ecoregions due to low abundance and poor habitat quality, although restoration is in progress. This population also is less vulnerable to sea level rise and receives the least amount of rain across the species range. The risk of ~~a~~ catastrophic events (such as tsunamis) on the North Coast Ecoregion pose~~s~~ a significant~~ly~~ ~~high~~ risk for ~~the species~~beach layia viability into the future, particularly considering greater than 70 percent of the species abundance occurs in this ecoregion).

Recovery efforts should especially target improving the risk profile of the North Coast Ecoregion for those populations most vulnerable to sea level rise, and bolster~~ing~~ the resiliency of the populations in the Central and South Coast Ecoregions in order to increase current and future resiliency of the species, and ensure adequate redundancy and representation in the future.

Comment [e1]: This section could use a careful review for sentence structure and grammar. It's not a very easy read and has quite few cumbersome sentences, a few of which I've pointed out.

Comment [e2]: ", and are not necessarily indicative of an increasing population size in general."

Comment [e3]: This is a pretty unwieldy sentence. Can it be streamlined?

Comment [e4]: This makes it sound like ALL species are limited by rainfall, which is not true. Keep this about beach layia.

Comment [e5]: A run-on sentence?

Table of Contents

1.0 ABBREVIATIONS AND ACRONYMS USED

ACT	The Endangered Species Act
AFB	Air Force Base
AFWO	Arcata Fish and Wildlife Office
ANOVA	Analysis of variance
BCM	Basin Characterization Model
BLM	Bureau of Land Management
CDFW	California Department of Fish and Wildlife (formerly known as the California Department of Fish and Game (CDFG)
CDPR	California Department of Parks and Recreation
CEQA	California Environmental Quality Act
CNDDB	California Natural Diversity Data Base
CSD	Community Services District
DEM	Digital elevation models
DNA	Deoxyribonucleic acid
DOD	Department of Defense
Friends	Friends of the Dunes, non-profit organization
GPS	Global Positioning System
HUC	Hydrologic Unit Code
INRMP	Integrated Natural Resources Management Plan
EPPA	Endangered Plan Protection Area
EREP	Eel River Estuary Preserve
ERWA	Eel River Wildlife Area
IPCC	Intergovernmental Panel on Climate Change
LiDAR	light detection and ranging
MHHW	mean higher high water
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NP	National Park
NS	National Seashore
NWR	National Wildlife Refuge
OHV	off-highway vehicles
Refuge	Humboldt Bay National Wildlife Refuge (NWR)
Service	U.S. Fish and Wildlife Service
SSA	Species Status Assessment
VLM	vertical land movement

2.0 INTRODUCTION

2.1 Listing History

Original Listing
FR notice: 57 FR 27848–27859
Date listed: June 22, 1992
Entity listed: Beach layia (*Layia carosa*)
Classification: Endangered

2.2 Species Basics

Beach layia is a succulent annual herb with predominantly white ray flowers and yellow disk flowers (Figure 1). Plants grow on dry, exposed beach sites that are spread across six isolated dune systems ranging from Freshwater Lagoon north of Arcata, California to the Guadalupe-Nipomo Dunes on Vandenberg Air Force Base (AFB) in Santa Barbara, California (Figure 2). Populations in the north occur intermittently over 70 miles (mi) (113 kilometers (km)), whereas the southern-most population is separated by 150 mi (241 km) from the next closest population to the north.

Figure 1. Beach layia. Photograph by Andrea Pickart.

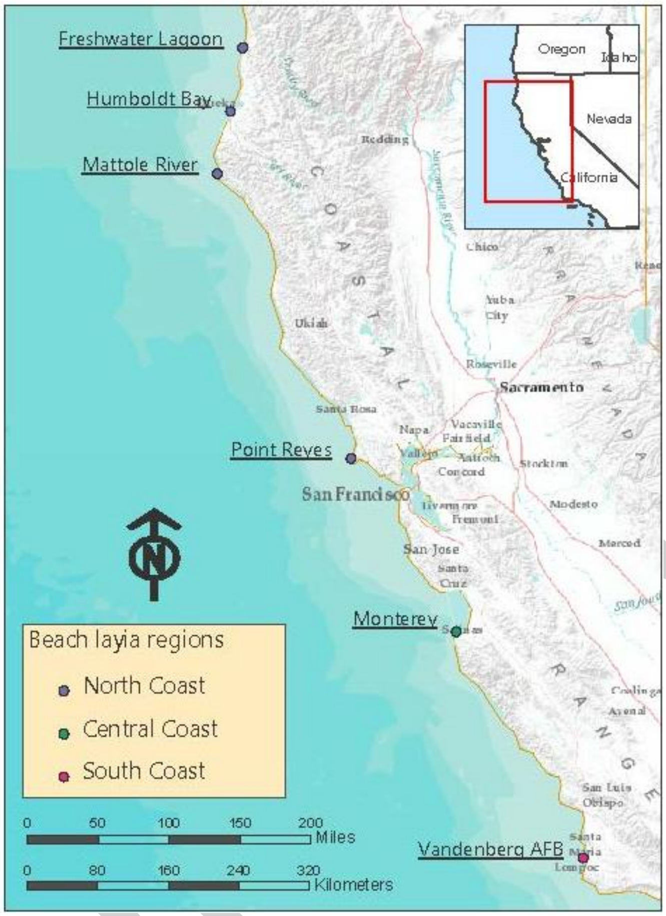

Figure 2. Six population centers (isolated dune systems) for beach layia along the coast of California.

2.3 Purpose

We, the Service, completed a 5-year review for beach layia in 2011 (Service 2011, entire) and at that time, found sufficient evidence to recommend downlisting based on the following:

(1) Over 90 percent of habitat occupied by beach layia is owned by a public entity subject to policies precluding development impacts, or is subject to development restrictions and mitigation requirements mandated by the California Coastal Act, local coastal plans, zoning ordinances, or the California Environmental Quality Act (CEQA).

(2) Approximately 91 percent of beach laya habitat is managed for conservation of sensitive dune habitat, and about 52 percent is managed for recovery of beach layia, There is no reason to believe the [then] existing commitment will change as a result of downlisting the species.

(3) Restoration of near-shore dunes and invasive species removal projects are ongoing, planned, or have been completed, by the majority of the largest landowners, including the Service, Bureau of Land Management (BLM), The National Park Service at Point Reyes National Seashore (Point Reyes NS), the California Department of Parks and Recreation (CDPR), Manila Community Services District (CSD), Friends of the Dunes (Friends), and Vandenberg AFB.

(4) Large populations of beach layia are present at Humboldt Bay, the mouth of the Mattole River and at Point Reyes NS. Based on population estimates made from 2007–2011, the average total annual population across its range is expected to exceed 10 million, even during low population years.

Comment [e6]: As you'll see in the Appendix, I think some problems need to be addressed with the population size estimates.

(5) Nuclear ribosomal deoxyribonucleic acid (rDNA) analysis results indicate no differences among populations of beach layia sampled at Vandenberg AFB, Monterey Peninsula, and Humboldt Bay.

(6) Beach layia appears well-adapted (though not yet adequately documented) to moderate levels of pedestrian, equestrian, and vehicle disturbance.

(7) Though there is good reason to expect sea level rise will impact beach layia habitat to some degree, the majority of occupied habitat [at the time of the 5-year review] appears to exist above the zone of likely impact.

Comment [e7]: Is there evidence to suggest that sea level rise will not significantly alter dune morphology in layia habitat (that is, in areas above the expected sea level in the future)? If so, a statement here is appropriate.

(8) Beach layia is frequently associated with other dune plant species currently listed as endangered under the Act and subject to similar threats, which should ensure that ongoing restoration and nonnative species control efforts continue in a portion of its habitat.

The Species Status Assessment (SSA) framework (Service 2016, entire) is intended to be an in-depth review of the species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The intent of this SSA is to conduct an analysis and prepare a report that is easily updated as new information becomes available and to support all functions of the Endangered Species Program. This SSA Report is not a decisional document by the Service; rather, it provides a review of available information strictly related to the biological status of beach layia. We will use this report, which summarizes our analysis of the best available scientific and commercial information, as well as our consideration of all relevant laws, regulations, and policies, to inform a potential reclassification decision.

Comment [e8]: Is listing the page numbers or the word "entire" a standard format for these reports? If not, I would delete them all, as it isn't a scientific convention.

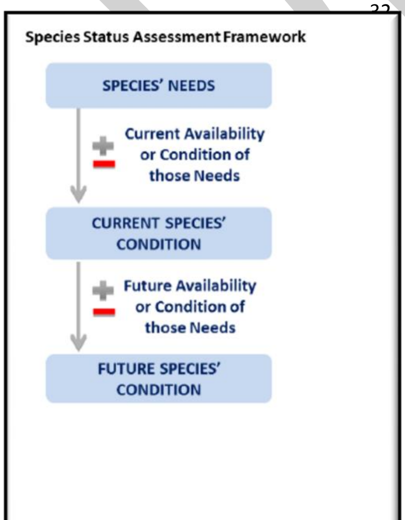

Figure 3. SSA Framework's three basic stages.

3.0 METHODOLOGY

This report is a summary of the Species Status Assessment analysis, which entails three iterative assessment stages (Figure 3): (1) The species' needs (ecology), (2) the species' current condition, and (3) the species' future condition (Smith *et al.* 2018, entire).

(1) Species Ecology. The SSA begins with a compilation of the best available biological information on the species (life history and habitat) and its ecological needs at the individual, population, and

Comment [e9]: Figure 3 is extremely blurry.

species levels based on how environmental factors are understood to act on the species and its habitat.

- Individual level: These resource needs are those life history characteristics that influence the successful completion of each life stage. In other words, these characteristics are survival and reproduction needs that make the species sensitive or resilient to particular natural or anthropogenic influences.

- Population level: These are components of beach layia's life history profile that describe the resources, circumstances, and demographics that most influence ***resiliency*** of the populations.

- Rangewide level: This is an exploration of what influences ***redundancy*** and ***representation*** for beach layia. This requires an examination of the plant's evolutionary history and historical distribution to understand how it functions across its range.

We researched and evaluated the best available scientific and commercial information on beach layia's life history. The majority of this information was compiled and analyzed most recently for the 2011 5-year review. This included monitoring data and habitat descriptions from land managers, visitations to many of the populations, assisting with a population estimate at the South Spit of Humboldt Bay, and analyzing the recovery criteria for each of the populations. At that time, the Service concluded that the downlisting criteria for the species had been met but that delisting criteria had not, primarily because of concerns about the viability of the Monterey and Vandenberg populations (Service 2011, p. 39).

For this analysis, we also considered new information available since 2011, including (but not limited to) life history research conducted in the spring 2012 to answer questions regarding range limiting factors that might be contributing to the low abundance of the Monterey, Vandenberg and Freshwater Lagoon populations (Imper 2014, entire). The study objectives were to compare plant vigor and reproductive success of representative beach layia in populations across its range and to correlate those attributes with climate and site factors (Imper 2014, p. 1).

(2) Current Species Condition. The SSA describes the current condition of the species habitat and demographics and the probable explanations for past and ongoing changes in abundance and distribution within the species ecological settings (i.e., areas representative of the geographic, genetic, or life history variation across the range). We identified potential threats, how they influence demographic and environmental features, and how that may affect the resiliency of the populations.

We grouped the populations of beach layia into three ecoregions – —North Coast Ecoregion, Central Coast Ecoregion, and South Coast Ecoregion – —based on differences in latitude and climate. In order to determine which populations should be grouped into which ecoregion, we obtained precipitation data from the National Oceanic and Atmospheric Administration (NOAA) Online Weather Data for each four general locations: Eureka, Point Reyes (San Raphael), Monterey, and Vandenberg (Santa Maria) (NOAA 2017a). Precipitation data was not available for every site every year. We completed an ~~Analysis~~ analysis of variance (ANOVA) for these data based on general location groupings (Service 2018, unpublished data). The ANOVA revealed that there was significant differences in precipitation among groups (p<0.001). To examine which groups differ from each other, we used a post-hoc Tukey test. This analysis revealed significant differences (p<0.001) in the following comparisons: Eureka-Monterey, Eureka-Vandenberg, Point Reyes-Monterey, and Point Reyes-Vandenberg. We found no significant differences in the comparisons of Eureka-Point Reyes (p=0.908) and Vandenberg-Monterey (p=0.444). Based on this, we grouped Point Reyes with the Eureka populations as the North Coast Ecoregion. Despite their similarity in precipitation, we separated Monterey from Vandenberg, Central Coast and South Coast Ecoregions respectively, based on differences in habitat characteristics and the large distance between them.

Comment [e10]: It's not clear what the analysis was here. Did you use precipitation from multiple years? If so, state what years. And, if you used multiple years, then I'm not sure ANOVA is the appropriate test, as each year is s sample of the same site (not a replicate). You'd need a repeated measures test?

We collected data on the abundance, distribution, and habitat factors of populations throughout the range of beach layia. Monitoring data was provided to us by the National Park Service (NPS) for the Freshwater and Point Reyes NS populations (Julian 2017, pers. comm.; Parsons 2017, pers. comm.); BLM for the Mattole River, South Spit, Ma-le'l South, and Samoa/Eureka populations (Hassett 2017, pers. comm.); the Humboldt Bay National Wildlife Refuge (Refuge) for the Lanphere and Ma-le'l North populations; California State Parks (Gray 2017, pers. comm.) for the Asilomar population; a private contractor, Joey Dorrell-Canepa, for the Indian Village Dunes population (Dorrell-Canepa 2017, pers. comm.); and the Department of Defense (DOD) for the Vandenberg AFB population (ManTech 2018).

We mapped and randomly sampled areas of known occupied habitat in the Humboldt Bay area in order to determine the current distribution and develop a population estimate. A description of our mapping and sampling methods are included as Appendix B.

We developed a table summarizing the estimated population size and area occupied for each population. We compiled the best available population trend data and analyzed them in relation to habitat characteristics and climate data. We compared our 2017 mapping efforts with previous mapping available in the Humboldt Bay area to determine trends in distribution. We created a delta table to track the changes in populations over time, and cause and effects tables to examine the relationship between actions and potential direct or indirect impacts to the species.

(3) Future Species Condition. Lastly, the SSA forecasts the species response to probable future environmental conditions and conservation efforts within a single, likely future condition scenario. The SSA characterizes a species ability to sustain populations in the wild over time (viability) based on the best scientific understanding of current and future abundance and distribution within the species ecological settings. The future timeframes evaluated in this SSA include a range of times that cover a variety of management plans, projections for local sea level rise for 32, 82, and 132 years from now presented in the most current literature in California (Griggs 2017, entire), and projections for climatic water deficit for 32 and 81 years from now presented in the California Basin Characterization Model (Flint *et al.* 2013, no page number).

In order to analyze the potential future impacts of sea-level rise to currently occupied beach layia habitat, we developed a simple model using light detection and ranging (LiDAR) based digital elevation models (DEMs) and probabilistic projections of sea level rise based on the methodology developed by Kopp *et al.* (2014, pp. 384–388). We classified the DEMs using sea level projections for 2050, 2100, and 2150 under emission scenario RCP 8.5 and calculated the proportion of currently occupied habitat that would be inundated. A more detailed description of our methods for this analysis is included as Appendix B. The potential effects of drought were analyzed using historical and projected climatic water deficit calculations presented in the California Basin Characterization Model dataset (Flint *et al.* 2013, pp. no page number).

For the purpose of this assessment, we generally define viability as the ability of beach layia to sustain resilient populations in natural coastal ecosystems over time. Using the SSA framework (Figure 3, above), we consider what beach layia needs to maintain viability by characterizing the status of the species in terms of its resiliency, redundancy, and representation (Service 2016, entire; Smith *et al.* 2018, entire).

- ***Resiliency*** is the ability of a population to withstand stochastic events and we assessed it by looking at the demographic and habitat characteristics of each population. We compiled abundance and habitat data for populations across the range of the species and evaluated these data as well as climate patterns.
- We evaluated ***redundancy***, the ability to withstand catastrophic events, by assessing the number and distribution of resilient populations across the range of the species.
- ***Representation***, the ability to adapt to changing physical and biological conditions, can be measured by the genetic, phenological, and demographic differences between populations. Because preliminary genetic work found no differences between beach layia populations (Baldwin 2007, pers. comm), we assessed representation by looking at phenological and demographic differences between populations and the number of different ecological settings in which resilient populations occur.

This SSA Report for beach layia includes:

(1) Species description, genetics information, and ecology, including the species' resource needs (Chapter 5.0);

(2) Characterization of the historical and current distribution of beach layia across its range (Chapters 6.0 and 7.0);

(3) An assessment of the current abundance and demographic conditions across its range (Chapter 8.0);

(4) An assessment of the current factors that negatively and positively influence the species, and the degree to which the various factors influence its viability (Chapter 9.0);

(5) An assessment of the potential future condition, including an evaluation of those factors that may influence the species in the future at the population- or rangewide-levels (Chapter 11.0); and

(6) A synopsis of 3Rs given the potential future condition (Chapter 13.0).

This document is a compilation of the best available scientific information (and associated uncertainties regarding that information) used to assess the viability of beach layia.

4.0 SPECIES BACKGROUND

4.1 Physical Description

Beach layia is a succulent annual herb belonging to the sunflower family (Asteraceae). The unbranched to highly branched plants range up to 6 inches (in) (15.2 centimeter (cm)) tall and 16 in (40.6 cm) across (Baldwin and Bainbridge 2012, p. 369). Characteristics distinguishing beach layia from similar species include its fleshy leaves, inconspicuous flower heads with short, 0.08 to 0.1 in (2 to 2.5 millimeter (mm)) long white ray flowers (occasionally purple) and yellow disk flowers, and bristles around the top of the one-seeded achene, or dry fruit (Service 1998, p. 43). The number of seed-heads on individual plants varies with plant size (Service 1998, p. 45). Typically unbranched, short plants on dry, exposed sites will produce a single head, while highly branched plants in moist dune hollows may produce more than 100 heads (Service 1998, p. 45).

In 1841, Thomas Nutall described this species as *Madaroglossa carnosa* based on specimens he collected in 1835 (Nutall 1841, p. 393). In 1843, John Torrey and Asa Gray transferred this species to the genus *Layia* (Torrey and Gray 1843, p. 394). In 1892, Edward Greene transferred it to the genus *Blepharipappus* (Greene 1892, pp. 244–248). However, subsequent taxonomic considerations of this species agreed with Torrey and Gray (Munz and Keck 1959, p. 1112; Ferris 1960, p. 163). Currently, the species is recognized as *Layia carnosa* (Nutt) Torr. & A. Gray by the Jepson Manual Vascular Plants of California (Baldwin *et al*. 2012, p. 369).

4.2 Genetics

Research on evolutionary relationships within the tarweed group (Madiinae; Compositae) by Baldwin (2006, entire) suggests beach layia is genetically distinct within the eight chromosome group of *Layia*, in accordance with its high degree of morphological and ecological distinction, and that discontinuity occurred relatively recently through accelerated phenotypic divergence from *L. gaillardioides*-like ancestors (Baldwin 2006, p. 74). Beach layia data for this research exhibit a high degree of genetic uniformity across its range, at least with respect to ribosomal DNA spacer sequences (Baldwin 2007, pers. comm.), which to date include samples from Vandenberg AFB, Monterey Peninsula, and Humboldt Bay. These data and conclusions are preliminary and, since only non-coding rDNA spacers were analyzed, there could be significant coding DNA differences between populations in response to natural selection, but this has not been studied.

4.3 Life History

As a winter annual, beach layia germinates during the rainy season between fall and mid-winter, blooms in spring (April to June), and completes its life cycle before the dry season (Service 1998, p. 45). Populations tend to be patchy and subject to large annual fluctuations in size and dynamic changes in local distribution associated with the shifts in dune blowouts, remobilization, and natural dune stabilization that occur in the coastal dune ecosystem. (Service 1998, p. 45) Beach layia plants often occur where sparse vegetation traps wind-dispersed seeds, but causes minimal shading. Seeds are dispersed by wind mostly during late spring and summer months (Service 1998, p. 45).

Beach layia is self-compatible and capable of self-pollination. Visits by anobiid beetles and halictid bees have been observed at Lanphere Dunes (Sahara 2000, p. 3). The small diurnal moth *Lithariapteryx abroniaeella*, micro bee flies (*Mythicomyia* sp.), and small native bees

(*Hesperapsis* sp.) have been seen visiting flowering beach layia at Vandenberg AFB (ManTech SRS Technologies 2016, p. 25).

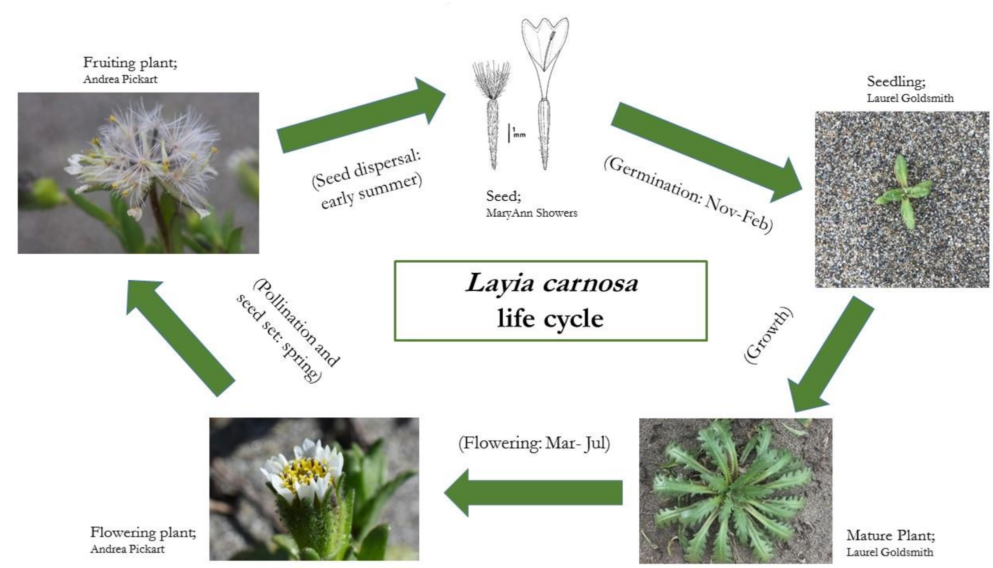

Figure 4. Life cycle diagram of beach layia (*Layia carnosa*).

4.4 Habitat

Beach layia occurs in the open spaces (see Figure 5, below) between the low growing perennial plants in the *Abronia latifolia – Ambrosia chamissonis* herbaceous alliance (dune mat) and *Leymus mollis* herbaceous alliance (sea lyme grass patches) (Sawyer 2009, pp. 743-745, 958-959). Both dune mat (active coastal dunes) and sea lyme grass patches (northern foredune grasslands) are listed as vulnerable to critically imperiled by the California Department of Fish and Wildlife (CDFW) and are tracked in the California Natural Diversity Database (CNDDB). Dune mat is composed of herbaceous low-growing vegetation adapted to the low nutrient soils and drought-like conditions of the dunes. It includes perennials such as (but not limited to): yellow sand verbena (*Abronia latifolia*), beach bur (*Ambrosia chamissonis*), beach bluegrass (*Poa macrantha*), coast buckwheat *(Eriogonum latifolium)*, beach pea *(Lathyrus littoralis)*, dune bluegrass *(Poa macrantha)*, dune goldenrod *(Solidago spathulata)*, and coastal sagewort (*Artemisia pycnocephala*) (Sawyer 2009, p. 743). Sea lyme grass (now treated as *Elymus mollis* the Jepson Manual, Baldwin 2012, p. 1446) is dominant or characteristically present in sea lyme grass patches and co-dominants include the same plants present in the dune mat community listed above (Sawyer 2009, p. 958). Typically, the total vegetative cover in both communities is relatively sparse and many annual species, including beach layia, colonize the space between established, tufted perennials. Beach layia can also occur in narrow bands of moderately disturbed habitat along the edges of trails and roads in dune systems dominated by invasive species.

Comment [e11]: Correct common name?

Coastal dune systems are composed of a mosaic of vegetation communities of varying successional stages. Beach layia occurs in early successional communities in areas where sand is actively being deposited or eroding. Too much sand movement prevents plants to establish, but areas with some movement on a periodic basis support early successional communities. Aeolian sand movement is essential for the development and sustainability of a dune system. Wind is also important to beach layia specifically because it is the mechanism by which seeds are dispersed. The achenes (hard fruits) have pappus (feathery bristles) that allow them to be carried by wind for a short distance. Though not all seeds may land on suitable habitat, this adaptation allows the small annual to spread across the landscape into uninhabited areas.

Comment [e12]: This might be the singular form of the word?

As a winter germinating annual, beach layia requires rainfall during the winter months (November – February) for germination and, though it is relatively tolerant to the drought-like conditions of upland dunes, it does need some moisture through the spring to prevent desiccation. Moisture also reduces the risk of burial as dry sand is more mobile and mortality caused by burial has been documented (Imper 2014, p. 6). Average annual rainfall in the North Coast Ecoregion is around 38 in (96 cm) while the Central Coast Ecoregion receives almost half that, 20 in (51 cm), and the South Coast Ecoregion receives 14 in (36 cm) (NOAA 2017a). Germination could possibly be prompted by low temperatures following the first major storm event of the year (Levine *et al.* 2008, p. 803); however, but this has not been studied for beach layia. Monitoring data provided by BLM for populations in Humboldt County from 2008–2017 indicate a positive correlation between rainfall during the water year (October–September) and abundance of beach layia (Figure 6). Plants in moist locations (dune hollows) tend to be larger and produce more flowering heads than plants in dry sites, which tend to be smaller with only one flowering head (Imper 2014, p. 7).

Comment [e13]: Run on

Comment [e14]: Grammar

Beach layia is often associated with other rare, threatened, or endangered species. The federally-listed species it shares habitat with include:

Table 1. Federally endangered and threatened species that co-exist at some beach layia population locations.

County	Common Name	Latin Name	Listing Status
Humboldt and Monterey	Menzies' wallflower	*Erysimum menziesii*	endangered
Marin and Monterey	Clover lupine	*Lupinus tidestromii*	endangered
Marin	Sonoma spineflower	*Chorizanthe valida*	endangered
Monterey	Monterey gilia	*Gilia tenuiflora* ssp. *arenaria*	endangered
Monterey	Monterey spineflower	*Chorizanthe pungens* var. *pungens*	threatened

4.5 Species Needs

In order for individuals to complete their life cycle and populations to maintain viability, beach layia requires:

Sandy soils with sparse native vegetation cover

Beach layia is an early succession species that occurs in the spaces between the low growing perennial plants in the sparsely vegetated dune mat community subject to shifting sands and wind-stressed conditions (see habitat description in section 4.4). During sampling conducted by the Arcata Fish and Wildlife Office in 2017 in the Humboldt Bay area (Appendix B), ocular estimates of open sand (conversely, total vegetation cover) were collected. Beach layia occurred most frequently in plots with 10-40% total vegetation cover (Figure 5). This need is partially fulfilled by the timing of the life cycle of the species. Beach layia emerges in winter months when many of the perennials die back above ground and completes its life history before most perennial species begin flowering (Barbour *et al*, p. 28)

Rainfall during winter germination period

As a winter germinating annual, beach layia requires rainfall during the winter months in order for seeds to germinate. Average annual rainfall in the North Coast Ecoregion is 38 inches while the Central Coast receives almost half, 20 inches, and the South Coast gets 14 inches on average. Monitoring data provided by the BLM indicate a positive correlation between rainfall during the water year (October – September) and abundance of beach layia (Figure 6).

Sunlight

All plants require sunlight for photosynthesis but some plants are more tolerant of shade than others. Beach layia tends to occur in areas that receive full sun exposure (as mentioned above it occurs between low-growing sparse vegetation). Additionally, increasing sunlight and temperatures in spring is a cue for flower development in most plants and shading could be one reason why beach layia does poorly in invaded areas (other native and nonnative annuals that are shade tolerant live in the understory of European beachgrass).

Pollination

Beach layia is self-compatible and capable of self-pollination and is visited by a variety of insects that may assist in cross-pollination (Sahara 2000). Even if beach layia reproduces mainly by selfing, it is still possible that outcrossed seeds have a higher probability of survival and contribute more to fitness (Sahara 2000), though this has not been tested. It is unclear what the role of pollinators are; however, sexual reproduction does ~~definitively~~ add to genetic diversity.

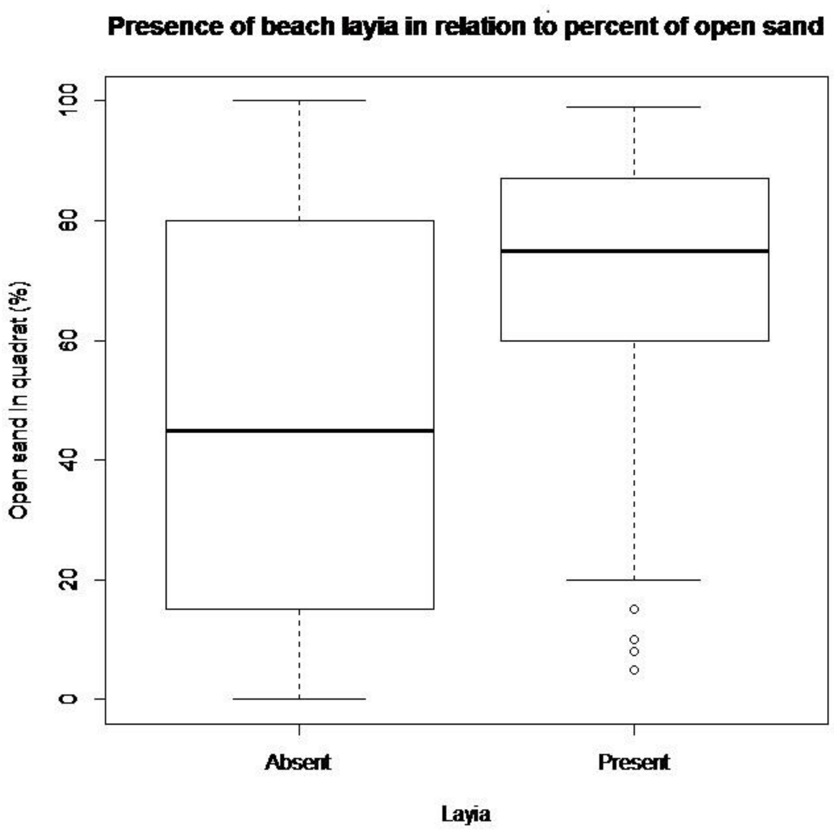

Figure 5. Beach layia occurred most frequently in sample plots with 60 to 90 percent open sand (10 to 40 percent total cover) in the 2017 Humboldt Bay area population estimate conducted by the Service (Appendix B).

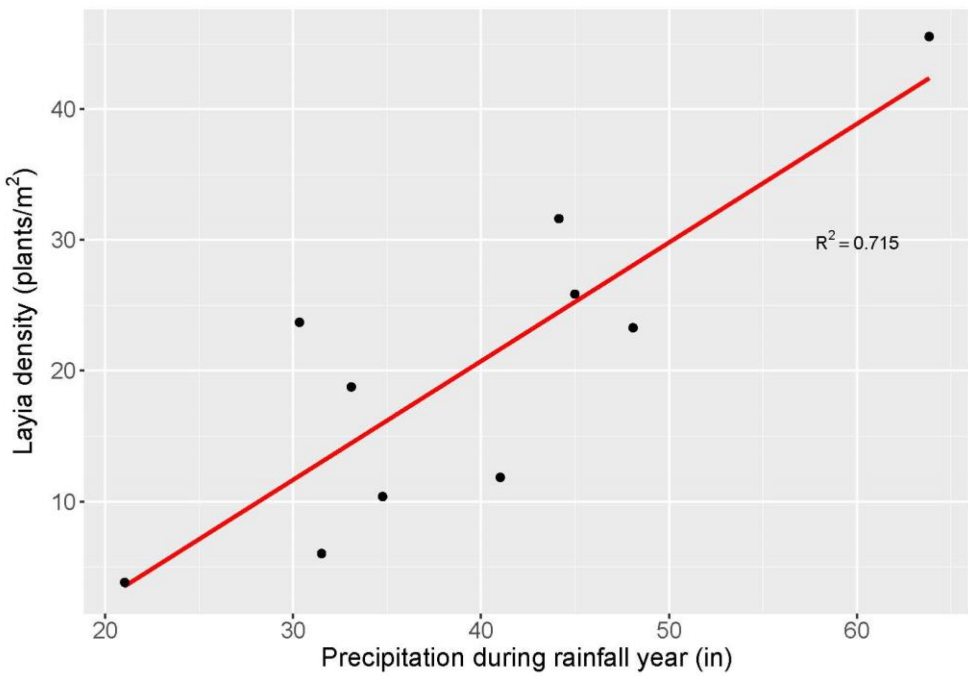

Figure 6. Rainfall is positively correlated with beach layia density in the North Coast Ecoregion (R^2 = 0.715). Beach layia densities averaged from BLM monitoring plots on the north and south spits of Humboldt Bay and the mouth of the Mattole River across 10 years (2008–2017) are plotted against the total rainfall for those water years (October–September).

5.0 HISTORICAL DISTIBUTION AND ABUNDANCE

Beach layia populations surveyed from Santa Barbara County to Humboldt County near the time that the recovery plan was written (1998) were estimated at 300,000 individuals (Service 1998, p. 43). Of the known historical populations, four are considered extirpated, including the San Francisco population, the Point Pinos population in the Monterey area, and two populations north of the Mad River in Humboldt County. All currently extant populations were known at the time of the recovery plan with the exception of the Freshwater Lagoon population that was discovered in 2000. Based on estimates conducted since the recovery plan was written and the current estimates, it is likely that the original estimate of 300,000 plants total was a gross underestimate (Service 2011, p. 21).

6.0 CURRENT CONDITION—DISTRIBUTION AND OCCUPIED AREA ESTIMATES

6.1 Distribution

No significant change in the distribution of beach layia has occurred since the species was listed with the exception of the discovery of the northern most population on the Freshwater Lagoon

Spit in the North Coast Ecoregion. The current distribution includes populations spread across dune systems in the following geographic areas covering more than 500 mi (805 km) of shoreline in northern, central, and southern California (Figures 7–13):

North Coast Ecoregion
Humboldt County—Freshwater Lagoon Spit, Humboldt Bay area, mouth of the Eel River, McNutt Gulch, and mouth of the Mattole River
Marin County—Point Reyes NS
Central Coast Ecoregion
Monterey County—Monterey Peninsula
South Coast Ecoregion
Santa Barbara County—Vandenberg AFB (located on part of the Guadalupe-Nipomo Dunes)

Beginning at Freshwater Lagoon Spit in northern Humboldt County, beach layia occurs intermittently over 70 mi (113 km) of shoreline as far south as the mouth of the Mattole River. From there, it jumps some 170 mi (274 km) south to Point Reyes NS (Marin County), and then another 120 mi (193 km) south to the Monterey Peninsula (Monterey County). Finally, a gap of about 150 mi (241 km) separates it from the southernmost site at Vandenberg AFB in Santa Barbara County.

Comment [e15]: Is this perhaps more than 150 mi? Just checking.

6.2 Occupied Area Estimates

Estimates of occupied habitat for beach layia cited in this analysis are primarily based on mapping of its distribution in the Humboldt Bay area in 2017 (Appendix B); Point Reyes NS in 2010 (Point Reyes NS 2010); the King Range National Conservation Area at the mouth of the Mattole River in 2004 (BLM 2005, p. 16), and the CNDDB (CNDDB 2017) in combination with information provided by land managers for smaller populations throughout the species' range. Recognizing that "occupied habitat" technically includes area that contains a seedbank but no vegetative plant growth, for the purpose of this analysis, "occupied habitat" refers to habitat that, at the time of the last surveys, supported above-ground/vegetative growth of the plant.

Overall, an estimated 595 ac (253 ha) of near-shore dunes habitat is currently known to support beach layia (Service 2017, unpublished data). The North Coast Ecoregion contains approximately 99.6 percent of the occupied habitat rangewide. Federal agencies own or manage about 73 percent of the occupied habitat (433 acres (ac) (175 hectares (ha)), State agencies 2.5 percent (15 ac (6 ha)), local governmental entities 2.5 percent (15 ac (6 ha)) and non-governmental organizations 14 percent (NGOs) 83 ac (34 ha), and the remaining 8 percent (50 ac (20 ha)) is private ownership.

Comment [e16]: In the next sentence you have "acres (ac)"

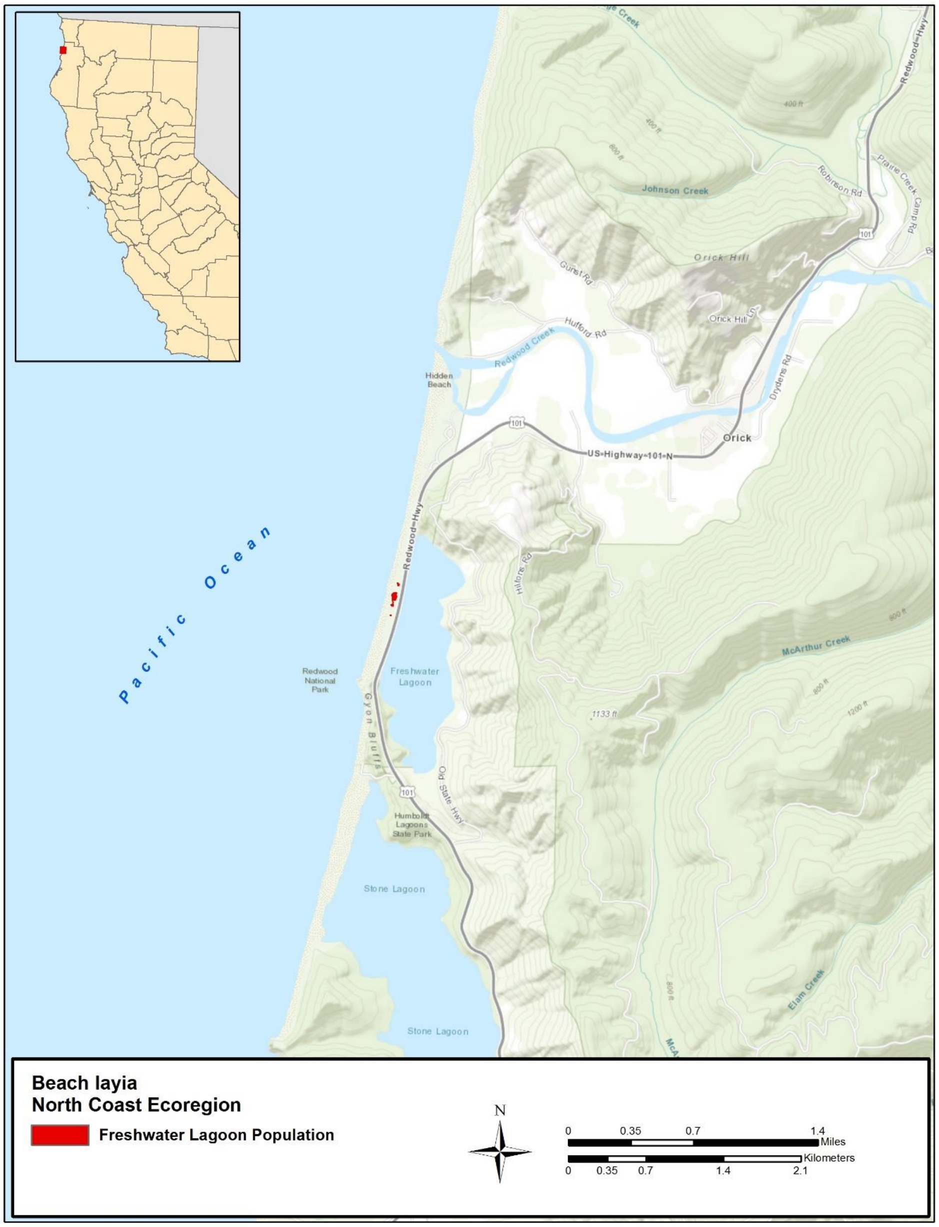

Figure 7. Distribution of beach layia at the Freshwater Lagoon Spit, Humboldt County, California, within the North Coast Ecoregion. Based on mapping conducted by the Service in 2017 (Appendix B).

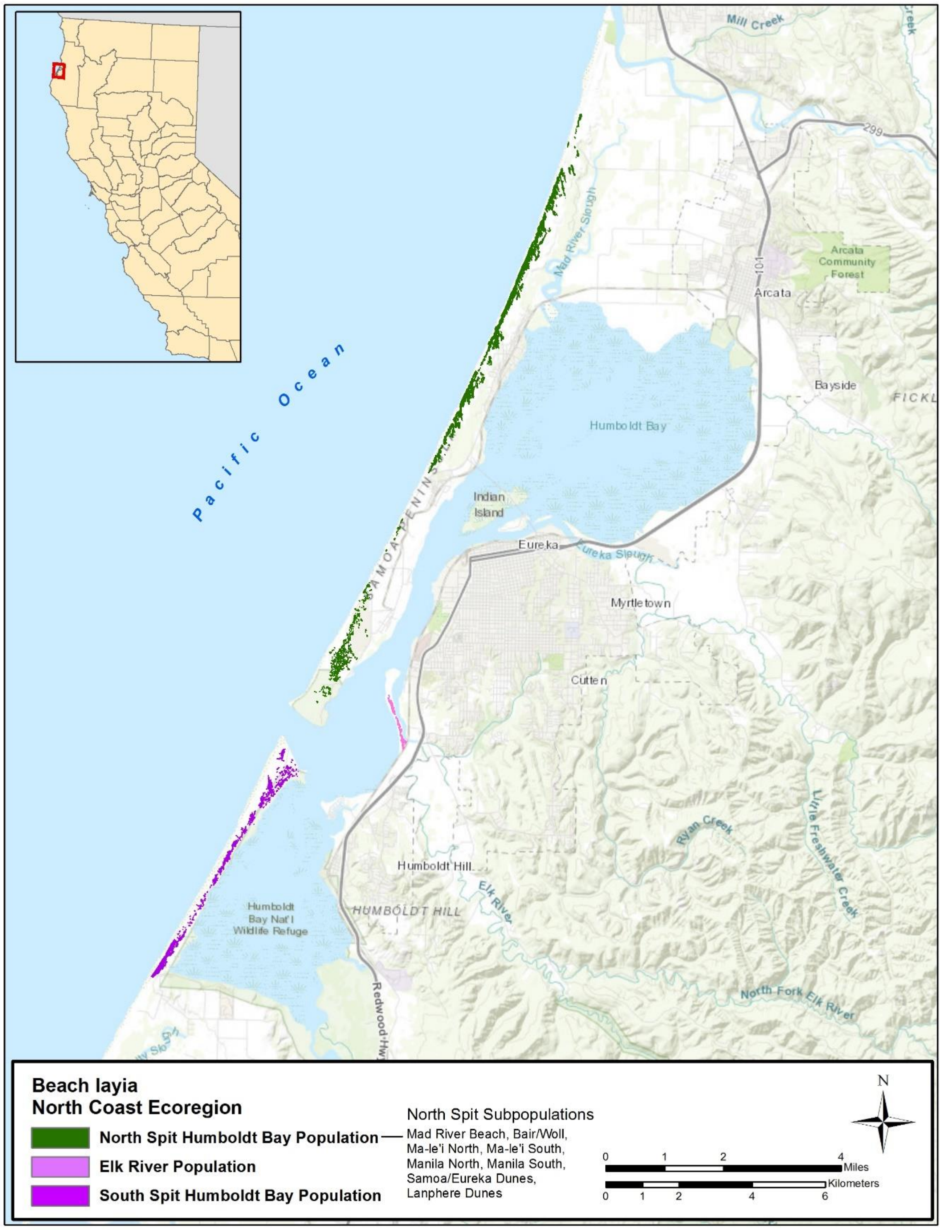

Figure 8. Distribution of beach layia in the Humboldt Bay area, Humboldt County, California, within the North Coast Ecoregion. Based on mapping conducted by the Service in 2017 (Appendix B).

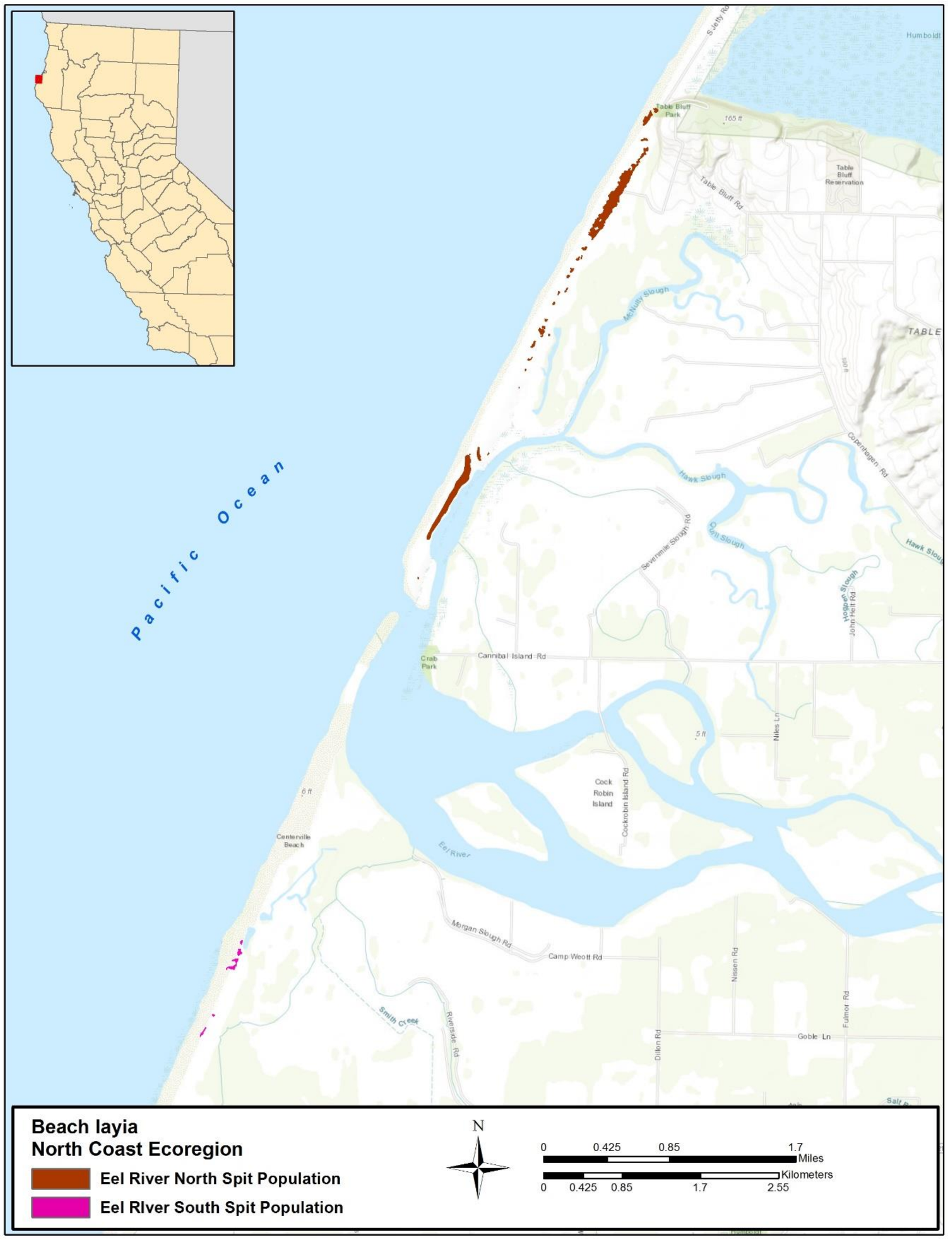

Figure 9. Distribution of beach layia near the mouth of the Eel River, Humboldt County, California, within the North Coast Ecoregion. Based on mapping conducted by the Service in 2017 (Appendix B).

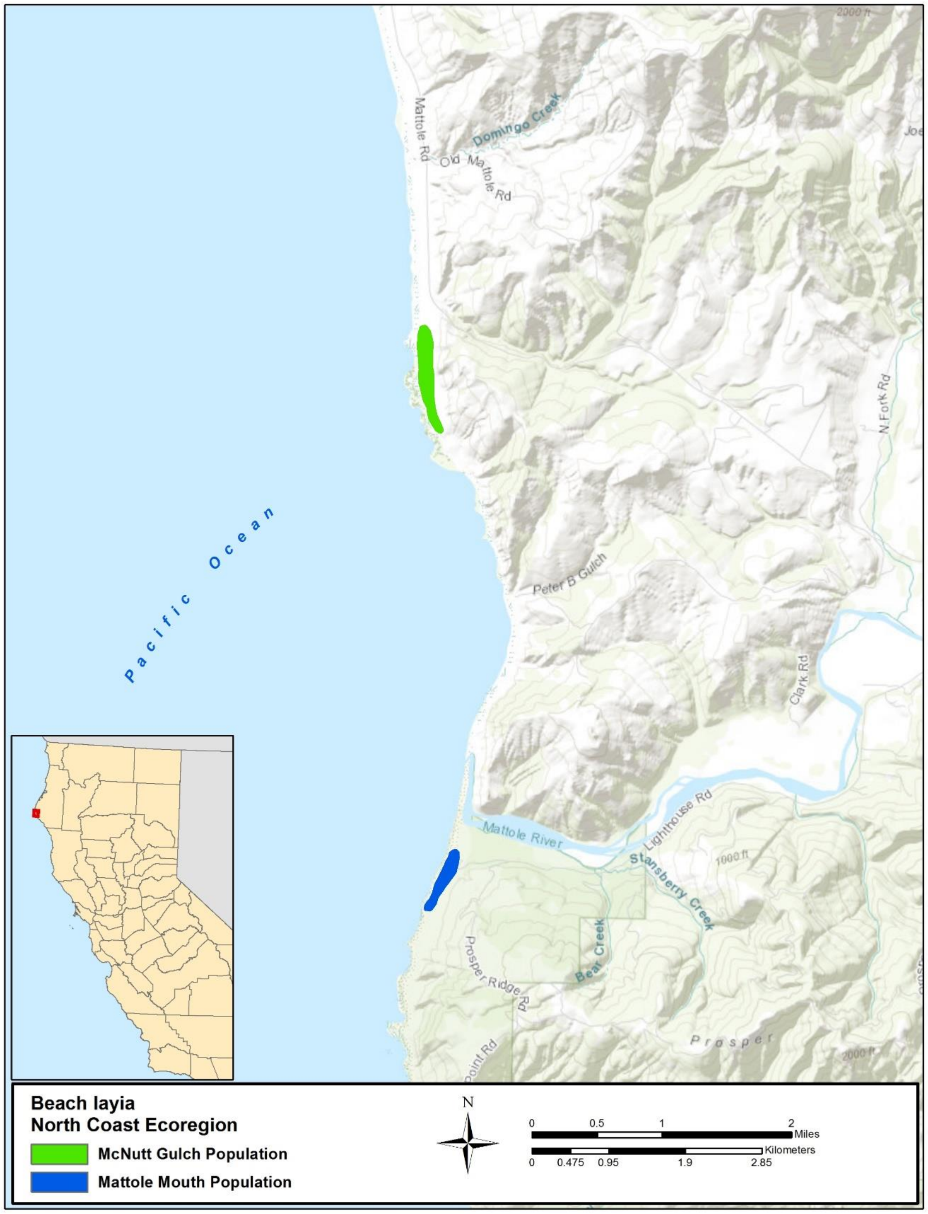

Figure 10. Distribution of beach layia at McNutt Gultch and the mouth of the Mattole River, Humboldt County, California, within the North Coast Ecoregion (California Natural Diversity Database (CNDDB) 2017). The extent of the McNutt Gultch population is likely much smaller than what is pictured here.

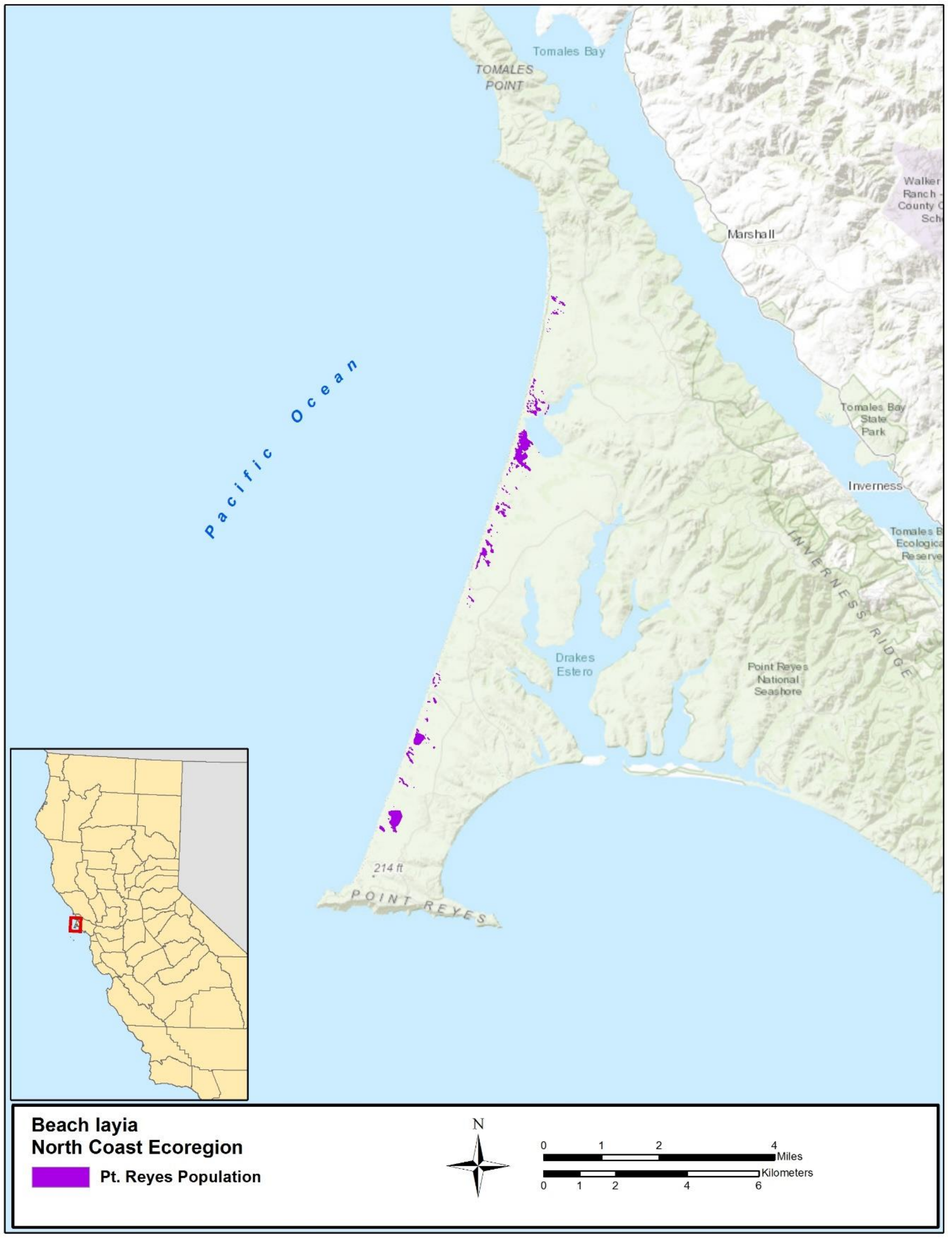

Figure 11. Distribution of beach layia at Point Reyes NS, Marin County, California, within the North Coast Ecoregion (Point Reyes NS 2010).

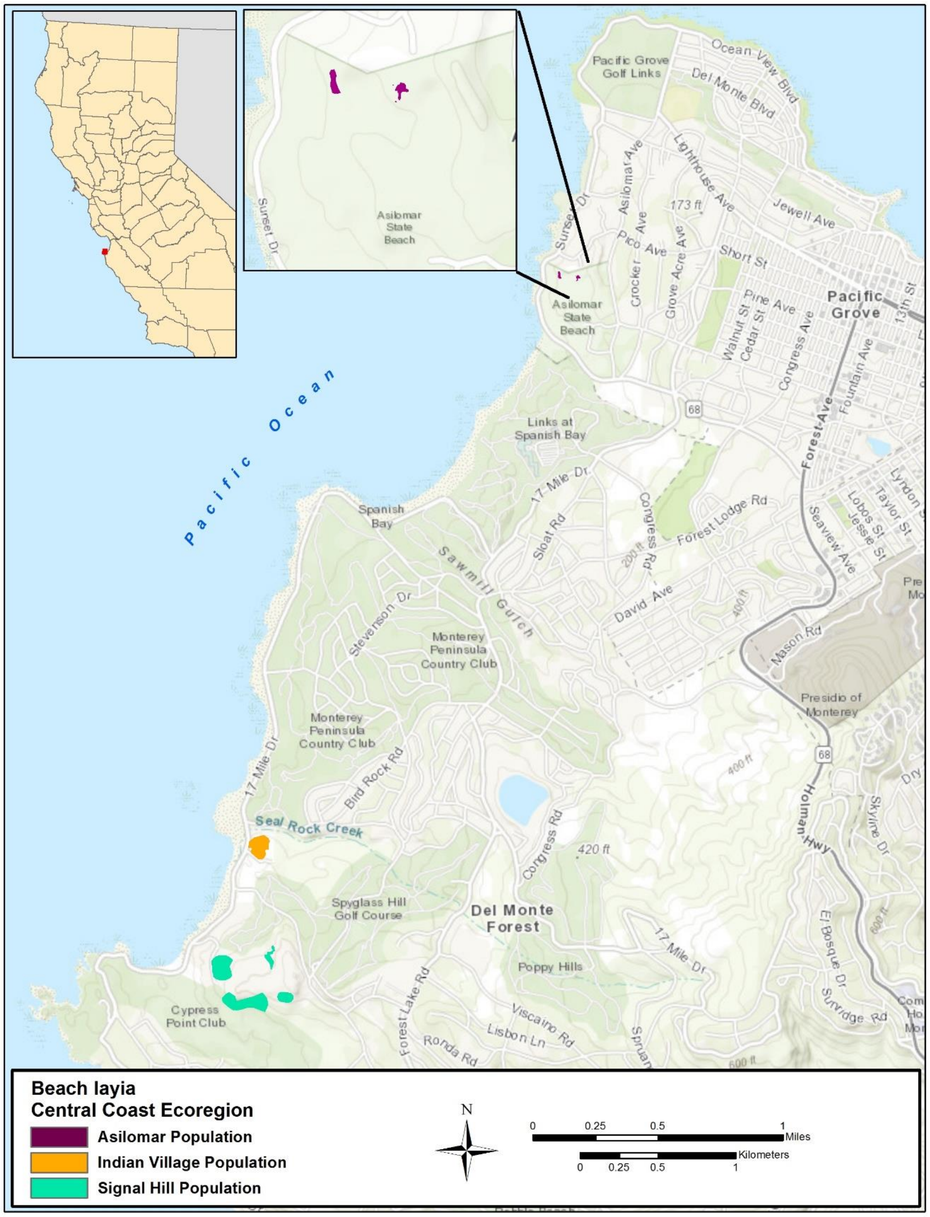

Figure 12. Distribution of beach layia in Monterey County, California, within the Central Coast Ecoregion. Occupied area at Aslilomar based on detailed mapping provided by California State Parks (Gray 2017, pers. comm.). Areas at Indian Village and Signal Hill based on the CNDDB (CNDDB 2017).

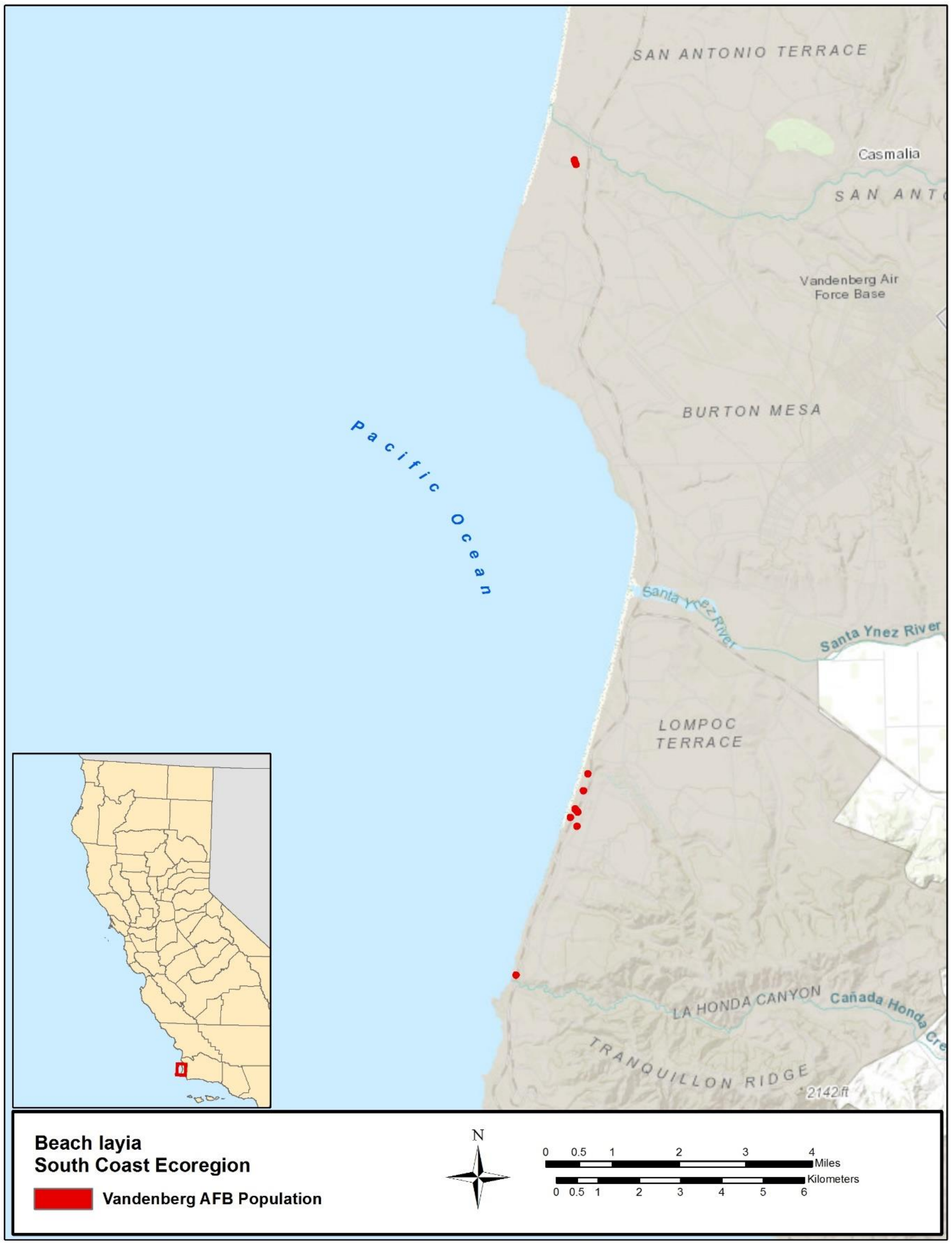

Figure 13. Distribution of beach layia at Vandenberg AFB, Santa Barbara County, California, within the South Coast Ecoregion (CNDDB 2017).

Table 2. Beach layia historical and current occupied ecoregions, populations, and occurrences, from north to south. Acreage and abundance estimates are based on the best available scientific and commercial information at the time of the 5-Year Review and for 2017.

Ecoregion	Meta-Population	Population	Sub-population	Restoration Status	Ownership	5-Year Review Acreage	2017 Acreage	5-Year Review Abundance Estimate (year) or Last Year Observed	2017 Abundance Estimate
North Coast	Freshwater Lagoon Spit	Freshwater Lagoon Spit		Restored	National Park Service (Redwoods NP)	1[1]	3[2]	587 (2010)[2]	842[2]
	Mouth of Little River	Mouth of Little River		Extirpated	State Parks	Extirpated[3]	0	1937[3]	Extirpated[3]
	Mouth of Mad River	Mouth of Mad River		Extirpated	Humboldt County	Extirpated[3]	0	1967[3]	Extirpated[3]
	Humboldt Bay Area	North Spit Humboldt Bay	Mad River Beach	Unrestored	Humboldt County	?	?	?	?
			Bair/Woll	Unrestored	Humboldt Bay NWR	?	13[4]	?	?
			Lanphere Dunes	Restored	Humboldt Bay NWR	38[5]	33[4]	1.2 million (2010)[6]	1.3 million[4]
			Ma-le'l North	Restored	Humboldt Bay NWR	Combined with Lanphere Dunes	29[4]	Combined with Lanphere Dunes	1.3 million[4]
			Ma-le'l South	Restored	BLM	20 (includes	48[4]	?	2.1 million[4]

[1] Actual amount of occupied habitat not determined; conservative estimate.
[2] Census and mapping conducted by National Park Service (Julian 2017, pers. comm.).
[3] California Natural Diversity Database (CNDDB 2017).
[4] Mapping and population estimate conducted by the Arcata Fish and Wildlife Office 2017 (Appendix B).
[5] Mapping conducted by the refuge (Service 1999).
[6] Population estimate based on monitoring conducted by the refuge (Pickart 2017, pers. comm.).

Ecoregion	Meta-Population	Population	Sub-population	Restoration Status	Ownership	5-Year Review Acreage	2017 Acreage	5-Year Review Abundance Estimate (year) or Last Year Observed	2017 Abundance Estimate
						Samoa)[5]			
			Manila North	Partially Restored	Friends of the Dunes and Manila CSD	12[5]	82[4]	?	1.4 million[4]
			Manila South	Unrestored	Private	?	47[4]	?	?
			Samoa/Eureka Dunes	Unrestored	BLM, City of Eureka	16 (Eureka Dunes)[5]	49[4]	?	6.7 million[4]
		Elk River		Unrestored	City of Eureka	1[1]	15[4]	?	468, 000[4]
		South Spit Humboldt Bay		Partially Restored	CDFW, BLM	75[7]	83[4]	3.8 million (2007)[8]	6.1 million[4]
	Eel River	North Spit Eel River		Unrestored	CDFW	30[9]	15[4]	?	4.7 million[4]
		South Spit Eel River		Unrestored	Wildlands Conservancy	>15[10]	1.5[4]	>3,000 (2009)[10]	11,307[11]
	Mattole	McNutt Gultch		Unrestored	BLM	1[1]	1[1]	?	?
		Mouth of Mattole River		"Pristine"	Private	27[3]	27[3]	3.3 million (2010)[12]	3.1 million[12]

[7] Mapping conducted by BLM (BLM 2007).
[8] Population estimate conducted by BLM, 95% Confidence Interval 2.2 – 5.4 million (Service 2011, p. 23).
[9] Estimate of occupied habitat from the 5-Year Review (Service 2011, p. 23).
[10] Clendenen 2011, pers. comm.
[11] Census conducted by the Arcata Fish and Wildlife Office (Goldsmith 2017, pers. obs.).
[12] Estimate based on average density from monitoring data collected by BLM (Hassett 2017, pers. comm.).

Ecoregion	Meta-Population	Population	Sub-population	Restoration Status	Ownership	5-Year Review Acreage	2017 Acreage	5-Year Review Abundance Estimate (year) or Last Year Observed	2017 Abundance Estimate
	Point Reyes NS	Point Reyes NS		Partially Restored	National Park Service (Point Reyes NS)	146[13]	146[13]	>66,000 (2004)[9]	2.7 million[14]
Central Coast	San Francisco	San Francisco		Extirpated		Extirpated[3]	0	1904[3]	Extirpated[3]
	Monterey Peninsula	Point Pinos		Extirpated	City of Pacific Grove	Extirpated[3]	0	1962[3]	Extirpated[3]
		Asilomar State Beach		Restored	State Parks	<0.1[15]	0.17[16]	190[15] (2009)	1,541[16]
		Indian Village Dunes		Restored	Private	0.55[15]	0.55[15]	1,783[15] (2009)	1,200[17]
		Signal Hill Dunes		Unrestored	Private	<1[1]	1[1]	?	?
South Coast	Vandenberg AFB	Vandenberg AFB		Partially Restored	Military	2.6[18]	0.83[19]	4,300[18] (2011)	5,069[19]
Approximate Total						**386**	**595**	**8.4 million**	**30 million**

[13] Mapping conducted by Point Reyes NS, 2001–2003 (Point Reyes NS 2010).
[14] Estimate based on sampling conducted by the National Park Service in Abbots Lagoon area (Parsons 2017, pers. comm.).
[15] Mapping and census conducted as part of a capstone project by a student at Monterey Bay State University (Johns 2009).
[16] Mapping and census conducted by California State Parks (Gray 2017, pers. comm.).
[17] Estimate provided by consultant (Dorrell-Canepa 2017b).
[18] Lum 2011, pers. comm.
[19] Mapping and census conducted by the Santa Barbara Botanic Garden (Schneider 2017).

7.0 CURRENT CONDITION—POPULATIONS

7.1 North Coast Ecoregion

The North Coast Ecoregion contains the largest area of occupied beach layia habitat (Table 2, above) and the largest populations in the range of the species. It includes a small population on the spit of Freshwater Lagoon, many populations in the Humboldt Bay area, two populations in southern Humboldt County near the mouth of the Mattole River, and a population at Point Reyes NS. The North Coast Ecoregion experiences approximately 38 in (96 cm) of annual rain on average (NOAA 2017a).

Humboldt Bay is considered to have the highest quality habitat for the species, in part due to the relative high proportion of dune mat at this location, and perhaps due to the higher rainfall (Pickart and Sawyer 1998, p. 23). We conducted a mapping, habitat assessment, and density sampling effort for the populations in the Humboldt Bay area during spring 2017 as part of an effort to document the extent, characterize the habitat, and estimate the abundance of beach layia in this ~~extensive~~ area (Appendix B). A total of 416 ac (168 ha) of occupied habitat were mapped in the Humboldt Bay area and the total estimate was approximately 33 million plants (95 percent confidence interval, 25 million – 42 million) (Appendix B).

Comment [e17]: See my comments in the Appendix

Acreages of occupied habitat vary across the North Coast Ecoregion: the Freshwater Lagoon Spit population totals 3 ac (1.2 ha) based on National Park Service census and mapping efforts over the last 17 years (Julian 2017, pers. comm.); the population at the mouth of the Mattole River is estimated at 27 ac (11 ha) (BLM 2005, p. 16); and the population at McKutt Gultch is approximately 1 ac (0.4 ha) (Imper 2017, pers. comm.). Another 146 ac (59 ha) were mapped at Point Reyes NS in 2010 by the National Park Service (Point Reyes NS 2010). The combined estimated total is approximately 622 ac (252 ha) of occupied habitat in this region compared to 386 ac (156 ha) estimated in the 2011 5-year review, though part of this increase could be due to increased effort in mapping.

7.1.1 Freshwater Lagoon Spit (Extant)

Beach layia was discovered in the spring of 2000 on the Freshwater Lagoon Spit (Figure 7, above), located at Redwood National Park in northern Humboldt County approximately 50 mi (80 km) south of the Oregon border (Julian 2017, pers. comm.). A total of 2,612 plants were counted over approximately 1 ac (0.4 ha) (Julian 2017, pers. comm.). A census of the population has been conducted every year since 2000 (Julian 2017, pers. comm.) and results indicate the population and individual patches fluctuate substantially, with a peak of 11,110 plants recorded in 2003, and as few as 263 plants in 2014 (Julian 2017, pers. comm.) (Figure 14, below).

The population fluctuations at Freshwater Lagoon Spit may have been influenced by a reduction in human traffic on the dunes resulting from park management implemented since 2001, which (while initially favorable) may have stimulated dune stabilization by native dune species, primarily grasses (Samuels 2007a, pers. comm.). Additionally, there is anecdotal evidence that the population fluctuations, and perhaps the relatively large number of small, few-flowered plants may have been caused by late-spring storm events that deposited sand on top of the plants after they germinated (Samuels 2007b, pers. comm.). A total of 842 plants were counted in 2017 (Samuels 2007b, pers. comm.) and the overall trend of this population is declining.

Comment [e18]: Should the 2011-2017 drought be mentioned here?

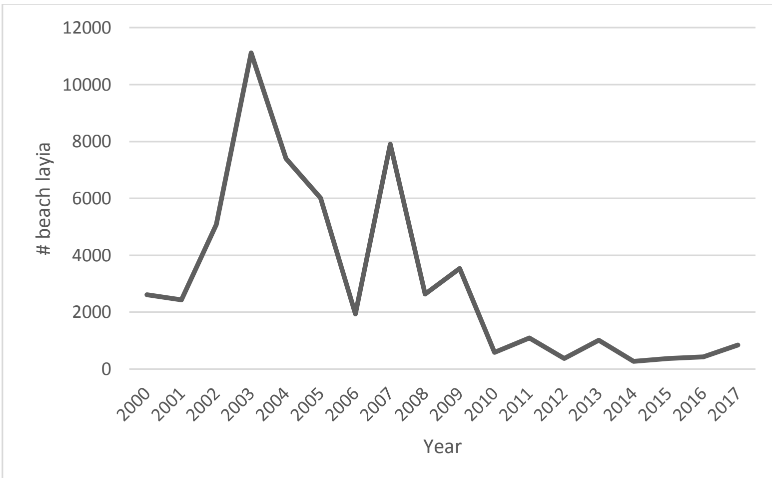

Figure 14. Population trend of the Freshwater Lagoon Spit population of beach layia, Humboldt County, California.

7.1.2 Little River State Beach (Extirpated)

A historical population located near the Mouth of the Little River. This population was last observed in 1937 and is thought to have been lost to construction of U.S. Highway 101 and invasion of nonnative plant species in the 1960's (CNDDB 2017). California State Parks have expressed interest in reintroducing beach layia to this area (Forys 2017, pers. Comm.).

7.1.3 Mouth of the Mad River (Extirpated)

A historical population occurred on the north side of the mouth of the Mad River and was removed when the river mouth naturally meandered north, eliminating the dune flora that was collected by Joseph Tracy in the early 20th century. The last observation made was in 1967 (CNDDB 2017).

7.1.4 North Spit Humboldt Bay (Extant)

This population extends across multiple land ownerships, including Humboldt County, the Humboldt Bay NWR (Refuge), BLM, Manila CSD, the City of Eureka, and private property (Figure 8, above). Mapping of beach layia on the North Spit of Humboldt Bay was conducted in 1999 (Refuge 1999, no page number) and in 2017 (Service 2017, unpublished data; Appendix B). The 1999 mapping effort yielded a total area of about 157 ac (63 ha) of occupied habitat. The 2017 surveys re-evaluated areas mapped in 1999 on parcels north of Lanphere (Bair/Woll) south to the entrance to Humboldt Bay (Refuge 1999) and resulted in 289 ac (117 ha) of occupied habitat (Appendix B). This increase between 1999 and 2017 is largely due to habitat improvement by the Refuge through the removal of nonnative, invasive species (Martinez *et al.* 2013, p. 170).

In order to further evaluate this population for this analysis, we define subpopulations on the North Spit of Humboldt Bay based primarily on property ownership and management strategy. We grouped properties based on past and current restoration status, and available monitoring data. The only biologically meaningful separation is the large distance between the Samoa/Eureka subpopulation and the rest of the occupied areas on the North Spit.

Mad River Beach Subpopulation

There is little data available for this subpopulation of beach layia on the county-owned Mad River Beach south of the mouth of the Mad River. This is the only subpopulation on the North Spit that was not mapped in either 1999 or 2017. We made observations in January 2018 that indicate beach layia is fairly abundant and widely distributed within the dune mat habitat in this area (Goldsmith 2018, pers. obs.). However, the vegetation community is dominated by invasive, nonnative species including European beachgrass (*Ammophila arenaria*), annual grasses (*Bromus diandrus* and *Briza maxima*) and yellow bush lupine (*Lupinus arboreous*) (Goldsmith 2018, pers. obs.). For the purposes of this evaluation, we lumped the occupied beach layia habitat on a parcel owned by the Refuge (known as the Long parcel) with this subpopulation due to its close proximity with Mad River Beach and lack of data for that parcel. The best available information indicates a conservative estimate of 1 ac (0.4 ha) for this subpopulation, although the amount of area occupied is likely substantially larger (Service 2017, unpublished data).

Bair/Woll Subpopulation

The Refuge purchased the Bair parcel in 2011 (Refuge 2013, p. 2). The Refuge does not own the adjacent Woll parcel (located directly north of Bair and south of the Long parcel); however, its acquisition and restoration is a high priority for the Refuge (Refuge 2013, p. 2). Beach layia occurs in the dune mat habitat on these parcels but the majority of the area is dominated by nonnative, invasive species including European beachgrass, iceplant, yellow bush lupine, and annual grasses (Pickart 2018, pers. comm.). Restoration has occurred on the southwest corner of Bair, closest to Lanphere. However, dedicated funding is required to successfully restore and maintain the remainder of this area (Pickart 2018, pers. comm.). For the purposes of this analysis, this area was not sampled enough years to generate a statistically valid population estimate. Occupied beach layia habitat encompasses approximately 13 ac (5.3 ha) (Service 2017, unpublished data; Appendix B).

Lanphere Dunes Subpopulation

The Refuge owns and manages 33 ac (13 ha) of occupied habitat that was previously owned by the Nature Conservancy. The first documented efforts to restore dune processes as a component of restoration began at the Lanphere Dunes in the 1980s (Pickart and Sawyer 1998, p.56; Martinez *et al.* 2013, p. 159). European beachgrass and iceplant were removed over many years and are now at a maintenance level (Pickart 2018, pers. comm.). Beginning 40 years ago, yellow bush lupine has been removed and the treatment area has shifted north onto the Bair parcel as the species has been eradicated in the initial treatment areas (Pickart 2018, pers. comm.). Additionally, annual grasses have been removed since 2000, although continuing effort is needed

(Pickart 2018, pers. comm.); at this time, dedicated funding has not been allocated for this effort into the future. This beach layia subpopulation has been inventoried since 1987 (Pickart 2018, pers. comm.), with survey efforts expanding in 2009 to include the Ma-le'l North subpopulation (see below) (Pickart 2018, pers. comm.). Over the years, beach layia at Lanphere Dunes has responded positively to restoration actions and negatively to lack of rainfall in the winter months, and on the whole appears stable (Figure 15). In 2017, abundance was estimated for both Lanphere Dunes and Ma-le'l North at approximately 1 million individual plants (Pickart 2017b, pers. comm.).

Comment [e19]: How does the methods used by Pickart for this estimate compare to the one you used (in the Appendix)?

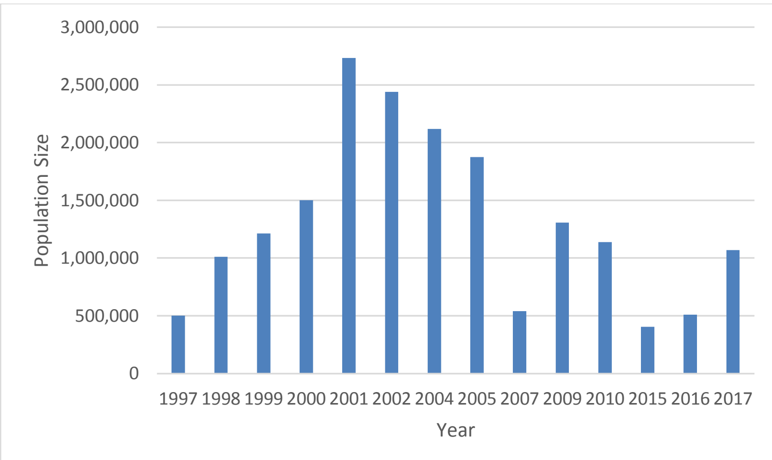

Figure 15. Population trends at the Lanphere Dunes subpopulation; the monitoring plot was expanded in 2009 to include the Ma-le'l North subpopulation. Humboldt Bay NWR, Humboldt County, California.

Comment [e20]: Why use a different format for this figure as the one used for Freshwater Lagoon?

Ma-le'l North Subpopulation

In addition to the Lanphere Dunes subpopulation, the Refuge also owns and manages the Ma-le'l North subpopulation, located directly south of Lanphere. It is the northern portion of the Ma-le'l Cooperative Management Area (CMA), which includes the Ma-le'l South subpopulation (see below), the southern portion of which is owned by BLM. Restoration occurred at Ma-le'l North between 2004 and 2009 (Pickart 2018, pers. comm.). European beachgrass and iceplant require periodic removal of resprouts, and yellow bush lupine and annual grasses are treated annually (Pickart 2018, pers. comm.). Approximately 29 ac (11.7 ha) of occupied beach layia habitat was mapped in 2017 (Appendix B). The monitoring that occurs at Lanphere was extended to include Ma-le'l North in 2009 (Figure 15).

Ma-le'l South Subpopulation

This subpopulation occurs in the southern portion of the Ma-le'l CMA, which is owned and managed by BLM. The BLM allows access for equestrian use and dog walking, neither of which are allowed at the Ma-le'l North subpopulation (Friends 2018, pers. comm.). Restoration occurred within this subpopulation from 1994 to 2008, and as a result, the nonnative, invasive European beachgrass only requires periodic handpulling of resprouts (Wheeler 2017, pers.

comm.). Iceplant and annual grasses are still prevalent and require treatment (Wheeler 2017, pers. comm.). Approximately 48 ac (19.4 ha) of occupied beach layia habitat were mapped in 2017 (Service 2017, unpublished data).

Monitoring data from plots established in 2009 indicate that this Ma-le'l South subpopulation was less abundant during drought years (2012–2015), and had a spike in abundance in 2017 after a winter of substantial rainfall (Figure 16) (Hassett 2017, pers. comm.).

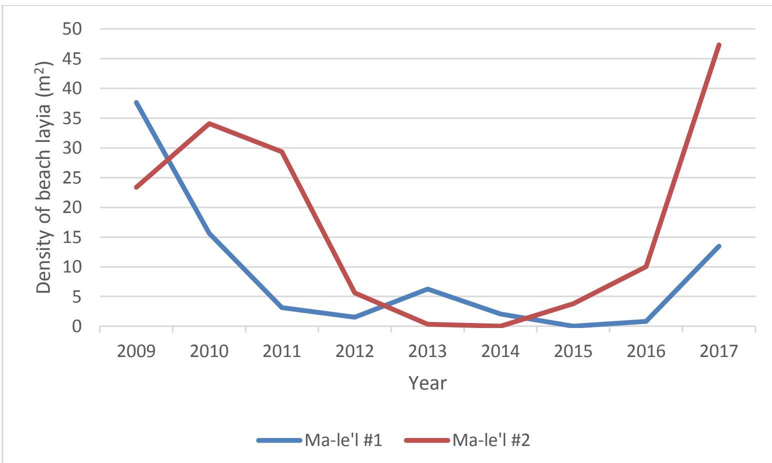

Figure 16. Monitoring data from two plots at the Ma-le'l South subpopulation (2009 to 2017), Humboldt County, California.

Comment [e21]: Make format consistent with previous two figures.

<u>Manila North Subpopulation</u>

This beach layia subpopulation totals approximately 62 ac (25 ha) of occupied habitat. It overlaps two properties owned and managed by (1) the Manila CSD, which provides water services to residents of the unincorporated community of Manila; and (2) the non-profit organization known as Friends of the Dunes (Friends), which is an organization dedicated to the conservation of dunes and natural resource education around Humboldt Bay (Friends 2018, entire). For the purposes of this analysis, we lumped these two properties due to proximity and similarity in restoration status. Friends have an irrevocable offer to dedicate title in fee recorded on their property, which transfers ownership to the State should the group cease to exist, or if any of the terms of the grant from the California Conservancy are violated (Friends Undated, Exhibit A).

Comment [e22]: Correct citation?

The portion of dunes owned by the Manila CSD previously had the nonnative, invasive European beachgrass and iceplant removed (Pickart 2018, pers. comm); however, restoration is no longer occurring on the property. Follow-up treatments are necessary, including many areas that have become re-invaded (Goldsmith 2017a, pers. obs.). Volunteer restoration has been ongoing on the Fried's property since 2008, primarily focusing on the foredune habitat (Berger 2018, pers. comm.). Though efforts to control nonnative, invasive species are continuing, annual grasses are expanding faster than the organization is able to respond, and progress with removal of European beachgrass is slow (Berger 2018, pers. comm.). There is no beach layia trend information available for this subpopulation and no monitoring occurring on either property.

Manila South Subpopulation

A portion of occupied beach layia habitat south of the Manila North subpopulation is privately owned and described herein as the Manila South subpopulation, comprising approximately 67 ac (27 ha) in 2017 (Service 2017, unpublished data; Appendix B). The property owner has recently expressed an interest in selling this property and it will likely be transferred to a public agency in the future, including development of restoration plans (Pickart 2018, pers. comm.). The nonnative, invasive European beachgrass is well established in both the foredunes and backdunes, and iceplant and annual grasses dominate large portions of the property (Goldsmith 2017b, pers. obs.). There is no beach layia trend information available and no monitoring occurring on this property.

Samoa/Eureka Subpopulation

The Samoa/Eureka subpopulation encompasses approximately 49 ac (20 ha) and includes all of the occupied beach layia habitat on the southern end of the North Spit of Humboldt Bay, all of which is managed by BLM. Part of the occupied habitat is owned by BLM, including an Endangered Plan Protection Area (EPPA) and a portion of an open Off-Highway Vehicle (OHV) riding area. The remainder of the occupied habitat is owned by the City of Eureka, including an industrial zoned area that contains an operational airport facility, an EPPA that is under a conservation easement held by the Center for Lands Management as mitigation for impacts associated with the airport, and the remainder of the open riding area that extends onto BLM property.

Overall, some restoration has occurred on both EPPAs, but nonnative, invasive species continue to fill in open areas and compete with beach layia. European beachgrass dominates the foredune, while iceplant, annual grasses, and yellow bush lupine are prevalent in the backdunes (Goldsmith 2017c, pers. obs). The open OHV riding area is highly stabilized by nonnative, invasive species (with the exception of established trails for OHVs); beach layia is typically only present on the edges of trails where some disturbance occurs (BLM 2016, p. 8).

Monitoring data is collected by the BLM in five plots in the EPPAs and two plots in the open riding area. Figure 17 depicts trends in the average density of beach layia throughout this subpopulation and highlights differences between management in EPPAs and the open OHV riding area from 2008 to 2017. Overall, the EPPAs have higher density of beach layia and density has increased significantly in those plots over the last 2 years, which correlates with increased precipitation.

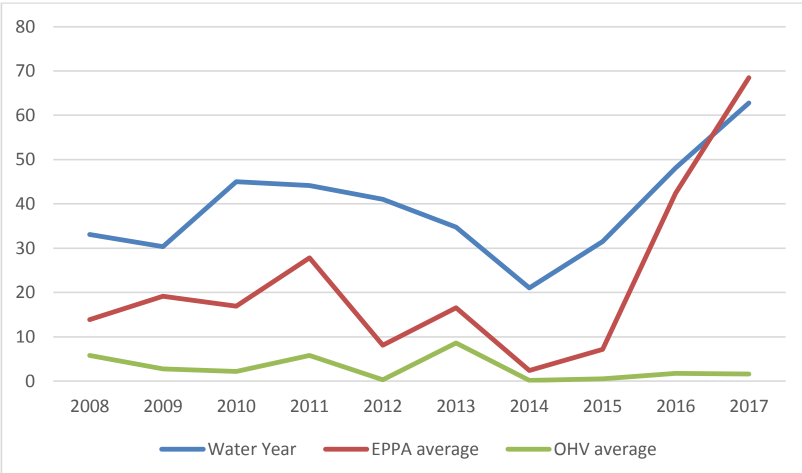

Figure 17. Density of beach layia in Endangered Plant Protection Areas (EPPAs) and Open (OHV) Riding Areas in relation to annual precipitation on the Samoa peninsula (Hassett 2017, pers. comm.), Humboldt County, California.

Comment [e23]: Ditto

7.1.5 Elk River Spit (Extant)

The Elk River Spit is a sand peninsula owned and managed by the City of Eureka that is approximately 1.2 mi (1.9 km) long by up to 0.1 mi (0.16 km) wide, located on the east shore of Humboldt Bay at the mouth of Elk River (Figure 8, above). This population was first mapped and surveyed by us (the Service) in 2017, resulting in occupied habitat totaling approximately 15 ac (6 ha) (Service 2017, unpublished data; Appendix B). The majority of the spit is dominated by nonnative, invasive European beachgrass (Goldsmith 2017d, pers. obs.) and there is no plan for restoration. The predominant use is recreation and fishing. There is no beach layia trend information available and no monitoring occurring on this property.

7.1.6 South Spit Humboldt Bay (Extant)

Habitat supporting beach layia on the South Spit of Humboldt Bay is of variable width and extends about 5 mi (8 km) south from Humboldt Bay's entrance to the base of Table Bluff (Figure 8, above) (BLM 2014, p. 3). The majority of the South Spit is owned by CDFW, designated as the Mike Thompson Wildlife Area; the remainder is owned by BLM, who also manages the entire area/subpopulation (BLM 2014, p. 3). For the purposes of this analysis, this area is refered to as the South Spit.

The beach layia population on the South Spit was estimated in 2003 and 2007 (BLM 2003, 2007), and again in 2017 using a different methodology (Service 2017, unpublished data; Appendix B). In 2003, total occupied habitat was mapped at 34.3 ac (13.9 ha), supporting an estimated 5.5 million plants (95 percent Confience Interval = 2.5 to 8.6 million) (Service 2011, p. 23). In 2007, 75 ac (30 ha) was mapped as occupied, for which the total population of was estimated at 3.8 million (95 percent Confidence Interval = 2.2 to 5.4 million) (Service 2011, p.

23). In 2017, the best available information indicate that occupied habitat increased to 83 ac (34 ha), with a population estimate of 6 million (95 percent Confidence Interval = 3.2 million to 8.8 million) (Service 2017, unpublished data; Appendix B). The steady increase in occupied beach layia habitat over time is due to the continued restoration effort to remove nonnative, invasive European beachgrass and iceplant (BLM 2014, p. 7; Wheeler 2017b, pers. comm.). Restoration began at the south end of the spit in 2003 and has progressed steadily northward. The South Spit is in the process of being nominated as an Area of Environmental Concern and BLM has plans to continue restoration along the whole spit (Wheeler 2017b, pers. comm.).

Two monitoring plots were established in 2008 on the southern end of the South Spit and data collected within those plots (Figure 18) show an increase in density of beach layia following restoration and a decline in recent drought years, and a subsequent increase as precipitation has increased (BLM 2014, p. 15). A third plot was established in 2016 at the line of active restoration, but no beach layia has yet been documented in this plot (Hassett 2017, pers. comm.). These monitoring data suggest that beach layia density increases dramatically following restoration, settles to a more moderate level as native plants fill in the previously invaded habitat, and that density is also strongly correlated to rainfall.

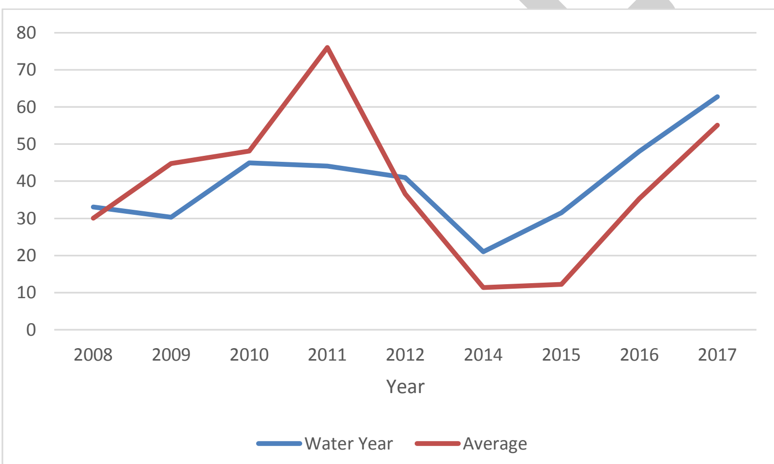

Figure 18. Density of beach layia within monitoring plots at the South Spit of Humboldt Bay, Humboldt County, California, in relation to precipitation. Note that no data was collected in 2013.

Comment [e24]: Format

7.1.7 North Spit Eel River (Extant)

Immediately south from the South Spit Humboldt Bay population is the North Spit Eel River population (Figure 9, above), encompassing 37 ac (15 ha) of occupied habitat that was mapped in 2017 within the CDFW’s Eel River Wildlife Area (ERWA) (Service 2017, unpublished data; Appendix B). CDFW is currently developing an *Ocean Ranch Unit Restoration Plan* that includes restoration of the near-shore dune habitat (van Hattem 2018a, pers. comm.). Removal of European beachgrass, iceplant, yellow bush lupine, and annual grasses could open up an estimated 300 ac (121 ha) of suitable habitat that is currently not occupied by beach layia (van Hattem 2018b, pers. comm.). At this time, there is no beach layia trend information available and no ongoing monitoring occurring for this population.

7.1.8 South Spit Eel River (Extant)

On the south side of the Eel River mouth (Figure 9, above), the Wildlands Conservancy owns approximately 100 ac (40 ha) of dunes that include 1.5 ac (0.6 ha) of occupied beach layia habitat and 11,307 individuals in 2017 (Service 2017, unpublished data; Appendix B). This recent survey information includes revisiting areas where the species was mapped in 2014 at which time the population was estimated at 500 individuals (Allee 2017, pers. comm.). Given that beach layia is present in the area and much of the potentially suitable habitat has not yet been surveyed, it is likely that the species occurs in other areas on the property that have not been mapped to date. The Wildlands Conservancy expect to restore their property, primarily focusing on the removal of the nonnative, invasive European beachgrass (Allee 2017, pers. comm.), thereby significantly improving the habitat for beach layia in the future. At this time, there is no beach layia trend information available and no ongoing monitoring occurring for this population.

7.1.9 McNutt Gulch (Extant)

In 1987, beach layia was found to occupy an area on privately owned dunes near the mouth of McNutt Gulch (Figure 10, above), approximately 4.5 mi (7.2 km) north of the mouth of the Mattole River by Berg in 1987 (CNDDB 2017). At that time, more than 500 plants were observed to occupy what were described as “excellent quality dunes” (CNDDB 2017). In 1988, two discrete population areas were distinguished, separated by a mile or more of beach and dunes by Lozier in 1988 (CNDDB 2017). Most recently in 2009, one patch was observed that included an estimated 200 plants occupying approximately 200 square feet (ft^2) (18.5 square meters (m^2)) (Imper 2018, pers. comm.). A full survey of the area has not been conducted. For the purpose of calculating total habitat occupied by beach layia for this analysis, this population is estimated to encompass 1 ac (0.4 ha), though CNDDB has a much larger area mapped (CNDDB 2017), and the most recent observation information (Imper 2018, pers. comm.) indicates the actual occupied area could be much smaller. At this time, there is no beach layia trend information available and no ongoing monitoring occurring for this population.

7.1.10 Mouth of the Mattole River (Extant)

This population of beach layia at the mouth of the Mattole River (Figure 10, above) was first recorded by Berg in 1987, when he reported greater than 1,000 plants occupying “excellent quality” dunes habitat (CNDDB 2017). This population resides within part of the King Range National Conservation Area, owned and managed by BLM, which is located 35 mi (56 km) south of the entrance to Humboldt Bay. In 2004, beach layia occupied approximately 27 ac (11 ha) of dunes on the south side of the river mouth (BLM 2004, no page numbers). Monitoring plots were established in the northern (Mattole #2) and southern (Mattole #1) portions of the occupied habitat and trends (Hassett 2017, pers. comm.) are depicted in Figure 19, below in relation to annual precipitation. Based on the average plant density that was recorded in the two monitoring plots in 2017 (Hassett 2017, pers. comm.) and the estimated occupied habitat of 27 ac (11 ha), as estimated in 2004, this population of beach layia is estimated to be approximately 3.1 million plants. This is a high abundance number, which correlates to an increase in precipitation most recently during 2017.

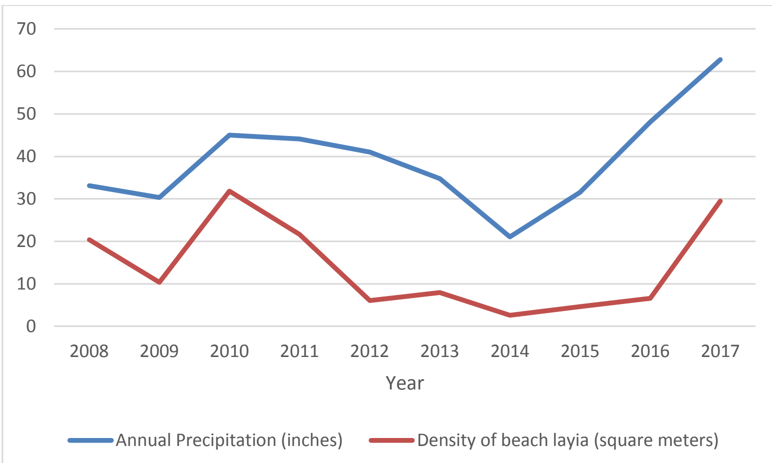

Figure 19. Average density of beach layia in two monitoring plots at the Mouth of the Mattole River, Humboldt County, California from 2008 to 2017 in relation to precipitation.

Comment [e25]: Format

7.1.11 Point Reyes National Seashore (Extant)

Moving south from the Mattole River, the next known occurrence of beach layia is located in Marin County, 200 mi (322 km) south of Humboldt Bay, in the dunes between Kehoe Beach Dunes and the Point Reyes lighthouse at Point Reyes NS (Service 1998, p. 44; Figure 11, above). This large dune system contains approximately 146 ac (59 ha) of dunes occupied by beach layia, based on mapping conducted since 2001 (Point Reyes NS 2010, no page numbers). Population estimates began in the 1980's; however, efforts were largely conducted by volunteers and do not appear to have been controlled sufficiently to provide accurate trends (Service 2011, p. 24). This population occupies 14 geographically concentrated areas (described by Point Reyes NS as "populations" but referred to herein as subpopulations), spread over 13 mi (21 km) of coastline (Point Reyes NS 2010, no page numbers).

Varying levels of survey intensity over the years hamper our ability to track population trends, and large variability in sampling data return large confidence intervals. However, sampling conducted from 2015–2017 in the Abbots Lagoon area, which includes recently restored areas, estimate increasing abundance (Table 3) (Parsons 2017, pers. comm.), which also correlates with an increase in precipitation during this timeframe. Restoration is ongoing and includes removal of nonnative, invasive European beachgrass and iceplant, which occur at various densities throughout the 14 subpopulations (Parsons 2017, pers. comm.). At this time, there is no formal, ongoing monitoring occurring for the 14 subpopulations.

Table 3. Estimates of the Abbotts Lagoon subpopulation based on transect sampling data.

Year	Estimated Abundance of Beach Layia
2015	56,000
2016	227,000
2017	2.7 million

7.2 Central Coast Ecoregion

The Central Coast Ecoregion includes the extirpated population area in San Francisco, an extirpated population (Point Pinos) on the Monterey Peninsula, and three extant populations on the Monterey Peninsula. This region differs from the North Coast Ecoregion in that it tends to experience substantially less rainfall, i.e., 17 in (43 cm) of annual rain on average compared to 38 in (96 cm) in the North Coast Ecoregion (NOAA 2017a). Additionally, differences in soil parent material on the Monterey Peninsula are likely, noting that this was proposed for examination but not completed during a 2012 Life History Study (Imper 2014, p. 2). The contribution of the Monterey Peninsula populations to the abundance of beach layia range-wide is relatively small. However, the significance of these populations to the recovery effort is comparatively great, due the geographic distance from the other two ecoregions, which adds to the ability of the species to withstand catastrophic events. Occupied habitat in this Ecoregion encompasses approximately 1.7 ac (0.7 ha) and has not changed appreciably since the time of the 5 year review.

7.2.1 San Francisco (Extirpated)

The San Francisco population is extirpated and its last known collection was in 1904 (CNDDB 2017), having previously occurred on the dune habitat in Golden Gate Park. The dune system that previously occurred here was destroyed for the development of Golden Gate Park and urbanization of San Francisco, although the area has also undergone surveys over the years (Cooper 1967, p. 42). At the time of the last collection in 1904, San Francisco dune reclamation projects had been in progress over multiple square miles of dunes for more than 30 years (Service 1998, p. 44). Thus, it is possible that other occurrences of beach layia in this remnant dune system were eliminated without detection.

7.2.2 Point Pinos (Extirpated)

A historical site for beach layia on the Monterey Peninsula (the type locality) occurred at the Point Pinos dunes, which is currently within the boundary of the Pacific Grove Golf Course, owned by the City of Pacific Grove. No plants have been recorded at this site since 1919 (CNDDB 2017). Approximately 20 ac (8.1 ha) of the Point Pinos dunes have undergone restoration and monitoring with endangered species as part of a plan related to the 2006 expansion of the golf course and transfer of the property from the U.S. Coast Guard to the City of Pacific Grove (Rana Creek 2015, p. 1). Beach layia was not part of the restoration plan, and despite annual monitoring for rare plants over the course of 10 years associated with the restoration activities, it has not been found at this locale.

7.2.3 Asilomar State Beach (Extant)

Beach layia was thought to be extirpated from this locale until 1990 when it was rediscovered within Asilomar State Beach (Figure 12, above) (Service 1998, p. 44). In 1994, 192 plants were documented, scattered in three relatively small areas of dunes near the north side of the park (Service 2011, p. 22). Since then, the population has remained within the same geographical footprint as originally rediscovered, and has been surveyed many times, as summarized in Figure 20 (Gray 2017, pers. comm.). Most recently in 2017, the occupied beach layia habitat consisted of a sparse layer of native dune mat vegetation with no presence of nonnative, invasive species (Dorrell-Canepa 2017, pers. comm.). A total of 1,560 plants were counted within 0.17 ac (688 m^2) (Gray 2017, pers. comm.). This 2017 count is the highest on record for this population, possibly correlated with the high amount of rainfall during the germination period. This population appears to be stable given its consistent year-to-year presence and relative protection from threats. However, even during a wet year with higher than normal numbers, such as 2017, the total population abundance is below the 1998 Recovery Plan goal of 5,000 individuals (Service 1998, p. 93).

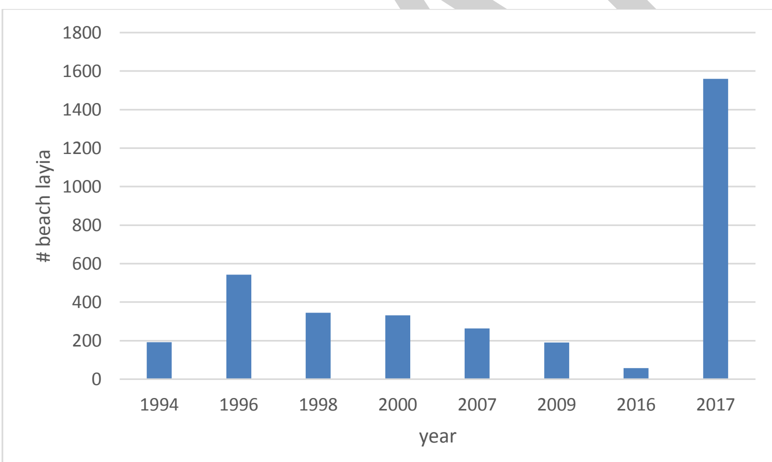

Figure 20. Abundance of beach layia at Asilomar State Beach, Monterey County, California.

Comment [e26]: Make formats consistent

7.2.4 Indian Village Dunes (Extant)

Two data points of information is available for the Indian Village Dunes population (Figure 12, above), which occurs on restored dune habitat. First in 2009, the population was estimated to be 3 to 5 ac (1.2 to 2 ha), of which about 0.55 ac (0.2 ha) supported a total of 1,783 plants (Johns 2009, p. 20). Second in 2017, the occupied area was estimated to be the same as in 2009, with an estimated 1,200 plants (Dorrell-Canepa 2017b, pers. comm.). These abundance numbers are below the recovery goal of 5,000 individuals as outlined in the 1998 Recovery Plan (Service 1998, p. 93). No historical estimates of acreage or abundance are available. Although not verified, there is evidence that this population may have been planted (CNDDB 2007). Owned by Pebble Beach Company, a conservation easement is held by the Del Monte Forest Foundation, which emphasizes conservation of the natural resources on the property (Service 2011, p. 25). At this time, there is no ongoing monitoring occurring for this population.

7.2.5 Signal Hill Dunes (Extant)

The Signal Hill Dunes population (Figure 12, above), located less than a mile south of the Indian Village Dunes and also owned by the Pebble Beach Company, has not been surveyed recently. It is highly fragmented and restricted to a small portion of approximately 25 ac (10 ha) of dunes located above the Spyglass Hill Golf Course (CNDDB 2017). The best available information for this population is from its last mapping effort in 2001, which documented beach layia occuping five semi-isolated areas of dune mat (Zander Associates 2001, p. 7), likely encompassing less than 1 ac (0.4 ha). The dunes are severely degraded by nonnative species, and pedestrian and equestrian traffic (Imper 2007, no page number). There is no beach layia trend information and no monitoring data available beyond that presented here. The 25 ac (10 ha) Signal Hill Dune system/complex is designated natural open space in the approved Del Monte Forest Land Use Plan Amendment (Zander Associates 2001, p. 8; California Coastal Commission 2012, p. 36). Additionally, in the future, a resource management plan will be written to address long-term protection and management of all the special status species on the property (Zander 2018, pers. comm.).

7.3 South Coast Ecoregion

The South Coast Ecoregion is represented by a single population located on Vandenberg AFB. This ecoregion has less annual rainfall than the Central and North Coast Ecoregions (i.e., 13 in (33 cm) as compared to 17 in (43 cm) and 38 in (96 cm), respectively) (NOAA 2017a); however, differences in rainfall between the central coast and south coast are not statistically significant as described in the Methodology (Section 3.0, above). The large distance between Monterey and Vandenberg, and differences in habitat characteristics, notably that the Vandenberg population area has higher average vegetation cover (Imper 2014, p. 6), are why we separated them into different ecoregions for this analysis. Occupied habitat was mapped in 2017 and was found to total less than 0.83 ac (0.33 ha) (Schneider & Calloway 2017, p. 10) which is less than the 2.6 ac (1 ha) was estimated in 2011 (Lum 2011, pers. comm.).

7.3.1 Vandenberg Air Force Base

Beach layia was first documented on Vandenberg AFB (owned by DOD; Figure 13, above) in 1929, and then not again recorded until 1995 when 80 plants were observed within about 400 ft^2 (37 m^2) of dune scrub habitat on the west side of Surf Road (CNDDB 2017). Since 1995, the population has been highly dynamic (Table 4). In 2012 and 2016, a census of all known occupied habitat was conducted and 2,397 and 1,855 plants were counted, respectively. Most recently, in 2017, a total of 5,069 plants were counted during a survey that was focused on areas that had not been surveyed in the past (Schneider & Calloway 2017, p. 6). Due to varying levels of survey effort, there is no beach layia population trend information for this entire population, although the number of beach layia within a restoration area on the south side of the AFB demonstrates the wide fluctuations in population size from year to year, which is often correlated to the amount of rainfall (Table 4).

Table 4. Rainfall totals and beach layia numbers within the South Vandenberg AFB restoration area (ManTech 2017, p. 9), Santa Barbara County, California. Rainfall average from 1927 to 2017 is 11.3 in (29 cm). Rainfall data is from Santa Barbara County Public Works Flood Control District (2017); water year = October–September.

Water Year	Beach Layia Abundance (# of individuals)	Rainfall in (cm)
2009–2010	2,959	19.4 (49)
2012–2013	797	7.3 (18.5)
2013–2014	53	7.2 (18.3)
2014–2015	366	8 (20)
2015–2016	542	11.7 (30)
2016–2017	2,916	22.1 (56)

The habitat on Vandenberg AFB is highly stabilized due to the presence of nonnative, invasive species, including iceplant, European beachgrass and veldt grass (Schneider & Calloway 2017, p. 14). Total vegetation cover is approximately 48 to 60 percent (Imper 2014, p. 6). Over the past 4 years restoration has occurred on the 89.6 ac (36 ha) south end of the AFB (ManTech 2017, p. 2). Application of herbicide is the primary treatment and it has been successful in reducing nonnative, invasive species cover from 59.6 ac (24 ha) to 11.6 ac (4.7 ha) of the 89.6-ac (36-ha) targeted area (ManTech 2017, p. 16). Buffer zones of 50 m were established around known populations of beach layia to avoid impacts to the species and treatments alternated between precise application of herbicide on invasive plants within the buffer zones during the fall when beach layia is dormant and broad scale treatments outside the buffer zones during the growing season when the herbicide is more effective (ManTech 2017, p. 2). A large area of dead biomass remains that is not suitable for beach layia colonization, and removal of nonnative, invasive species in the vicinity of the known, occupied beach layia habitat has been recommended to DOD (ManTech 2017, p. 20). Restoration is currently proposed on an additional 651-ac (263-ha) habitat area on the north end of the AFB (ManTech 2017, p. 1).

8.0 CURRENT CONDITION—FACTORS INFLUENCING VIABILITY

In this chapter, we examine existing factors that are negatively and positively influencing the resiliency of beach layia individuals, populations, and the species rangewide (i.e., threats and existing voluntary or regulatory conservation efforts); we also identify those factors not carried forward in our analysis because we determined that they are not likely to increase the risk of extinction. Threats are defined as any action or condition that is known to or is reasonably likely to negatively affect individuals of a species (Service 2017, p. 1). This includes those actions or conditions that have a direct impact on individuals, and those that affect individuals through alteration of their habitat or required resources. Thus, a threat as described herein is a general term that describes the source of an action or condition, or the action/condition itself, that may negatively affect beach layia.

Each threat is considered in terms of its scale, intensity, and duration, as well as potential direct or indirect impacts it may have on a species or its habitat across its life history stages. Some threats may be affecting the species at all life stages or all individuals within a population, or possibly affecting all populations within the species range. It is possible that a threat may be specifically affecting a single resilience factor, such as the amount of suitable habitat, or a specific life stage. Some threats, while present and acting on individuals of the species, may not rise to the level of affecting the population(s). Factors influencing current condition can include both negative and beneficial actions (Figure 21). Consideration and analysis is also given to the cumulative effects of these factors on the species' overall viability. The overall current condition is expressed in terms of population resilience, and species redundancy and representation.

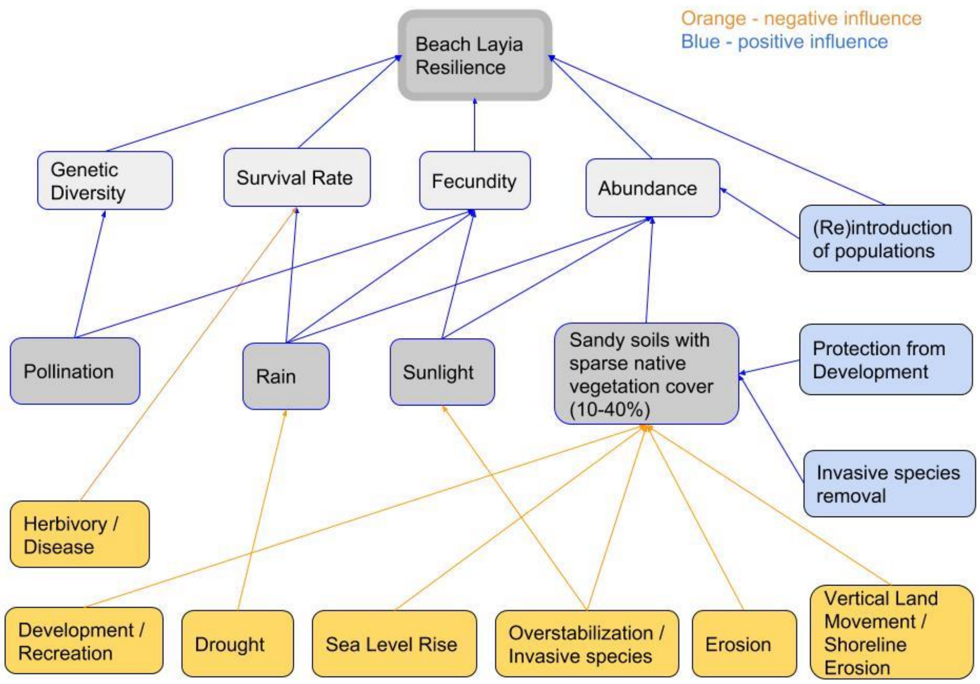

Figure 21. Influence diagram for beach layia.

8.1 Threats Considered and Not Carried Forward

8.1.1 Development

In the past, beach layia populations have disappeared in areas where occupied habitat was converted for commercial, industrial, or residential purposes (e.g., Point Pinos, San Francisco).

Range-wide, development is not likely to increase beach layia's risk of extinction since the majority of occupied habitat either occurs on public lands, is covered under beneficial resource management plans with an emphasis on conservation of natural resources, or is covered under local coastal plans and zoning ordinances that protect sensitive dune habitat (Redwoods NP 2000; BLM 1995, 2002, 2004; Service 2002, 2009; Friends 2007; Humboldt County Planning Department 1995; Kovacs 2007, pers. comm.; Wear 2006, pers. comm.; Rodgers 2007, pers. comm.; CDRP 2004a, 2004b; Pebble Beach Company 1989; Monterey County Planning and Building Inspection Department 2005; ManTech SRS Technologies, Inc. 2010). The remaining occupied habitat that is most susceptible to human destruction or modification includes the dunes located near the mouth of McNutt Gulch (Section 7.1.9, above) that is privately owned, and the Signal Hill Dunes on the Monterey Peninsula (Section 7.2.5, above), though this area is designated as open space (Zander Associates 2001, p. 8; California Coastal Commission 2012, p. 36).

Human pressures on coastal systems will increase significantly in the coming decades due to population growth, economic development, and urbanization (high confidence) (Intergovernmental Panel on Climate Change (IPCC) 2014, p. 67). Remote areas such as the Mattole (Sections 7.1.9 and 7.1.10) are less likely to be impacted by development; however, one of the populations in the Mattole area (McNutt Gultch, Section 7.1.9) is on private property and thus susceptible to potential future development. Populations in more urban areas, such as the entirety of the beach populations within the Central Coast Ecoregion in Monterey, are more likely to be impacted by development; however, some conservation measures are in place, including the Indian Village Dunes is under a conservation easement (Pebble Beach Company 1989), Asilomar State Beach is managed for the protection of sensitive species (CDPR 2004c, pp.12–19), and Signal Hill Dunes are designated as open space (Zander 2018, pers. comm.).

Comment [e27]: ?

Most of the populations in the Humboldt Bay area are on state and Federal lands, or lands owned by a non-profit/conservation group, and are not likely to change ownership or be negatively impacted by development. Exceptions include areas owned by the City of Eureka (the Samoa/Eureka Dunes subpopulation (Section 7.1.4) and the Elk River Spit population (Section 7.1.5)) and the privately owned Manila South subpopulation (Section 7.1.4). The city owned EPPA that overlaps a portion of the Samoa/Eureka subpopulation within the larger North Spit Humboldt Bay population area is under conservation easement (Sanchez 2017, pers. comm.; Pickart 1993) and the remaining city owned properties that harbor occupied beach layia habitat (i.e., the Eureka Airport and Elk River Spit) are under protection from development by the local coastal plan (Humboldt County Planning Department 2014, p. 27-31). The Manila South subpopulation within the North Spit Humboldt Bay population area is likely to be sold to a public entity in the near future (Pickart 2018, pers. comm.).

At this time, the best available scientific and commercial information indicate that development, overall, may have some negative influence on individual beach layia plants within portions of two populations in the North Coast Ecoregion. However, potential impacts are not expected to result in population- or rangewide-level effects.

8.1.2 Herbivory/Disease

Observations of herbivory (deer browsing) indicate that individual plants or flowering heads have been removed from the population at Asilomar State Beach in Monterey (Gray 2017, pers comm; Imper 2014, p. 7). Although herbivory has not been noted in other locations, it is possible it could occur elsewhere. Herbivory has the potential to reduce the abundance of populations, but not to a significant degree, and is not considered a significant threat to the species across its range. Installation of deer fencing around the Asilomar State Beach population or caging of individual plants (though this would be challenging due to the small size of the plants) could be effective in preventing impacts. Additionally, there are no known diseases that pose a threat to beach layia. At this time, the best available scientific and commercial information indicate that herbivory and disease are not resulting in population- or rangewide-level impacts to beach layia.

Comment [e28]: On the dunes, deer are not the primary herbivores, so this parenthetical is odd. It makes it sound like they are the *only* herbivores. Rabbits and insects are likely to consume the most plant material.

Seed consumption is often important on the dunes. See the paper on Tidestrom's lupine by Tiffany Knight and students. Also note the relationship with Ammophila and seed consumption they observe.

I think this section needs more careful consideration.

8.2 Threats Considered and Carried Forward

8.2.2 Overstabilization/Competition with Invasive Species

Areas that are described as overstabilized, for the purpose of this analysis, have high vegetative cover and restricted sand movement either due to presence of nonnative, invasive species or presence of species (native or nonnative) that move in after an area is stabilized by invasive species. For example, coyote brush (*Baccharis pilularis*) is a common native shrub that is not a part of the dune mat community, but commonly appears on dunes after an invasion (McBride and Stone 1976, p. 124; Sawyer 2009, pp. 583, 743). Overstabilization is a different ecological process from natural succession in which native vegetation changes over time from the semi-stable dune mat community to more stabilized communities, such as the *Carex obnupta* Herbaceous Alliance (i.e., a slough sedge sward that occurs in seasonally flooded dune swales providing sediment retention and nutrient uptake) or *Pinus contorta* ssp. *contorta* Forest Alliance (i.e., beach pine forest) (Barbour and Pickart 2007, p. 157). Both overstabilization and natural succession have a negative impact on the abundance of beach layia because the species requires open sand to colonize an area (Service 2011, pp. 32–33). The difference is that large portions of the range of beach layia have been made unsuitable by overstabilization and competition with both native and nonnative invasive species while dune systems that are naturally succeeding often still contain areas of semi-stable dunes—though they may shift over time—that are suitable for beach layia. Dunes are naturally subject to cyclic stabilization and rejuvenation in response to major tectonic events, but nonnative species can greatly accelerate stabilization (Service 2017b, no page number). The Freshwater Lagoon Spit is the only beach layia population that is currently impacted by stabilization caused by native species, namely red fescue (*Festuca rubra*) (Samuels 2017, pers. comm.). Although no measures are in place to address the stabilization effects, there is an experimental project underway to remove native species in order to create more suitable habitat for beach layia (Samuels 2017, pers. comm.).

Beach layia was listed, in part, due to the past introduction and invasion of its habitat by a variety of nonnative, invasive plant species (Service 1998, p. 45). These species adversely affect the long-term viability of coastal dune plants, including the entire distribution of beach layia through either direct competition for space (57 FR 12323); stabilization of the dunes (57 FR 12318); and in some cases, enrichment of the soils, which then stimulate invasion by other aggressive species (Maron and Connors 1996, p. 309). Beach layia is currently not under the threat of invasive species at the Lanphere Dunes subpopulation (Section 7.1.4), Ma-le'l North subpopulation

(Section 7.1.5), Mouth of the Mattole population (Section 7.1.10), and Asilomar State Beach population (Section 7.2.3). The most common invasive species in dune systems throughout the range of beach layia are described in the following section. Evidence suggests these taxa will continue to invade beach layia habitat, necessitating routine and long-term management action. Many of them have been mapped within the various dune systems occupied by beach layia (e.g., Johns 2009, p. 24; Point Reyes NS 2015, p. i; Mantech 2018, p. 1), and there has been significant efforts for their removal or control (e.g., Service 2011, p. 10 ; Point Reyes NS 2015, p. 105; Mantech 2018, p. 1). However, much potentially suitable habitat for beach layia remains to be restored, as identified in the 1992 Recovery Plan (i.e., the Mouth of the Mad River, the majority of the North and South Spits of Humboldt Bay, Elk River Spit, the North and South Spits of the Eel River, McNutt Gultch, Point Reyes NS, Signal Hill Dunes, and Vandenberg AFB (Recovery Criterion 2, see Section 11.0). A permanent strategy for maintaining this habitat is yet to be developed (Specific Delisting Criterion 1, see Section 11.2).

8.2.1.1 Nonnative, Invasive Species Negatively Influencing Beach Layia

European beachgrass (*Ammophila arenaria*) is a beach grass native to Europe that was widely distributed to stabilize and establish sand dunes for property protection and erosion control (Global Invasive Species Database 2018). It can compete with and displace native vegetation communities and forms dense monospecific stands very different from the sparse native coastal vegetation that are the norm for some invaded areas (Pickart 1997, p. 3). It is a strong competitor partly because it can rapidly accrete sand, survive burial, resist drought conditions, produce vigorous rhizomes, and resist erosion (Hertling & Lubke 2000, pp. 522-524; Hilton *et al.* 2005, pp. 175-185).

Two species of iceplant (*Carpobrotus edulis* and *C. chilensis*) occur throughout beach layia's range, readily hybridizing with each other. These nonnative succulents form large, low-growing mats that displace native species, and over time, increase the organic matter of the soil by altering the nutrient poor environment and making it suitable for other nonnative species (Chenot 2014, p. 301-308).

Yellow bush lupine (*Lupinus arboreus*) is a short-lived perennial shrub native to central and southern California where it occurs as a component of the native dune scrub community. It was introduced to northern California's coastal dunes and now occurs as an invasive species in dune habitat where no other large, native shrubby lupines existed previously (Service 2017b, no page number). Once yellow bush lupine becomes established, it causes elevated nitrogen levels that facilitate invasion by other native and nonnative species (Pickart *et al.* 1998a, pp. 59-67). Eventually, desirable native species in invaded areas are almost entirely displaced by a combination of lupine shrubs, weedy grasses, or adventive natives, especially coyote brush (Service 2017b, no page number).

A collection of nonnative grass species other than European beachgrass have invaded the coastal dune systems of California. These include, but are not limited to, ripgut brome (*Bromus diandrus*), quaking grass (*Briza maxima*), rattail fescue (*Festuca bromoides*), yellow hairgrass (*Aira praecox*), velvet grass (*Holcus lanatus*), vernal sweetgrass (*Anthoxanthum odoratum*), and veldtgrass (*Ehrharta erecta*). Although some of these species are perennial, we refer to them collectively as invasive annual grasses for convenience in differentiating them from European beach grass. Throughout the North Spit Humboldt Bay meta-population, invasive annual grasses overstabilize dunes and outcompete native dune mat species (Service 2013, p. 2). Once annual grasses are eliminated, native communities can flourish. For example, at the Lanphere Dunes subpopulation where areas dominated by ripgut brome were removed (Service 2015, pp. 12-14), a dramatic increase in native cover and species diversity ensued, including increased numbers of the federally endangered Humboldt Bay wallflower.

Beach layia responds positively to the removal of nonnative and native invasive species, and a spike in density of beach layia often occurs following restoration activities (BLM 2014, pp. 15-16. The restored areas typically have had little to no beach layia present prior to restoration. Those restored areas that surveyors subsequently find beach layia are presumably colonized by wind dispersed seed in the vicinity, though it is possible that a seedbank for beach layia could be present at some sites. A marked increase in beach layia abundance immediately following invasive species removal has been documented at the South Spit Humboldt Bay population (BLM 2014b, p. 16), although initial spikes in population size, such as that observed here, are often short lived. This is because as the native perennial species reestablish, beach layia abundance numbers tend to stabilize at a more moderate level.

When conservation objectives are to restore habitat for the benefit of beach layia habitat, it is appropriate to remove secondary, native woody vegetation that became established in the stabilized conditions created by invasive, nonnative species (Wheeler 2017, pers. comm.) or remaining dead biomass (ManTech 2017, p. 18) during the restoration process. An example of a native woody species that is known to occupy coastal dune habitat after a nonnative species invasion is coyote brush (*Baccharis pilularis*); the presence of this species is contrary to recovery goals for dune mat habitat that beach layia relies on (Sawyer 2009, pp. 583, 743)

Many land managers are currently engaged in invasive species removal and many other land owners/managers that have not yet restored potential beach layia habitat have plans for restoration in the future. The Refuge, BLM, Manila CSD, Point Reyes NS, and CDPR have made substantial efforts to implement research and management aimed at controlling nonnative and native invasive species and restoring beach layia habitat. These efforts, along with effectiveness monitoring, should continue and expand. While the negative influence posed by invasive species has been addressed to some extent, at least temporarily, no mechanisms have been implemented to ensure continued funding and implementation of invasive species control programs rangewide, nor the necessary monitoring associated with such restoration.

In summary, overstabilization and the associated competition with native and nonnative invasive species occurs at almost all of the populations, with the exception of the Lanphere Dunes subpopulation within the North Spit Humboldt Bay population, the Mouth of the Mattole River population, the Asilomar State Beach population and the Indian Village Dunes population. Efforts to remove invasive species that are adversely affecting beach layia's resource needs are reducing these negative influences and thus improving the species resiliency at most populations. However, invasive species continue to significantly degrade suitable habitat and reduce the abundance of individuals, including potentially suitable habitat at the mouth of the Mad River, and occupied beach layia habitat throughout the majority of the North and South Spits of Humboldt Bay, Elk River Spit, the North and South Spits of the Eel River, McNutt Gultch, Point

Reyes, Signal Hill Dunes, and Vandenberg AFB, causing a reduction in beach layia resiliency throughout its range.

8.2.2 Changing Climate Conditions

Changes in weather patterns have been observed in recent years and are predicted to continue (Frankson *et al.* 2017, p. 1). This can include extreme events such as multi-year droughts, heavy rain events, or global and local sea-level rise (Frankson *et al.* 2017, pp. 2–5). All of these have the potential to remove, reduce, and degrade habitat as well as remove individual plants, reduce germination and survival rates, and reduce fecundity. The best available scientific and commercial information at this time do not indicate how historical changes in climate may have affected beach layia, though monitoring data indicate that recent drought conditions have had a negative impact on population size (BLM 2016, p. 6; ManTech 2016, p. 29). Reduced greenhouse gas emissions may help reduce the magnitude of impacts caused by changing climate by reducing the global atmospheric concentration of carbon dioxide, the dominant greenhouse gas of concern (National Academy of Sciences 2010, p. 1).

8.2.2.1 Drought

As depicted in Figure 6 in the species needs Section 4.5, above, density data from BLM monitoring plots in Humboldt County show a positive correlation with amount of rainfall (Hassett 2017, pers. comm.). Recent drought years (2012–2016) had a negative effect on the abundance of beach layia populations across the range of the species (BLM 2016, p. 6; BLM 2014b, p. 16; Pickart 2017, pers. comm.; Gray 2017, pers. comm.; ManTech 2017 p. 9). A dramatic increase in abundance was observed in 2017 after a wet winter (BLM 2016, p. 6; BLM 2014b, p. 16; Pickart 2017, pers. comm.; Gray 2017, pers. comm.). The longevity of the seedbank is unknown and it is therefore impossible to predict how many years of drought beach layia may be able to withstand, but it appears from these data that it can at least weather 4 years of consecutive drought.

In addition to needing rain to germinate, plants in moist locations (dune hollows) tend to be larger and produce more flowering heads while plants in dry sites can become desiccated and tend to be smaller with only one flowering head (Imper 2014, pp. 6-7). It is reasonable to predict, based on this observation, that one of the effects of drought across the species range could be a reduction in fecundity. It is also possible that individual plants that may have been exposed to enough rain to germinate could experience desiccation during dry periods in the growing season, and that drought conditions could reduce survival rates, though this has not been studied. Another way that dry conditions could decrease survival rates is through burial. Sand is more mobile when it is dry (Nield 2011, p. 513) and observations have been recorded of beach layia individuals dying before completing their life cycle due to burial (Imper 2014, pp. 6–7).

8.2.2.2 Sea Level Rise

An increase in the volume of the world's oceans can lead to localized changes in sea level depending on many contributing factors (Griggs *et al.* 2017, p. 11); this is discussed further under potential future condition (Section 8.0). Rising sea levels can lead to removal or reduction of habitat, and the removal of individual plants, seedbanks, and whole populations. Given that beach layia only occupies coastal dune systems, sea level rise has the potential to have a significant impact on the species range-wide by causing shoreline erosion, increased overwashing, and inundation. However, there is no evidence that rising seas are currently influencing beach layia, and it is unknown how changes in sea levels may have affected the species in the past. Management of habitat in such a way that soils, habitat, and plants are able to migrate inland can assist in avoiding habitat loss in the future.

Coastal dune systems are vulnerable to erosion from rising seas and storm surges, and drought has the potential to desiccate individuals, reduce germination and survival rates, and reduce fecundity. However, the best available information suggest that changing climate conditions at this time are not a significant negative influence on beach layia populations across its range.

8.2.3 Erosion/High Level of Disturbance

The erosion of soil in a dune system can be caused by many factors and any form of erosion or heavy soil disturbance can result in the removal of habitat, individual plants, and seedbank. In this section, we discuss erosion associated with high levels of disturbance that is caused by pedestrian, equestrian, OHV, and grazing activity. Direct trampling of individuals caused by these activities can occur at any point during beach layia's life cycle. Populations can be impacted through the loss of individuals and seedbank, and a reduction in survival and fecundity rates (e.g., BLM 2016b, p. 4).

The best available information suggest that trampling from both pedestrian and equestrian activities occur at insignificant levels at most populations throughout beach layia's range with the possible exception of the Signal Hill Dunes population on the Monterey Peninsula (Service 2011, p. 11), though the current level of impact is unknown. Monitoring data and anecdotal evidence consistently indicate a strong preference by beach layia for moderately disturbed habitat adjacent to roads and trails (whether pedestrian or equestrian) in what otherwise would be unoccupied habitat (Pickart 2011a, pers. comm.; Wear 2011, pers. comm.; Wheeler 2011, pers. comm.; Clendenen 2011, pers. comm.). Dispersed equestrian use has been allowed at the South Spit Humboldt Bay population since BLM began management of the area in 2002, and beach layia abundance has remained high, suggesting that dispersed equestrian use, at least where large areas of occupied habitat are concerned, is compatible with large populations (Wheeler 2017b, pers. comm.).

OHV activity within beach layia habitat across its range is significantly reduced since the time of listing. Most occupied habitat is restricted from OHV use with the exception of the following locations within the North Coast Ecoregion:

(1) The designated open riding area on the North Spit of Humboldt Bay (i.e., only a portion of the Samoa/Eureka subpopulation – high level of use).
(2) The South Spit Humboldt Bay population (access for commercial fisheries at designated areas).
(3) Incidental occasional use of the ERWA (low use primarily for fishing access) within the North Spit Eel River population.
(4) The Eel River Estuary Preserve (unauthorized use), which encompasses the entirety of the South Spit Eel River population.
(5) Privately owned land at the McNutt Gultch population (current use unknown).

A comparison of monitoring plots within the designated riding area on the North Spit of Humboldt Bay to closed areas harboring beach layia in the Samoa/Eureka subpopulation nearby demonstrates lower beach layia abundance within the riding area (BLM 2016a, BLM 2016b, Hassett 2017, pers. comm.; see also Figure 17 in Samoa/Eureka subpopulation discussion (within Section 5.1.4, above). However, it is important to note that in the OHV area, beach layia is restricted to the edges of trails and the remainder of the habitat is overstabilized and dominated by invasive vegetation, whereas the other monitoring plots are in areas managed for endangered plants where invasive vegetation is removed annually. The increased abundance in those plots could have more to do with invasive species management than the direct impacts of OHV use (Wheeler 2017, pers. comm.). The Eel River Estuary Preserve was previously heavily used by OHVs, but use is now prohibited, the area is patrolled and only occasional unauthorized use occurs (Allee 2018, pers. comm.). For this beach layia population, plants occupy the old trail system and the remainder of the habitat is dominated by European beachgrass (Goldsmith 2017e, pers. obs.).

Although livestock trampling was identified as a threat when beach layia was listed (Service 1998, p. 46), the only population that is possibly exposed to livestock is within the private property near the mouth of McNutt Gulch (Imper 2018, pers. comm.). No information is available on whether or not livestock are currently present, and if so, the degree of impact to the McNutt Gulch population of beach layia. Livestock trampling previously occurred at the Mouth of the Mattole River population, but fencing was replaced in 1997, thereby eliminating this threat (BLM 2014a, p. 5). Additionally, livestock were removed from the South Spit Eel River population that occurs on the Wildlands Conservancy Preserve (Allee 2018, pers. comm.). Overall, trampling from livestock only remains a possible threat for the McNutt Gultch population and the current status of the impact of livestock on that population is unknown.

In summary, the best available scientific and commercial information suggests that human induced disturbances are not resulting in significant, negative population- or range-wide impacts given most beach layia habitat is under some level of protection and responds well to slight disturbance. However, some risk to the species viability at North Coast Ecoregion populations remains. Trampling caused by pedestrians and equestrians does not appear to be impacting the abundance of beach layia populations with the possible exception of the Signal Hill Dunes population. Restriction of OHV access has elevated the species' resiliency at the Samoa/Eureka subpopulation on the North Spit of Humboldt Bay (because all OHV activity is restricted to a designated riding area) and the South Spit Eel River population within the Eel River Estuary Preserve (with the exception of occasional unauthorized use). Restriction of livestock has improved the abundance and distribution of the Mouth of the Mattole River population, and the only population that might be impacted by livestock is the McNutt Gultch population, though the current status of livestock on that property is unknown.

8.2.4 Vertical Land Movement/Shoreline Erosion

Uplift or subduction (i.e., the geological process that occurs at convergent boundaries of tectonic plates where one plate moves under another and is forced to sink due to gravity into the mantle) both during and between seismic events can affect whether a beach/shoreline is prograding (i.e., advancing toward the sea as a result of the accumulation of waterborne sediment) or eroding. Vertical Land Movement (VLM) is site specific and appears to vary in direction and magnitude across the Humboldt Bay region (Patton *et al* 2017, pp. 26-27). Removal or reduction of both habitat and individual plants can be caused by subduction while uplift may counter balance the effects of sea level rise and allow for migration of habitat inland. Sudden movements associated with earthquakes can cause tsunamis, which have the potential to remove habitat and whole populations in one event.

As with many ecosystems, dunes often undergo periods of cyclic stabilization and rejuvenation (Pickart and Sawyer 1998, p. 4). Rejuvenation events are the result of changes in relative sea level, which, in turn, are attributed, at least in the past, to tectonic activity, including tsunamis (e.g., Vick 1988; Pacific Watershed Associates 1991; Clarke and Carver 1992; Komar and Shih 1993 *in* Pickart and Sawyer 1998). Both uplift and subsidence can trigger reactivation of dunes, with the former potentially building or expanding dunes through increased sediment supply, while the latter can destroy dunes through increased wave action or limit the expansion of new dunes (Pickart and Sawyer 1998, p. 4).

A historical shoreline analysis of the dune-backed shorelines of the Humboldt Bay area using aerial imagery dating 1939–2016 revealed varying patterns of erosion and accretion (McDonald 2017, pp. 10-13).

- Most of the sandy shorelines around Humboldt Bay are stable to prograding, with the exception of the North Jetty area that has been eroding rapidly since 1939 (2.08 ± 0.16 m/year).
- The North Spit of Humboldt Bay from Samoa to Mad River Beach has been stable to prograding (no significant change to less than 1m/year).
- The Clam Beach to Little River shoreline stretch has shown high accretion (2.56 ± 0.15 m/year).
- The South Spit of Humboldt Bay has shown moderate accretion (1.27 ± 0.06 m/year).

These long-term rates of change provide historical reference for monitoring coastal responses, including potential risks to beach layia populations, to sea level rise and climate events (McDonald 2017, p. 1). The results of this study suggest that the southern end of the North Spit of Humboldt Bay is particularly vulnerable to shoreline erosion.

The San Andreas Fault runs along the eastern edge of Point Reyes NS where the Pacific plate moves relative to the North American Plate helping to create a floral composition that is sometimes distinct from that of the Marin County "mainland" (Point Reyes NS 2007, p. xxvii). Tectonic uplifting along the fault has created an incredibly steep, varied, and unstable topography. The great plant community diversity is attributed, in large part, to this area's varied geologic history and structure, hydrology, and climate. While the plates move an average of only 1.4-2 in (3.5 –5.1 cm) per year, the movement is not steady (National Park Service 2016, no page number). Stress builds as the plates lock together for years at a time. When the plates finally slip, they release energy in the form of an earthquake that creates displacement on the landscape. Displacement occurring along this fault system is a natural process and would likely and gradually affect shorelines of not only Tomales Bay along the eastern edge of the seashore, but also along the outer beaches of the Point Reyes Peninsula, where the Point Reyes NS population of beach layia grows. A vulnerability assessment conducted for Point Reyes NS indicates that the portion of shoreline where beach layia occurs in that area has a vulnerability index of high and very high based on the geomorphology, historical shoreline change rate, regional coastal slope, relative sea-level change, mean significant wave height, and tidal range (Pendleton *et al.* 2005, pp. 3, 15).

The Monterey Peninsula was formed parallel to the San Andreas Fault by a series of complicated tectonic movements which have shaped Monterey's coastline with varying levels of uplift and subsidence (Revell Coastal 2016, p. 2-1). Southern Monterey Bay receives sand from the Salinas River, contains actively eroding dunes, and has a history of sand mining which exacerbates coastal erosion (Revell Coastal 2016, p. 2-2). The dunes at Asilomar were found to be less vulnerable to erosion than those on the northern portion of the peninsula (EMC Planning Group 2015, Figure 5). We were unable to obtain information on specific current or historic VLM or shoreline erosion for the Monterey Peninsula, but this information indicates that the areas that beach layia occur are relatively safe. We were also unable to obtain information for Vandenberg AFB for this analysis.

Given this information, it appears that most of the populations of beach layia on the North Spit of Humboldt Bay (with the exception of Samoa/Eureka) and the South Spit of Humboldt Bay are currently safe from shoreline erosion, though sudden movements could occur at any time and alter the trends that have been observed in recent history. Rising sea levels and storm surges also play a role in shoreline erosion and overtopping of foredunes has been observed on both the North and South Spits of Humboldt Bay in recent years. A similar study of historic shoreline analysis is currently being conducted for the mouth of the Eel River, but the results are not yet available. No information was found for the Mattole populations. Although Point Reyes NS appears to be uplifting the vulnerability assessment conducted by Pendleton *et al* indicates that the shoreline where beach layia occurs is vulnerable to erosion. The areas where beach layia occurs on the Monterey Peninsula appear to be relatively safe currently, though more information is needed. Overall, the North Coast Ecoregion as a whole is currently not at risk from VLM and shoreline erosion, neither is the Central Coast Ecoregion, and risk to the South Coast Ecoregion is unknown. This particular threat is complicated, needs more study and, as mentioned above, is compounded by other threats such as sea level rise.

9.0 CURRENT CONDITION—SUMMARY

9.1 Summary of Current Condition—Factors Influencing Viability

While all of the threats discussed above have the potential to negatively influence the resiliency of beach layia populations, the two threats that are currently having the greatest negative impact on populations or the species rangewide are: (1) Overstabilization/competition with invasive species, and (2) drought conditions associated with changing climate conditions. These two threats reduce abundance of beach layia more than any others and, especially when combined, have the potential to have significant negative impacts to populations across the range of the species by reducing the amount of sparsely vegetated habitat and rainfall needed for seedling establishment. Though some populations have been restored, the threat of invasion is always present, especially since most restored sites are near invaded areas. Drought has the ability to negatively affect any population and, furthermore, could have a negative impact to all populations simultaneously. Many of the invasive species that negatively affect beach layia or its habitat, such as European beachgrass and iceplant, are also drought tolerant (Hertling & Lubke 2000, pp. 522-524; Hilton *et al.* 2005, pp. 175-185, Earnshaw *et al* 1987, pp. 421-432). During multi-year drought, it is possible that invasive species could persist while beach layia declines, affording less open space for germination of beach layia when a sufficient amount of rainfall is received (given the seedbank survives). Efforts to remove nonnative or native invasive species and reverse the effects of overstabilization are ongoing throughout the species range (e.g., BLM 2014, p. 17; Pickart 2013, p. 159; ManTech 2016, p. 1; CDPR 2004c, p. 3-14). However, these efforts are time consuming, costly, and often slow-going; thus, at this time, these threats are considered to significantly influence multiple populations throughout the range of beach layia currently, and likely to continue to be a significant issue moving into the future (see Section 8.3.1, below).

9.1.1 Three Rs

The most resilient (healthy) populations of beach layia occur in the North Coast Ecoregion mostly because of large population size, but also in part due to the area's desirable habitat characteristics (presence of sparsely vegetated native dune mat community and, in some cases, absence of invasive species), which is a direct result of large scale restoration efforts on the North and South Spits of Humboldt Bay and at Point Reyes NS (BLM 2014, p. 17; Pickart 2013, p. 159; Parsons 2017, pers. comm.). However, much restoration is still needed (i.e., in 9 of 13 extant populations, which includes 5 of 8 subpopulations within the North Spit Humboldt Bay population).

Less resilient populations include all populations in the Central and South Coast Ecoregions largely due to low abundance even in years with higher than normal numbers (often associated with high annual precipitation). The Asilomar and Indian Village populations in the Central Coast Ecoregion have high quality habitat (as it has been measured and analyzed in this SSA, i.e., predominantly native species with low cover), but beach layia is still restricted to small areas, the populations have not expanded since the time of listing, and suitable habitat may be limited specifically in the Signal Hill Dunes population.

At this point in time, there are no significant known genetic differences between populations or among ecoregions, per a genetic study that indicates homogeneity across the species range (Baldwin 2007, pers. comm.); thus, our analysis of representation in this SSA uses the number ecological settings in which resilient populations occur as a proxy for genetic diversity. The lowered resiliency (health) of populations in the southern two ecoregions as characterized by continued low abundance in those ecoregions, varying levels of threats affecting species needs, and the limited availability of quality habitat in the South Coast Ecoregion (and possibly at the Signal Hill Dunes population in the Central Coast Ecoregion) increase the risk against long-term viability of the species. Currently, there are multiple populations throughout the historical range of the species providing adequate redundancy and a higher outlook of viability in the face of potential catastrophic events. The large distance between the three largest population centers in the North Coast Ecoregion (i.e., Humboldt Bay Area, Mattole, and Point Reyes NS meta-populations; see Table 2) supports adequate redundancy for the species viability, given the low likelihood of a catastrophic event extirpating all of those meta-populations at once. Habitat improvement at the Signal Hill Dunes and Vandenberg AFB populations, and (re)introduction to high quality habitat (such as restored areas on the Monterey Peninsula like Carmel-by-the-Sea and the extirpated Point Pinos population) would help spread the risk of losing a large portion of the Central or South Coast Ecoregions if they are affected negatively by a single catastrophic event.

9.1.2 Uncertainties

- Limiting factors for the populations on the Monterey Peninsula.
- Defined timelines for restoration plans and dedicated funding.
- Potential current, realized effects of VLM in the Central and South Coast Ecoregions.
- Sediment budgets (currently being studied in Humboldt Bay area, results expected in 2021)
- Historical shoreline trends that may have adversely affected the current populations of beach layia in the Central and South Coast Ecoregions.
- Seedbank longevity, especially in light of current and expected continued drought conditions.
- Optimal disturbance regime to help influence the most beneficial management considerations for recovery actions.

10.0 POTENTIAL FUTURE CONDITIONS

The future timeframes evaluated in this SSA include a range of times that cover a variety of management plans which are expected to last the next 1-2 decades and predictions for local sea level rise for 32, 82, and 132 years from now that are presented in the most current literature in California (Griggs 2017, entire; Anderson 2017, pers. comm.). Therefore, our definition of future is a range from approximately 15 to 32 years from now and we present additional outlooks as far out as 132 years. As an annual species, beach layia is sensitive to changes in habitat and climatic conditions and can respond strongly from year-to-year as seen in the large fluctuations in population abundance data range-wide (ManTech 2018, p. 9; Gray 2017, pers. comm.; Hassett 2017, pers. comm.; Julian 2017, pers. comm.; Parsons 2017, pers. comm.; Pickart 2017, pers. comm.), which make future population trends difficult to predict. The viability assessment at each timeframe is, therefore, heavily focused on habitat availability and suitability of conditions as they relate to species needs. Also, for the purposes of this analysis, a single, potential future condition scenario is presented (see additional discussion under Section 3.0, Methodology).

10.1 Distribution and Habitat Outlook

Suitable occupied and unoccupied habitat is limited to coastal dune systems that are subject to modification or destruction by overstabilization/competition with nonnative and native invasive species, changing climate conditions (drought and sea level rise), erosion from various disturbance activities (e.g., recreation), and VLM/shoreline erosion (see Section 6.2, above). Significant habitat modification in any portion of beach layia's range could lead to reduced population(s) size, growth rate, and habitat quality for those affected populations, thus resulting in a higher risk level for the species to be viable in the future. The most vulnerable beach layia populations into the future, given current and potential future impacts to availability of sparsely vegetated native dune mat habitat subject to periodic disturbance during the dormant season include the following (8 of 13) populations:

North Coast Ecoregion—Freshwater Lagoon Spit, portions of North Spit Humboldt Bay (including the Mad River Beach, Bair/Woll, Manila South, and Samoa/Eureka Dunes subpopulations), Elk River, North Spit Eel River, South Spit Eel River, McNutt Gultch, and unrestored portions of Point Reyes NS.

Central Coast Ecoregion—Signal Hill Dunes

These populations represent the entire range of the species, and include two of the three largest population centers in the North Coast Ecoregion, the latter of which harbors greater than 70 percent of the species abundance rangewide (Table 2). Additionally, reduced annual rainfall and expected drought conditions have the potential to impact the resiliency of all populations. Depending on the severity of the impacts to beach layia's resource needs, populations or portions there-of could be lost in the future.

10.2 Population Abundance Outlook

The best available information indicates that the abundance of beach layia is positively correlated to availability of quality habitat (sparsely vegetated native dune mat with minimal invasive species) and negatively correlated with less than average amounts of rainfall. Areas with extensive available habitat that are not inundated with native or nonnative invasive species and are receiving ongoing invasive species management are more likely to continue to support resilient populations into the future. Given the best available information at this time, the following populations are those most likely to experience the least risk of extinction into the future:

North Coast Ecoregion—portions of North Spit Humboldt Bay (including Lanphere Dunes, Ma-le'l North, Ma-le'l South, and Manila North subpopulations), South Spit Humboldt Bay, Mouth of the Mattole River, and Point Reyes NS.

See Section 8.3, below, for further discussions on the threats most likely to influence beach layia's future resiliency in these populations.

Populations in areas where habitat is limited or unsuitable in the future (see Section 8.1, above) are likely to be more susceptible to threats that continue or worsen in the future, potentially resulting in reduced population(s) size and growth rate. Drought, resulting from changing climate conditions, is the most prominent negative influence (unrelated to habitat availability) on rainfall required for germination that beach layia needs for long-term persistence into the future (see Section 8.3.2, below).

The populations in the Central Coastal Ecoregion on the Monterey Peninsula, possibly simply due to the limited availability of habitat, appear to be the greatest at risk of declines in abundance in the future based on their small size and expected continued threats in the future. Additionally, these population abundance numbers continue to be far from reaching the recovery goal of 5,000 individuals (Service 1998, p. 93). The Vandenberg AFB population in the South Cast Ecoregion is also relatively small and could be at risk due to limited suitable habitat; however, this risk is low compared to the Central Coast Ecoregion populations because invasive species removal activities are currently being conducted and expected to continue into the future (ManTech 2017, p. 1)

10.3 Factors Influencing Viability

10.3.1 Overstabilization/Competition with Invasive species

Beach layia's resource need for sparsely vegetated native dune mat habitat with periodic disturbance (see Sections 4.3–4.5, above) is directly linked to the risk posed by overstabilization/competition with native and nonnative invasive species. Many areas across the species range are restored, are in the process of being restored, or have plans for future restoration. Exceptions include portions of the North Spit Humboldt Bay population (i.e., Manila South subpopulation and parts of the Samoa/Eureka Dunes subpopulation), the Elk River population, and the McNutt Gultch population, all of which occur in the North Coastal Ecoregion, and the Signal Hill Dunes population in the Central Coast Ecoregion. These populations are likely to see a reduction in abundance of beach layia because there are no existing management activities and no management plans to improve existing unhealthy habitat conditions in the future. If invasive species continue to spread and fill in the open spaces between native vegetation that beach layia occupies, the species' ability to persist into the future will be negatively affected by reducing the available area for seeds to germinate (i.e., the health of the species as a whole will be reduced from current conditions).

10.3.2 Changing Climate Conditions

The Fifth Assessment Report of the IPCC projects many changes in climate by the end of the 21st century, relative to the 1986 to 2005 averages (IPCC 2014, p. 8-12). It is likely that the intensity and duration of droughts will increase on a regional to global scale (IPCC 2014, p. 53). Coastal systems and low-lying areas will increasingly experience submergence, flooding, and erosion throughout the 21st century and beyond, due to sea level rise (IPCC 2014, p. 62). The magnitude of projected changes varies widely, depending on which scenario of future greenhouse gas emissions is used (IPCC 2014, p. 60-62). A climate change vulnerability assessment of California's terrestrial vegetation predicts that 0 to 163 square km (km^2) (0 to 63 square mi (mi^2)) of the current 400 km^2 (154 mi^2) of coastal dune and bluff scrub will remain suitable by the end of the century (Thorne *et al.* 2016, pp. 177-185). Local probabilistic sea level predictions above mean higher high water (MHHW), as summarized in Table 5 below, show that all areas where beach layia currently occurs are likely to experience sea level rise, and some parts of the Humboldt Bay Area meta-population are expected to experience higher levels of sea level rise (Griggs 2017; Anderson 2017, pers. comm.). Projections for future precipitation vary widely depending on the climate scenario utilized, but climatic water stress (discussed in Drought Section 8.3.2.1, below) is expected to increase into the future due to projections of increased temperature (Flint *et al.* 2013).

Table 5. Local probabilistic sea level rise predictions for beach layia populations across the range of the species under RCP 8.5 (Griggs 2017; Anderson 2017, pers. comm.).

Meta-populations	Feet above MHHW

(Populations)	(95% probability)		
	2050	**2100**	**2150**
Humboldt Bay Area meta-population			
Bair (portion of Bair/Woll subpopulation), Lanphere Dunes, Ma-le'l North, and Ma-le'l South subpopulations	1.4	4.3	7.9
Manila North and Samoa (portion of Samoa/Eureka Dunes subpopulation) subpopulations	1.7	4.8	8.7
South Spit Humboldt Bay population	1.9	5.2	9.3
Eel River meta-population	1.9	5.2	9.3
Point Reyes NS meta-population	1.4	4.4	7.7
Monterey Peninsula meta-population	1.4	4.4	7.7
Vandenberg AFB meta-population	1.4	4.6	7.9

10.3.2.1 Drought

Beach layia, as a succulent species, is relatively tolerant to the drought-like conditions of upland dunes, but it requires some amount of rain for germination and to prevent desiccation during the growing season and, like many annuals, it responds positively to rainfall. A correlation between rainfall and population abundance has been observed in monitoring data collected by BLM in the Humboldt Bay area (as shown by Figure 6 in Section 4.5, above). The high likelihood of increased intensity or duration of droughts is expected to negatively influence beach layia populations throughout the species' range because rain is required for germination. Range-wide impacts could be significant as this threat has the ability to impact all populations across the range of the species in any given year and potentially for years at a time.

We utilized the California Climate and Hydrology Change Graphs, a graphing tool that presents climate and hydrology data from the California Basin Characterization Model (BCM) dataset (Flint *et al.* 2013, entire), to analyze the potential impact of drought on beach layia in the future. This tool graphs historical and projected future values of various climate variables for Hydrologic Unit Code 8 (HUC-8) level watersheds. Four future climate scenarios demonstrate a range of precipitation and temperatures projected by the 18 scenarios available from the BCM.

We chose to utilize the climatic water deficit calculations because they take into account changes in air temperature, solar radiation, and evapotranspiration, and can be used as an estimate of drought stress on plants (Stephenson 1998, p. 857). There are large uncertainties with respect to future precipitation levels (some scenarios predict a hot dry future while others predict a hot wet future). While climatic water deficit magnitudes vary across the models, the trends are consistent in that all projections indicate increasing values (Table 6). Climatic water deficit values, both historical and projected, are higher in watersheds in the Central and South Coast Ecoregions. The South Coast Ecoregion has the highest values and is therefore considered to be the most vulnerable to stress caused by drought, followed by the Central Coast Ecoregion, and then the Point Reyes NS population at the southern end of the North Coast Ecoregion. The three watersheds in Humboldt County (which encompass all of the North Coast Ecoregion populations except Point Reyes NS) are least likely to be stressed by drought, both currently and into the future, but the trend in climatic water deficit is still increasing.

Table 6. The lowest values out of the four models depicted in the California Climate and Hydrology Change Graphs (CCSM4_rcp85, CNRM_rcp85, GRDL_A2, MIROC-esm_rcp85) for 30-year average climatic water deficit at three time steps, one historical and two future.

Meta-populations (Populations)	**Climatic Water Deficit (cm)**		
	2010	**2050**	**2099**
Freshwater Lagoon Spit meta-population			
Freshwater Lagoon Spit	38	39	43
Humboldt Bay Area meta-population			
North Spit Humboldt Bay, South Spit Humboldt Bay, Elk River	38	39	43
North Spit Eel River, South Spit Eel River (Eel River Estuary Preserve)	49	51	56
Mattole meta-population			
McNutt Gultch, Mouth of Mattole River	37	37	41
Point Reyes NS meta-population	72	74	79
Monterey Peninsula meta-population	88	88	94
Vandenberg AFB meta-population	97	97	102

A confounding factor in the analysis of drought effects on beach layia is the possibility that drought-tolerant invasive species will expand into open areas during drought years, thus reducing available suitable habitat even when sufficient rainfall is present. Two of the most common nonnative, invasive species that compete for habitat with beach layia—European beachgrass and iceplant—are both drought tolerant (Hertling & Lubke 2000, p. 522-524, Lechuga-Lago 2016, p. 8-9).

<u>10.3.2.2 Sea-Level Rise</u>

Coastal areas are expected to be negatively influenced by sea level rise (IPCC 2014, p. 67), though the relationship between sea level, sediment budget, aeolian sand movement, and other factors that determine the resiliency or vulnerability of a coastal dune system are all site specific. Coastal areas in and around the Humboldt Bay Area (meta-population) were recently studied (Patton *et al.* 2017, entire) to obtain measurements of land subsidence (i.e., the gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials) and develop a better understanding of how this land movement contributes to changes in local sea level. Results indicate that recorded movements contribute to rates of local sea level rise up to 2-3 times greater than anywhere else in California (Patton *et al.* 2017, p. 3). This is a concern for beach layia because the largest populations are in the Humboldt Bay area, including representation of greater than 70 percent of the species rangewide abundance.

In order to analyze the potential future impacts of sea-level rise to currently occupied beach layia habitat, we developed a simple model (Figure 22) to provide a rough estimate of the amount of habitat that could be lost due to sea level rise. This analysis does not take into account the sediment budget of the sites, erosion due to wave action, or the ability of the dune systems to migrate inland. We assessed the vulnerability of currently occupied beach layia habitat by using LiDAR based DEMs and projections of sea level rise based on the methodology developed by Kopp *et al.* (2014, pp. 384-393) as presented in Rising Seas in California (Griggs 2017, entire) and unpublished work by *Northern Hydrology & Engineering* presented at the December 2017 Humboldt Bay Initiative (Anderson 2017, pers. comm.). Unfortunately, localized projections are not available for the Freshwater Lagoon Spit population at the north end of the species' range nor the Mouth of the Mattole River and McNutt Gultch populations, so those populations were excluded from this analysis. The methodology developed by Kopp *et al.* (2014) takes into account oceanographic processes, ice sheet melt, glacier and ice cap melt, land water storage, and local vertical land motion to project probabilistic local sea level change using tide gauge data. We classified the DEMs using the sea level projections for 2050, 2100, and 2150 under emission scenario RCP 8.5 and calculated the area of currently occupied habitat that would be inundated for each year. Our analysis output (Table 7, below) provides a proportion of currently occupied habitat that has a 95 percent probability to be at or below MHHW under emission scenario RCP 8.5 in 2050, 2100 and 2150. A more detailed description of our methods for this analysis are included as Appendix B.

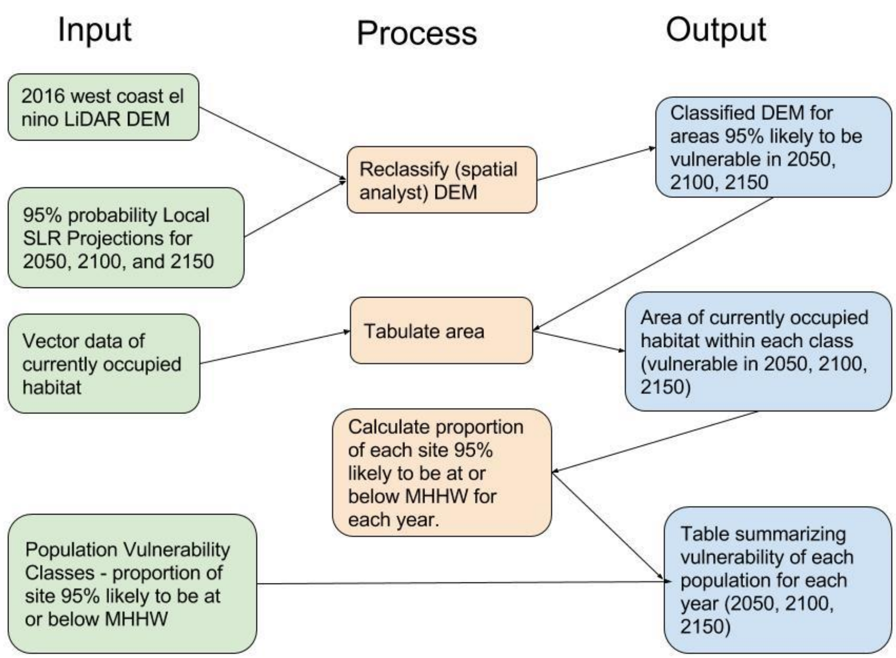

Figure 22. Workflow of vulnerability assessment of currently occupied beach layia habitat in relation to projected future sea levels.

Table 7. Proportions of currently occupied habitat projected to be under mean higher high water in 32, 82, and 132 years. The Freshwater Lagoon Spit, Mouth of the Mattole River, McNutt Gulch populations were not included in this analysis due to lack of localized projection data in those areas.

Ecoregion	Tide Gauge (Beach layia Populations)	2050	2100	2150
North Coast	Mad River Slough (a portion of the North Spit Humboldt Bay population to include Lanphere Dunes, Ma-le'l North, Ma-le'l South subpopulations)	0.00	0.01	0.17
	North Spit (Manila North, Manila South, Samoa/Eureka Dunes, Elk River Spit)	0.00	0.04	0.15
	Hookton Slough (South Spit Humboldt Bay, North Spit Eel River, South Spit Eel River)	0.00	0.15	0.45
	San Francisco (Point Reyes NS)	0.00	0.00	0.01
Central Coast	Monterey (Asilomar Staet Beach, Indian Village Dunes, Signal Hill Dunes)	0.00	0.00	0.00
South Coast	La Jolla (Vandenberg AFB)	0.00	0.00	0.00

The Point Reyes NS, Monterey Peninsula, and Vandenberg AFB populations appear to be under the least threat of habitat loss caused by sea level rise. The Humboldt Bay Area populations are significantly more vulnerable at least partially because of land subsidence occurring there. The populations around Humboldt Bay vary in vulnerability due to the differing elevations in which beach layia currently occurs and the difference in subsidence rates at the different tide gauge stations (Mad River Slough has the least VLM, and Hookton Slough has the most). The model predicts that the majority of areas currently occupied by beach layia are expected to remain above MHHW level through 2050 but that by 2100 some areas, especially the South Spit Humboldt Bay and both Eel River Spit populations, are likely to be vulnerable to inundation. That vulnerability increases over time, though our confidence in the model decreases. It is important to note that some populations have more accommodation space to migrate inland as they are connected to the mainland (for example, Lanphere Duns and Ma-le'l North and South populations) and that other sites, such as Elk River Spit and South Spit Humboldt Bay are narrow low lying areas surrounded by water and their ability to migrate is hard to predict.

Reducing impacts associated with changing climate conditions is challenging, requiring creativity and likely ongoing management considerations into the future. Management of habitat that promotes migration of soils, habitats, and plants to inland areas can assist in the longterm preservation of the species in the face of rising sea levels. There is a study underway to assess the vulnerability of dune systems in the Eureka littoral cell (a littoral cell is a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks; the Eureka littoral cell encompasses the populations from Mad River Beach to the Eel River Estuary Preserve (Sections 5.1.4 through 5.1.8)), how the dunes in that area may respond to rising sea levels, and what management strategies may best promote migration of habitat inland. Results of this study should be available in 2021 (Pickart 2017, pers. comm.). The current hypothesis being tested by this study is that dunes dominated by native vegetation allow for sediment to be moved by wind action up and over the foredune, thus replenishing the dune system and promoting a resilient dune system with an ability to migrate, while a system that is overstablilized by invasive species traps sand near the ocean where it is vulnerable to erosion from storm surges and wave run-up (Pickart 2017, pers. comm.).

Within all three ecoregions, increased intensity/duration of droughts and sea level rise are likely to continue into the future. Assuming these modeled conditions are realized in the future, negative effects to beach layia across its range include loss of suitable coastal dune habitat, loss of individuals, as well as a reduction in germination, fecundity, and survival rates. These effects would result in a higher risk for the species not to persist in the future.

The best available information indicate that the populations most likely to experience negative impacts from drought include those in the Central and South Coast Ecoregions. Although it is difficult to quantify the magnitude of potential impacts, an increase in climatic water deficit is predicted for all watersheds in which beach layia currently occurs. Also, negative effects from multiyear drought have the potential to impact all populations across the range of the species, though the best available information regarding the longevity of the seed bank does not indicate how many years of drought the species can survive. In contrast, populations within the North Coast Ecoregion appear to be the most vulnerable to the effects of sea level rise, particularly those on the southern end of Humboldt Bay, including (95 percent probablility that 15 percent of the currently occupied habitat in that area will be under MHHW by 2100 (82 years)).

10.3.3 Erosion/High Level Disturbance

Human pressures on coastal ecosystems will increase significantly in the coming decades due to population growth, economic development, and urbanization (IPCC 2014, p. XX). Areas such as the Signal Hill Dunes in Monterey may already experience a high level of recreational use and the impacts of recreation are likely to increase in the future, potentially resulting in damage or loss of suitable habitat. Habitat could be degraded or made unsuitable by intense usage by humans which is probable due to the high density population in the area. However, it should be taken into consideration that beach layia requires a certain amount of light disturbance (albiet an unknown amount, see Sections 4.5, 5.1.4, and 7.1.2). For example, the best available data indicates that in areas where recreational activities have been limited (such as Freshwater Lagoon Spit), abundance of beach layia has decreased (Samuels 2017, pers. comm.) and is likely to continue to do so in the future with similar, beneficial levels of disturbance. There is a balance between a moderate amount of disturbance and heavy disturbance that beach layia requires and this balance is not well understood (see discussion of this stressor in current condition analysis – needs some language crafting). It would be ideal to conduct a study on the impacts of disturbance on beach layia and base management on those findings. Restricting access to a certain extent (but not completely) in areas of heavy use, monitoring the populations, and conducting adaptive management accordingly would be favorable for this species into the future. One option could be alternating trail use (i.e., every few years closing some trails and opening others) rather than restricting use to certain trails or boardwalks so that there is still periodic disturbance, but not excessive trampling.

10.3.4 Vertical Land Movement/Shoreline Erosion

VLM is accounted for in the sea level rise analysis described above (Kopp *et al.* 2014; Anderson 2017; Griggs 2017) as it relates to habitat loss due to local sea level rise. Uplift is not likely to make currently suitable habitat unsuitable in the future. Rather, uplift is likely to help maintain habitat and the species needs by reducing the magnitude of local sea level rise. However, sudden movements associated with earthquakes can cause tsunamis that have the potential to remove habitat in one catastrophic event.

As mentioned above, a study looking at the historic trends of shoreline erosion (MacDonald 2017) indicates that the majority of the shoreline on the North and South Spits of Humboldt Bay are stable to prograding, the exception being the Samoa/Eureka population. Additionally, the areas in and around Humboldt Bay are subsiding, which contributes to the rate of local sea level rise (Patton *et al.* 2017, p. 1). Populations particularly vulnerable to habitat loss being intensified by VLM include the southern end of the North Spit Humboldt Bay, Elk River Spit, South Spit Humboldt Bay, and both the North and South Spit Eel River populations. Within the near-term future (i.e., 32 years), the best available data indicate these populations would not be lost. However, the viability of the species to persist further into the future (i.e., 82 years and beyond) is less likely for these populations, potentially resulting from lowered resiliency due to loss of abundance and distribution of populations in the North Coast Ecoregion.

Tectonic uplifting is occurring along the San Andreas fault at the Point Reyes NS (National Park Service 2016, no page number), but vulnerability assessment conducted for Point Reyes NS indicates that the portion of shoreline where beach layia occurs in that area has a vulnerability index of high and very high (Pendleton *et al.* 2005, pp. 3, 15). The future resiliency of this population in relation to VLM and shoreline erosion is unclear.

There are minimal beneficial management measures that could be implemented to change the negative influences of VLM and shoreline erosion on beach layia habitat. We recommend implementing studies to better understand VLM, sediment budget, and historical shoreline trends in order to better understand how they may affect beach layia in the future.

In summary, VLM and shoreline erosion is variable, very site specific and closely tied to the threat of sea level rise. At this time, our understanding is that areas in Humboldt Bay are projected to continue to subside into the future though shoreline trends are stable to prograding while Point Reyes NS is projected to continue to uplift though the shoreline has been classified as vulnerable. This contrasting information makes it challenging to project the future resiliency of the North Coast Ecoregion and we don’t have an understanding of the potential future effects to the Central and South Coast Ecoregion. More information is needed, as well as studies on the sediment budgets of these dune systems.

11.0 RECOVERY CRITERIA EVALUATION

11.1 Downlisting Criteria

Downlisting Criterion 1 (Addresses Listing Factors A, D and E): *Habitat occupied by the species that is needed to allow delisting has been secured, with long-term commitments and, if possible, endowments to fund conservation of the native vegetation.*

There has been significant improvement in the security of habitat occupied by beach layia since the recovery plan was prepared, including land acquisition by Federal agencies, State and local agencies, and non-governmental organizations (NGO), adoption of local coastal plans under the

California Coastal Act, and implementation of management plans that address the needs of the species. Of the estimated 640 ac (259 ha) of dunes habitat currently occupied by beach layia, approximately 91percent is owned by Federal and State governmental entities or other land owners with existing resource management direction precluding development within sensitive dunes habitat. Because of the significant amount of occupied dune habitat that is now on protected lands, we conclude that this recovery criterion has been adequately met.

Downlisting Criterion 2 (In part, addresses Listing Factors A, D and E): *Management measures are being implemented to address the threats of invasive species, pedestrians, and OHVs at some sites.*

The Service, BLM, National Park Service (Redwood NP, Point Reyes NS), and several other land managers in the northern portion of the range, and the CDPR, DOD, and several other managers in the southern portion of the range have all instituted relevant management policies since the recovery plan was completed or since the species was listed. Those policies have reduced, and in many cases, eliminated the threats to beach layia posed by native and nonnative invasive species, pedestrians, and OHV activity. As a result of the many management measures currently implemented across the range of beach layia to address the threats of invasive species, pedestrians, and OHVs, we conclude that this criterion has been adequately met for the purpose of downlisting.

Downlisting Criterion 3 (In part, addresses Listing Factor E): *Monitoring reveals that management actions are successful in reducing threats of invasive nonnative species.*

Management actions over the past 12 years may have reduced the threats from native and nonnative invasive species, at least in the short-term. As a result of these successful invasive species management measures, we conclude that adequate success has been demonstrated to satisfy this downlisting criterion.

Downlisting Criterion 4 (In part, addresses Listing Factors A, D and E): *Additional restored habitat has been secured, with evidence of either natural or artificial long-term establishment of additional populations, and long-term commitments (and endowments where possible) to fund conservation of the native vegetation.*

Commitments by land managers across beach layia's range, as described in Downlisting Criterion 1 above, have resulted in secured habitat in multiple geographic areas since the recovery plan was completed. Additionally, restoration has been conducted with a commensurate response by beach layia, and there is a long-term commitment to conservation of its habitat in the future. As a result, we conclude that for the purpose of downlisting, this criterion has been adequately met.

11.2 Delisting Criteria

General Delisting Criterion (In part, addresses Listing Factors A, D and E): *Full recovery will be achieved when the dune system it inhabits is: (1) Secure; (2) with experience to demonstrate that exotic [nonnative or native] (invasive) plants and other threats (recreational use, OHVs,* *etc.) are controlled; and managers have demonstrated their ability to keep the threats under control. (3) The taxon needs to be secure in the [then] presently-occupied range, and opportunities should be taken to introduce these plants to restored habitat in or near its historical range. To be counted toward recovery, (re)introduced populations should be naturally reproducing in vegetation that also appears to be persisting without excessive maintenance. (4) The determination that delisting is possible must be based on at least 15 years of monitoring, to include wet and drought years. (5) Aspects of demography and population biology must be understood to be assured that populations are likely to persist. The species can be considered for delisting when sites are secure from habitat modification (development), occupied habitat is stable or improving, and free of weed invasion.*

We do not consider this general criterion for delisting to have been met because many populations are still under threat from native and nonnative invasive species, and not all land managers have demonstrated an ability to keep that threat under control.

Specific Delisting Criterion 1 (In part, addresses Listing Factors A, D and E): *The Humboldt Bay dune system, on both the North and South Spits, has (1) Substantially all of the European beachgrass removed from the foredune; iceplant, yellow bush lupine, and pampas grass (Cortaderia sp.) must be greatly reduced, degraded dunes restored, and vehicle management implemented (including fencing and patrolling where needed). (2) New populations of beach layia must be established and persist for at least 10 years, and monitoring for at least 15 years should demonstrate that populations are increasing in response to availability of habitat. (3) There must be written assurance of long-term support for continued management of the dunes and for biological monitoring.*

We do not consider this specific criterion for delisting to have been met because much of the North and South Spits of Humboldt Bay are still dominated by European beachgrass, iceplant, and yellow bush lupine, no new colonies have been established, and written assurance of long-term support for continued management has been not been provided for all populations.

Specific Delisting Criterion 2 (In part, addresses Listing Factors A, D and E): *The population at Point Reyes NS is expanded in response to the same measures described for the Humboldt Bay dunes. The main exotic [nonnative] plant problems to be addressed are foredune European beachgrass and iceplant.*

While there has been progress toward meeting this criterion, we consider the objective of this criterion as partially met. Additional restoration (currently in progress) is necessary in order for this criteria to be met for delisting.

Specific Delisting Criterion 3 (In part, addresses Listing Factors A, D and E): *The occurrences in the dune systems south of San Francisco at the Monterey Peninsula and Vandenberg (the latter a part of what is known as the Guadalupe-Nipomo dune system)—Spyglass Hill [=Signal Hill Dunes]; Point Pinos; Pico Avenue, Pacific Grove [=Asilomar State Beach], Vandenberg AFB—have received foredune beachgrass control, iceplant management, and are managed and enhanced to protect 5,000 individuals or more per site.*

We do not consider this specific criterion for delisting to have been met because European beachgrass and iceplant control is still needed at the Signal Hill Dunes and Vandenberg AFB populations. Also, the three extant populations on the Monterey Peninsula are below the recovery goal of 5,000 individuals as reported in 2017 (1,541 at Asilomar State Beach, 1,200 at Indian Village Dunes, and unknown at Signal Hill Dunes (Grey 2017, pers. comm.; Dorell-Canepa 2017, pers. comm.)).

11.3 Adequacy of Criteria

Although the recovery criteria for beach layia (Service 1998, pp. 89–90, 92–93) are in some cases subject to interpretation, and could be written more specific to the individual species needs, that is to be expected with a multi-species recovery plan. At this time, all downlisting and delisting criteria are considered adequate and appropriate with respect to recovery of this species, with the possible exception of Specific Delisting Criterion 3. We recommend research to determine whether the stated population size goals for populations located near the limits of the range for beach layia are feasible and practical. The conservation strategy outlined by these criteria addresses all the currently known threats to beach layia. Elements of the criteria include habitat protection and management secured by appropriate agreements (such as conservation easements, covenants) to address listing factors as outlined in Section 4(a) of the Act.

12.0 OVERALL SYNTHESIS

The threats identified for beach layia at the time of listing were displacement by invasive, nonnative vegetation, recreational uses such as OHV activities and pedestrians, and urban development (Service 1998, p. 45). Since then, habitat-related impacts have been significantly reduced. About 91 percent of the currently occupied habitat is owned by Federal, State, and local agencies, special districts, or NGOs, or covered under conservation easements (Service 2011, p. 38), with at least some management direction aimed at conserving the dune habitat across its range in all three ecoregions. The majority of the remainder of occupied habitat is subject to restrictions mandated by County local coastal programs, the California Coastal Act, and CEQA. The majority of the largest landowners, including BLM, the Refuge, Manila CSD, Friends, the Wildlands Conservancy, DOD, the National Park Service, CDFW, and California State Parks are engaged in or pursuing restoration activities at some level to reduce the threat of native and nonnative invasive species. However, while significant progress has been made in invasive species removal, large areas remain infested to such a degree that entire population(s) are at risk of not being viable in the future, and no mechanism(s) has yet been implemented to ensure that monitoring and restoration are implemented on a routine basis in the future, nor has a permanent and dedicated source of funding been allocated for that purpose with the exception of the Asilomar State Beach population, which has long-term funds specifically earmarked for conservation of the dunes on an annual basis, as part of the agreement with the onsite conference center (Service 2011, p. 5). Consequently, beach layia remains vulnerable to the persistent encroachment of native and nonnative invasive species throughout its range, and overstabilization of its habitat in most populations (8 of 13, including 5 of 8 subpopulations within the North Spit Humboldt Bay population) and only roughly half (7 of 13, including 4 of the 7 subpopulations within the North Spit Humboldt Bay population) are currently being monitored. Future restoration, monitoring, and adaptive management is necessary to reduce beach layia's risk of extinction into the future.

The current risks to beach layia's persistence associated with sea level rise and multi-year droughts are expected to continue into the future, increasing in magnitude as a result of ongoing changing climate conditions. Three of the populations in the North Coast Ecoregion may be vulnerable to destruction from frequent inundation and increased erosion resulting from sea level rise; the Point Reyes NS population and all four extant populations in the Central and South Coast Ecoregions appear to be relatively safe into the future. Our analysis suggests that all currently occupied habitat will be safe in 2050 (32 years) and approximately 80 percent of currently occupied habitat in the Humboldt Bay area may occur at elevations above MHHW in 2100 (82 years), but that number may be as low as 20 percent by 2150 (132 years). As an early successional species and given its life history characteristics, beach layia will undoubtedly be able to exploit a portion of the newly disturbed habitat resulting from sea level rise as long as both native and nonnative invasive species are controlled, and suitable habitat is able to migrate inland (*i.e.*, movement is not inhibited by development). Continued changing climate that results in drought conditions has potential to pose significant risk to the long-term viability of beach layia to persist in the future.

Population monitoring data indicate the range-wide population of beach layia at the time of the 5-year review (2011) was substantially larger than suggested at the time of listing (1992), by an order of magnitude (Service 2011, p. 40). Since the population data available at the time of listing do not appear to have been based on detailed quantitative data, there is no evidence to indicate the suggested increase was due to an actual expansion of the populations. The data collected in 2017 (an estimate of at least 25 million in the Humboldt Bay area alone; Table 2) continue to show larger numbers than previously recorded. However, these data include areas that had never been estimated for abundance values before (Elk River Spit and North Spit Eel River (ERWA) populations), and 2017 values also correspond with a wet year, which given the species biology, results in elevated abundance numbers (e.g., Figure 6). Dramatic fluctuations in population size from year to year are noted in populations throughout the range, positively correlating in part with precipitation (BLM 2016, p. 6). The population abundance estimates for 2017 (Table 2) should therefore be considered to be a 'best case scenario' and not necessarily the new norm.

Comment [e29]: See caveats in Appendix. Biased upwards?

The extant populations in the Humboldt Bay area harbor the greatest number of beach layia plants within the species range. The North Spit Humboldt Bay population through and including the South Spit Eel River poulation includes the largest proportion of occupied beach layia habitat within the North Coast Ecoregion, and is also the largest population center across the range, likely exceeding 25 million individuals (this is the lower end of the 95 percent confidence interval of the 2017 estimate) (Appendix X; Table 2, above). The Mouth of the Mattole River population, estimated in the millions, occupies about 27 ac (11 ha), and at least for the present, is relatively free of invasive species (Wheeler 2017, pers. comm.). The Point Reyes NS population at the very southern end of the North Coast Ecoregion was estimated, based on sampling conducted in 2017, at 2.7 million (Parsons 2017, pers. comm.). That population is surrounded by extensive near-shore dunes, portions of which have been restored and other portions of which are receiving ongoing restoration.

The Vandenberg AFB and Freshwater Lagoon Spit populations at the extreme north and south ends of the range, and the three populations in the Central Coast Ecoregion, remain at relatively higher risk to not persist in the future compared to the North Coast Ecoregion populations. The species needs that may not be present or may be significantly reduced in the future within these southern two ecoregions includes (1) Sparsely vegetated dune habitat with native dune mat species, (2) minimal (but undetermined amount) of disturbance, and (3) an adequate amount of rainfall during the germination period (see sections 8.1–8.3, above). It is not clear whether those populations are being limited by environmental factors unrelated to invasive species encroachment or processes leading to over-stabilization of its habitat. As noted in our 2011 5-year review (Service 2011, p. 40) and reaffirmed here, while the current population estimates suggest the taxon is not at as great a risk of extinction as originally thought, caution must be taken in interpreting the population data. As an annual species, beach layia responds almost immediately to changes in its environment (e.g., increase in abundance in wet years as seen in many populations in 2017 and increase in abundance following restoration (BLM 2014, p.16)). At the same time, a great amount of effort and resources have been expended to secure its habitat and reverse the loss of habitat to invasive species since its listing in 1992 (e.g. restoration on North and South Spits of Humboldt Bay, Point Reyes NS, Asilomar State Beach, Indian Village Dunes, and Vandenberg AFB).

Beach layia continues to be at some risk of not persisting in the future due to the chronic negative influences posed by habitat loss from native and nonnative invasive species, the potential for sea level rise to eliminate some of its habitat in the future, and the threat of increasing drought conditions in the future. In particular, the populations in the Central and South Coast Ecoregions, and the northernmost population in the North Coast Ecoregion (Freshwater Lagoon Spit) remain at high risk of extirpation in the future because of low abundance, less available habitat compared to other population areas, and increasing vulnerability to stress caused by drought (Table 2; see also Sections 6.2.2 and 8.3.2, above).

12.1 Three Rs Discussion

The most resilient populations of beach layia occur in the North Coast Ecoregion, mostly due to the high abundance within populations in that region, but also in part due to desirable habitat characteristics (particularly lack of native or nonnative invasive species) at many (6 of 11; 54 percent) of the populations. However, most populations (7 of 11; 64 percent) within the North Coast Ecoregion, particularly those on the southern end of the Humboldt Bay area, are more vulnerable to the threat of sea level rise, which could impact habitat availability in the future.

At this time, the populations in the Central and South Coast Ecoregions appear to have lower resiliency than the North Coast Ecoregion populations largely due to low abundance. Even in years with higher than normal abundance numbers (such as 2017; Table 2), the Central and South Coast Ecoregion populations fall below the recovery goal of 5,000 individuals per population (Service 1998, p. 93). Several of the populations in the Central Coast Ecoregion have high quality habitat. Nonetheless, beach layia continues to be restricted to small areas, the occupied area has not expanded, and sparsely vegetated native dune mat habitat with low levels of disturbance remains limited.

The number of populations in the Central and South Coast Ecoregions with lower levels of resiliency compared to the rest of the species range reduces the species overall ability to maintain adequate representation and redundancy into the future. The number of ecological settings in which resilient populations occur is used as a proxy for genetic diversity in this analysis because no differences have been found in the genetics and phenology of plants in different populations to date. Therefore, the low number of populations and abundance values for the Central and South Coast Ecoregions (compared to the populations and subpopulations spread across the North Coast Ecoregion) reduces the likelihood of adequate redundancy of the species in the future. However, the sizable distance between the three largest population centers within the North Coast Ecoregion (North Spit Humboldt Bay, Mouth of the Mattole River, and Point Reyes NS) boosts the likelihood of adequate redundancy in the future, since the likelihood that a catastrophic event would wipe out all three population centers at once is relatively low (though certainly not impossible). Improvement of habitat at the Signal Hill Dunes and Vandenberg AFB populations, as well as (re)introduction to high quality habitat (such as at Carmel-by-the-Sea or the extirpated Point Pinos population area within the Central Coast Ecoregion) would also help ensure adequate redundancy in the future by increasing the number of resilient populations and the connectivity of those populations in the Central and South Coast Ecoregions.

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APPENDIX A—Existing Regulatory Mechanisms and Voluntary Conservation Efforts

1.0 FEDERAL—Department of the Interior

1.1 SERVICE

The Humboldt Bay NWR includes both the Lanphere Dunes Unit (former Lanphere-Christensen Dunes Preserve), and the Ma-le'l Dunes Unit (also known as Ma-le'l North) properties located on the North Spit of Humboldt Bay, which together contain about 38 ac (15 ha) of occupied habitat. The Refuge is managed in accordance with a 15-year Comprehensive Conservation Plan (CCP)(Humboldt Bay NWR 2009, entire), which incorporates restoration and management goals designed to benefit beach layia and the other listed species present. Management direction for the NWR System ultimately is contained in part 601 of the Service's Manual (Service 2006), which assigns highest management priority to fulfilling refuge purposes, including compliance with laws such as the Act and the Migratory Bird Treaty Act. Next highest priority for management of refuges is given to maintaining biological integrity, diversity, and environmental health (Service 2001). That direction, although general, would theoretically provide for post-delisting maintenance of beach layia as a component of the natural dunes community within the Refuge. Inevitably however, once beach layia is delisted, and after a minimum 5-year post-delisting monitoring period mandated under the Act has passed, the management priority given to population monitoring and maintaining its habitat will receive less emphasis, particularly where conflicts in management (funding, staff availability) exist between fulfilling the refuge purposes (for example, compliance with Act and Migratory Bird Treaty Act) and maintaining beach layia. One way to ensure future conservation of the species and its habitat may be to include specific guidance within the Comprehensive Conservation Plan to maintain the species on the Refuge.

1.2 BLM

The BLM owns several properties that support beach layia, including the Samoa Peninsula Management Area on the North Spit of Humboldt Bay (includes Manila Dunes Area of Critical Environmental Concern; Manila Dunes Research Natural Area, Ma-le'l Dunes South property; Samoa Dunes Recreation Area), and dunes located within the King Range National Conservation Area at the mouth of the Mattole River. Together, these areas include about 47 ac (19 ha) of habitat currently occupied by beach layia. The BLM also holds a conservation easement on dunes owned by CDFW on the South Spit of Humboldt Bay. In 2005, the BLM adopted their King Range Management Plan (BLM 2004, entire), which formalized future monitoring and protection of the beach layia population while it remains listed under the Act. Management direction for the Samoa Peninsula Management Area, and the South Spit Management Plan include provisions for future habitat restoration and protection of beach layia so long as it remains listed (BLM 1995; AFWO 2002). Subsequently, it would depend on whether the species remains on their agency Sensitive Species List.

However, with respect to BLM commitment to future management, there are no regulations or policies that speak directly to conservation of this species after it is delisted by the Federal and State government (Willoughby, BLM, 2007, pers. comm.). The only meaningful protection after delisting must be contained in the individual Resource Management Plans, and specific activity plans, such as are written for Areas of Critical Environmental Concern. These plans generally are written for a 10 to 15 year planning horizon. Therefore, in order for beach layia to receive long-term protection on BLM lands after it is delisted, the relevant Resource Management Plan or other site specific plans would need to be amended, and perhaps an agreement made to maintain the species on the agency sensitive species list, such that the future threats from native or nonnative invasive species, OHVs, and other threats are monitored and dealt with as needed to maintain viable populations.

1.3 National Park Service (Point Reyes NS)

Point Reyes NS includes abundant near-shore dunes potentially suitable for beach layia, and approximately 146 ac (59 ha) of currently occupied habitat (Point Reyes NS 2010, p. XX). The enabling legislation for Point Reyes NS was somewhat unique within the National Park Service in that it emphasized conservation of the undeveloped coastline over, and above, the provision of recreational opportunities (Rodgers, Point Reyes NS 2007, pers. comm.). The current draft General Management Plan and Environmental Impact Statement for Point Reyes NS includes general direction to "stabilize and improve populations" of listed species, and original plans were to include new guidance in the form of a Resource Stewardship Strategy, to include a 300-ac (12-ha) dunes restoration program that would benefit a portion of the Beach layia habitat there (Rodgers 2007, pers. comm.). Financial constraints have prevented the Point Reyes NS from updating the General Management Plan and finalizing the Resource Stewardship Strategy. However, great strides in dune restoration have occurred. Since 2001, Point Reyes NS has restored a net of 250 ac (101 ha) in a net 461-gross-ac (186-gross ha) project area, ultimately improving about 600 ac (243 ha) of coastal dune habitats along the seashore (Parsons 2018, pers. comm.).

1.4 Redwood NP

The northernmost occurrence of beach layia at Freshwater Lagoon Spit, in northern Humboldt County, is owned by Redwood NP. Their management follows a General Management Plan, completed in 2000, which covers a period of 20 years (Arguello, Redwood NP and State Parks 2007, pers. comm.). They have no specific direction for management of Freshwater Lagoon Spit. Redwood NP has taken measures to reduce pedestrian, vehicle, and unrestricted camping impacts on the native dunes, which likely has both benefited, and perhaps negatively affected beach layia. No active restoration of its habitat has been conducted.

Since the population of beach layia was discovered in 2000, park staff has monitored the population annually. As a federally listed species, beach layia is automatically included on the Redwood NP Sensitive Plant List, and therefore is taken into account in planning of all park projects. Currently, Redwood NP has no management direction to ensure the monitoring and responsive management necessary to maintain beach layia once this species is delisted both at the Federal and State levels. Specific management direction could be added to the General anagement Plan when it is renewed in another 13 years (Samuels 2017, pers. comm.).

2.0 FEDERAL—Department of Defense

2.1 Vandenberg AFB

The southernmost distribution of beach layia is at Vandenberg AFB in Santa Barbara County. Management and restoration goals affecting beach layia are generally described in the Integrated Natural Resources Management Plan (INRMP) for the facility. The INRMP for Vandenberg AFB was recently updated (signed by Diane Noda 2012). The INRMP indicates the intent of the facility to "implement an effective, long-term management program for protection and conservation of special status plants," and describes management considerations and protections relevant to beach layia, including listing the local and State environmental laws with which the AFB must comply. The INRMP element outlining control of invasive species gives high priority to restoration of listed species habitat. While the INRMP does not specify, or mandate a plan to restore beach layia habitat, it does provide for security of its habitat. The facility has no current obligation or policy direction to proactively manage for beach layia, or maintain its habitat once the species is delisted.

3.0 STATE

3.1 CDFW

The extensive dunes on the South Spit of Humboldt Bay, which extends south to the mouth of the Eel River, are owned by CDFW. Approximately the northern 70 percent of those dunes is managed by the BLM under a conservation easement. The southern portion is contained within CDFW's ERWA, managed under the general provisions for state wildlife areas contained in Title 14 of the California Administrative Code. In general, the ERWA is open to the public, with restricted vehicle use and consumptive and non-consumptive uses such as hunting and other special activities subject to the approval of the Regional Manager. OHV use is restricted to the ocean wave slope and a single dune access road, which is posted. In general, management guidance for state wildlife areas contains the flexibility to respond to changing resource needs. No enhancement projects or habitat manipulation have been conducted or are planned for beach layia. Since the ERWA was acquired primarily for its wetlands, any future habitat restoration projects would likely emphasize the wetlands, or take a holistic habitat approach which, while potentially benefiting beach layia, probably would not emphasize specific needs for the species (Kovacs, CDFW 2007, pers. comm.).

3.2 CDPR

The CDPR owns and manages only one site supporting beach layia at Asilomar State Beach on the Monterey Peninsula. As a result of extensive restoration over the past 20 years, that park contains exceptionally high quality near-shore dunes habitat, which supports a relatively small population of beach layia (Table 2; Madison 2007). Management of Asilomar State Beach is guided at the highest level by the Department Operations Manual (CDPR 2004a, entire), and more specifically, the Asilomar State Beach General Plan (CDPR 2004b, entire). The Department Operations Manual generally advances a holistic approach to natural resource management, and "does not attempt to solely preserve individual species except threatened or endangered species in special situations." Ultimately, the Manual allows for waiver or modification of department policy on a case by case basis by the Director. Due to limitations of park management policy (variability in staffing levels, staff interest and management priorities), there is no guarantee that appropriate management will continue long-term for beach layia. There appears to be no specific agency direction which would ensure future conservation of beach layia after it is delisted (Madison 2007, pers. comm.).

Asilomar State Beach is relatively unique within California State Parks in that a portion of the proceeds from the on-site conference center goes to habitat maintenance in the park, and has successfully funded an aggressive dunes restoration effort. Although allocation of funding remains somewhat discretionary (L. Madison, pers. comm. 2007), this funding mechanism is as close as any across the range of beach layia to meeting the stated recovery goal for an endowment enabling long-term habitat maintenance.

4.0 LOCAL GOVERNMENT AND SPECIAL DISTRICTS

4.1 Manila CSD

The Manila CSD owns a large portion of the near-shore dunes on the North Spit of Humboldt Bay. The CSD developed a long-term management plan calling for restoration and maintenance of its native dunes and endangered species, as well as recreation and beach access (Wear 2006, pers. comm.). The dune restoration has not been completed, and the management plan does not include any financial provision to fund long-term management; funding is currently dependent on the CSD receiving grants (Pickart 2007, pers. comm.)

4.2 City of Eureka

The City owns a significant amount of near-shore dunes around Humboldt Bay, including an estimated 16 ac (6.5 ha) of habitat occupied by beach layia in the southern portion of the North Spit (Humboldt Bay NWR 1999).

The City also owns the Elk River Spit on the east shore of the bay, supports 15 ac (6 ha) of dunes occupied by Beach layia. The City has no specific direction for management of its lands with respect to listed species. With the exception of about 84 ac (34 ha) of their land on the North Spit zoned as Natural Resource, their land is zoned for coastal dependent industry, and is currently utilized for a variety of recreational activities, including OHV activity, a dragstrip, a bed and breakfast, an airport, and past dumping of dredge spoils and sand mining (Shikany, City of Eureka 2007, pers. comm.). The 84 ac (34 ha) of dune habitat is covered under a conservation easement held by the Center for Natural Lands Management. The easement provides general direction for future conservation of the natural resources. A local non-profit organization (Friends of the Dunes) periodically conducts invasive species removal projects on about 25 percent of the property (Wear 2007b, pers. comm.). A restoration plan developed for this property in the 1990's has not been implemented and the overall habitat condition continues to decline for beach layia, however, there is interest by the Center for Lands Management to initiate some small scale restoration (Sanchez 2017, pers. comm.).

The Elk River Spit is also zoned as Natural Resouurce, although the City is exempt from the Humboldt County Zoning ordinance. However, the City is subject to the local coastal plan, which would likely require consideration of mitigative measures for any projects there, or on the

North Spit, that impact near-shore dunes habitat. Such projects would also likely trigger review under CEQA.

4.3 County of Monterey

5.0 VOLUNTARY CONSERVATION

5.1 Friends of the Dunes (Friends)

The Friends, an organization dedicated to the conservation of the dunes ecosystem around Humboldt Bay, acquired in YYYY a significant near-shore dune holding on the North Spit of Humboldt Bay, with the assistance of the California Coastal Conservancy. As part of that agreement, there is an irrevocable offer to dedicate fee title on the property to the state, if the terms of the state grant are violated (Friends website; Exhibit A, undated). Those terms preclude most kinds of development, and stipulate the primary management shall be for public access, open space, habitat conservation and outdoor recreation.

5.2 Pebble Beach Company

The Pebble Beach Company owns two of the three extant sites for beach layia on the Monterey Peninsula:

Indian Village Dunes: Other than Asilomar State Beach, this is perhaps the best intact dune habitat on the Monterey Peninsula. This habitat currently supports the largest population of beach layia on the peninsula. Although owned by Pebble Beach Company, the Del Monte Forest Foundation holds a conservation easement (Pebble Beach Company 1989) formalized in 1999. The easement restricts most kinds of development on the property. While not expressly mandating conservation of the dunes habitat, the easement contains a provision for "management, maintenance and improvement activities for the conservation, protection and enhancement of the natural habitat."

Signal Hill Dunes: These dunes are included in the approved Del Monte Forest Preservation and Development Plan (Certified by the Coastal Commission on May 9, 2012). As part of that plan, in return for approval of a golf course located on Signal Hill, a conservation easement would be dedicated by the Pebble Beach Company covering the Signal Hill Dunes Conservation Area, which would mandate the future monitoring and restoration necessary to maintain the dunes and resident endangered species in perpetuity (Coastal Commission 2012).

5.3 Other Private Owners

With the exception of a portion of habitat owned by the City of Eureka, virtually all property supporting beach layia on the North Spit of Humboldt Bay is zoned Natural Resources in the Humboldt County General Plan. The local coastal program (Humboldt County 1995, entire) and County zoning ordinance afford considerable protection to beach layia and its habitat which, among other restrictions, prohibits vehicles above the wave slope except in the Samoa Dunes Recreation Area. The County planning documents also recommend management to restore degraded dunes, including removal of nonnative, invasive plant species, fencing of rare plant habitat, and limiting public access.

APPENDIX B—Arcata Fish and Wildlife Office Beach Layia Analysis Information

<u>*Humboldt Bay population estimation*</u>

To estimate the number of beach layia individuals in the Humboldt Bay area, we utilized a randomized sampling protocol limited to the extent of potential beach layia habitat in the region. We counted the number of beach layia individuals within meter-squared quadrats at each generated sampling point. We also recorded ocular estimates of open sand, as well as noted the presence of rare or invasive species within the quadrat. We used these data to estimate population abundance across the study area.

Study area

The Humboldt Bay area is located in Humboldt County, California and contains the largest number of beach layia throughout the distribution (Exhibit 1, below). Beach layia requires low-competition and open sand to germinate and reproduce (citation). The extensive dune systems and associated restoration have activities have provided large expanses of suitable habitat for the species. Beach layia patches in the area extend non-continuously from the mouth of the Eel River to the mouth of the Mad River. Given that the Humboldt Bay area is the stronghold for the species, the need to estimate the population size was evident when examining the overall status of the species.

Comment [e30]: Re-write

Sampling point generation

To obtain an unbiased estimation of ~~-~~ beach layia density throughout the Humboldt Bay area, we generated random sampling locations within potential beach layia habitat. Since beach layia is restricted to open, coastal dune systems where competition is low, we aimed to define an area of potential beach layia habitat that was representative of these conditions and within reasonable proximity to known beach layia patches. We established the area of potential habitat starting with the most recent beach layia mapping effort from 1999 that was conducted by the Humboldt Bay National Wildlife Refuge. Given the age of the dataset, our establishment of potential beach layia habitat was dynamic and updated in the field during sampling activities. To do this, we generated hard-copy maps of the area at a scale of 1:4,000 or better (approximately 1 inch = 100 meters) to bring ~~in~~to the field for annotation. We added areas where beach layia had not been previously mapped and removed areas that were previously populated, but had degraded due to changes such as invasive species colonization. We then used these annotated hard copies to update the 1999 mapping effort shapefile. This resulted in a high-quality dataset that detailed the extent of beach layia habitat in the Humboldt Bay area.

To initiate sampling, we started with the shapefile of the 1999 mapping effort and buffered it by 10 meters in ArcMap 10.5 to ensure more complete coverage of potential habitat. We used this buffered shapefile as our initial sampling extent. We then created random sampling locations (NAD83 UTM Zone 10) in within the buffered shapefile using the Create Random Points tool. We generated sampling locations quasi-proportionally based on size of the area, the minimum number of points sufficient for analysis, heterogeneity of the area, and personal knowledge of the area. Since we had elected to use a meter-squared size quadrat, we selected a minimum distance between points to be one meter, which ensured that there was no overlap in sampling area. We used the program DNRGPS to transfer the location data of these points onto Garmin Global Positioning System (GPS) units.

> **Comment [e31]:** Please list the total area from which random points were selected. Also, list the number of random points that were sampled. What was the percent of the total area sampled?

Field data collection

We used the Garmin GPS units to navigate to each sampling location. If the sampling location was located within wholly unsuitable habitat, then we established an alternate location by using a random number generator to select an integer between 1 and 10 and walking the resultant number of meters to the new location. We determined the bearing at which we walked from the original point by visually inspecting the surroundings and then orienting towards any potentially suitable beach layia habitat. In instances where we identified previously unmapped layia patches, we generated sampling points in the field at an approximately equal density to other patches in the area. At each field-generated point we collected a GPS reading onto the Garmin as well as noted the NAD 83 UTM coordinates for Zone 10.

> **Comment [e32]:** How does that bias your pop estimates? If I'm reading the correctly, it biases your estimates upward. How often did this happen? Listing the number of times would be useful.

> **Comment [e33]:** Dates of sampling? How does that match with the phenology of the plant?

Once at the predetermined sampling location, we faced due north and placed a meter-squared PVC quadrat on the ground with the lower-left corner of the quadrat at the sampling location. We recorded the number of beach layia individuals within the quadrat as well as ocular estimates of the percent cover of open sand, invasive species, and annual grasses. We also noted the presence of other rare and sensitive species including Menzie's wallflower (*Erysimum menziesii*; federally endangered), dark-eyed gilia (*Gilia millefoliata*), and short-leaved evax (*Hesperevax sparsiflora* var. *brevifolia*).

Population estimation

An estimate of the total number of beach layia plants, and the variance of that estimate, were generated by applying stratified random sampling methods, whereby the entire geographic domain for which the population estimate is desired is first partitioned into non-overlapping strata, and then within each strata each sampling location is selected via simple random sampling without replacement (Thompson, 2002). When stratifying a sampling domain over geographic space, it is common to stratify according to variables known to relate the abundance of the target species, like elevation, or habitat type. For beach layia, the myriad of land ownership types translate into differing land management practices, both current and historical. Hence, strata boundaries were drawn according to ownership boundaries, and a stratified population estimate was computed.

> **Comment [e34]:** Very confusing sentence – please re-write.

Results

Exhibit 1: Abundance estimates with upper and lower confidence intervals for the populations/subpopulations sampled.

> **Comment [e35]:** Please show how you calculated the Cis.

Population/Subpopulations	Estimate	Lower C.I.	Upper C.I.
Lanphere Dunes	1,346,635	386,215	2,307,055
Ma-le'l North	1,336,549	564,088	2,109,011
Ma-le'l South	2,124,974	560	4,477,709
Manila North	1,467,726	346,689	2,588,763
Manila South	3182815	1,172,717	5,192,913

Samoa/Eureka Dunes	6,681,384	4,074,115	9,288,653
Elk River Spit	468,840	264,052	673,627
South Spit Humboldt Bay Unrestored	6,070,183	3,293,259	8,847,106
South Spit Humboldt Bay Restored	6,148,523	3,188	12,299,497
North Spit eel River (ERWA)	4,747,357	2,691,540	6,803,173
TOTAL	**33,574,985**	**25,270,550**	**41,879,420**

Sea level rise vulnerability assessment

To assess the vulnerability of beach layia to the effects of sea level rise, we calculated areal proportions of each beach layia population that have a 95% probability of being inundated based on regionally specific predicted SLR values in Rising Seas in California (Griggs 2017) and unpublished work by Northern Hydrology & Engineering (NHE; Anderson 2017). We used Mean Higher High Water (MHHW) in NAVD88 from three local tide gauges as benchmarks to define the threshold of elevation that is inundated at current sea elevation. For each area, we added the predicted values of sea level rise to this benchmark to determine elevations that would be inundated at three points the future: 2050, 2100, and 2150. Then we used a LiDAR-derived digital elevation model (DEM; 2016 and 2010 depending on coverage) at a 1-m resolution to obtain elevation values for each square-meter of the beach layia populations. We then used the Reclassify tool in ArcMap 10.5 to classify the DEM into areas that were either above or below the inundation threshold for each of the three points in the future. Using polygon shapefiles of beach layia populations at each location and the reclassified DEMs as inputs, we used the Tabulate Area tool to calculate the proportion of habitat that would be vulnerable to sea level rise for each of the years at each location.

Comment [e36]: While I think I understand what you've done, I'm concerned that sea level rise may also change dune morphology beyond the area of inundation. Can you consider this, or at least discuss it?

Example:

If the MHHW for an area is 2.8 ft (85 cm) in NAVD88, then we assume that all elevations at or below 2.8 ft (85 cm) NAVD88 are inundated at a frequency that would prevent establishment of beach layia at that location. If predicted sea level rise for that location is 0.9 ft (27 cm) by 2050 then we would add 0.9 ft (27 cm) to 2.8 ft (85 cm) to determine that by 2050 all elevations at or below 3.7 ft (113 cm) NAVD88 would be inundated at a frequency that would prevent establishment of beach layia. Using a DEM and the Reclassify tool in ArcMap, we can classify each pixel as above or below the inundation threshold, which we had determined to be 3.7 ft (113 cm) NAVD88. Then, with the Tabulate Area tool, we can calculate the amount of area above and below the predicted inundation threshold within the beach layia habitat, which allows us to calculate a proportion. So, if we ran the Tabulate Area tool and 2,153 ft^2 (200 m^2) of a polygon was below the threshold and 8,611 ft^2 (800 m^2) was above the threshold, then we could calculate that 20% of the beach layia habitat in that area is vulnerable to sea level rise by the year 2050.

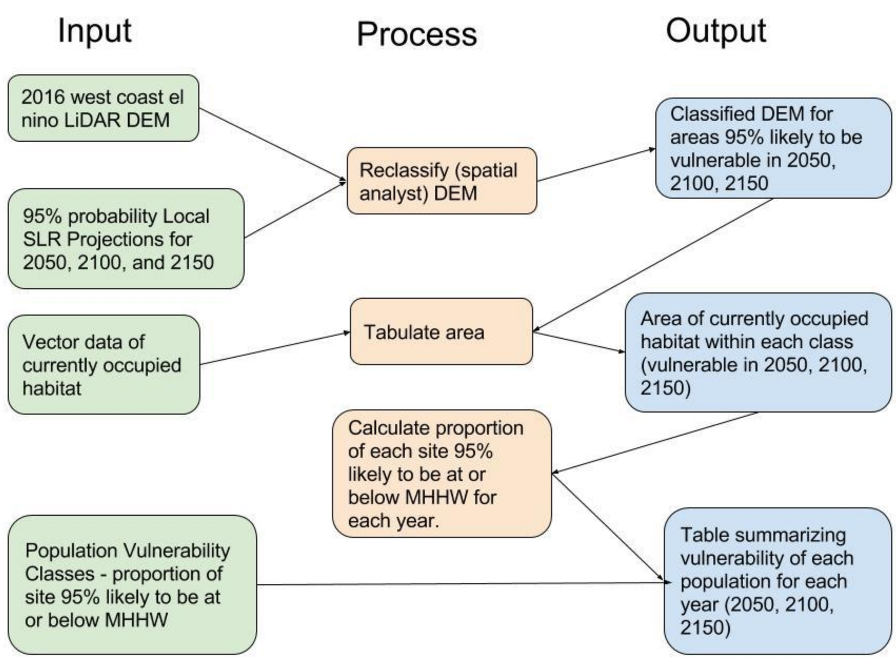

Exhibit 2: Workflow of vulnerability assessment of currently occupied beach layia habitat in relation to projected future sea levels.

Results:

Exhibit 3: Proportions of currently occupied habitat projected to be under mean higher high water in 32, 82, and 132 years.

Ecoregion	Site	2050	2100	2150
North Coast	Mad River Slough (Lanphere Dunes, Ma-le'l)	0.00	0.01	0.17
	North Spit (Manila, Samoa, Elk River)	0.00	0.04	0.15
	Hookton Slough (South Spit, Eel River)	0.00	0.15	0.45
	Point Reyes NS	0.00	0.00	0.01
Central Coast	Monterey Peninsula	0.00	0.00	0.00
South Coast	Vandenberg AFB	0.00	0.00	0.00

APPENDIX C—Detailed Recovery Criteria Evaluation

[insert]